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Article

Research Productivity for Augmenting the Innovation Potential of Higher Education Institutions: An Interpretive Structural Modeling Approach and MICMAC Analysis

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Abstract: Current literature merely identifies the driving factors of research productivity in higher education institutions without directly examining their interrelationships that would offer some fundamental insights into the nature of these factors. Thus, this work intends to identify those driving factors and establish their structural relationships to determine those factors with crucial roles in advancing research productivity. Due to the subjectivity of the identified driving factors and the notion that the evaluation of their relationships reflects an expert judgment, an interpretive structural modeling (ISM) approach and the Matrice d'impacts croisés multiplication appliquée à un classement (MICMAC) analysis were adopted. Results show that institutional support, reward system, research funding, mentoring, and electronic information resources are the most crucial factors influencing research productivity. When addressed, these driving factors would motivate other driving factors, contributing to higher research productivity. In particular, these findings encourage higher education institutions to (1) efficiently allocate research funds and design mentoring programs, (2) offer efficient research incentive schemes, (3) develop initiatives that would support promising research proposals beneficial to the institution, and (4) collaborate with external organizations to grant funding for research proposals. These results contribute significantly to the literature as it provides meaningful insights that aid decision-makers in higher education institutions in resource allocation decisions, policy-making, and the design of efficient initiatives for augmenting their innovation potential.

Keywords: research productivity; higher education institutions; driving factors; interpretive structural modeling; MICMAC analysis

1. Introduction

The nature in which research investments lead to socio-economic growth is often not well defined. Nevertheless, compelling empirical evidence suggests that basic research, innovation, and discovery create commercially viable technologies, stimulating private sector-led economic and social development (e.g., [1]). Return on investment on publicly funded research and development (R&D) is approximated at 20%, higher than the 6.8% on stock and 3.1% on bonds. In agricultural systems research, for instance, the proliferation of new crop varieties that promote increased productivity resulted from improved biotechnology research [2,3]. Furthermore, research funded by the National Breast Cancer Foundation

led to a 10% change in policy, 11% new product development, and 14% change in clinical practice [4]. Policymakers and scientific communities witnessed the expansion of scientific information, recognizing the importance of university research. Thus, emphasis on collaborations in various sectors (e.g., industry) to improve research productivity (RP) [5] has become an important policy agenda. Consequently, since Higher Education Institutions (HEIs) are the catalyst of knowledge transfer and research, RP became a crucial indicator of most university ranking systems, compelling HEI leaders to seek ways to motivate lecturers to conduct research and publish their outputs [6]. Henry et al. [7] emphasized that HEIs should regularly evaluate the RP of academics to assess potential career growth and address future challenges.

Various studies attempted to identify the driving factors of RP (e.g., [8]). Several works (e.g., [9,10]) have categorized these drivers into two main groups: (1) human and (2) organizational. The human–organizational dichotomy is a widely recognized framework for identifying driving factors of RP. Drivers under the “human” category include research skills and competence [11], self-efficacy [12], global innovativeness [13], individual factors [10], self-determination [14], mentoring [15], and dynamics of professional life [16], among others. On the other hand, organizational factors include institutional support [17], departmental culture [18], tenure and promotions [19], research-oriented culture [19], and situational factors [20]. However, some pointed out that human and organizational drivers do not entirely influence RP (e.g., [10]). Understanding the role of technology use on RP has become increasingly important [21]. Thus, numerous attempts investigated the impact of using technology on raising the productivity level of academics (e.g., [22]). In addition, the impact of financial resources such as research funding [23,24] and reward systems [24,25] also became a point of interest in exploring RP. Evidence suggests that both factors strongly influence RP [26].

Although there have been many works in the literature investigating various driving factors of RP, only a few studies use a framework that incorporates all possible factors that may drive RP in an attempt to evaluate them critically [27]. Moreover, current literature merely identifies the driving factors of RP without directly exploring their interrelationships, which may provide an in-depth analysis of their intricacies and give rise to a better understanding of their nature. The lack of understanding of the interrelationships among the driving factors of RP may provide a constricted view of its fundamental structure. Furthermore, such an understanding of the interrelationships is crucial in gaining meaningful insights into the design of initiatives that would better comprehensively address RP. While there is an accumulating set of empirical evidence that the identified driving factors in the literature influence RP, it is essential to consider that these driving factors may impact other driving factors due to their loosely defined boundaries.

