Dynamic interactions of research, publication, researchers, institutions, and countries: A Quintuple Helix model perspective on research impact

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ABSTRACT
This review paper introduces and explores the Research Impact Quintuple Helix Model, a comprehensive framework designed to analyse and enhance the impact of research across societal, economic, and environmental dimensions. Unlike traditional models focusing on sectoral collaboration for innovation and economic development, this model integrates five critical elements - Research, Publication, Researchers, Institutions, and Countries - offering a holistic approach to understanding research impact. The study systematically examines the dynamic interactions among these elements, emphasising their collective role in fostering collaborative synergies, interdisciplinary research, and effective resource allocation. By aligning research activities with broader societal needs and environmental considerations, the model aims to extend the scope of research impact beyond academic achievements, highlighting the importance of policy alignment, societal engagement, and sustainable practices. Key comparisons with the standard Helix models demonstrate the unique contributions of the research impact quintuple helix model, illustrating its potential to address specific challenges in maximising research benefits. The paper identifies strategic collaborations and policy implications that could significantly enhance the societal benefits of research, advocating for a structured integration of the model's elements into research and policy-making processes. The review concludes by recognising limitations in the existing literature and calling for empirical studies to validate and refine the model. Future research should incorporate quantitative methods to measure the impact effectively, aiming to transform theoretical insights into actionable strategies for a sustainable and impactful research ecosystem.

Keywords: Research Impact, Quintuple Helix Model, Interdisciplinary Collaboration, Policy Alignment, Sustainable Research Practices

INTRODUCTION

In academic research, the concept of 'research impact' has evolved beyond traditional productivity and quality measures. It now encompasses a broader evaluation of the significance of scholarly work, emphasising its importance in societal, economic, and cultural contexts (Robertson, 2016). This shift reflects a growing recognition of the value of

research, acknowledging its contributions to academic discourse and broader societal implications. Unlike traditional measures—where research productivity is gauged by the number of publications and research quality by the superiority of those publications - research impact focuses on tangible outcomes that extend beyond the academic sphere. It scrutinises how research influences policy development, drives innovation, and enhances societal welfare (Gasparyan et al., 2018). While various aspects of research impact, such as productivity, quality, and collaboration, have been studied, the literature remains fragmented. There is a lack of comprehensive analyses that systematically address the factors contributing to research impact across different dimensions. Existing studies often examine these factors in isolation without providing a holistic overview of how they interact to enhance research impact.

Helix models have become central to understanding innovation and knowledge creation, emphasising cross-sector collaboration. The evolution from the Triple Helix to the Quintuple Helix Model highlights the increasing importance of integrating societal and environmental dimensions into innovation processes. These models have expanded the scope of innovation, linking it to broader societal and ecological goals (Carayannis & Campbell, 2010; Carayannis & Campbell, 2009; Etzkowitz & Leydesdorff, 2000). Building on this foundation, this paper introduces the Research Impact Quintuple Helix Model (RIQHM), a framework developed to systematically analyse and understand the interactions among various factors contributing to research impact. By organising these factors - Research, Publication, Researchers, Institutions, and Countries - within a structured model, the RIQHM facilitates strategic collaboration and provides a means for researchers to enhance their work's societal, economic, and cultural impact.

This paper aims to address a critical gap in the literature by introducing and applying the RIQHM to examine the diverse factors influencing research impact. The objective is to provide a systematic framework that categorises and understands these factors within the model's five elements - Research, Publication, Researchers, Institutions, and Countries. The paper aims to enhance research's academic, societal, economic, and cultural impacts. The RIQHM emphasises the importance of strategic collaboration among academia, industry, government, civil society, and the environment in fostering research beyond traditional academic confines. By analysing how these factors interact, the paper provides strategic insights for researchers, policymakers, and institutions to optimise research activities and maximise societal benefits.

REVIEW OF LITERATURE

Research Impact Contributing Factors

The literature identifies several key factors that contribute to the impact of research, spanning both internal and external dimensions. Internal factors include the quality of research, collaboration networks, and the strategic orientation of the research agenda. High-quality research, characterised by rigorous methodology and relevance, is a primary determinant of impact, as it tends to receive more citations and influence policy decisions (Carbon, 2011; McFadden & Souba, 2007). Collaboration is another crucial factor; involvement in extensive collaboration networks, particularly international collaborations, significantly enhances research visibility and impact. For example, Liao et al. (2024) highlighted that collaboration within well-integrated knowledge networks positively influences citation counts, a proxy for research impact.

External factors include government policies, funding mechanisms, and societal needs. Policies prioritising research funding and incentivising collaboration between academia and industry are essential in creating an environment conducive to impactful research (Howard et al., 2018). Furthermore, aligning research with societal challenges, such as healthcare, environmental sustainability, and economic development, often determines its broader societal impact (O'Connell, 2019).

These factors play significant roles across different academic and industrial fields. In healthcare and biomedical research, for instance, integrating big data and biobanks has been highlighted as critical for advancing research impact, particularly in epidemiology and genetics (Cambon-Thomsen et al., 2011; Howard et al., 2018). The emphasis on collaboration and data sharing in these fields has facilitated the development of more comprehensive health policies and interventions. Similarly, in cancer research, Liao et al. (2024) demonstrated that collaboration networks and industry involvement are pivotal in enhancing the impact of research, particularly in emerging areas like synthetic lethality.

In the pharmaceutical industry, factors such as supply chain configuration and risk management significantly influence the impact of research. Huq et al. (2015) discussed how disturbance factors like quality defects in supply chains can affect research outcomes, emphasising the importance of understanding these risks to maintain the integrity and impact of pharmaceutical research.

In engineering and materials science, research impact is often determined by the ability to innovate and integrate new technologies. The recognition and enhancement of factual impact over traditional impact metrics, as discussed by Wang (2015), is critical in fields like natural fibre research, where the practical application of research is a crucial measure of impact.

The factors recognised in specific fields can be effectively applied to enhance research impact in other domains. For instance, the emphasis on collaboration networks in biomedical research, highlighted by Liao et al. (2024), is equally applicable in environmental science and sustainability studies. In these fields, interdisciplinary collaboration is crucial for addressing complex global challenges such as climate change, where the integration of diverse expertise can significantly enhance the impact of research (Liao et al., 2024).

Similarly, the strategies used in healthcare research, such as integrating big data and biobanks for more comprehensive health outcomes, can be adapted for use in the social sciences. For example, social scientists can leverage large datasets and collaborative networks to enhance the impact of research on policy and community interventions, thereby ensuring that research findings are theoretically robust and practically applicable in real-world settings (Howard et al., 2018).

Moreover, government policies and funding are essential in driving impactful research in public health and education, which can inform strategies in emerging technologies and digital innovation. By aligning research agendas with national priorities and societal needs, fields such as artificial intelligence, cybersecurity, and digital transformation can leverage these factors to achieve more significant societal impact (O'Connell, 2019). The insights gained from these established fields demonstrate that the strategic alignment of research with external factors, such as policy frameworks and societal challenges, is essential for maximising research impact across all disciplines.

Evolution and Scope of Helix Models

The Helix models have evolved significantly, adding complexity and expanding the understanding of innovation and knowledge creation. The Triple Helix Model, introduced by (Etzkowitz & Leydesdorff, 2000), was the first to formalise the relationship between universities, industry, and government as a foundational innovation and economic development framework. This model emphasised the synergistic interaction among these three entities, forming the basis of a knowledge-based economy by enhancing knowledge transfer and innovation capabilities (Etzkowitz & Leydesdorff, 2000; Hamid et al., 2019).

Building upon the Triple Helix, the Quadruple Helix Model introduced by Carayannis and Campbell (2009) integrated the 'media-based and culture-based public' and 'civil society' into the innovation process. This expansion acknowledged the critical role of societal engagement, cultural dynamics, and media in fostering innovation and knowledge production. The Quadruple Helix model represented a shift towards a knowledge society, emphasising the co-evolution of the knowledge economy with societal values, which is crucial for sustainable development (Carayannis & Campbell, 2009).

The Quintuple Helix Model marked the latest evolution, incorporating the natural environment as a critical fifth helix. This model emphasises the need for a socio-ecological transition, addressing global challenges such as climate change by integrating environmental sustainability into the innovation process. The Quintuple Helix provides a comprehensive framework for linking ecology, knowledge, and innovation, fostering synergies between economic growth, societal development, and ecological sustainability (Carayannis et al., 2012). This model has further refined the understanding of how innovation can be leveraged to meet the demands of the 21st century, particularly in addressing environmental and societal challenges.

Each stage in the evolution of the Helix models has broadened the scope of innovation and knowledge creation, shifting the understanding of how different sectors interact to produce societal benefits. The Triple Helix Model primarily focused on economic outputs and the critical role of higher education in driving innovation. This model laid the groundwork for understanding how the collaboration between universities, industry, and government could enhance the dynamics of innovation in a knowledge-based economy (Etzkowitz & Leydesdorff, 2000; Sundari et al., 2021).

The Quadruple Helix Model expanded this understanding by including societal engagement and cultural dynamics. It recognises that innovation does not occur in a vacuum but is deeply embedded in societal values and public discourse. This model expanded the applicability of innovation beyond purely economic metrics, incorporating societal impacts as essential outcomes of the innovation process (Carayannis & Campbell, 2009), including media and civil society as key players in this model, highlighted the importance of public participation and cultural contexts in the innovation ecosystem.

The Quintuple Helix Model addressed the environmental dimension, which has become increasingly critical considering global sustainability challenges. By positioning the natural environment as a driver of innovation, this model expanded the concept of knowledge production to include sustainable development goals. This shift in understanding makes the Quintuple Helix particularly applicable to contemporary issues such as climate change, where interdisciplinary and transdisciplinary approaches are essential (Carayannis et al., 2012; González-Martinez et al., 2023).

