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Astronomy and astrophysics publication research metrics among southeast Asian countries

Ryan Manuel D. Guido

Center for Astronomy Research and Development, Rizal Technological University, Mandaluyong City, 1550, Philippines

ABSTRACT

This study explored the productivity of six (6) selected Southeast Asian countries: Indonesia (ID), Malaysia (MY), Philippines (PH), Singapore (SG), Thailand (TH), and Vietnam (VN) in the field of astronomy and astrophysics. It aims to provide an analysis of the research productivity in Scopus publication of the mentioned countries in terms of (i) published documents, (ii) citations, (iii) international collaboration, and (iv) open access in the Scimagojr database in the span of 11 years (2013 – 2023). Data were processed using Python packages and Excel to illustrate data visualization, interpretation, and forecasts of each term. The Compound Annual Growth Rate (CAGR) was also used in the study to discuss the comparative performance of each country further. The study reveals that TH has the most promising performance among SEA countries based on the above metrics. It has shown a decreasing trend in the number of citations. In contrast, PH has the highest CAGR of 16.76%, but it still lacks other metrics, and SG has the lowest CARG (-0.78%), which means decreasing research publications among the SEA countries under the study. Other results are shown in the paper.

INTRODUCTION

This study aimed to investigate the landscape of research metrics within the Scopus publications across Southeast Asian (SEA) countries. It delved into various metrics, including the number of published documents, the extent of citations garnered, the percentage of international collaborations, and the percentage of open-access initiatives. Moreover, this study aims to give an up-to-date and comprehensive analysis of research production in astronomy and astrophysics (AAPhy) as measured by Scopus journal publications' metrics. This timely and vital assessment will serve as a firm foundation for evaluating the current and future initiatives to advance astronomy and astrophysics research in the SEA region.

More specifically, studies like this on research metrics could offer valuable insights to institutions (Dela Cruz et al., 2023), enabling an examination of strategies to enhance its competitiveness relative to its neighboring countries. Given the Philippines' wealth of institutions and scientists engaged in the field of AAPhy, understanding and leveraging these findings could facilitate the country's advancement within the academic and scientific landscape.

This investigation provides a thorough analysis of the developing research profiles (Potter & Pearson, 2023), identifies challenges in the sets of metrics, and uncovers opportunities for fostering further growth and collaboration in the SEA research ecosystem. This study also enriches our understanding of the research endeavors within the SEA region. It provides valuable insights into countries to shape the future trajectory of research in AAPhy. The researches in the field of AAPhy is being guided by the sets of standards as per strategic initiatives of the International Astronomical Union (IAU), founded in 1919, unites the global scientific community, comprising over 12,783 members from 93 nations. It organizes conferences, defines fundamental astronomical constants, establishes nomenclature, and promotes astronomy through outreach programs, fostering

*Corresponding author
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KEYWORDS

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collaboration and advancing research. Recognized by the United Nations, the IAU is pivotal in bestowing names to celestial bodies, emphasizing diversity, youth participation, and collaboration with international organizations to promote astronomical research and education.

In recent years, higher education institutions (HEIs) in SEA have faced increasing pressure to boost research publications (Oladipupo et al., 2020), driven by promotion requirements for faculty members or else for them to perish (Kelly et al., 2020), and graduation candidacy for the graduate students. This push has led HEIs to prioritize research output, acknowledging its importance for institutional success (O'Keeffe, 2020). However, the effectiveness of this approach depends greatly on the research culture and environment within each institution. Factors like collaborations and academic position significantly influence research performance, while challenges like job security and ineffective support to researchers exacerbate issues in the research environment. For graduate students, publishing is essential for university research productivity (Knudson, 2019), emphasizing the importance of engaging in the institution's research culture and building relationships. There is a notable expectation for faculty members pursuing graduate studies to actively contribute to thesis and dissertation publications (Niles et al., 2020) thereby enhancing institutional research productivity and individual academic progress. Several studies have demonstrated that collaborative research yields significantly greater outcomes in terms of scholarly and real-world impact than individual research endeavors (Guido & Orleans, 2020). This collaborative approach is widely regarded as beneficial by researchers and institutions alike. Effective collaborative works exhibit clear and relevant roles and skills, share common goals, and possess knowledge integration and resource-sharing abilities, fostering innovation (Macfarlane, 2017). Measurable indicators, such as research performance and citation counts, serve as metrics for assessing academic relevance and the impact of collaborative research efforts (Kuzhabekova et al., 2018).

Research indicates that Nobel laureates tend to publish more frequently than the average researcher, believing that increased publication output enhances the likelihood of significant outcomes from their endeavor. This frequent publication activity is often associated with introducing novel and relevant contributions to the scientific community (Meng & Gao, 2020). Emphasizing knowledge creation, impact, and collaborative efforts, the culture surrounding research publications fosters academic proficiency, boosts research performance, and creates professional opportunities within the academe.

Citations serve as a robust measure for assessing the quality and impact of scientific research. It signifies that a paper has achieved a level of recognition within the scientific community (Ivanović & Ho, 2019), contributing distinctively to the advancement of knowledge (Jensen et al., 2020). Researchers commonly utilize citations to gauge the scientific impact of their work, with metrics such as h-index providing a quantifiable measure of a researcher's influence. Moreover, citations denote the ongoing relevance and utilization of scientific articles, reflecting their continued contribution to the field. Citation analysis enables researchers to explore the dissemination of knowledge within specific research areas, identifying influential publications and driving intellectual development. This approach is invaluable for understanding the dynamics of scientific research publications, identifying key contributors and institutions, and recognizing global trends. Furthermore, citation-based analysis is integral to literature reviews and can guide future studies and essential research directions.

MATERIALS AND METHODS

This study utilized the largest bibliometric database (Scopus) to quantitatively assess the research profile in the SEA over the past 11 years in AAPhy, summarize the quality of research using conventional metrics of research quality, and predict a potential increase in research metrics over the period. The study will focus on the research metrics. It will be explored with other Southeast Asian (SEA) countries in terms of the following metrics: (i) published documents, (ii) the number of citations, (iii) the percentage of international collaborations, and (iv) the percentage of open access. This study also displayed a country-by-country comparison matrix between (i) the number of published documents and the number of citations, (ii) the number of published documents and the percentage of international collaborations, (iii) the number of published documents and the percentage of open access, (iv) citations and percentage of international collaborations, (v) citations and percentage of open access, and (vi) percentage of international collaboration and percentage of open access. In addition, the forecast of each SEA in terms of (i) published documents is another feature of this study.

This study focuses on the 11 years for the annual number of research publications restricted solely to the Scimago data entries in astronomy and astrophysics from 2013 to 2023. The data from Scimago Journals and Country ranks are raw data that contain an excessive amount of information. Based on the matrix used in this study, data were extracted from six (6) SEA countries with significant performance: Indonesia (IN), Malaysia (MY), Philippines (PH), Singapore (SG), Thailand (TH), and Vietnam (VN). The extracted data were processed and cleansed using Python programming and its various fundamental packages for scientific computing. Some data representations (percentage of international collaborations and percentage of open access) were not normalized compared to other variables (published documents and citations). This study's data presentation aims to allow simultaneous visualization of the two different variables with their distinct scales. This study would like to show the absolute values of each variable to provide a clear representation of their magnitudes and enable the visualization of relationships between variables that may not be evident when normalized. Thus, some variables were presented using the two y-axes approach.