Determining the relationships of factors that influence a particular concept to better understand such a concept has been popular in various contexts. For instance, in the education sector, analyses of the interrelationships of factors were reported for engineering education [28,29], management education [30], technical education [31], and teamwork training [32], among others. A similar approach can be observed in the knowledge management and innovation domain. Some examples include knowledge management innovation in healthcare sustainability [33], automobile industries [34], green innovation performance [35], and innovation capability [36]. The practical application of understanding the relationships of driving factors under a common theme has been gaining prominence in the supply chain (e.g., [37]), healthcare (e.g., [38]), information technology (e.g., [39]), service sector (e.g., [40]), and among others. This list is not intended to be comprehensive.

In this work, a comprehensive list of driving factors was obtained through a literature survey. Due to the subjectivity of these driving factors and the notion that the evaluation of the interrelationships between them is based on the experts’ judgments, interpretive structural modeling (ISM) was adopted to describe their contextual (e.g., causal) relationships. ISM and its corresponding graphical representation, the *Matrice d’impacts croisés multiplication appliquée à un classment* (MICMAC), is a popular tool for defining contex-

tual relationships among elements representing causes or driving factors of a particular problem or issue [41]. In ISM, elements with direct or indirect relationships are organized into a directed graph (e.g., [42]), where the elements are considered vertices and their relationships as directed edges or arcs. Since the judgments of experts determine how the different elements are related, ISM becomes interpretive, taking into account the subjectivity of the decision-making process. Such adoption of the ISM-MICMAC approach has been demonstrated in a myriad of overarching applications for more than a decade, with recent reports in rural development [43], supply chains [37,44], project management [45–47], management of technology [48,49], disaster resilience [50], medical tourism [51], public safety [52], environmental studies [53], energy planning [54], e-commerce [55], among others. Literature surveys reported by Gardas et al. [56] and Attri [57] expound on the breadth and depth of its applications. To illustrate such an application of ISM-MICMAC analysis in exploring the relationships of driving factors of RP, a case study in the Philippines is presented in this work. In describing the direct relationships of the driving factors under consideration, a purposive survey of domain experts, who have significant knowledge and experience in managing R&D initiatives, was conducted. The main departure of this work is to identify the relevant factors that drive RP and establish their significant relationships in order to identify crucial driving factors as inputs in decision-making and policy design. The remainder of this article is organized as follows. Section 2 identifies the driving factors of RP and discusses their theoretical and empirical relationships derived from the current literature. The background of the ISM and MICMAC analysis is detailed in Section 3, and their application for modeling RP is presented in Section 4. Section 5 elaborates the results, and some policy takeaways are highlighted in Section 6. It ends with a conclusion and discussion of future works in Section 7.

2. Review of the Driving Factors of Research Productivity

This section presents the driving factors of RP in HEIs based on an extensive literature review. In the Google Scholar database, the keywords “research productivity” AND “higher educational institutions” OR “university” were used to generate the journal articles that were considered for the literature survey. Then, the year of publication was introduced as a filter. In this case, only journal articles published in 2010–2020 were obtained. Subsequently, only those articles that discuss at least one driving factor of RP were considered qualified. Content analysis was performed on the qualified journal articles to determine the driving factors. The final list of driving factors is presented in Appendix A.

2.1. Research Skills and Competence

RP is affected by research skills and competence [58]. Studies by Nakanjako et al. [59] supported this claim and emphasized the significant association of research competence to RP. Research competence is the set of demonstrable skills and characteristics that enable the research faculty to successfully carry out research works [60]. These skills involve a set of proficiencies in analysis and mastery of sophisticated IT tools, working in interdisciplinary environments, building research networks, developing language skills, forging corporate culture, learning management skills, and strengthening awareness of research relevance as well as assessing the impact of particular research initiatives on the environment [61,62].

2.2. Self-Efficacy

Contextually, self-efficacy is defined as having confidence in successfully demonstrating tasks related to conducting research [12]. Earlier studies (e.g., [63]) identified that self-efficacy had no positive and significant impact on RP. They found that the relationship between self-efficacy and RP is equivocal because cross-sectional analysis could not accurately estimate the reciprocal relationship between them. Further investigation using different analytical methods is necessary to reach a justifiable conclusion. Later studies (e.g., [12]) responded to the need to better evaluate the relationship between self-efficacy and RP and reached a different conclusion. Hemmings and Kay [64] explored two promi-

ment Australian universities, and their findings suggest that research self-efficacy is strongly related to research results. On the other hand, Callaghan [65] investigated popular South African universities and found that research self-efficacy significantly influences research results. Garnasih et al. [12] examined the direct and indirect influences between research self-efficacy and RP at private universities in Riau, Indonesia. They found a significant impact of research self-efficacy on RP. Academics with high research self-efficacy consider difficulties a test, and they are bound to handle these difficulties rather than avoid them. The more self-efficacious in research an academic is, the more likely they would produce research outputs. Furthermore, some studies (e.g., [64]) have assessed that three measures of research self-efficacy could explain total variance in publication output: reporting and supervising research, skills related to the conduct and management of research, and writing significant works and reviewing articles or books [12,64].