Stakeholders across sectors have leveraged the Helix models to enhance innovation, knowledge creation, and societal impact. Universities have used these models to reinforce their role as pivotal players in innovation systems, aligning research agendas with industry needs and governmental policies to maximise societal contributions. Through the Triple Helix framework, universities have enhanced their engagement with industry and government, thereby increasing their impact on economic and social development (Etzkowitz & Leydesdorff, 2000; Hamid et al., 2019).

Industries have benefited significantly from closer collaboration with academia and government. By participating in the Helix models, industries gain access to cutting-edge research, technological advancements, and a highly skilled workforce, enhancing innovation capabilities and market competitiveness. The Quadruple and Quintuple Helix models have further enabled industries to integrate societal and environmental considerations into their innovation strategies, ensuring long-term sustainability (Sundari et al., 2021).

Governments have used the Helix models to craft policies that foster innovation ecosystems, ensuring that public investments in research and development yield tangible societal benefits. The inclusion of civil society and the natural environment in the Quadruple and Quintuple Helix models has empowered societal stakeholders to play a more direct role in the innovation process. This inclusion ensures that innovations are not only economically viable but also socially and environmentally sustainable, leading to more holistic policies and practices that address long-term global challenges (Carayannis et al., 2012; Carayannis & Campbell, 2009; González-Martinez et al., 2023).

Synthesis of Literature Review

The literature on research impact contributing factors and the evolution of Helix models underscores the necessity of integrating these two domains to fully understand and enhance research's societal, economic, and cultural impact. While substantial research has identified various factors - such as research quality, collaboration networks, and alignment with societal needs - that contribute to research impact, the academic discourse remains fragmented, lacking a comprehensive framework that systematically organises these factors. Concurrently, the evolution of Helix models, notably the transition from the Triple to the Quintuple Helix, has demonstrated the increasing importance of cross-sector collaboration and the inclusion of environmental sustainability in innovation processes. However, these models have traditionally focused on fostering innovation rather than directly addressing research impact.

This synthesis highlights a critical gap in the literature: the need for a model that not only leverages the collaborative advantages of the Helix frameworks but also explicitly targets the enhancement of research impact across multiple dimensions. The RIQHM is proposed to solve this gap, integrating the identified impact factors within a structured Helix-based framework. By doing so, the RIQHM offers a novel approach that aligns research activities with societal, economic, and environmental goals, ensuring that research contributions extend beyond academic boundaries to drive meaningful change worldwide. This model advances the theoretical understanding of research impact and provides practical tools for researchers, policymakers, and institutions to enhance their research outcomes to maximise societal benefits strategically.

METHOD

We used a scoping review methodology, as recommended by Tricco et al. (2018) and Peters et al. (2021), and specifically adapted it to investigate the determinants of research impact. This approach was chosen to map and synthesise the broad and complex literature on research impact, which spans multiple disciplines and includes diverse types of evidence. The six-stage method helps identify gaps in the existing research and contributes to the development of the RIQHM.

Stage 1: Identification of the Research Question

The first stage of this scoping review involved defining a clear and focused research question: What are the critical factors within the Research Impact Quintuple Helix Model (RIQHM) that influence the impact of research, and how can these factors be leveraged to enhance the academic, societal, economic, and cultural benefits of research? This question guided the subsequent stages of the review, ensuring that the investigation remained aligned with the study's aim of systematically categorising and understanding the determinants of research impact within the RIQHM framework.

Stage 2: Development of the Search Strategy

We developed a targeted keyword strategy focusing on these determinants to understand the factors that influence research impact comprehensively. The decision to concentrate on factors or determinants of research impact rather than include terms related to the helix models in the initial search was deliberate. The Research Impact Quintuple Helix Model (RIQHM) represents a novel framework we propose in this study. As such, our primary focus was identifying the key components that can influence research impact across various dimensions.

The initial literature review informed the selection of keywords to capture the broad spectrum of factors contributing to research impact. These keywords included “research impact,” “impact of research,” “contributing factors to research impact,” “determinants of research impact,” “research influence,” “research utilisation,” “academic impact,” “research dissemination,” “research engagement,” “research outcomes,” “policy influence of research,” “public engagement in research,” “societal impact of research,” “economic impact of research,” “research metrics,” “scholarly impact,” and “research visibility”.

While our primary search strategy focused on identifying literature that discusses these determinants, we also searched separately for literature related to the helix models. This separate search was necessary to review how helix models have evolved, identify the stakeholders involved, and understand the advantages they provide in existing frameworks. By approaching the literature search in this two-pronged manner, we ensured a thorough exploration of both the factors influencing research impact and the role of helix models in enhancing that impact.

Stage 3: Literature Search

The literature search used two primary academic databases: Web of Science and Scopus. These databases were chosen for their extensive collections of peer-reviewed articles and their ability to provide a comprehensive overview of interdisciplinary literature on research impact. The initial search yielded 2,825 research papers from Scopus and 11,860 from Web of Science. A snowball search method was employed in addition to the database searches to ensure comprehensive coverage. This technique involved reviewing the reference lists of the initially identified studies to uncover additional relevant studies that might have been

missed in the primary search. This combined approach helped to ensure that the literature review was thorough and inclusive of all significant contributions to the field.

Stage 4: Screening and Selection of Studies

Following the literature search, the records obtained from both databases were systematically screened based on their abstracts to determine their relevance to the study. This rigorous screening process identified 71 of the most relevant papers, as they directly addressed the determinants of the impact of the research. These selected papers were then used for in-depth analysis in this review.

To narrow the selection further, titles and abstracts were carefully examined to ensure that the chosen articles significantly contributed to our understanding of research impact and its driving factors. During this process, duplicate entries were removed, and inclusion criteria were established, favouring empirical research, theoretical discussions, and detailed reviews that provided insights into the various influences on research impact. The review focused on works published in English. Additionally, to capture a diverse range of viewpoints, grey literature, including reports, policy documents, conference papers, and academic blogs, was incorporated. This approach ensured that perspectives from all relevant stakeholders were considered, enriching the overall analysis of the literature.

Stage 5: Data Charting and Thematic Analysis

After selecting relevant studies, we conducted a detailed charting process that systematically extracted and organised essential data points from each study. Utilising NVivo software and following the guidelines established by Byrne (2022). Our predefined inclusion criteria guided this process, favouring empirical research, theoretical discussions, and comprehensive reviews that provided insights into the various factors influencing research impact.

The data was initially organised into five principal themes: Research, Researchers, Publications, Institutions, and Countries. Each theme encompassed several preliminary characteristics that served as categories for structuring the extracted data. As the analysis progressed, additional characteristics emerged from the data, systematically integrated into their respective themes. The thematic analysis was iterative, with specific characteristics, such as funding and collaboration, intersecting multiple themes. In these instances, careful consideration was given to categorising these factors within the most contextually appropriate theme while acknowledging their relevance across other thematic areas.

Stage 6: Collation, Summary, and Reporting of Results

In the final stage of our study, we systematically collated, summarised, and reported the results of our thematic analysis. The data were organised according to the five principal themes: Research, Researchers, Publications, Institutions, and Countries. Each theme was explored in depth, with sub-themes identified and categorised based on the emerging patterns from the data.

The reporting process involved providing a narrative account of the characteristics within each theme, supported by key findings presented in tables. We also highlighted each theme's challenges and potential contributions, providing a structured understanding of the factors influencing research impact. This comprehensive reporting laid the groundwork for integrating the identified research impact contributing factors with the concept of the helix model, setting the stage for the development of the Research Impact Quintuple Helix Model.

RESULTS

Characteristics and Role of Research

Table 1 presents a detailed overview of the literature insights on various research characteristics and identifies several challenges and potential contributions to research impact. Basic research is fundamental for advancing knowledge and influencing cultural and policy decisions (Calvert, 2006; Schauz, 2014). Applied research, on the other hand, addresses practical needs and often involves academia-industry collaborations, emphasising societal engagement and practical applications (Bentley et al., 2015; Fecher & Hebing, 2021; Salvador et al., 2021).

Monodisciplinary research provides deep, specialised insights within a single discipline but may not adequately address complex, multi-disciplinary problems (Garcia Rodriguez et al., 2023). In contrast, multi-disciplinary research involves collaboration across various disciplines, enhancing innovation potential without fully integrating perspectives (Campbell et al., 2017; Hicks, 2021). Interdisciplinary research integrates multiple disciplines to address complex issues holistically, providing a comprehensive perspective that significantly enriches research impact (Bammer, 2013; Choi & Pak, 2006; Huutoniemi et al., 2010).

Niche research focuses on specialised areas and often leads to significant breakthroughs, influencing policy and practice (Karakose & Demirkol, 2021; Nassauer & Legewie, 2021; Raković et al., 2023). Popular research, in contrast, attracts widespread attention, sets the direction for future studies, and influences policy, but it must balance originality and depth in crowded fields (Anderson et al., 2020; Weingart et al., 2021). Quantitative research, known for its emphasis on numerical data and large-scale analysis, is crucial for identifying patterns and testing hypotheses (Streefkerk, 2019). Qualitative research provides detailed insights into human experiences, essential for understanding complex social phenomena (Mori & Nakayama, 2013). Mixed methods research combines quantitative and qualitative approaches to understand research questions comprehensively (Dawadi et al., 2021; Retrouvey et al., 2020; Timans et al., 2019).