Comparative Analysis of Research Output with Southeast Asian Nations

The study analyzes the research metric results using the criteria established by Scopus. It provides information regarding the number of published documents and citations, international collaboration, and open access in the country in the field of AAPhy. The study compared the data based on its metrics over time with the data based on the SEA country by using the aforementioned criteria to provide some context for the data.

Temporal trends

Over time, the evolution of the number of publications was characterized by a compound annual growth rate (CAGR) (Hassan Al Marzouqi et al., 2019), as well as their trends in documents (*Dt*), citations (*Ct*), International Collaborations (*ICt*), and Open Access (*OAt*).

R-squared

The statistical analysis reveals the degree to which the data in each matrix matches the expected research progress. It is very useful for predicting rank order performance and a demonstration for comparison (Rights & Cole, 2018). It is used for general regression models that use maximum likelihood for

parameter estimation and is widely used for logistic regression. It is also used for general regression models. Together with the forecasting analysis, it explains the accumulated progress over the intervals, allowing for more accurate predictions and inferences about how individual SEA countries will fare in the future. The R^2 value reveals a proportion of the variance for consistency of progress over time-based on the strength and similarity of trends (Humphrey et al., 2019).

RESULTS AND DISCUSSION

1. Southeast Asia Research Profile

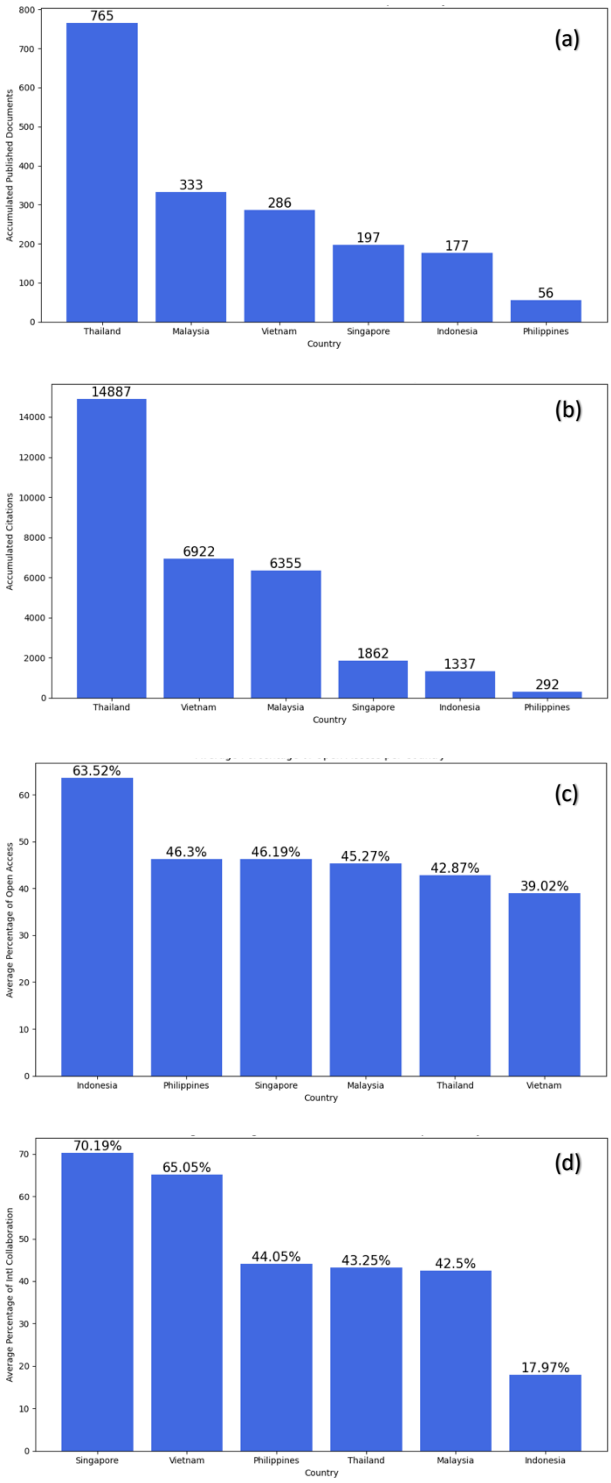


Figure 1: Southeast Asian countries Research Profile: (a) Accumulated Published Documents, (b) Accumulated Citations, (c) Average Percentage of International Collaboration, and (d) Average Percentage of Open Access.

The research profile of Southeast Asian countries includes various essential variables that together illustrate the scientific landscape of the region. Published documents accumulated are a key measure of research output, indicating the amount of scholarly work conducted in the region. This statistic demonstrates the extent of scientific activity and enhances the respective nations' intellectual resources, promoting innovation and knowledge sharing. Accumulated citations measure the influence and prominence of research outputs, reflecting how Southeast Asian research contributes to the worldwide scientific conversation. Significant citation counts bolster the prestige of individual researchers and institutions and indicate the impact and significance of the region's research contributions worldwide.

The average proportion of international collaboration highlights the significance of global relationships and the flow of knowledge in promoting scientific pursuits. Working with colleagues from around the world allows for the exchange of different knowledge, resources, and viewpoints, enhancing the quality and influence of research outcomes. Additionally, it enhances intercultural comprehension and facilitates the incorporation of local research endeavors into the worldwide scientific community. Finally, the mean percentage of open access demonstrates the dedication to democratizing knowledge and advancing the accessibility of research findings. Open-access publications facilitate the widespread distribution of research products, maximizing their societal impact and promoting additional research and innovation. Adopting open-access principles not only increases the visibility of research, but also encourages transparency and inclusiveness in the scholarly communication system. This eventually supports scientific progress and societal development in Southeast Asia and other regions.

Figure 1a represents the SEA AAPhy Scopus performance from 2013 to 2023. Figure 1a represents the SEA countries' accumulated published Scopus documents. It shows that TH has the most (765), followed by MY (333), VN (286), SG (197), ID (177), and PH (56) in the span of eleven years.

Figure 1b shows the SEA countries' accumulated citations from the 13 years of performance; it reveals that TH has accumulated the most citations with 14887, followed by VN (6922), MY (6355), SG (1862), ID (1337), and PH (292). Figures 1a and 1b show TH's performance in terms of published documents and citations, which may be disclosed with the notion that TH has an astronomy institute in its government compared to other countries.

Figure 1c displays the average percentage of international collaborations in SEA countries. It shows that SG has the highest number of international collaborations, ranging from 70.19%. It also expresses that VN has a lot of international collaborations, with 65.05%, followed by PH (44.05%), TH (43.25%), MY (42.5%), and lastly, PH (17.97%). It shows that four SEA countries have less than 50% of their international collaboration engagement in AAPhy.

Figure 1d illustrates the percentage of open-access publications in the SEA countries. Noticeably, for the past 13 years, most AAPhy research in SEA has been below the 50% mark, except ID, with 63.52% in open access. This reflects that most publications in AAPhy in SEA are not open-access. After ID, PH (46.3%), SG (46.19%), MY (45.27%), TH (42.8%), and lastly, the least publications on open-access is VN (39.02%). It can also be interpreted that, unlike other regional countries like those in the developed countries, they have sufficient funding necessary to apply for open access compared to SEA publishing conditions.