2.3. Global Innovativeness

Some studies (e.g., [66,67]) show that personality characteristics (e.g., agreeableness, neuroticism) influence performance and career advancement. These personality characteristics were identified based on a lexical hypothesis in the 1980s and 1990s. Global innovativeness, commonly referred to as openness, significantly influences RP because innovation is usually deemed essential in the generation of valuable knowledge outputs [68–70]. However, Rubin and Callaghan [71] regarded global innovativeness as synonymous with technological propensity and found little evidence suggesting a significant relationship between global innovativeness and RP. This claim supported the longstanding view that certain academic RP might inherently be unreceptive to the innovative-seeking behavior of research academics.

2.4. Individual Factors

Several individual factors have been instrumental in stimulating the research behavior of academics. Such factors are largely associated with the demographic attributes of research academics [10]. The investigation of the influence of individual factors on RP can be traced back to the early 1960s (see [72]). It was found that demographic variables of academics affect the number of publication outputs. For instance, since females tend to withdraw because they adhere to the feminine role or are differentially excluded from participation, male research academics publish more than their female counterparts [73]. The different levels of research outputs for the male and female members of the faculties in an organization are caused by competing pressures to adhere to or disregard gender role norms, which together produce a pattern of multiple impacts on career and family decisions and outcomes [74]. This finding is consistent with later studies (e.g., [75,76]), highlighting that males are more research-productive than female academics. Hesli and Lee [75] presented comprehensive insights regarding such differences in research outputs concerning gender. In the works of Sax et al. [77], the same factors affect faculty RP for both men and women, while family-related characteristics, such as having dependent children, have little to no impact on research outputs. Furthermore, obtaining tenure enables professors to develop research programs and secure funding, both essential for future success in pursuing academic careers [78]. Teaching time also affects RP, as a significant amount of time is necessary to prepare for lectures, and it takes away time spent conducting research [75]. This insight is supported by several works in the literature (e.g., [79,80]). However, although a heavy teaching load may negatively affect RP (e.g., publishing academic papers), it has a positive effect on advising or mentoring [75].

2.5. Self-Determination

A way to conceptualize the motivation of academics to pursue scholarly work is through self-determination. Vansteenkiste et al. [81] stressed that self-determination is how a social context can promote autonomous motivation and its adaptive qualities. Evaluating research motivation has been constantly emphasized in the domain literature (see [82,83]).

Peng and Gao [14] investigated the impact of motivation on RP in terms of journal publications. Their study considered the intrinsic and extrinsic factors that influence motivation. Intrinsic motivation denotes the “engagement in certain tasks or behaviors primarily for their own sake, whereas extrinsic motivation pertains to actions taken for external incentives or rewards” [14]. Curiosity-spawned activities such as exploration are examples of intrinsically motivated behaviors as they do not depend on external pressure but rather satisfy one’s satisfaction [84]. The seminal work of Deci and Ryan [85] categorized extrinsic motivation into four distinct forms of regulation, namely, external, introjected, identified, and integrated. Intrinsic and extrinsic motivation were consistently associated with higher performance in academic and research-related activities [86].

2.6. Mentoring

Mentorship is a kind of personal relationship wherein the more experienced individual would act as a guide, role model, and teacher to the less experienced individual, and who would also provide necessary support in pursuing the desired profession [87,88]. Mentoring programs are increasingly common in academia [89]. According to some studies [90–92], mentor and mentee collaborations contribute to the improvement of the mentee’s publication productivity [89]. Sorkness et al. [15] developed an approach for research career mentoring based on the attributes identified by previous studies (e.g., [93,94]). These attributes include developing disciplinary research skills, aligning mentor and mentee expectations, motivating, facilitating coping efficacy, advancing equity and inclusion, and promoting professional development [93].