Furthermore, research impacts vary significantly across different audiences. Academicians value detailed, rigorous, and peer-reviewed research, focusing on novelty and theoretical contributions (Penfield et al., 2014). Users seek practical applications and immediate solutions, emphasising usability and real-world applicability (Beck et al., 2022). Policymakers rely on evidence-based inputs for decision-making and benefit from clear, actionable insights (Aiyede, 2023; Lauder, 2014; O'Grady & Roos, 2016; Williamson, 2019). Addressing the challenges associated with the research characteristics can significantly elevate the impact. Innovative funding strategies and clear demonstrations of long-term benefits are essential to secure support, particularly for basic and niche research. Overcoming inherent limitations in scope and integration, evident in applied, monodisciplinary, and some multi-disciplinary efforts, calls for adaptive research designs that transcend traditional boundaries. Furthermore, simplifying the management of interdisciplinary projects and mitigating the rigidity and contextual limitations in quantitative methods will foster more comprehensive and flexible research approaches. Alleviating pressures on academicians and the constraints on policymakers will require more collaborative, transparent, and adaptable strategies. Enhancing communication, broadening engagement strategies, and fostering a culture that values depth and practicality will enable the research community to effectively translate these diverse strengths into substantial societal and academic advancements.

Table 1: Literature Insights, Challenges and Potential Contributions of Research Characteristics

Characteristics	Literature Insights	Challenges	Potential Contribution
Basic and Applied Research			
Basic Research	Driven by a quest for knowledge and understanding of fundamental principles (Schauz, 2014). Influences scientific autonomy, cultural values, and policy decisions. Long-term benefits for foundational knowledge (Calvert, 2006).	Funding difficulties; Difficult to measure impact; Lack of immediate public and policy support	Enhances scientific literacy and provides the foundational theories and knowledge that spur further innovation and technological breakthroughs.
Applied Research	Targets practical objectives and addresses societal or industrial needs (Bentley et al., 2015; Salvador et al., 2021). Collaborates between academia and industry. Focus on societal engagement and practical applications (Fecher & Hebing, 2021). Basic research lays the groundwork for discoveries, whereas applied research translates insights into tangible outcomes (Bentley et al., 2015; Godin, 2006).	Limited scope; Dependency on external factors; Risk of obsolescence	Directly addresses societal needs, translating scientific discoveries into practical applications that improve daily life and economic development.
Monodisciplinary, Multidisciplinary and Interdisciplinary Research			
Monodisciplinary	Focuses on a single discipline with deep, specialised insights. May not address complex problems spanning multiple disciplines (Garcia Rodriguez et al., 2023).	Limited perspective; Isolation; Adaptability issues	Fosters depth of knowledge and expertise in specific fields, leading to expert-driven advancements and high-quality academic output.
Multidisciplinary	Collaborates across various disciplines without integrating perspectives. Enhances innovation potential and addresses multifaceted challenges (Campbell et al., 2017; Hicks, 2021).	Coordination complexity; Surface-level integration; Communication barriers	Catalyses innovation by integrating diverse disciplinary perspectives, enhancing problem-solving capabilities and broadening the applicability of research outcomes.
Interdisciplinary	Integrates multiple disciplines to address complex issues holistically (Bammer, 2013; Choi & Pak, 2006). Provides a holistic perspective, enriching research impact (Huutoniemi et al., 2010).	High complexity in management; Funding and institutional support; Training and education	Solves complex global challenges by integrating methodologies from multiple disciplines, leading to holistic solutions and new fields of study.
Niche vs Popular Research Topics			
Niche Research	Focuses on specialized areas within broader fields (Nassauer & Legewie, 2021; Raković et al., 2023). Influences policy and practice, often leading to breakthroughs (Karakose & Demirkol, 2021).	Funding difficulties; Limited recognition and visibility; Limited scope of influence	Drives advancements in specialised, often underexplored areas, potentially leading to pioneering discoveries that open new avenues of scientific inquiry.

Popular Research	Attracts widespread attention and sets the direction for future studies. Can influence academic discourse and policy. Must balance originality and depth in crowded fields (Anderson et al., 2020; Weingart et al., 2021).	Maintaining originality and depth; High competition; Balancing impact and quality	Shapes research agendas and public discourse, significantly influencing policy-making and public awareness of critical issues.
Quantitative and Qualitative Research			
Quantitative Research	Emphasises numerical data and statistical analysis. Ideal for large-scale studies and pattern identification (Streefkerk, 2019).	Contextual limitations; Rigidity; Statistical complexity	Provides robust empirical data that supports broad generalisations and policymaking, influencing large-scale social and economic decisions.
Qualitative Research	Focuses on understanding human experiences through detailed insights. Crucial for decision-making despite being cited less frequently (Mori & Nakayama, 2013). Combines both approaches for a holistic understanding (Dawadi et al., 2021; Timans et al., 2019). Essential for comprehensive research impact (Retrouvey et al., 2020).	Subjectivity; Difficulties in generalisation; Time and resource intensive	Offers an in-depth understanding of human behaviours and societal contexts, crucial for policy formulation and understanding complex social phenomena.
Research Target Audience			
Academicians	Value detailed, rigorous, and peer-reviewed research. Focus on novelty, methodology, and theoretical contributions (Penfield et al., 2014).	Narrow audience reach; Pressure for publishable results; Funding constraints	Influences educational practices and the development of academic fields, enriching academic discourse and promoting intellectual growth.
Users	Seek practical applications and immediate solutions. Emphasise usability and real-world applicability (Beck et al., 2022).	Utility focus; Lack of deep engagement; Varying quality needs	Transforms industries and consumer behaviour through innovative solutions and applications, driving economic growth and improving quality of life.
Policymakers	Rely on evidence-based inputs for decision-making (Aiyede, 2023; Williamson, 2019). Benefit from clear, actionable insights (Lauder, 2014; O'Grady & Roos, 2016).	Time constraints; Political considerations; Communication gaps	Informs public policy and strategic decision-making, leading to improved governance, public services, and societal welfare.

Characteristics and Role of Research Publication

Table 2 provides an in-depth summary of the literature on various publication characteristics, highlighting numerous challenges and potential contributions to enhancing research impact. Pre-publication presentations and discussions in conferences, seminars, webinars, and preprints play a pivotal role in the preliminary dissemination of research. These platforms provide opportunities for immediate communication, fostering scholarly dialogue and collaboration (Foster et al., 2019). Conferences and seminars facilitate real-time exchange and critique, significantly shaping the evolution of research projects. Webinars and preprints disseminate research findings rapidly, promoting early visibility, especially for early-career researchers (Alfonso & Crea, 2023; Soderberg et al., 2020). Despite concerns over quality and credibility, preprints serve as a litmus test for new ideas, enabling researchers to gauge community response and refine their work (Berg et al., 2016; Sarabipour et al., 2019). Conference presentations can influence the likelihood of a study being published in prestigious journals, establishing credibility and reach (Gorodnichenko et al., 2021).

Publication venues such as journal articles, patents, blogs, and policy briefs play crucial roles in shaping research impact. Journal articles enhance researchers' careers through high-quality outputs, but they face challenges regarding accessibility and resources (Brown, 2017). Patents offer measurable implications for technological innovation and track knowledge flows in social sciences (Jaffe & De Rassenfosse, 2017; Karki, 1997). Blogs extend the reach of research findings to broader audiences, although their impact often relies on the credibility of underlying scholarly work. Policy briefs and white papers translate research into actionable insights, significantly affecting policy decisions and business strategies.

Ranking and impact factors of publication venues, such as Impact Factor (IF), CiteScore, SCImago Journal Rank (SJR), and Source Normalised Impact per Paper (SNIP), provide quantifiable insights into a journal's influence within the academic community. Metrics like IF calculate an average citation count for articles, indicating influence (Falagas et al., 2008; Garfield, 2006). However, critiques highlight the variability of impact factors across disciplines and their potential influence on publication behaviour (Seglen, 1997). Innovations like SNIP and percentile-based assessments offer more contextual and equitable comparisons (Bornmann & Marx, 2013; Moed, 2010). Conference prestige influences research dissemination and impact through longevity, acceptance rates, and international collaborations (Lee, 2019; Singh et al., 2020).

Open access and subscription-based publications represent two pivotal approaches to scholarly communication. Open access publications enhance visibility and accessibility, promoting greater community engagement and interdisciplinary collaboration (Bolick et al., 2017; Molloy, 2011). Subscription-based journals, historically having higher citation rates, see this disparity diminish when considering discipline and journal age (Björk & Solomon, 2012). The open access model faces economic challenges, particularly barriers that limit participation from researchers in lower-income countries (Bonaccorso et al., 2014).

Table 2: Literature Insights, Challenges and Potential Contributions of Publication Characteristics

Characteristics	Literature Insight	Challenges	Potential Contribution
Pre-publication			
Conferences and Seminars	Offer invaluable opportunities for immediate communication of discoveries, fostering scholarly dialogue and collaboration (Foster et al., 2019). These gatherings facilitate real-time exchange and critique, significantly shaping the evolution of research projects.	May not reach a wide audience outside the conference; feedback can be limited to session attendees.	Increases citations and visibility; enhances networking that may lead to future collaborations and projects.
Webinar Presentation	Accessible to remote participants, broadening engagement opportunities. Transformative in disseminating research findings rapidly (Alfonso & Crea, 2023; Soderberg et al., 2020).	Dependence on technology; may lack the personal engagement of in-person events.	Fosters deep understanding and detailed feedback; can be recorded and shared for broader impact.
Preprints	Preprints provide an open-access avenue for sharing results, accelerating scientific communication despite quality and credibility concerns, and promoting early visibility, especially for early career researchers (Berg et al., 2016; Sarabipour et al., 2019).	Quality and credibility concerns; potential for spreading unverified information.	Promotes early visibility, especially beneficial for early career researchers; can influence subsequent research directions and discussions.
Publication Venues			
Journal Articles	Enhance researchers' careers through high-quality, credible outputs but face challenges in accessibility and resource limitations (Brown, 2017). Provide quantifiable insights into a journal's influence and reach within the academic community (Falagas et al., 2008; Garfield, 2006).	Access issues, especially in subscription-based models; pressure to publish in high-impact journals.	Drives academic reputation and career advancement; influences funding and tenure decisions.
Books and Book Chapters	Serves as a substantial academic resource; often more detailed than articles (Seglen, 1997).	Longer publication time; may not be as accessible as journal articles.	Contributes to deep, foundational understanding in fields; often used in academic curricula.
Patents	Offer measurable impacts on technological innovation and are increasingly used to track knowledge flows in social sciences (Jaffe & De Rassenfosse, 2017; Karki, 1997).	Complex and costly application process; requires disclosure of information that might be kept proprietary.	Drives technological advancement and can have significant economic impacts.
Conference Papers	Allows researchers to share early results and gain feedback. Influences research dissemination and impact through factors like longevity, acceptance rates, and international collaborations (Lee, 2019; Singh et al., 2020).	It may have a lesser impact than journal articles and limited audience reach.	Enhances research visibility and can lead to collaborations and further studies.
Online Blogs	Extend the reach of research findings to broader audiences, although their impact often relies on the credibility of the underlying scholarly work (Brown, 2017).	Less credibility than peer-reviewed publications; variability in quality.	Influences public opinion and can make research accessible to non-academics.