2. Quantity of Research Output

Now, let us explore the research metrics of the SEA countries in the past 11 years. By meticulously analyzing various parameters such as publication outputs, citation counts, percentage of international collaborations, and percentage of open access. This can gain invaluable insights into the region's dynamic landscape of scientific research. PH has the most promising results of having a 16.76% CAGR, the highest among the SEA countries, and a sixteenfold increase in Scopus publications. It is followed by ID with an impressive growth in annual research publications, increasing from 8 to 27. This denotes a CAGR of 11.69% over the 11 years. TH follows this with a CAGR of 10.39%, VN (10.16%), and MY (4.51%). SG has slackened performance at -0.78%, which means it has lost its average annual basis over the period. This negative CAGR could mean decreasing research demand or shifting to different needs and trends.

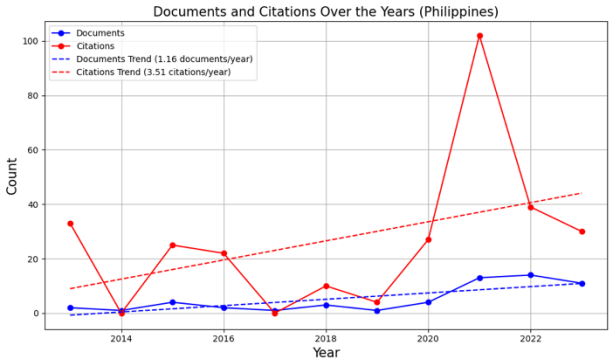
Table 1: SEA Descriptive Compound Annual Growth Rate

Country	TPD	Vb	Vf	CAGR
ID	177	8	27	11.69%
MY	333	24	39	4.51%
PH	56	2	11	16.76%
SG	197	12	11	-0.78%
TH	765	32	95	10.39%
VN	286	10	29	10.16%

Note: TPD – total published documents, Vb – beginning value, Vf – final value, CAGR – Compound Annual Growth Rate

3. Comparative Analysis

Figure 2 illustrates the published documents and citations among SEA countries in the field of AAPhy. Based on their performance, VN researchers were increasing compared to some SEA countries with a decreasing citation. Starting from around 2015, most SEA countries' citations have decreased, while VN from 2015 has shown an increasing trend. This suggests that research from VN is getting attention and has citations compared to other SEA countries. It is also notable in the figure that SG and TH have been decreasing their citations since 2014.



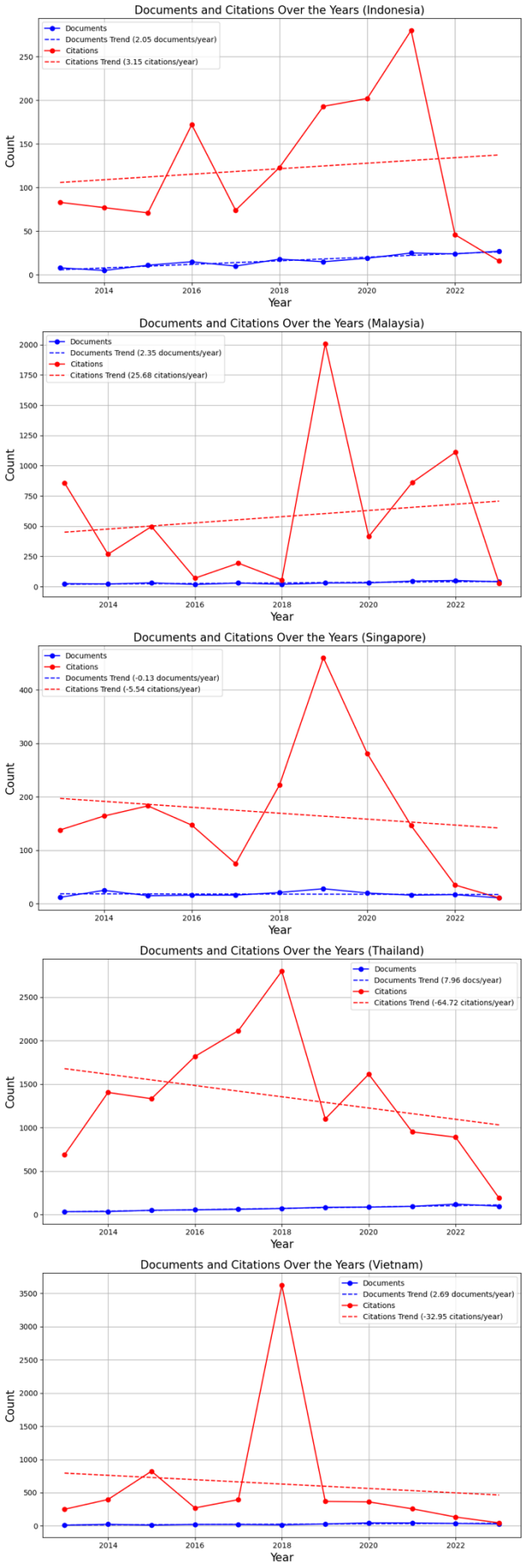
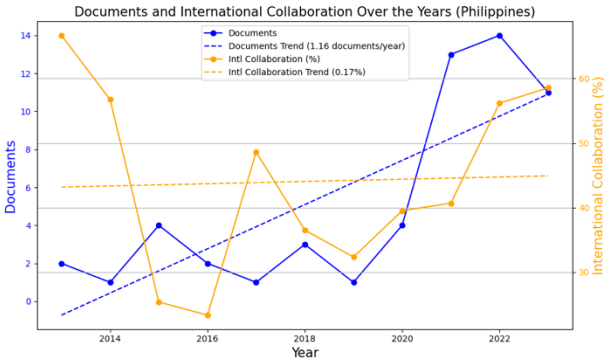


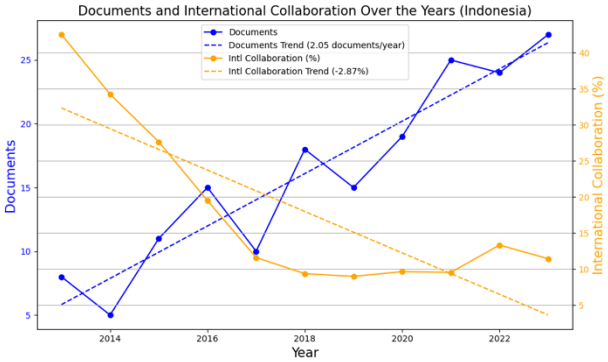
Figure 2: SEA Country's Published Documents and Citation

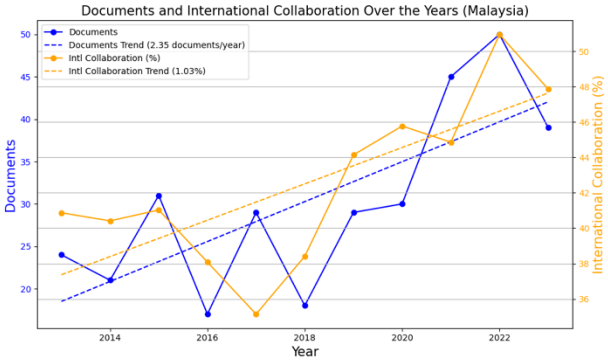
Philippine document and citation statistics reveal remarkable research output and influence patterns, with trends (*Dt = 1.16, and Ct = 3.51*), increasing the PH trend for both documents and citations. Although the quantity of documents published yearly varies, citation counts consistently rise, demonstrating that Philippine research is gaining global recognition and importance. This suggests that improvements in research facilities, international cooperation, and focusing on high-quality research may contribute to the country's positive results. These findings underline the importance of continual research and innovation investment to improve the Philippines' worldwide research status. Document and citation data from Indonesia reflect an intriguing research environment (*Dt = 2.05, and Ct = 3.15*). Despite fluctuations in published documents, citation counts have consistently increased, indicating that Indonesian research is gaining global importance and repute. Through citations, research outcomes are improving due to improved research infrastructure, expanding international relationships, and greater emphasis on critical societal challenges (Viera, 2023). These findings show that Indonesia must invest in research and innovation programs to strengthen its global research status and advance science and society.