2.7. Dynamics of Professional Life

In many countries, institutions allot a significant amount of resources for R&D training designed to provide academics with the skills and competencies for increased productivity in their academic work [16]. These include research workshops, masterclasses, seminars, and short courses, particularly for early career and senior researchers. As a response to such investments, academics would respond with desirable work outcomes [95]. However, as Kozhakhmet et al. [16] found, training and development practices do not directly affect RP but are mediated by self-efficacy. Many studies supported this claim. For instance, Lambie [96] emphasized that training and development practices increase self-efficacy by increasing academic confidence in research. The self-efficacy of academics leads to more research collaboration [16], enables the academics to manage their research directions [97], and facilitates a positive organizational climate [98,99].

2.8. Institutional Support

During economic and social transitions, such as transitioning to a more research productive institution, institutional support measures the degree to which institutions have incentive schemes, initiatives, and strategic plans to respond to insufficient institutional infrastructure or ineffective implementation [100–102]. The significant impact of institutional support on RP has been reiterated over the years (e.g., [17,24,103]). Furthermore, among other factors, the influence of effective management support increases the research performance of an institution [104]. The potential relationship between RP and institutional support lies in the socialization of research academics into a research culture and in setting RP as one of the parameters for measuring excellence and enhancing academic careers [105]. Nygaard [17] pointed out that institutional support (and characteristics) should align with individual goals since RP will depend significantly on the subjective understanding of research academics regarding abilities, expectations, and perceptions. Furthermore, policies that will allow the faculty to spend adequate time conducting research-related activities highly influence the research performance of an institution [106].

2.9. Departmental Culture

Departmental culture pertains to the institution's internal collaboration or affiliation [107]. Ponomariov and Boardman [108] studied how affiliation affects the productivity of an individual researcher. They found that internal collaborations positively affect the quantity and quality of research outputs. The continuous decline in the productivity of single-authored publications has often been associated with improved research results [109,110]. In particular, as research collaboration of affiliation increases, the number of publications [18] and citations also increases [111]. Ductor [18] pointed out that access to ideas provided by affiliations begets opportunity but publishing high-quality research articles requires significant individual ability and effort over time. It implies that particular individual types play a significant role in making the affiliation's impact on RP significant.

2.10. Tenure and Promotion

Scott et al. [19] argued that promotion and tenure processes are the two most prominent, outcome-oriented aspects of faculty development. An individual achieving tenure and promotion demonstrates his or her excellence in academic practice, including teaching, scholarship, and service [112]. Tenure and promotion are among the most controversial and hotly debated topics in academia [113]. Negative perceptions of tenure and promotion are prevalent in HEIs. One common misconception is that once an academic is awarded through tenure and promotion, they have minimal incentive to allocate more effort to academic work [114]. However, some studies (e.g., [19,115]) assessed that the productivity of the faculty tends to maintain or increase following the granting of tenure. Academics, once promoted and granted tenure, would want to maintain employment mobility, and professional responsibilities may compel them to remain productive scholars [19]. However, a lack of support from the institutions (e.g., provision of research assistants and research funding) discourages academic researchers from pursuing tenure and promotion through research outputs [116].

2.11. Research-Oriented Culture

Cloete et al. [117] emphasized that to improve RP, the organization must not only focus on the organizational structure but also on the research culture of the organization. A research culture serves as a framework for the organization on its view regarding research dissemination, discussion, production, and valuation [118]. Commencing a good research culture requires clear goals and leadership. Research culture includes observed behavior regularities (e.g., the language and rituals, norms observed by research groups, and focus of research leadership) and institutional research policies and agendas [107]. Empowerment, training in research skills, and travel funding incentives are more powerful incentives to conduct, present and publish research outputs [19].

2.12. Situational Factors

Situational factors are considered underlying reasons that would bring success to the organization. These include good working conditions, a positive group climate, and frequent organizational communication. A study conducted by Salazar-Clemeña and Almonte-Acosta [107] showed that positive group climate, working conditions, and corporate communication are some common characteristics that emerged in different kinds of researchers. In their work, respondents see institutional policies such as lack of provision for working conditions and environment as weaknesses in enhancing research. Similarly, Rockenbach et al. [119] noted that institutions must successfully increase diversity programs addressing campus climate and supporting racial diversity. Intended or unintended, HEIs develop campus-specific climates that impact individual faculty outcomes and strategic organizational outcomes [120]. According to Guillaume et al. [121], eliminating intergroup bias and improving efficiency in workgroups working on innovation and complex tasks by promoting knowledge elaboration is one way of achieving a good campus climate.