Ranking and Impact Factor of Venue			
Impact Factor	Provide quantifiable insights into a journal's influence and reach within the academic community (Falagas et al., 2008; Garfield, 2006). Metrics like IF calculate an average citation count for articles, indicating influence.	Focus on citation metrics can distort publication incentives; may encourage gaming the system.	Can significantly affect journal choice, influencing research dissemination and academic careers.
Other Metrics (SJR, SNIP, CiteScore)	Offer broader context; adjust for field-specific differences. Highlight the variability of impact factors across disciplines and their potential influence on publication behaviour (Seglen, 1997). Innovations like SNIP and percentile-based assessments offer more contextual and equitable comparisons (Bornmann & Marx, 2013; Moed, 2010).	Complexity may confuse authors; not as universally recognised as IF.	Helps balance the assessment of research impact across diverse academic fields.
Ranking of Conference Venues	Establishes the prestige and credibility of conferences, attracting high-quality research and renowned speakers. Influences research dissemination and impact through factors like longevity, acceptance rates, and international collaborations (Lee, 2019; Singh et al., 2020).	High-ranked venues can be highly competitive and exclusive; may not be accessible to early career researchers.	Enhances the visibility and credibility of research presented, potentially leading to higher citation rates and stronger academic collaborations.
Open Access vs Subscription-Based			
Open Access	Enhances visibility and accessibility of research findings, promoting greater community engagement and interdisciplinary collaboration (Bolick et al., 2017; Molloy, 2011).	Associated costs (APCs) may be prohibitive, particularly barriers that limit participation from researchers in lower-income countries (Bonaccorso et al., 2014); quality concerns with predatory journals.	Enhances research accessibility and inclusivity, potentially leading to greater impact and collaboration.
Subscription-Based	Historically, it had higher citation rates, though the disparity diminishes when considering factors like discipline and journal age (Björk & Solomon, 2012).	Access is restricted to subscribers, limiting research reach and public engagement.	Maintains academic standards but may have a limited impact due to access restrictions.
Post-publication Promotion			
Social Media Sharing	Significantly boosts publications' visibility and citation rates, establishing a direct correlation between promotional efforts and scholarly impact (Boyd et al., 2022; Martin et al., 2022; Rogers, 2019).	Risks spreading misinformation; dependent on engaging content creation.	Broadens impact, enhancing public engagement and quickly disseminating findings to a global audience.
Research Promotion	Effective communication strategies are fundamental for disseminating research findings to a diverse audience and extending the reach and influence of academic endeavours (Ross-Hellauer et al., 2020).	May require significant marketing resources; effectiveness depends on the platform used.	Promotes academic recognition and can lead to further media coverage, enhancing overall research visibility.

Post-publication research promotion, showcasing, and social media sharing significantly amplify the impact of scholarly work. Effective communication strategies are fundamental for disseminating research findings to a diverse audience (Ross-Hellauer et al., 2020). Social media boosts publications' visibility and citation rates, directly correlating promotional efforts and scholarly impact (Boyd et al., 2022; Martin et al., 2022; Rogers, 2019). Reducing linguistic uncertainty in research articles enhances the appeal and assertiveness of communication, contributing to more significant research promotion and impact (Yao et al., 2023).

Addressing the challenges associated with these publication characteristics can significantly elevate their impact. Researchers and institutions should leverage diverse publication formats judiciously to ensure that research findings are accessible and credible. Emphasising quality and strategic promotion, especially in prestigious venues and through impactful social media usage, can mitigate the effects of these challenges. Adopting metrics like the Impact Factor while considering alternative metrics that offer broader context ensures a balanced and fair assessment of research impact. By actively engaging in these strategies, researchers can enhance the visibility and credibility of their work, overcoming barriers to maximise the academic and societal effects of their research.

Characteristics and Role of Researcher

Table 3 offers a comprehensive overview of literature insights into various researcher characteristics, pinpointing several challenges and potential contributions to research impact. Academic experience is foundational in shaping researchers' capabilities and impact. Formal academic expertise builds a solid foundation for understanding and teaching within specific fields (Wayment & Dickson, 2008), while practical research experience applies this knowledge in real-world contexts (Lopatto, 2007). Effective mentorship in PhD programmes is crucial for navigating complex research challenges (Belavy et al., 2020), and developing research self-efficacy is essential for sustained academic engagement and output (Bieschke et al., 1996). Integrating teaching with research enhances research productivity (Horta et al., 2012), and early research experiences significantly shape career trajectories (Lopatto, 2007; Paglis et al., 2006). Involving more students in research activities is linked to their professional and academic growth (Wayment & Dickson, 2008).

Affiliation with prestigious institutes and memberships in scientific associations are critical for research impact. Prestigious institutes provide substantial resources and a stimulating environment that enhances productivity and innovation (Stock et al., 2023; Zhang et al., 2022). Memberships in scientific associations expand professional networks, offer access to specialised resources, and enhance researchers' reputations (DuMez, 2000). Affiliation changes often lead to varied impacts on productivity, depending on the circumstances of the move and the features of the new setting (Abramo et al., 2022; Halevi et al., 2016).

Demographic characteristics such as age, gender, and ethnicity significantly influence the impact of the research. Older, more experienced researchers with higher motivation levels often achieve greater research output (Kyvik & Aksnes, 2015; Wahid et al., 2022). Gender disparities in publication rates are notable, with males usually publishing more frequently than their female counterparts (Pfeiffer et al., 2016). Ethnicity and cultural backgrounds also subtly affect publication success (Laurance et al., 2013). Policies and practices that recognise and address these demographic influences are essential for enhancing equitable dissemination and research impact (Bentley, 2012; Fukuzawa, 2014; Kyvik & Aksnes, 2015; Laurance et al., 2013; Pfeiffer et al., 2016; Wahid et al., 2022).

Domain knowledge provides a deep understanding of specific fields, essential for resolving complex problems effectively. This expertise boosts innovative idea generation (Niknafs & Berry, 2017) and enhances research productivity (Alexander et al., 1994; Rugaber, 2000; Wahid et al., 2022). Teams with rich collective domain expertise are likely to achieve publication success (Laurance et al., 2013; Puuska, 2010).

Multidisciplinary research integrates diverse perspectives and expertise, fostering groundbreaking discoveries. University-industry collaborations can significantly boost scientific productivity (Manjarrés-Henríquez et al., 2009), and disciplinary diversity correlates with innovative output (Campbell et al., 2017). However, the benefits of multidisciplinary research may extend beyond traditional academic metrics (Hicks, 2021), and supportive institutional structures are crucial for effective collaboration (García-Rodríguez et al., 2023).

Personality traits such as cognitive abilities, motivation, interpersonal skills, and specific personality characteristics significantly shape a researcher's effectiveness. Critical thinking and creativity are essential for tackling complex problems (George, 2023), while motivation drives impactful research outputs (Vu et al., 2022). Interpersonal abilities enhance collaboration and communication (Arora et al., 2011), and traits like openness and conscientiousness are linked to academic success (Jensen, 2015).

Understanding the research system, including methodologies, ethical guidelines, and technological tools, enhances research productivity and quality. Proficiency in using advanced databases and data analysis tools is critical (Hendrix, 2024; Zippia, 2023). Knowledge of academic and cultural contexts ensures the relevance of research findings (Gisbert & Chaparro, 2020; Master Class, 2021), and effective resource utilisation is crucial for impactful studies (Fournier-Viger, 2016; Thomas, 2023).

Teamwork, collaboration, networking, and joint publications enhance research productivity, quality, and impact. Collaborative networks enrich research outputs (Jeong et al., 2011), and co-authorship offers insights into strategic positioning for increased research impact (Melin & Persson, 1996). International and interdisciplinary collaborations effectively tackle global issues like pandemics (Dusdal & Powell, 2021; Kyvik & Reymert, 2017; Lewis, 2021).

Addressing the challenges associated with the researcher's characteristics can significantly improve the impact. Balancing teaching and research demands, managing affiliation changes, and keeping abreast of advancements require robust support systems. Addressing demographic disparities and fostering personal adaptability is crucial. Continuous professional development, equitable practices, and supportive academic environments will enhance researchers' contributions, fostering transformative research.