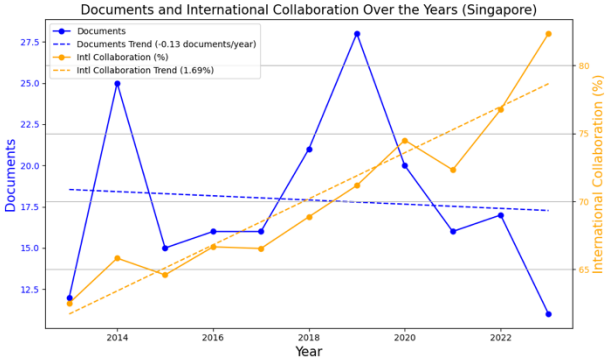
Over the past decade, document and citation data from Malaysia show a broad research ecosystem with noticeable patterns (*Dt = 2.35, and Ct = 25.68*). Although the number of published publications has fluctuated, showing research effort, citations must be more consistent. However, despite differences, citations appear to rise over time, demonstrating worldwide academic recognition and the importance of Malaysian research contributions. With this situation, the study of Li (2023) suggests that additional collaboration, funding, or study methods may be used to increase Malaysian research quality and significance. Additional analysis could examine specific research areas or factors that explain the observed patterns to better understand Malaysia's intellectual contributions and effects. Singapore's document and citation counts fluctuate over time (*Dt = -0.13, and Ct = 5.54*). Both variables increased until 2019, while documents and citations decreased after 2019. This pattern suggests a shift in Singaporean academic research culture and influence. More specific research is needed to understand these changes.

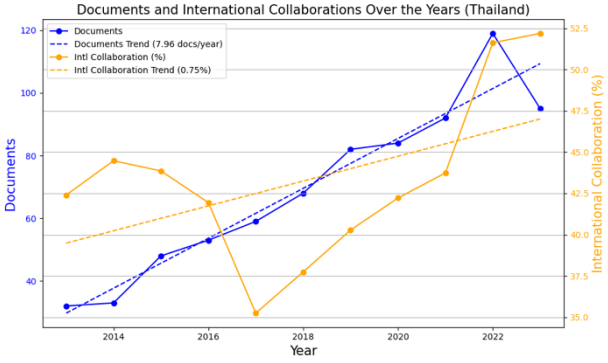
Document data from Thailand shows a fascinating pattern over time (*Dt = 7.96);* however, these documents are not cited well *(Ct =-64.72*). Between 2013 and 2023, the number of papers fluctuated from 32 to 119, and the number of citations increased from 2017 to 2020. Thailand's research is becoming more influential and recognized in the academic community, which may be due to higher research quality, wider dissemination platforms, and increased international relationships. The number of documents and citations in Vietnam has been patterned throughout time (*Dt = 2.69, and Ct = 32.95*). The number of documents ranged from 10 to 45, but citations climbed, peaking at 3623 in 2018. Although Vietnam may produce fewer documents than other countries, its research quality and influence have improved as measured by citations. This suggests prioritizing effect over quantity in research outcomes (Colavizza, 2023).











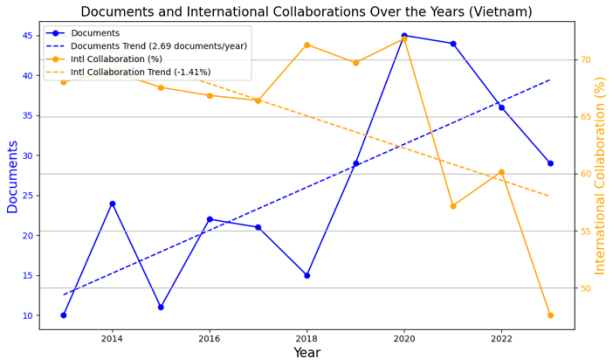
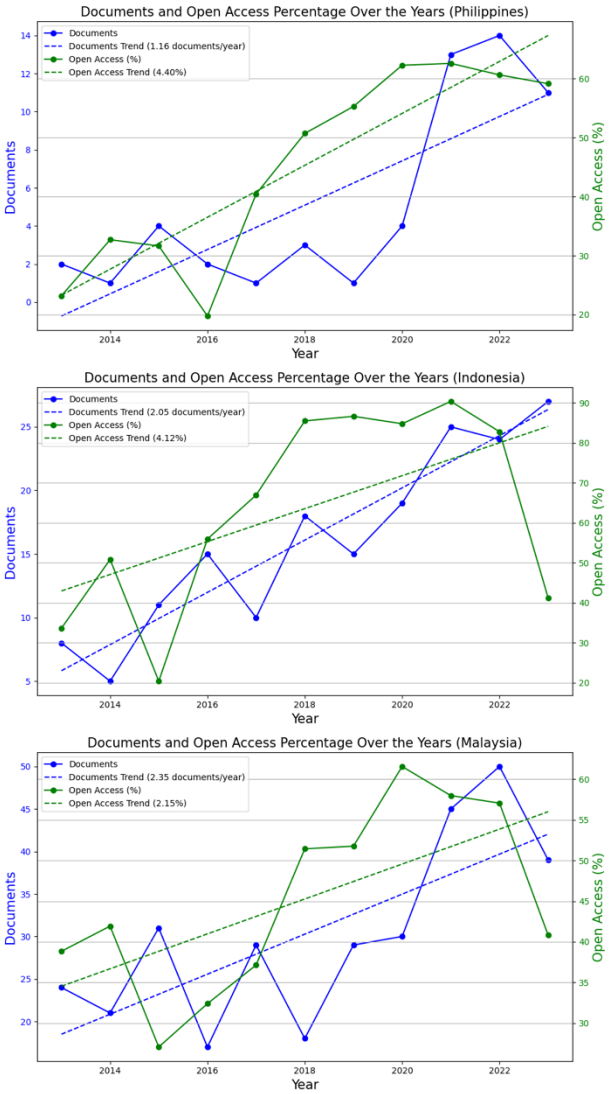


Figure 3: SEA Country's Published Documents and International Collaborations

Data on Philippine research documents and international cooperation show noteworthy trends (*Dt = 1.16, and ICt = 0.17%*). Increasing international collaboration is shown by the number of collaborative research initiatives, even though published documents vary annually. Global collaborations are increasingly valued for advancing research goals and employing a wide range of knowledge. The rise in foreign cooperation shows Philippine scholars' proactive participation in the global scientific community. This interaction enhances information sharing and research impact. This tendency shows the Philippines' commitment to cooperative and inclusive research. This is crucial for solving complex issues and fostering creativity in a fast-changing society. However, Indonesia's increasing document accounts over time with decreasing international research collaboration percentage may reflect its active participation in the worldwide scientific community (*Dt = 2.05, and ICt = -2.87%*). The number of documents is increasing, but collaborative research activities are decreasing, which needs to improve international cooperation. This trend shows Indonesia's decreasing commitment to international cooperation, information sharing, and using a variety of experiences to solve complex challenges and inspire creativity. Indonesia is increasing its research and becoming a valuable scientific contributor through less international relationships. This spreads information and advances society worldwide.