2.13. Electronic Information Resources

The emergence of new technological advancements caused the major shift of educational materials in traditional libraries or learning commons from printed content to electronic information resources while maintaining the facility's efficiency of information management [122]. These tools and resources (e.g., Google classroom, electronic library, Scopus (Elsevier, Amsterdam, The Netherlands) and Turnitin (Advance Publications, Oakland, California, United States)) have increasingly become invaluable assets in academic institutions as effective media for research and teaching [123,124]. They also enhance academic institutions' research activities [125,126] and allow convenient access to a wide range of accurate and timely information on various research subjects [124]. A study conducted by Barjack [127] proved the positive relationship between technology use and RP. Similarly, it is found that the increase in RP [22] and research competency [128] was associated with the effective utilization of the available technological resources.

2.14. Research Funding

Substantial evidence on the effect of research funding on RP can be traced back to the early case study conducted by McAllister and Narin [129]. They found a strong relationship between the funding and the number of published research papers. Research agendas have been driven by funding sources, and technology partnerships are encouraged [130]. Research funding promotes academic engagement, particularly with industrial partners (e.g., patent licensing, and consultancy) [130]. Györfy et al. [131] observed a strong effect of a 47% increase in publication output consequent to receiving a research grant. Research funding also facilitates publication outputs and fosters dissemination through higher citation metrics and altmetrics, which are predominantly considered measures of research impact [132]. In the USA, the government continues to be the primary source of outside funding for R&D in all sectors of the economy and higher education [133]. Thus, industry funding for universities continues to remain low. In the context of the global pandemic, Tantengco [134] emphasized that R&D expenditure correlates to RP. However, research funds in some regions (e.g., the Philippines) are obtained through internal sources within the university-set budget or external sources from local and international governments and agencies [135]. Due to the considerable amount of funding invested in promoting scientific development, there is a need to evaluate the performance of academics against the amount of allocated funds and determine the efficiency of existing funding allocation strategies [136].

2.15. Reward System

Traditionally, the reward system was widely used by the private sector as a compensation strategy for workers [137,138]. It was expanded when the same monetary award incentive was introduced for research publications in the 1980s [139,140]. Research institutions seek to increase self-directed RP by implementing a positively enforcing reward system [136]. The monetary incentive has been successful in China's international scientific publication as it experienced an exponential increase over the past 20 years [139]. Different countries approach the reward system differently. In some, the incentives only apply to science and engineering, while others apply to a wide range of disciplines [138]. Most countries focus the incentives directly on individuals rather than institutions [139]. However, adequate performance indicators need to be established before adopting a performance-based incentive plan [136]. Assigning academic-relative value units to scholarly activity can be a quantifiable metric to measure the RP [140,141].

2.16. Research Gaps and Contribution

The positive impact of the investment on research activities has been consistently reported to be significant for the growth and productivity of the economy [142]. In fact, various industries have allocated resources to the innovation and development of their products and services [143,144]. However, the impact and relationship of the benefits of

R&D to an organization's value and performance have not yet been widely explored [145]. An evaluation of the innovation performance of ASEAN countries with the most significant emerging economies (i.e., Indonesia, Malaysia, Philippines, Singapore, and Thailand) has been recently conducted by Nimtrakoon [146]. The study confirmed that R&D initiatives drive the company's profitability and market performance. Especially in developing countries, the advancement of knowledge due to RP is claimed to have a significant impact on pressing societal and environmental issues [13]. Nevertheless, initiatives for innovation should not only focus on the industry but also on academic institutions. Consequently, most academic institutions have practiced existing support systems for research activities [147]. In fact, various governments have introduced assurance mechanisms and initiatives to hold HEIs accountable for their RP [148]. Consequently, HEIs are the top-performing organizations in significant research outputs [149].

Kwiek [150] characterized the top-performing researchers in HEIs and found a significant difference between the RP of academics with high and low positions. Low-position academics significantly dominate soft field research while high-position academics perform in more demanding field research. Subsequent findings of Kwiek [150] suggest that top-performing researchers in HEIs are more productive with international colleagues and collaborators. Evidently, several factors significantly affect the RP in HEIs. Thus, there is a need to exhaustively determine the factors that drive RP in HEIs to structure an overarching framework among these factors. Sufficiently, various works in the literature have already established these factors (e.g., [14,150]). However, the interrelationships of these factors with each other remain unexplored. Establishing a linear relationship of a complex system may be insufficient to explain the underlying relationships that govern such a system. Thus, it is crucial to determine the complex relationships among the driving factors to provide a robust decision support tool for improving the research performance of HEIs. The main contribution of this study is to establish the interrelationships of these driving factors of RP and determine the significant relationships to formulate policy directions that would be beneficial to research managers in their respective institutions.