Table 3: Literature Insights, Challenges and Potential Contributions of Researchers' Characteristics

Characteristic	Literature Insights	Challenges	Potential Research Impact Contribution
Academic Experience			
Academic Expertise	Builds a solid foundation for understanding and teaching within specific fields (Wayment & Dickson, 2008).	Integrating theoretical knowledge with practical application can be challenging.	Enhances innovation and impact of scholarly work.
Mentorship and Self-efficacy	Effective mentorship is crucial for navigating complex research challenges (Belavy et al., 2020).	Mentoring requires time and resource investment.	Improves research efficacy and productivity.
Teaching and Research Integration	Enhances research productivity (Horta et al., 2012).	Balancing teaching and research duties can be difficult.	Shapes career trajectory and academic growth.
Affiliation and Memberships			
Institutional Prestige	Provides resources and a stimulating environment (Stock et al., 2023; Zhang et al., 2022).	Access to prestigious institutes may be limited.	Enhances productivity and innovation.
Scientific Associations	Expand professional networks and offer access to specialised resources (DuMez, 2000).	Memberships can be costly.	Enhances research quality and impact.
Impact of Affiliation Changes	Affects productivity depending on the circumstances of the move (Abramo et al., 2022; Halevi et al., 2016).	Adapting to new environments can hinder performance temporarily.	Shapes research trajectories.
Demographic Characteristics			
Age and Experience	Older researchers often achieve greater output (Kyvik & Aksnes, 2015; Wahid et al., 2022).	Age-related biases and barriers.	Enhances productivity and impact through experience.
Gender Disparities	Notable gender disparities in publication rates (Bentley, 2012; Fukuzawa, 2014; Pfeiffer et al., 2016).	Gender biases and systemic barriers.	Addresses visibility and influence of research contributions.
Ethnicity and Cultural Backgrounds	Native language and institutional prestige affect publication success (Laurance et al., 2013).	Cultural biases and access issues.	Enhances research dissemination and recognition.
Domain Knowledge			
Expertise and Innovation	Enhances ability to resolve complex problems effectively (McCutchen, 1986; Niknafs & Berry, 2017).	Requires continuous learning and adaptation.	Improves research quality and depth.
Impact on Productivity	A strong predictor of understanding and integrating new data (Alexander et al., 1994; Rugaber, 2000).	Keeping up with rapid advancements in the field.	Enhances productivity and innovation.
Collaborative Research	Teams with domain expertise achieve publication success (Laurance et al., 2013; Puuska, 2010).	Coordination among diverse experts can be challenging.	Amplifies collective output and impact of research groups.

Involvement in Multidisciplinary Research			
University-Industry Relationships	Boosts scientific productivity (Manjarrés-Henríquez et al., 2009).	Balancing academic and industry interests.	Drives innovation and practical applications.
Innovation and Diversity	Correlates with innovative output (Campbell et al., 2017; Omodei et al., 2017).	Managing diverse team dynamics.	Enhances research innovation and applicability.
Institutional Support	Promotes diverse and innovative outcomes (García-Rodríguez et al., 2023; Hicks, 2021).	Requires robust institutional policies and support.	Foster effective multidisciplinary research.
Personality Traits			
Cognitive Abilities	Critical thinking and creativity are essential (George, 2023).	Varies widely among individuals.	Enhances problem-solving and innovation.
Motivation	High motivation leads to effective learning and impactful research (Dweck, 2006; Vu et al., 2022).	Sustaining motivation over time.	Drives research productivity and quality.
Interpersonal Abilities	Collaboration and communication skills enhance team effectiveness (Arora et al., 2011).	Developing these skills requires effort and practice.	Improves teamwork and research dissemination.
Specific Traits	Openness and conscientiousness impact research approach (Jensen, 2015).	Personality traits are hard to change.	Fosters innovation and thoroughness in research.
Understanding of the Research System			
Methodological Proficiency	Utilizes advanced databases and tools effectively (Hendrix, 2024; Zippia, 2023).	Keeping up with technological advancements.	Enhances research precision and reliability.
Academic and Cultural Contexts	Tailor methodologies to specific conditions and challenges (Gisbert & Chaparro, 2020; Master Class, 2021).	Adapting to diverse academic environments.	Ensures relevance and applicability of research findings.
Institutional Resources	Effective resource utilization and ethical compliance (Fournier-Viger, 2016; Thomas, 2023).	Access to resources may be limited.	Maximises societal and academic impact.
Teamwork, Collaboration, and Networking			
Collaborative Efforts	Enhances research initiatives' scope and depth (Campbell et al., 2017; Hicks, 2021; King et al., 2010).	Coordination among team members.	Makes research more comprehensive and innovative.
Co-authorship and Social Capital	Important for strategic positioning and networking (Jeong et al., 2011; Li et al., 2013; Melin & Persson, 1996).	Developing and maintaining co-authorship networks.	Increases visibility and citation rates of research.
International and Interdisciplinary Collaborations	Effective in tackling global issues (Dusdal & Powell, 2021; Kyvik & Reymert, 2017; Lewis, 2021).	Managing diverse international and interdisciplinary teams.	Solves complex global challenges through varied impacts of cooperation.

Characteristics and Role of Institution

Table 4 provides an overview of the literature, revealing insights into various institutional characteristics and highlighting several challenges and potential contributions to the research's impact. Appropriate time allocation support enhances research impact by allowing scholars to optimise their focus on critical research activities. Effective time management relies on institutional support to reduce teaching and administrative burdens, simplify grant applications, and provide easy access to resources such as libraries and online databases (Iqbal & Mahmood, 2011). Promoting a balanced work-life environment also significantly contributes to research productivity and sustainability, enhancing overall productivity and boosting morale and motivation among researchers (Kalev & Dobbin, 2022; Wahid et al., 2022). Practices like offering sabbaticals, study leave, and access to time management tools further empower researchers to manage their time effectively (Adam, 2023).

Leadership, high values, and strict policies are critical in fostering research productivity, quality, and impact. Leadership in academic governance involves directing research efforts to align with the institution's mission and values, maintaining rigorous standards, and supporting innovative research endeavours (Askeland, 2020; Middlehurst et al., 2009). Ethical integrity, including honesty, transparency, and fairness, is crucial in maintaining high research quality and societal relevance (Bromley et al., 2015; Macklin, 2003). Stringent research ethics policies provide guidelines for conducting responsible and ethical research, enhancing research quality and impact (Hammersley, 2009; Resnik & Elliott, 2013).

Institutional support, facilities, resources, and libraries are foundational to enhancing research productivity, quality, and impact. Institutional support fosters domestic and international collaboration and critical research productivity drivers (Ju, 2010). The significance of facilities, including state-of-the-art laboratories and technical support staff, is crucial for advanced research endeavours (Kinney, 2007). Effective resource allocation is necessary to boost research productivity and career advancement (McGill & Settle, 2012; Rawls, 2018). Libraries and access to information are indispensable in the research process, with digital library database resources significantly impacting academic research productivity (Boukacem-Zeghmouri et al., 2016; Rafi et al., 2019; Ugwuona & Dike, 2015).

Organised research training, workshops, and mentorship significantly enhance researchers' capabilities and expertise. Training workshops and seminars on practical research skills and methodologies elevate research productivity and quality (Hicks, 2021; Hoffmann et al., 2017). Mentorship provides personalised guidance, bridging theoretical knowledge and practical application, contributing to individual researchers' professional growth (Ransdell et al., 2001). However, the effectiveness of these programmes can be diminished by weak research orientation and unsupportive environments, highlighting the need for supportive institutional frameworks (Ibegbulam & Jacintha, 2016).

Recognition and rewards enhance research productivity, quality, and impact. Recognition and rewards, including non-monetary rewards such as personalised appreciation, boost workplace morale and intrinsic motivation (O'Flaherty et al., 2021). The relationship between various forms of recognition and employee performance underscores the need for personalised recognition programmes to enhance motivation and improve research productivity and quality (Mounika, 2021). Aligning academic incentives with societal impact encourages research that benefits society (Grant, 2021). The reward system in academia often prefers quality over quantity, significantly advancing research quality and impact (Cole & Cole, 1967; Merton, 1968). A blockchain-backed token system has been proposed

to address challenges in academic recognition, suggesting a shift towards a more decentralised and democratised system for acknowledging academic contributions (Lee et al., 2023). Accurate and fair authorship attribution is crucial for ensuring proper acknowledgment of contributions, directly influencing research productivity, quality, and impact (Wager, 2019).

Research funding is crucial for advancing academic and scientific work, with internal grants providing seed funding for new projects and external funding boosting research competitiveness and productivity (Jacob & Lefgren, 2011; Thelwall et al., 2023). Funding significantly influences post-degree research careers and productivity, with PhD funding dramatically enhancing research visibility and shaping academic career trajectories (Horta et al., 2018; Nisticò, 2018). Adequate research funding elevates the scholarly stature of institutions through increased publication and citation scores (Amara et al., 2015; Dhillon et al., 2015). Diverse funding sources tailored to specific cultural and institutional contexts are necessary to foster innovation and productivity (Doh et al., 2018; Fukuzawa, 2014). Funding impacts on publication productivity vary based on numerous factors, requiring a nuanced understanding of the funding-performance relationship (Lelievre et al., 2011; Neufeld, 2016).

Streamlining administrative processes, effective resource allocation, continuous policy evaluation, and adaptive strategy formulation are essential. Training and mentorship programmes must be continually assessed for relevance and updated to equip researchers with the latest knowledge and tools. Emphasising quality recognition and aligning incentives with societal impact will enhance motivation and productivity. Adequate and tailored research funding is crucial for sustaining innovation and productivity. By actively engaging in these strategies, institutions can improve the visibility and impact of research, contributing to significant academic and societal advancements.

Characteristics and Role of Country

Table 5 provides a summary of the literature insights on various national characteristics, highlighting numerous challenges and potential contributions to research impact. Budgets, fiscal policies, and the mobilisation of public-private financial resources are pivotal in defining the scope, quality, and impact of R&D. Government funding plays an instrumental role in basic research, enhancing productivity and innovation (Xu & Huang, 2019). Public R&D expenditure directly correlates with private-sector research productivity (Guellec & Van Pottelsberghe De La Potterie, 2003). Fiscal policies and reforms, such as China's transition to a decentralised education financing system, significantly influence the equitable distribution of research funding (Podger et al., 2018). Public policies and private R&D investment complement each other, with public R&D policies stimulating private investment through tax credits and subsidies (Audretsch et al., 2002; Becker, 2015).