Malaysia's document and foreign collaboration statistics clearly show the country's research environment and global involvement (*Dt = 2.35, and ICt = 1.03%*). Over the past decade, Malaysia has progressively boosted overseas cooperation, exhibiting a proactive attitude to building global scholar relationships. This trend shows Malaysia's commitment to using diverse skills and resources to solve complex challenges and foster innovation. Through international cooperation, Malaysia enhances research quality, knowledge sharing, and cross-cultural understanding. Malaysia's growing participation in the global scientific community shows its importance as a member who advances several fields through international collaborations. Additional research might examine what motivates Malaysia to collaborate abroad and how this may affect its research ecosystem and innovation landscape. The percentage of foreign cooperation and the number of papers in Singapore has increased. This shows increased global research community engagement driven by multinational partnerships and collaborations. Such trends enhance Singapore's scientific variety and global academic status, allowing knowledge sharing and cross-cultural collaboration (*Dt = -0.13, and ICt = 1.69%*).

Thailand's document data and foreign collaboration are intriguingly linked (*Dt = 7.96, and ICt = 0.75%*). The quantity of documents provided annually has varied, but worldwide cooperation has increased. This percentage fluctuated from 35.24 to 52.2% from 2013 to 2023. Thai researchers are increasingly interested in working with foreign colleagues to use diverse knowledge, access new resources, and increase the quality and impact of their research. These relationships could boost Thailand's scientific prestige, knowledge sharing, and innovation. Thai document and international collaboration statistics show a steady pattern of active research with overseas collaborators over time. Despite the variation of documents published yearly, worldwide connections are promoted, as indicated by the continuous or rising percentage of international collaborations. The increase suggests that Thai researchers are proactive in collaborating with foreign partners. This collaboration seeks to gain expertise, resources, and global impact on research products. These relationships should improve knowledge sharing, cross-cultural understanding, and worldwide research and innovation. Vietnam's document data and foreign collaboration show a subtle and complex pattern (*Dt = 2.69, and ICt = -1.47%*). Although publications vary between 10 and 45 annually, international cooperation remains between 60% and 70%. This shows that Vietnam's research community collaborates internationally, regardless of document production. This shows a constant commitment to global cooperation and knowledge exchange, which can improve research outputs by embracing varied perspectives and expertise.



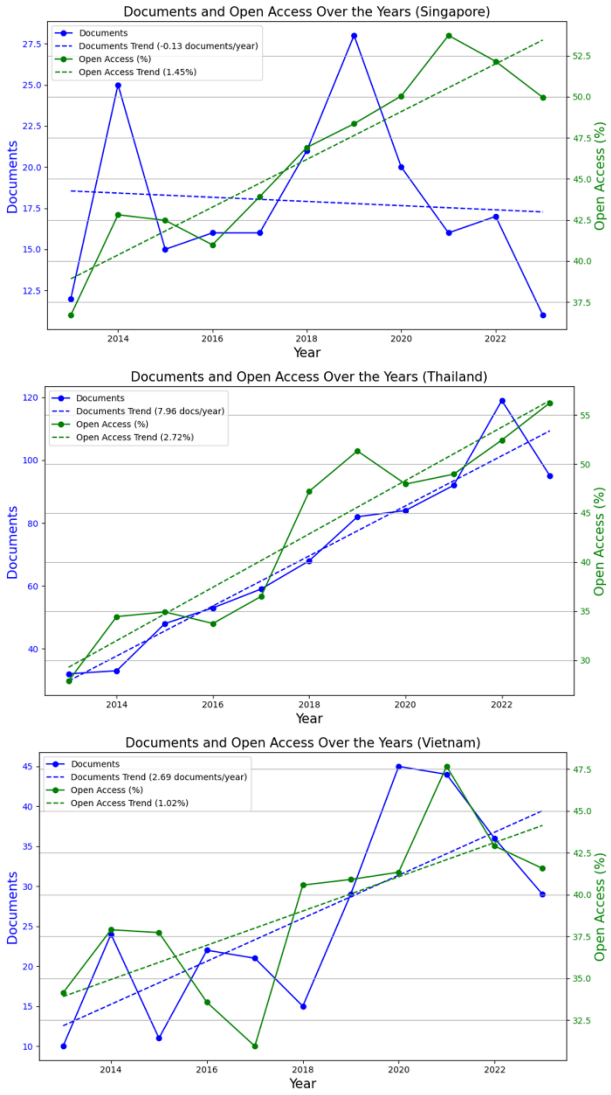


Figure 4: SEA Country's Published Documents and Open Access

Document and open-access publishing data in the Philippines reveal research results of availability and dispersion (*Dt = 1.16, and OAt = 4.40%*). The number of published documents changes. Still, open-access publications are rising, showing a growing commitment to sharing research findings for free. This shows the Philippines' efforts to promote scientific honesty, fairness, and knowledge exchange. Open-access publishing helps researchers increase their reach, collaboration, innovation, and social progress (Bordons, et al., 2023). This trend shows how open science methods improve global research fairness and the public benefit from scientific development. Document data and open-access publishing rates show Indonesia's commitment to scientific transparency (*Dt = 2.05, and OAt = 4.12%*). The number of open-access papers published in Indonesia is rising despite annual variations. This implies that Indonesia is aggressively promoting research transparency. Indonesia's use of open science concepts shows its grasp of their importance in promoting knowledge accessibility, influence, and democracy. Open-access publication strategies helps distribute its knowledge (Reyes et al., 2023). This method encourages collaboration, innovation, and social progress. This shows Indonesia's role in global research and its dedication to scientific understanding for society's benefit.

Document data and open-access publication rates in Malaysia show a shift toward greater transparency and availability in research (*Dt = 2.35, and OAt = 2.15%*). Open-access articles are increasing steadily, even though the number of publications distributed changes annually. Malaysia's support for transparent and inclusive research sharing shows a commitment to expanding knowledge availability and academic collaboration. Malaysia uses open-access publication tactics to boost its research's visibility and make knowledge more accessible, supporting innovation and social progress. Further research should examine Malaysia's growing use of open-access publishing and its effects on research visibility, cooperation, and social influence. The proportion of open-access publications to total papers in Singapore has steadily increased (*Dt = -0.13, and OAt = 1.45%*). This suggests a purposeful effort to make research findings more accessible to the public and academic community. Open access promotes information sharing, transparency, and inclusivity in academic research. Singapore's rising adoption of open-access publishing shows its commitment to improving research accessibility and societal impact worldwide. Thailand's document count and open-access publishing percentage reveal research output availability (*Dt = 7.96, and OAt = 2.72%*). However, open-access availability increased from 27.87% to 56.24% between 2013 and 2023, despite a range of 32 to 119 publications each year. This trend shows the Thai research community's growing commitment to making academic knowledge more accessible. This commitment may affect institutional requirements, funding agency laws, and the worldwide open scientific movement. Open access helps increase knowledge, cooperation, and the societal impact of Thai research. Document statistics and open-access publication rates in Vietnam show a remarkable trend (*Dt = 2.69, and OAt = 1.02%*). The annual production of papers ranges from 10 to 45, but open-access publications have increased to 72% in recent years. This suggests that Vietnam's research community actively pursues open-access principles to improve scientific knowledge distribution. This could boost Vietnam's research's global recognition and influence.