3. Preliminaries

Interpretive structural modeling (ISM) is a graph theoretic tool that structures homogeneous concepts or elements into a directed graph, where vertices are represented by these elements and directed edges or arcs are described by their contextual relationships [41]. The digraph then portrays the complexity of the domain problem defined by these concepts or elements. In effect, ISM reveals the mental model of how one understands the problem. However, while the direct relationships of the problem can be explicitly defined via its pictorial representation (i.e., the digraph), its complexity remains poorly understood due to the presence of indirect relationships. The strength of the ISM is to transform a poorly understood problem by comprehensively addressing both the direct and indirect relationships among its elements, and in turn, it develops a clearly-defined structure that can be better understood by the domain stakeholders. Thus, ISM extracts unknown, non-trivial information about the complexity of a given problem.

Harary et al. [151] provided the foundations of the ISM, and its philosophical basis was presented by Warfield [41]. A more detailed approach to its conceptualization and analysis was defined by the Researchers of the Battelle Memorial Institute in Columbus, Ohio, in 1974. For brevity, readers are advised to refer to Harary et al. [151] for the mathematical basis of the ISM. The following steps describe the procedure carried out in this work:

Step 1. Identify the elements under consideration. Note that these elements, to some extent, must be homogeneous with respect to the concept under investigation (e.g., research productivity). This process may be carried out by, but is not limited to, reviewing the domain literature, conducting a survey, implementing a focus group discussion, or a combination of these methods.

Step 2. Considering that the structural model would be established by a small group of domain experts eliciting judgments individually, a structural self-interaction matrix

(SSIM) is constructed for each expert. Otherwise, when the group decides on a consensus, one SSIM is generated, representing the group decision. These experts are asked to decide on the contextual relationship (i.e., represented by the relation \mathcal{R}) between two elements. Four notations are used to describe the relation between a pair of elements:

- V for the relation from i to j but not in both directions;
- A for the relation from j to i but not in both directions;
- X for the relation from i to j and from j to i (i.e., both directions);
- O for the no relation that exists between i to j .

Step 3. Convert the SSIM into a binary matrix representation using the following relation:

- V implies that $i\mathcal{R}j = 1$ and $j\mathcal{R}i = 0$;
- A implies that $i\mathcal{R}j = 0$ and $j\mathcal{R}i = 1$;
- X implies that $i\mathcal{R}j = 1$ and $j\mathcal{R}i = 1$;
- O implies that $i\mathcal{R}j = 0$ and $j\mathcal{R}i = 0$.

Step 4. Construct an initial reachability matrix (R) for each SSIM using Equation (1).

$$R = A + I \quad (1)$$

where $A = (a_{ij})_{n \times n}$ is an adjacency matrix where $a_{ij} = \begin{cases} 1 & \text{if } i\mathcal{R}j = 1 \\ 0 & \text{if } i\mathcal{R}j = 0 \end{cases}$; and I is an identity matrix with a size $n \times n$.

Step 5. Aggregate the initial reachability matrices. In most cases, the aggregation is carried out via the majority rule [152]. A majority rule selects alternatives with a majority preference, that is, 50% of the votes plus one [42,55]. Consider an aggregate reachability matrix $R^{Agg} = (r_{ij}^{Agg})_{n \times n}$. Thus, $r_{ij}^{Agg} = 1$ if the majority of experts favor the existence of the contextual relationship from element i to element j . Otherwise, $r_{ij}^{Agg} = 0$. The aggregation of the expert's views by a majority rule depicts the strength of the supporters of a proposal as superior compared to its opponents. A stricter criterion may be set at two-thirds of the experts declaring $r_{ij} = 1$ [152]. Note that this step is skipped if the expert group generates a consensus.

Step 6. Generate the final reachability matrix $R^* = (r_{ij}^*)_{n \times n}$ by checking transitive links or relationships, such that, if $r_{ij}^{Agg} = 1$ and $r_{jk}^{Agg} = 1$, then $r_{ik}^* = 1$, for elements i, j , and k . The commonly used approach in enumerating transitive links is Warshall's algorithm [153].