Economic strength and structure significantly influence a nation's research capabilities. High-income countries lead in global innovation due to robust economies and ample resources but struggle with sustainability and social impact (Acharya & Pathak, 2019). Capitalist economies drive private R&D investment focused on short-term gains, while socialist economies direct resources toward strategic research areas despite potential inefficiencies (Diamond, 1984; Podger et al., 2018). GDP plays a crucial role in research development, but high GDP does not guarantee efficient research spending (Allareddy et al., 2015). The availability of natural and technological resources impacts research productivity, with resource-rich and technologically advanced nations leading in fields such as biotechnology and robotics (Ali & Ali, 2023).

Table 4: Literature Insights, Challenges and Potential Contributions of Institutions' Characteristics

Characteristic	Literature Insights	Challenges	Potential Research Impact Contribution
Appropriate Time Allocation Support			
Time Management	Effective time management through reduced teaching and administrative burdens (Iqbal & Mahmood, 2011).	Balancing research with teaching and administrative responsibilities.	Enhances productivity by allowing researchers to focus on critical research activities.
Work-Life Balance	Promoting diversity, inclusivity, and mental health support enhances productivity (Kalev & Dobbin, 2022).	Maintaining a balanced work-life environment can be challenging.	Boosts morale and motivation, leading to sustained high research productivity.
Time Management Tools	Offering sabbaticals, study leave, and access to time management tools (Adam, 2023).	Ensuring researchers effectively use time management resources.	Empower researchers to manage their time effectively, enhancing research impact.
Leadership, High Values, and Strict Policies			
Academic Governance	Effective leadership aligns research efforts with institutional mission and values (Askeland, 2020; Middlehurst et al., 2009).	Balancing strategic leadership with resource allocation.	Fosters high-calibre research and innovation, enhancing institutional impact and reputation.
Ethical Integrity	Upholding principles such as honesty, transparency, and fairness (Bromley et al., 2015; Macklin, 2003).	Ensuring adherence to high ethical standards.	Maintains trustworthiness and credibility of research, preserving public trust.
Research Ethics Policies	Rigorous guidelines for informed consent, confidentiality, and conflict of interest management (Hammersley, 2009; Resnik & Elliott, 2013).	Developing and enforcing comprehensive ethics policies.	Enhances the quality and impact of research through responsible and ethical practices.
Support, Facilities, Resources, and Libraries			
Institutional Support	Promotes domestic and international collaboration, enhancing productivity (Ju, 2010).	Providing consistent administrative support.	Fosters a collaborative environment and supports academic adaptation and performance.
Quality Facilities	Access to high-quality facilities and technical support (Kinney, 2007).	Ensuring continuous availability and maintenance of facilities.	Provides necessary infrastructure and expertise for advanced research endeavours.
Libraries and Information Access	Significant impact of digital library database resources on productivity (Rafi et al., 2019).	Maintaining updated and comprehensive library resources.	Ensures researchers have access to essential information, enhancing research productivity.
Organised Research Training, Workshops, and Mentorship			
Skill Development Workshops	Practical research skills and advanced methodologies (Hicks, 2021; Hoffmann et al., 2017).	Providing diverse and comprehensive training programmes.	Equips researchers with advanced tools and techniques, improving research quality.
Mentorship	Personalised guidance bridging theoretical knowledge and practical application (Ransdell et al., 2001).	Ensuring availability of experienced mentors.	Enhances professional growth and research capabilities, leading to high-quality research outputs.

Recognition and Rewards			
Recognition and Rewards	Boosting workplace morale and intrinsic motivation through non-monetary rewards (O'Flaherty et al., 2021).	Implementing effective recognition strategies.	Increases engagement and research quality by enhancing researchers' sense of value and belonging.
Alignment with Societal Impact	Aligning academic incentives with societal benefits (Grant, 2021).	Balancing recognition strategies with diverse researcher needs.	Encourages research that has tangible societal benefits, enhancing its overall impact.
Fair Authorship Attribution	Ensuring proper acknowledgment of contributions (Wager, 2019).	Addressing disparities in the distribution of recognition and resources.	Enhances research productivity, quality, and impact by ensuring fair and accurate authorship attribution.
Research Funding			
Internal and External Funding	Essential roles of internal and external funding sources (Jacob & Lefgren, 2011; Thelwall et al., 2023).	Securing sufficient funding for research projects.	Supports the initiation and sustainability of research projects, enhancing scientific productivity and visibility.
Impact on Career Trajectories	Significant influence on post-degree research careers and productivity (Horta et al., 2018; Nisticò, 2018).	Managing the complexities of funding applications and allocations.	Shapes academic careers and enhances research visibility and productivity.
Institutional Impact	Adequate funding elevates the academic stature of institutions (Amara et al., 2015; Dhillon et al., 2015).	Addressing funding disparities across institutions.	Increases publication and citation scores, contributing to institutional reputation and output.

Government policies and interventions are vital in shaping research outcomes. Regulatory frameworks maintain research integrity and credibility, while strategic planning directs research toward national priorities (Kanger et al., 2020; Sadeh et al., 2020). Education and training policies ensure a skilled research community, with STEM education playing a crucial role (Martin, 2016). Government-facilitated collaboration and public engagement translate research into practical applications (Liu et al., 2022). International cooperation in research fosters global scientific advancement, with policies encouraging exchanging ideas and resources (Trajtenberg, 2001).

Demographic structures and social fabric, including educational attainment, age distribution, gender, first language, and immigration, shape the research landscape. Age and gender dynamics influence research productivity, with younger researchers bringing innovation and older researchers contributing experience (Levin & Stephan, 1989; Stack, 2004). Gender disparities, particularly among women with young children, highlight the importance of considering life stages in evaluating research outputs (Costas et al., 2010; Gonzalez-Brambila & Veloso, 2007). Language proficiency and immigration policies also impact research productivity, with language training and supportive immigration policies enhancing research outcomes (Glennon, 2023; Tariq et al., 2016).

Political structures significantly influence research environments. Democratic governments offer a conducive environment for research through academic freedom and transparent systems, fostering diverse research agendas and stable, ethical environments (Kim, 2011; Tavits, 2004). In contrast, authoritarian regimes focus resources on prioritised fields but face challenges due to limited academic freedom and censorship (Colombo, 2019; Tadjoeddin, 2010). Political structures also impact international research collaborations, with democratic nations engaging more actively in global networks (Kim, 2011).

Addressing the challenges associated with these national characteristics can significantly improve the impact. Equitable funding distribution requires transparent and inclusive fiscal policies. Strengthening international collaborations and providing targeted support for low-income countries can mitigate resource limitations. Institutional policies promoting work-life balance and gender equity can address gender disparities in research productivity. Comprehensive language training programmes can overcome language barriers for non-native English-speaking researchers. Encouraging democratic governance and fostering international research networks can create more stable and open research environments. By addressing these challenges through strategic policy interventions and international cooperation, the full potential of research impact can be realised, driving innovation and societal progress.

Table 5: Literature insights, Challenges and Potential Contributions of National Characteristics

Characteristic	Literature Insights	Challenges	Potential Research Impact Contribution
Budgets, Fiscal Policies, and Public-Private Financial Resources for R&D			
Investment in Basic Research	Government funding enhances research productivity and innovation (Guellec & Van Pottelsberghe De La Potterie, 2003; Xu & Huang, 2019).	Disparities in primary research funding between countries.	Enhances foundational knowledge and drives innovation.
Fiscal Policies	Fiscal reforms influence the equitable distribution of research funding (Podger et al., 2018).	Ensuring effective implementation and addressing structural changes.	Promotes equity in education finance, improving research quality and reach.
Public-Private R&D Investment	Public policies stimulate private R&D investment through tax credits and direct subsidies (Audretsch et al., 2002; Becker, 2015).	Balancing public and private sector investments without crowding out private R&D.	Enhances private sector innovation and research productivity.
Financing Challenges for Small Firms	Diverse funding sources are needed to address the R&D funding gap for small and new firms (Hall, 2002, 2005; Hall & Lerner, 2010; Hall & Oriani, 2006).	Ensuring sustainable and impactful funding for SMEs.	Supports innovation and growth in emerging firms, driving economic development.
Public Subsidies and Venture Capital	Impact of government-managed and independent venture capital on high-tech firms (Grilli & Murtinu, 2014).	Managing the balance between public subsidies and private investments.	Fosters high-tech innovation and supports R&D within SMEs.
Economy, Resources, Industrialisation, and Level of Urbanisation			
Economic Strength and Structure	High-income countries lead global innovation but struggle with sustainability and social impact (Acharya & Pathak, 2019).	Balancing economic strength with sustainable and socially impactful research.	Drives global innovation and supports diverse research infrastructures.
Economic Models	Capitalist economies invest heavily in R&D for short-term gains (Diamond, 1984). Socialist economies focus on strategic research but may lack efficiency (Podger et al., 2018).	Addressing inefficiencies and balancing short-term and long-term research investments.	Encourages diverse research agendas and strategic innovation.
GDP and Natural Resources	Higher GDP supports diverse research infrastructures (Allareddy et al., 2015). Natural and technological resources influence research productivity (Ali & Ali, 2023).	Ensuring efficient research spending and equitable resource distribution.	Enhances research capabilities and supports advanced technological research.
Industrialisation and Urbanisation	Industrialisation and urbanisation foster innovation but can strain resources (Dela Vega et al., 2021).	Managing resource strain and ensuring sustainable urban development.	Supports ongoing R&D and fosters environments conducive to innovation.
Government Policies and Interventions			
Regulatory Frameworks	Vital for technological progress and sustainable development (Sadeh et al., 2020).	Ensuring effective regulation while promoting innovation.	Maintains research integrity and credibility.