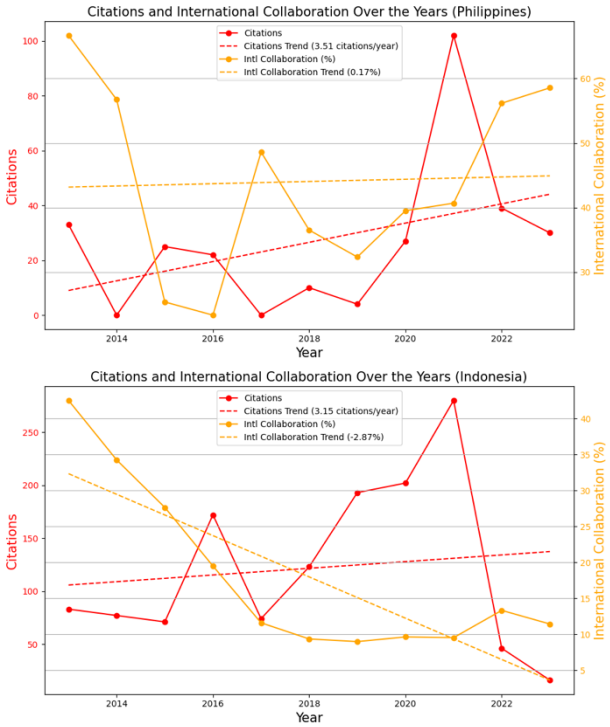
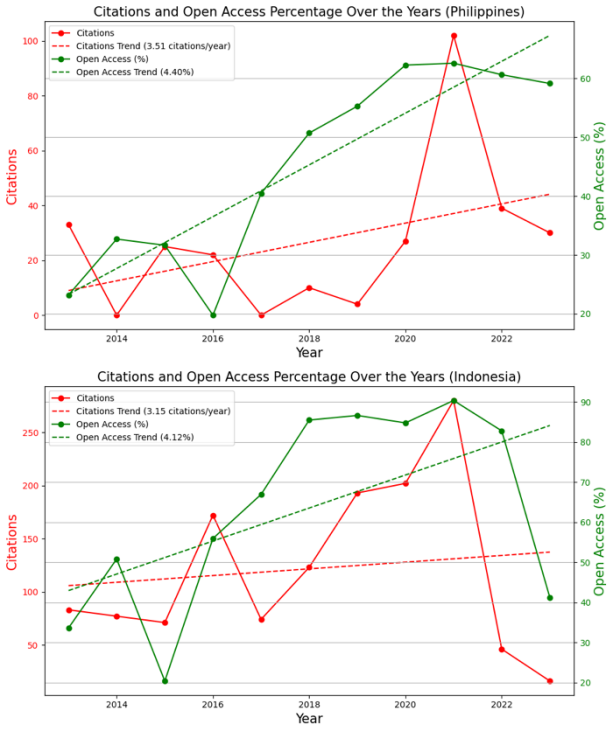


Figure 5: SEA Country's Citation and International Collaborations

According to citation and international collaboration data, the Philippines' research ecosystem is active and encouraging (*Ct = 3.51, and ICt = 0.17%*). Though citations vary annually, the rising proportion of overseas collaborations shows active participation in the global scientific community (Timms, 2018). This shows cooperative efforts foster knowledge exchange and various perspectives and boost Philippine research's global awareness and influence. Citations and international collaborations are positively correlated, demonstrating the relevance of global relationships in furthering research goals and the effect on research studies (Hou et al., 2018). These advances show the Philippines' commitment to using global networks and collaborating to solve complex scientific challenges, advancing knowledge and public welfare. Citations and foreign collaborations in Indonesian research show the country's academic achievements and global influence (*Ct = 3.15, and ICt = -2.87%*). While citations have fluctuated, Indonesia's growing number of foreign collaborations shows its commitment to cross-border relationships. Collaboration increases knowledge flow and Indonesian research's global visibility and influence. Indonesia uses diverse knowledge and resources to solve complex challenges and promote innovation through international collaborations. Indonesia is an engaged member of the global scientific community and works to improve understanding and address global socioeconomic issues.

The fraction of overseas collaborations and citations in Malaysia reveals its research environment and worldwide involvement (*Ct = 25.68, and ICt = 1.03%*). Citations and international collaborations show Malaysia's scientific community involvement. The two variables positively correlate, suggesting international cooperation may increase citation rates. Better exposure, more views, and wider networks may explain this. This emphasizes the need for foreign connections for Malaysia's research ecosystem to advance scientific knowledge and global prominence. A deeper investigation into how foreign collaborations increase citations could shed light on Malaysia's research strategy and international engagement. The data from Singapore shows a direct correlation between citations and international cooperation (*Ct = -5.54, and ICt = 1.69%*). Increasing overseas links boosts the influence and recognition of Singaporean research in the global academic community, as shown by higher citation rates. These findings demonstrate the importance of international cooperation to help in elevating research worldwide (Basur et al., 2023). This trend also shows Singapore's proactive promotion of international cooperation to boost innovation and knowledge-sharing.

Citations and collaborations abroad in Thailand are strongly correlated, reflecting the country's research environment (*Ct = -64.72, and ICt = 0.75%*). Citations continued to rise from 686 to 1888 from 2013 to 2023, and international collaborations increased from 35.24 to 52.2%. The global academic community recognizes Thai research, and researchers increasingly collaborate with overseas colleagues. These linkages should promote competence, knowledge flow, and the global impact of Thai research. The proportion of foreign collaborations and citations in Vietnam reveals intriguing scientific trends (*Ct = -32.95, and ICt = -1.41%*). Citation counts have ranged from 45 to 3623, although foreign collaborations have remained between 60% and 70%. Vietnam's research outputs, as shown by citations, may vary, but there is a continual effort to collaborate internationally. This may imply a strategy to use global expertise and resources to increase research quality and significance, boosting innovation and information sharing in the Vietnamese research community.