Step 7: Determine the reachability set V_i^r and antecedent set V_j^a ($\forall i, j$) from the R^* . The reachability set V_i^r is defined as

$$V_i^r = \{j : r_{ij}^* = 1, j = 1, \dots, n\} \quad (2)$$

On the other hand,

$$V_j^a = \{i : r_{ij}^* = 1, i = 1, \dots, n\} \quad (3)$$

The intersection V_i^\cap set is defined as

$$V_i^\cap = V_i^r \cap V_i^a \quad (4)$$

The driving power $V_i^{driving}$ of i is simply the cardinality of V_i^r , denoted by $V_i^{driving} = |V_i^r|$. The dependence power $V_i^{dependence}$, on the other hand, is defined as $V_i^{dependence} = |V_i^a|$.

Step 8. Perform level partitioning. Segregation of the elements into a hierarchical structure of κ levels provides useful, practical insights into these elements. In this step, Algorithm 1 provides the iterations of the partitioning rules.

Algorithm 1: Level partitioning.

1. Start
2. Step 1: For each i , evaluate V_i^r and V_i^\cap .
3. Step 2: If $V_i^r = V_i^\cap$, assign i to Level 1.
4. Step 3: For each $j, j \in \{1, \dots, n\} \setminus i$, evaluate V_j^r and V_j^\cap .
5. Step 4: If $V_j^r = V_j^\cap$, assign j to Level 2.
6. Step 5: Repeat Step 3 and Step 4 for all remaining elements until all elements are assigned to $1, \dots, \kappa$ levels.
7. End

Step 9. Draw the digraph in which the relationships of the reachability matrix and transitive links are removed. The elements are considered vertices in the digraph, and the contextual relationships represent the edges. If $r_{ij}^* = 1$, then there is a directed edge from element i to element j . The interpretive structural model is constructed by incorporating the level partitions in Step 8.

Step 10. Analyze the driving power and the dependence power. As an extension of the ISM, the MICMAC analysis evaluates the driving power and dependence power of the elements. By constructing a $V_i^{driving} \times V_i^{dependence}$ map, they are classified into four clusters:

- Elements with high driving power and weak dependence power are considered independent elements.
- Elements with strong driving and strong dependence power are the linkage elements.
- Elements having strong dependence power and weak driving power are referred to as dependent elements.
- Elements with weak driving and weak dependence power are autonomous elements.

4. The Application of ISM-MICMAC Analysis in Understanding the Relationships of Driving Factors of Research Productivity

The following are the steps of adopting the ISM-MICMAC analysis in determining the relevant relationships between the driving factors of RP and, consequently, identifying priority factors.

Step 1: List the driving factors of research productivity.

The final list of RP driving factors is shown in Appendix A. These driving factors were obtained through an extensive literature review, as described in Section 2. Moreover, corresponding codes were assigned to driving factors for convenience of representation.

Step 2: Construct an individual SSIM for each expert.

Five experts were asked to elicit judgments on the contextual relationships among RP driving factors. Expert 1 is a Professor of Mechanical Engineering and the current Vice-President for Production, Extension, and Business Affairs of a state university. Expert 2 is a Dean of the College of Business Management of a state college. Meanwhile, Expert 3 is a Director of External Affairs of the same state college. Expert 4 is an Associate Professor and a Director of a research center in a state university who has published over a hundred peer-reviewed journal articles in management, engineering, and the public sector. Finally, Expert 5 is a Chair of a Tourism Management Department of a state university and has published over 20 journal articles in tourism and marketing. The mean age is 42 years old, and the mean academic experience is 19 years. All hold a Ph.D. degree and hold administrative functions in their organizations. Experts were briefed about the study and the corresponding questionnaire, which was drafted in the context of the ISM. The questionnaire was distributed to the experts, and questions regarding the questionnaire were immediately addressed. A corresponding SSIM was constructed for each expert, with entries representing V, A, X, and O, as discussed in Step 2 of Section 3. Table 1 shows a sample SSIM of Expert 4.

Table 1. A sample structural self-interaction matrix.

Driving Factors	RS	RF	EIR	SF	ROC	TP	DC	IS	DPL	M	SD	IF	GI	SE
Research skills and competence	O	A	A	X	A	A	X	A	A	A	A	X	V	V
Self-efficacy	A	X	A	A	A	O	A	A	A	A	X	X	O	
Global innovativeness	O	O	O	A	X	O	V	A	A	A	A	A		
Individual factors	O	O	O	V	X	O	O	O	A	A	A			
Self-determination	O	O	O	V	V	O	V	O	V	O				
Mentoring	A	A	O	V	V	O	V	A	A					
Dynamics of professional life	O	O	O	V	V	O	V	O						
Institutional support	X	X	V	V	V	V	V							
Departmental culture	A	A	O	A	V	A								
Tenure and promotions	X	V	O	O	V									
Research-oriented culture	A	A	A	A										
Situational factors	O	O	O											
Electronic information resources	O	O												
Research funding	X													

Step 3: Set up the corresponding initial reachability matrices.