Strategic Planning	Directs research towards societal challenges (Kanger et al., 2020).	Aligning research efforts with national priorities.	Fosters impactful research addressing societal needs.
Education and Training Policies	Essential for a skilled research community (Martin, 2016).	Ensuring continuous support for STEM education.	Cultivates a capable pool of researchers, advancing scientific progress.
International Cooperation	Enhances global scientific advancement through collaboration (Trajtenberg, 2001).	Managing the complexities of international collaboration.	Encourages global exchange of ideas and resources, elevating research quality.
Demography and Social Structure			
Age and Research Productivity	Age influences research productivity with variances across fields (Gonzalez-Brambila & Veloso, 2007; Levin & Stephan, 1989).	Addressing the different needs and contributions of various age groups.	Creates a dynamic research environment with a mix of innovative ideas and experience.
Gender and Research Output	Gender disparities in publication rates, especially among women with young children (Costas et al., 2010; Stack, 2004; Wahid et al., 2022).	Addressing gender biases and supporting gender-sensitive research assessments.	Promotes equitable research environments, enhancing overall productivity.
Language Proficiency	English language proficiency can be a barrier to research productivity (Li & Zhang, 2022; Tariq et al., 2016).	Providing language training and support.	Improves research output and inclusion in the global academic community.
Immigration Policies	High-skilled immigration policies impact research productivity (Doran et al., 2022; Glennon, 2023).	Managing immigration policies to retain high-skilled researchers.	Enhances research productivity and innovation through diverse talent.
Political Structure			
Democratic Governments	Offer a conducive environment for research through academic freedom and innovation (Kim, 2011; Persson et al., 2007; Tavits, 2004).	Ensuring stable funding amidst political and economic fluctuations.	Foster diverse research agendas and supports global research collaborations.
Authoritarian Governments	Focused resource allocation leads to advancements in targeted areas, but limited academic freedom restricts research scope.	Balancing targeted advancements with broader academic freedom.	Drives rapid advancements in prioritised fields.
Political Economy of Conflict	Socio-political dynamics influence research and development during transitions (Colombo, 2019; Tadjoeddin, 2010).	Managing socio-political transitions and their impacts on research.	Enhances understanding of local and global political dynamics in research contexts.

DISCUSSION

Research Impact Quintuple Helix Model and Its Dynamic Interactions

Figure 1 illustrates the Quintuple Helix Model for Research Impact, emphasising the dynamic interactions among research domains that catalyse significant outcomes, thereby enhancing research impact. This model centres around the complex relationships among five core elements: Research, Publication, Researchers, Institutions, and Countries. For instance, the collaboration between Researchers and Institutions not only enhances Research and Publications but also promotes mutual growth and the dissemination of knowledge. Research, Countries, and Publications interactions demonstrate how national policies and economic conditions guide research directions and outcomes.

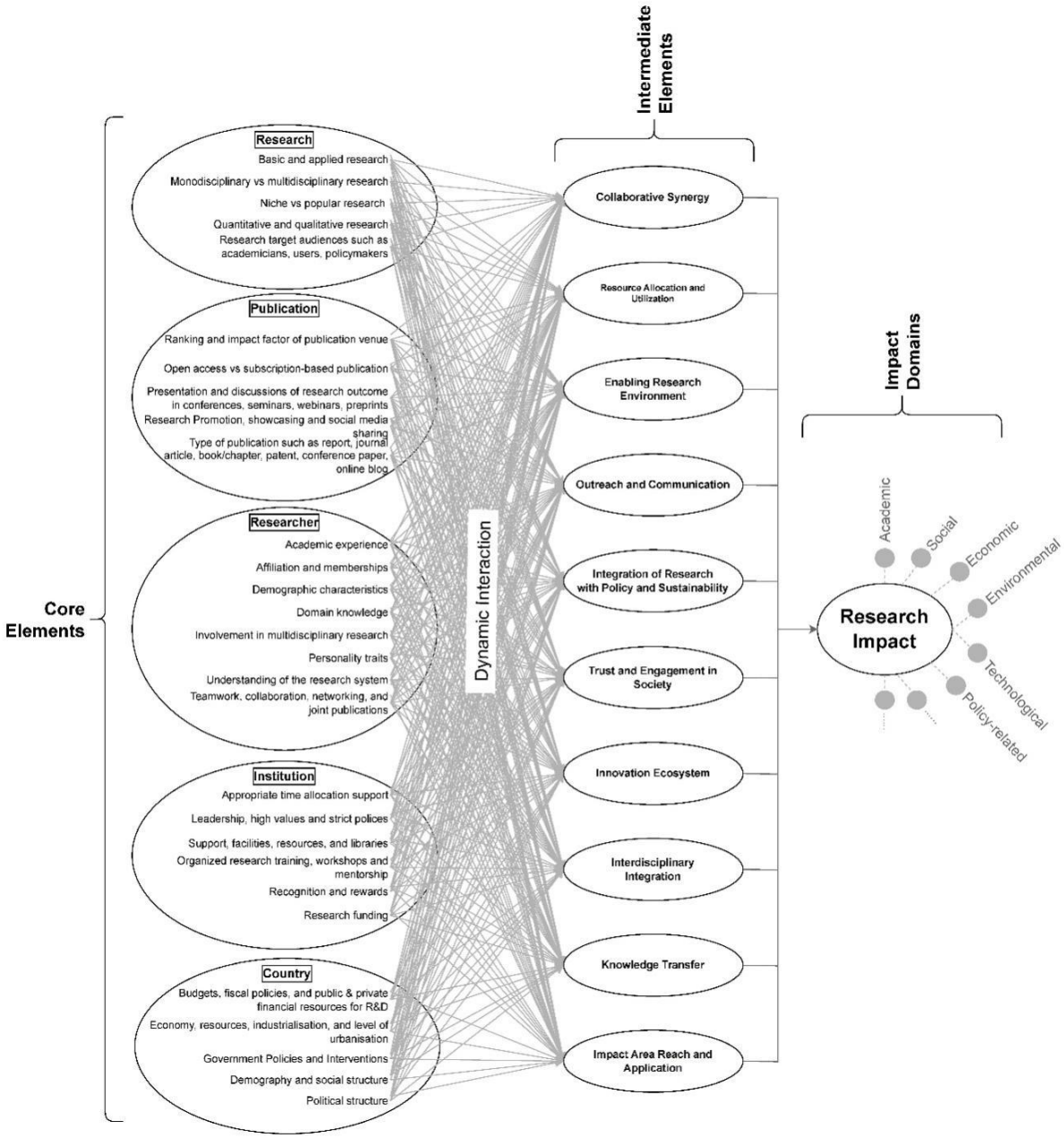

Figure 1: Interaction among Research Contribution Factors

These interactions collectively foster Collaborative Synergy, enhancing interdisciplinary research and facilitating Resource Allocation, which is critical for providing necessary resources. They also create an enabling environment for research and improve Outreach and Communication, thus increasing research's visibility and societal impact (Flynn & Rose, 2020). Additionally, these relationships help align research with policy, build social trust and engagement, and promote innovative practices and technology adoption (Hartwich & Springer-Heinze, 2003). This holistic approach ensures that research is interdisciplinary and profoundly impacts targeted areas or communities.

Academic discourse highlights that while knowledge creation and innovation are central to research impact, their influence extends further. Helix models provide a foundational understanding of these contributing factors. A comprehensive view includes elements such as Collaborative Synergy and Interdisciplinary Integration, which are crucial for expanding research scope and depth through cross-disciplinary collaboration (Dalziel et al., 2012). Resource Allocation and Utilisation, alongside an Enabling Research Environment, support scholarly progress. The importance of Outreach and Communication is emphasised in literature for extending the reach of research findings, thereby enhancing their societal impact (Anderson et al., 2020). Integrating research with policy and fostering trust and community engagement is crucial for ensuring research aligns with societal needs and gains wider acceptance (Weingart et al., 2021). Moreover, incorporating innovative practices and technology in research is vital for driving efficiency and discoveries. Lastly, Knowledge Exchange and Application, coupled with Impact Reach and Application, are pivotal in bridging the gap between theoretical research and practical application, ensuring that research achieves meaningful and measurable impacts in specific areas or communities (Springer-Heinze et al., 2003).

Contribution of Each Helix in the Quintuple Helix Model to Research Impact

The Quintuple Helix Model for Research Impact is an advanced conceptual framework that integrates five core elements - Research, Researchers, Publications, Institutions, and Countries - each contributing uniquely to enhancing research impact. This model provides a structured approach to understanding how interdisciplinary collaboration, strategic alignment with societal needs, and effective dissemination practices can collectively advance research's societal, economic, and environmental outcomes.

Research (Helix 1): Contribution to Research Impact

Research serves as the foundational element of the Quintuple Helix Model, driving knowledge creation and innovation. The literature distinguishes between basic and applied research, each with distinct contributions to research impact. Basic research, driven by a quest for fundamental understanding, is critical for advancing scientific knowledge and influencing cultural and policy decisions (Calvert, 2006; Schauz, 2014). In contrast, applied research addresses practical needs and often involves academia-industry collaborations, emphasising societal engagement and translating scientific discoveries into practical applications (Bentley et al., 2015; Fecher & Hebing, 2021; Salvador et al., 2021). Both forms of research contribute significantly to the broader societal impact by fostering innovation and addressing real-world challenges.

Monodisciplinary research offers deep, specialised insights within a single discipline but may not adequately address complex, multi-disciplinary problems (Garcia Rodriguez et al., 2023). Conversely, multi-disciplinary and interdisciplinary research approaches integrate multiple disciplines to address complex issues holistically, significantly enhancing research

impact through comprehensive perspectives and innovative problem-solving (Bammer, 2013; Choi & Pak, 2006; Hicks, 2021).