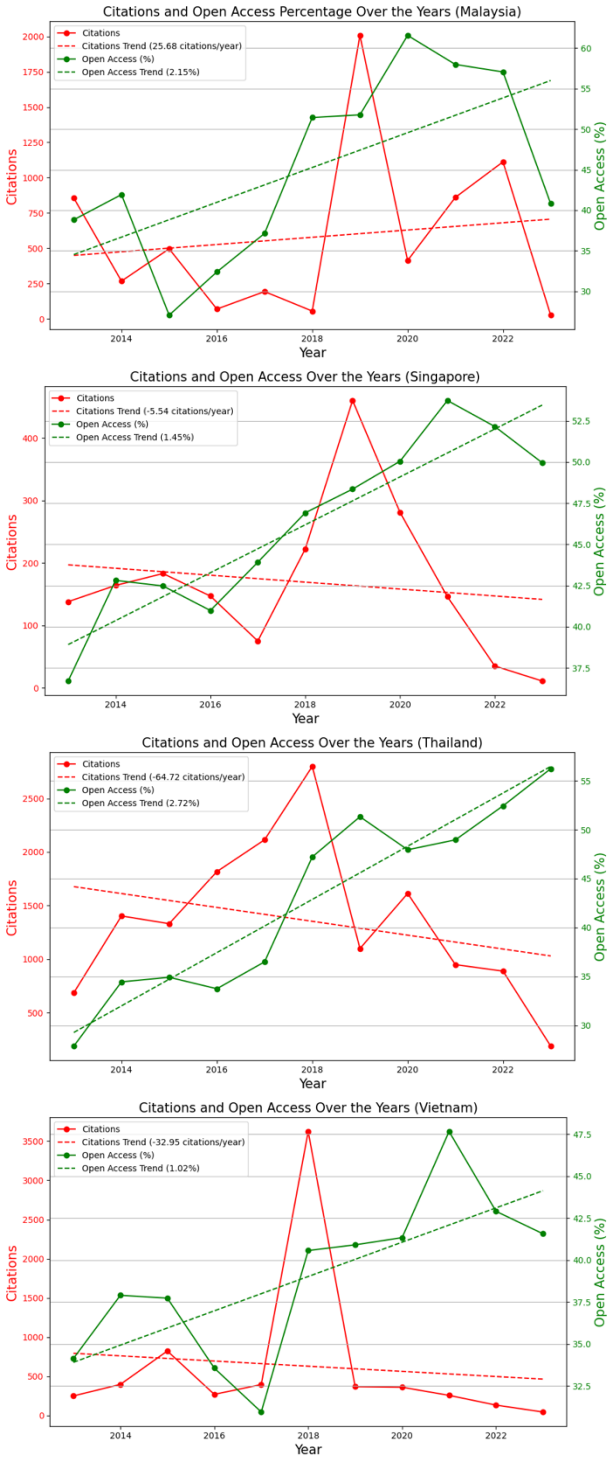


Figure 6: SEA Country's Citation and Open Access

Citations and open-access publishing percentages in the Philippines convey a captivating story about intellectual influence and accessibility (*Ct = 3.51, and OAt = 4.40%*). Despite fluctuating citation counts, the Philippines' growing number of open-access papers shows its commitment to academic openness. Philippine researchers use open-access strategies to increase visibility, accessibility, information, and societal benefits. The high correlation between citations and open access suggests that unrestricted access to research boosts its exposure and influence within and outside the scientific community. These trends show the Philippines' dedication to research transparency, justice, and inventiveness, which advances science and society.

Indonesia's citations and open-access publishing rates reveal the country's intellectual influence and commitment to knowledge sharing (*Ct = 3.15, and OAt = 4.12%*). Indonesia's dedication to making scientific findings freely available shows the rise of open-access articles despite fluctuating citation counts. This trend shows Indonesia's recognition of open scientific principles' role in promoting research findings' prominence, availability, and social impact. Open-access publication policies help Indonesia distribute its research and promote cooperation, innovation, and societal benefits. This emphasizes the role of global research and its commitment to advancing science to benefit society (Ferreira et al., 2020).

Citations and open-access publication numbers show Malaysia's research climate and commitment to openness (*Ct = 25.68, and OAt = 2.15%*). The citations show Malaysian research's prominence. Malaysia's growing number of open-access articles shows its commitment to making scientific findings widely available. The rising trend suggests that open-access publishing is becoming more important for Malaysian research distribution and impact, which could boost citation rates. Through open-access methods, Malaysia promotes information democratization, global collaboration, and research dissemination. Further research on the association between citations and open access may elucidate the reasons behind the observed patterns and improve Malaysian research's social impact. Singapore links citations to open-access articles throughout time (*Ct = -5.54, and OAt = 1.45%*). The fraction of open-access publications and Singaporean research output citations are positively correlated. This suggests that publicizing research findings increases their academic impact. These findings show that open access rules boost Singaporean research exposure and reach. This boosts global knowledge sharing and cooperation. Thailand's citations and open-access paper percentages reveal its research output's reach and impact (*Ct = -64.72, and OAt = 2.72%*). From 2013 to 2023, citations ranged from 686 to 1888, but open-access papers rose from 27.87% to 56.24%. The pattern suggests the Thai research community is trying to promote academic research. Institutional regulations, financial requirements, and global open science campaigns may affect this. Open-access publishing can improve research accessibility, collaboration, and Thai research's global impact. Citations and open access paper percent in Vietnam show a striking disparity (*Ct = -32.95, and OAt = 1.02%*). Citation counts have ranged from 45 to 3623, although open access publication has consistently increased. This trend has reached 72% in recent years. Open-access articles may have better citation rates due to increased visibility and distribution. It also shows Vietnam's scientific community's purposeful and concerted effort to implement open science ideas, enhancing knowledge and social influence.

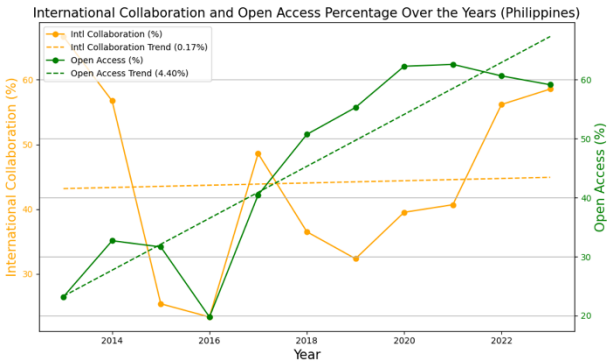


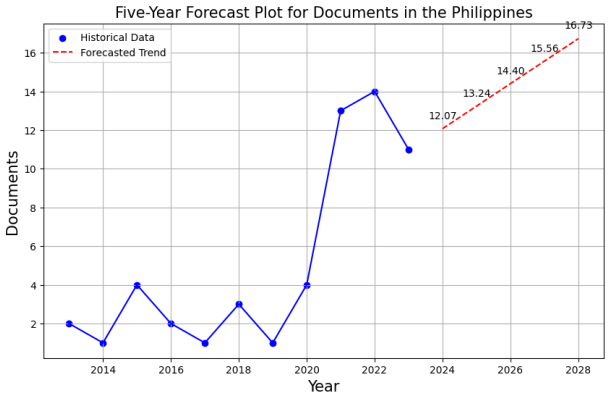
Figure 7: SEA Country's International Collaboration and Open Access

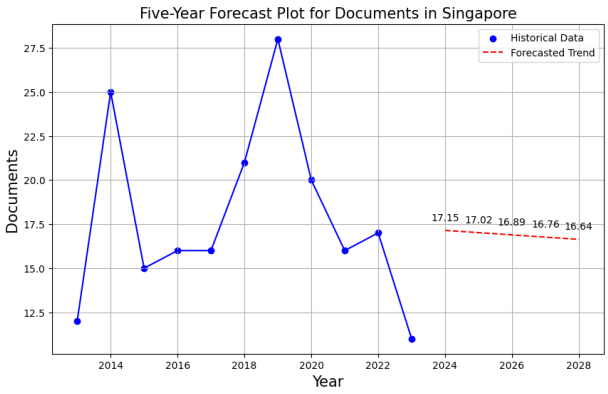
The data about the percentage of international collaborations and the percentage of open-access publications in the Philippines shed light on the country's dedication to both global involvement and the availability of research efforts (*ICt = 0.17%, and OAt = 4.40%*). The increasing patterns in both indicators indicate a deliberate endeavor by researchers in the Philippines to encourage cooperation across international boundaries while simultaneously advocating for unrestricted knowledge sharing. The Philippines strategically positions itself as a significant contributor to the global scientific community by aggressively engaging in international partnerships and adopting open-access publishing methods. This approach ensures that the country's research outputs are easily accessible to scholars and the public. This method not only improves the exposure and influence of Philippine scholarship but also enables wider information sharing, encourages creativity, and ensures fair access to scientific discoveries, ultimately contributing to societal improvement worldwide. The data about the proportion of foreign collaborations and the proportion of open-access publications in Indonesia offer useful insights into the country's global involvement and dedication to transparent dissemination of knowledge. Indonesia's proactive efforts to build international connections and promote open science concepts are reflected in the rising trends of both measures (*ICt = -2.87%, and OAt = 4.12%*). Indonesia's acknowledgment of the significance of cooperation and availability in promoting scientific understanding and tackling societal issues is emphasized by this twin dedication. Through active engagement in international collaborations and the adoption of open-access publication formats, Indonesia increases the visibility and influence of its research. It promotes collaboration, innovation, and wider societal advantages within and beyond. This highlights Indonesia's position as an engaged participant in the worldwide research community and its commitment to promoting scientific knowledge to improve society.