Publications (Helix 2): Contribution to Research Impact

The publication process is a critical pathway through which research findings are disseminated and made accessible to a broader audience. Various publication venues, such as journal articles, books, patents, and policy briefs, play crucial roles in shaping research impact (Brown, 2017; Jaffe & De Rassenfosse, 2017; Karki, 1997). Journal articles, particularly those in high-impact journals, significantly enhance a researcher's career and the visibility of their work. However, they often face challenges related to accessibility and the pressure to publish in prestigious venues (Falagas et al., 2008; Garfield, 2006).

Open Access publications have emerged as a powerful tool for enhancing research impact by increasing visibility and accessibility, thereby promoting greater community engagement and interdisciplinary collaboration (Bolick et al., 2017; Molloy, 2011). Post-publication promotion, including social media sharing and strategic research promotion, further amplifies the impact of scholarly work, demonstrating the importance of effective communication strategies in extending the reach of academic endeavours (Boyd et al., 2022; Rogers, 2019).

Researchers (Helix 3): Contribution to Research Impact

Researchers are central to the research process, with their characteristics and actions directly influencing research impact. Academic experience, including formal expertise and practical research experience, shapes researchers' capabilities and impact (Lopatto, 2007; Wayment & Dickson, 2008). Effective mentorship and the development of research self-efficacy are also crucial, as they enhance researchers' productivity and ability to navigate complex research challenges (Belavy et al., 2020; Bieschke et al., 1996).

Furthermore, researchers' affiliation with prestigious institutions and participation in scientific associations expand their professional networks and access to resources, thus enhancing research quality and impact (Stock et al., 2023; Zhang et al., 2022). Demographic factors, including age, gender, and ethnicity, also play significant roles in research productivity, with older, more experienced researchers often achieving greater output, while gender disparities and cultural biases may affect publication success and visibility (Kyvik & Aksnes, 2015; Laurance et al., 2013; Wahid et al., 2022).

Institutions (Helix 4): Contribution to Research Impact

Academic institutions provide the necessary infrastructure, resources, and support that enable high-quality research. Leadership within institutions plays a critical role in aligning research efforts with institutional missions and societal needs, fostering innovation, and maintaining rigorous research standards (Askeland, 2020; Middlehurst et al., 2009). Institutional support, including access to high-quality facilities, effective resource allocation, and comprehensive research training, significantly enhances research productivity and quality (Ju, 2010; Kinney, 2007).

Recognition and reward systems within institutions are also pivotal in motivating researchers and enhancing research impact. Aligning academic incentives with societal impact goals ensures that research efforts contribute meaningfully to broader societal and environmental objectives, while fair authorship attribution and the promotion of ethical research practices maintain the credibility and trustworthiness of research outputs (Grant, 2021; Wager, 2019).

Countries (Helix 5): Contribution to Research Impact

National policies and economic conditions profoundly influence the research landscape and the impact of research. Government funding, fiscal policies, and public-private partnerships are critical in defining the scope, quality, and direction of research and development (R&D) efforts (Guellec & Van Pottelsberghe De La Potterie, 2003; Xu & Huang, 2019). High-income countries often lead in global innovation due to their robust economies and extensive resources, although they face challenges related to sustainability and social impact (Acharya & Pathak, 2019).

Government policies supporting education, particularly in STEM fields, and fostering international cooperation in research are essential for cultivating a skilled research community and promoting global scientific advancement (Martin, 2016; Trajtenberg, 2001). Additionally, the political structure of a country, whether democratic or authoritarian, influences research environments, with democratic nations typically providing a more conducive environment for diverse research agendas and global collaborations (Kim, 2011; Tavits, 2004).

Comparison with Standard Helix Models

The primary objective of standard helix models (Triple, Quadruple, Quintuple) is to explain and enhance innovation and knowledge creation dynamics through the interaction and collaboration of different sectors or stakeholders. These models aim to foster environments that drive innovation by leveraging the strengths and synergies of each sector involved. The Triple Helix Model focuses on the collaboration between universities, industry, and government to promote innovation and economic development (Leydesdorff, 2012). The Quadruple Helix Model extends this by incorporating civil society, media, and culture, highlighting the role of public engagement and cultural dynamics. The Quintuple Helix Model further includes the natural environment, emphasising sustainable development and ecological considerations (Carayannis & Campbell, 2009).

In contrast, the Research Impact Quintuple Helix Model systematically examines the factors influencing the impact of research. It provides a structured framework delineating Research, Publication, Researchers, Institutions, and Countries that shape and enhance research impact. This framework is developed to understand and improve research's societal, economic, and cultural implications, organise and analyse contributing factors, and provide a comprehensive guide for researchers, policymakers, and institutions to maximise research benefits. Key concepts include systematic organisation, multidimensional evaluation, interconnectedness, and practical applications of research findings.

The Research Impact Quintuple Helix and standard helix models emphasise the importance of collaboration and use a structured approach to analyse complex phenomena (Leydesdorff, 2012). While helix models focus on sectoral collaboration for innovation and economic development, the Research Impact Quintuple Helix Model is tailored to understanding and enhancing research impact across various dimensions. Despite these differences, both approaches are complementary, integrating insights on collaboration and structured frameworks to improve outcomes in their respective domains.

Practical Implications

This review delineates the crucial role of strategic collaborations in academic research, highlighting that such networks among researchers, academic institutions, and industry partners are not merely a convergence of diverse entities but a fusion of expertise, resources, and perspectives. This integration is pivotal for fostering innovative research

outcomes, transcending traditional academic confines, and embracing a multidisciplinary approach to addressing complex global challenges. The success of these collaborative efforts hinges on supporting national policies and institutional frameworks, serving as catalysts in nurturing these partnerships, thereby enhancing research's relevance to real-world problems and augmenting its societal benefits. Key strategic collaborations identified include:

- Government Policies: These play a central role in sculpting the research and development landscape, providing essential support through funding, infrastructure development, and regulatory frameworks, fostering academia-industry collaborations, and enhancing the scope and quality of research outputs.
- Resource Management emphasises targeted funding for areas promising substantial societal, economic, and cultural returns and extends beyond financial allocation to encompass necessary infrastructure and support systems.
- Interdisciplinary Research: Academic institutions must actively foster endeavours across various sectors and disciplines, enhancing innovation potential when diverse knowledge bases converge.
- Research Dissemination: Utilizing open-access models and digital platforms to amplify research visibility and impact, ensuring insights are leveraged for broader societal benefit.
- Capacity Building: Investing in comprehensive training and mentorship programmes within academic institutions to enhance research quality and societal impact.

Limitations and Future Studies

This review offers a comprehensive analysis but is subject to several limitations, primarily relying on academic literature, which might emphasise perspectives and potentially overlook insights from industry-based research. The generalisability of findings across various fields is limited, as applicability may differ based on specific disciplinary or regional contexts. Moreover, the focus on qualitative analysis may limit exploring certain aspects that quantitative methods could reveal more effectively. Notably, this paper does not employ data-driven approaches commonly used in predicting citations, collaborations, h-indexes, and author influence, which represent significant factors not addressed in our qualitative thematic analysis. Future research should incorporate quantitative data to validate the theoretical constructs of the Quintuple Helix Model and explore longitudinal studies to observe how research impact evolves under this model.

CONCLUSIONS

This review paper has systematically explored the RIQHM illustrating its potential to enhance the understanding and implementation of research impact across multiple dimensions. By integrating the perspectives of Research, Publication, Researchers, Institutions, and Countries, this model offers a comprehensive framework that aligns with contemporary scientific endeavours' dynamic and interconnected nature.

Our examination reveals that research impact is not a linear outcome of academic activities but a multifaceted phenomenon shaped by a complex interplay of various factors within the quintuple helix framework. The collaboration between Researchers and Institutions exemplifies how mutual growth and knowledge dissemination are pivotal, emphasising that the quality and reach of research are significantly influenced by the underlying support structures and policies at both institutional and national levels.

Furthermore, the comparison with standard helix models, such as the Triple, Quadruple, and Quintuple Helix, highlights the unique contributions of the RIQHM in addressing specific challenges and opportunities in enhancing research impact. Unlike standard models, which primarily focus on innovation and economic development through sectoral collaboration, the RIQHM broadens the scope to include societal, financial, and environmental dimensions, fostering a more holistic approach to research impact.

The practical implications of this model are profound. It necessitates strategically fostering environments that enhance collaborative synergies, interdisciplinary research, and effective resource allocation. Institutions and policymakers are urged to consider these elements when designing strategies to strengthen the societal benefits of research. Moreover, this model encourages the adoption of policies that promote transparency, intersectoral collaboration, and sustainable practices that align with global development goals.

Despite this model's strengths, our review recognises limitations in the existing literature and suggests areas for future research. The generalisability of findings and reliance on qualitative analysis are noted concerns, pointing to the need for more empirical studies and data-driven approaches to validate further and refine the model. Future research should aim to incorporate quantitative methods to measure the impact and effectiveness of the RIQHM, potentially transforming theoretical constructs into actionable strategies.

In summary, the RIQHM enhances our understanding of the multifaceted nature of research impact and serves as a guiding framework for future studies and policy-making. By addressing the intricate interactions among its five core elements, this model opens new avenues for achieving a sustainable and impactful research ecosystem that resonates with the broader goals of societal advancement and global cooperation. As we move forward, it is imperative that all stakeholders in the research community - academics, researchers, policymakers, and institutions - collaborate to leverage the insights from this model, driving the evolution of research impact towards more integrated and beneficial outcomes.

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CONFLICT OF INTERESTS

The authors declare that they have no competing interests, including no conflicts of interest

AUTHOR CONTRIBUTION

Conceptualization: [all authors]; Methodology: [M.Arsalan]; Formal analysis and investigation: [M.Arsalan]; Writing - original draft preparation: [M.Arsalan]; Writing - review and editing: [all authors]

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