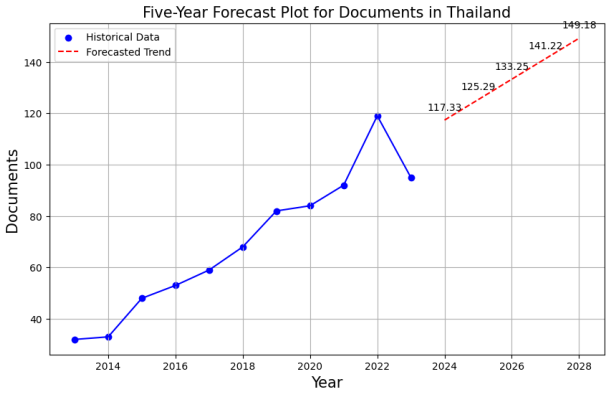
The statistics about the proportion of international collaborations and the proportion of open-access publications in Malaysia depict a research environment distinguished by active global participation and easy availability of research findings (*ICt = 1.03%, and OAt = 2.15%*). Malaysia's dedication to cultivating global collaborations and facilitating the dissemination of research findings is seen in the rising trend observed in both variables. Malaysia's adoption of this dual strategy highlights its acknowledgment of the significance of cooperation and openness in promoting scientific understanding and societal influence. Through active engagement in international partnerships and adopting open-access publication formats, Malaysia improves the caliber and prominence of its research and fosters knowledge dissemination and innovation worldwide. Examining the combined impact of international collaborations and open access on research outcomes and societal advantages could offer significant insights into Malaysia's research strategy and global engagement endeavors. The data from Singapore reveals a fascinating correlation between the proportion of foreign collaborations and open-access articles (*ICt = 1.69%, and OAt = 1.45%*). Although there may not be a direct cause-and-effect connection between these two variables, their simultaneous rise indicates possible synergies in advancing global involvement and enhancing accessibility to research. As Singaporean researchers continue interacting with overseas partners, distributing their findings through open-access channels enhances their work's worldwide reach and influence. Singapore's dedication to promoting a cooperative and open research atmosphere that encourages the sharing of information and global innovation is highlighted by this trend.

The data on Thailand's proportion of international collaborations and the proportion of open-access publications demonstrate a fascinating correlation that reflects the country's changing research environment (*ICt = 0.75%, and OAt = 2.72%*). Between 2013 and 2023, the percentage of international collaborations fluctuated between 35.24% and 52.2%, while the percentage of open-access papers has increased significantly, ranging from 27.87% to 56.24%. This indicates an increasing dedication within the Thai research community to actively collaborate with overseas partners and improve the availability of academic publications. These patterns indicate a larger worldwide movement towards collaborative and open science practices to promote the interchange of knowledge, foster innovation, and positively impact society.

The statistics about the proportion of foreign collaborations and the proportion of open-access articles in Vietnam reveal a fascinating correlation (*ICt = -1.41%, and OAt = 1.02%*). Although there have been variations, with international collaboration rates ranging from 60% to 70% and open access rates reaching a peak of about 72%, Vietnam's research environment consistently shows a strong dedication to both features. This indicates an inclusive and comprehensive approach to sharing research, where global partnerships promote various viewpoints and knowledge. At the same time, open access standards guarantee that research findings are widely available. This combination improves the quality and relevance of research results, encourages global knowledge flow, and positively influences society. It positions Vietnam as an active participant in the global research community.







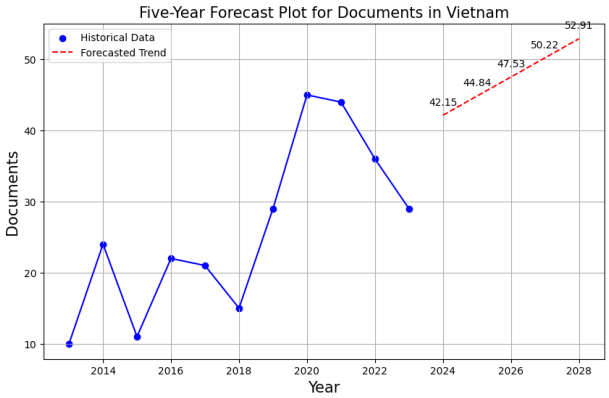


Figure 8: SEA Country's Publication Forecast

Forecast. Forecasting can provide valuable insight into future research activities, specifically for the next five years. It can serve as a benchmark for assessing the growth and performance of research engagements over time, making informed decisions, strategic planning, and adapting to changing circumstances in the research landscape.

Document projections for each country provide useful insights regarding research production in the next five years. The forecasts show that ID will have an increasing publication from 28 to 36 by 2028, PH from 12 to 16 by 2028, SG from 17 to 16, TH from 117 documents to 149, the highest among the region, and VN from 42 to 52. However, Indonesia is expected to keep slowly increasing the number of document creations. This suggests that education and research infrastructure spending boost Indonesian research. Malaysia's forecast predicts consistent research production in the following years. This reflects a sophisticated research setting with well-established processes, but raises worries about expansion restrictions. Predictions for the Philippines and Singapore are more variable. Despite occasional fluctuations, the Philippines is rising slower than other nations. This may signal further research capacity building and the need to tackle rapid expansion challenges. Singapore's prediction shows a shifting trend, suggesting research output may be unpredictable in five years. These

variances may be due to changes in study priorities, funding, or the research landscape. These forecasts show opportunities and difficulties for the research community in each country's projected research output.

CONCLUSION

The research landscapes in the Philippines, Indonesia, Malaysia, Singapore, Thailand, and Vietnam are experiencing significant changes marked by strong expansion and a determined dedication to enhancing worldwide scientific understanding. There is a significant increase in scholarly publications in these countries, showing a thriving research culture prioritizing academic investigation and knowledge sharing. Furthermore, there is an increasing trend of forming collaborative partnerships, demonstrating a joint endeavor to combine knowledge and resources to address intricate scientific problems globally. Significantly, there is a collective commitment to the principles of open access, guaranteeing that research findings are readily available to researchers, policymakers, and the public. This promotes openness and stimulates innovation. These advancements establish each nation as an essential contributor to the worldwide scientific community, actively contributing to the shared goal of scientific advancement and societal improvement.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

The author undertook all phases of this study, encompassing conceptualization, research design, data collection, scientometric analysis, interpretation of findings, and manuscript writing.

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