An initial reachability matrix was constructed for each SSIM using the representation described in Step 3 of Section 3. Table 2 shows the corresponding initial reachability matrix of the SSIM in Table 1.

Table 2. A sample initial reachability matrix.

Driving Factors	RS&CSE	GI	IF	SD	M	DPL	IS	DC	TP	ROC	SF	EIR	RF	RS
Research skills and competence	1	1	1	1	0	0	0	0	1	0	0	1	0	0
Self-efficacy	0	1	0	1	1	0	0	0	0	0	0	0	1	0
Global innovativeness	0	0	1	0	0	0	0	1	0	1	0	0	0	0
Individual factors	1	1	1	1	0	0	0	0	0	1	1	0	0	0
Self-determination	1	1	1	1	1	0	1	0	1	0	1	0	0	0
Mentoring	1	1	1	1	0	1	0	0	1	0	1	1	0	0
Dynamics of professional life	1	1	1	1	0	1	1	0	1	0	1	1	0	0
Institutional support	1	1	1	0	0	1	0	1	1	1	1	1	1	1
Departmental culture	1	1	0	0	0	0	0	1	0	1	0	0	0	0
Tenure and promotions	1	0	0	0	0	0	0	1	1	1	0	0	1	1
Research-oriented culture	1	1	1	1	0	0	0	0	0	1	0	0	0	0
Situational factors	1	1	1	0	0	0	0	1	0	1	1	0	0	0
Electronic information resources	1	1	0	0	0	0	0	0	0	1	0	1	0	0
Research funding	1	1	0	0	0	1	0	1	1	0	1	0	1	1
Reward system	0	1	0	0	0	1	0	1	1	1	1	0	1	1

Step 4. Construct an aggregate initial reachability matrix.

For this work, the aggregation of the initial reachability matrices assumes the following process. First, a priority weight w_k is assigned to the k th expert, which represents the importance of the judgment of expert k in relation to his or her knowledge and experience in the RP domain. w_k follows the normalization $\sum_k w_k = 1$. Secondly, $r_{ij}^{Agg} = 1$ if $\sum_k w_k r_{ij} \geq \alpha$ where α represents an aggregation threshold. Otherwise, $r_{ij}^{Agg} = 0$. α is set to filter out weak relationships between driving factors i to j . In this study, $\alpha = 0.75$, elucidating a supermajority rule. Table 3 presents the aggregate initial reachability matrix.

Table 3. The aggregate initial reachability matrix.

Driving Factors	RS&C	SE	GI	IF	SD	M	DPL	IS	DC	TP	ROC	SF	EIR	RF	RS
Research skills and competence	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Self-efficacy	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Global innovativeness	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Individual factors	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0
Self-determination	1	1	1	0	1	0	1	0	0	0	1	1	0	0	0
Mentoring	1	1	1	0	0	1	0	0	1	0	1	1	0	0	0
Dynamics of professional life	1	1	1	1	0	0	1	0	1	0	1	1	0	0	0
Institutional support	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1
Departmental culture	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Tenure and promotions	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Research-oriented culture	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0
Situational factors	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0
Electronic information resources	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Research funding	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Reward system	0	1	0	0	0	0	0	0	0	1	1	0	0	1	1

Step 5: Compute the final reachability matrix.

The final reachability matrix, shown in Table 4, was obtained using Step 6 (Section 3) with the aid of Warshall's algorithm.

Table 4. The final reachability matrix.

Driving Factors	RS&C	SE	GI	IF	SD	M	DPL	IS	DC	TP	ROC	SF	EIR	RF	RS
Research skills and competence	1	1	1*	1*	1*	0	1*	0	1*	0	1*	1*	0	0	0
Self-efficacy	1*	1	1*	1*	1	0	1*	0	1*	0	1*	1*	0	0	0
Global innovativeness	1*	1*	1	1*	1*	0	1*	0	1*	0	1	1*	0	0	0
Individual factors	1*	1*	1	1	1*	0	1*	0	1*	0	1	1	0	0	0
Self-determination	1	1	1	1*	1	0	1	0	1*	0	1	1	0	0	0
Mentoring	1	1	1	1*	1*	1	1*	0	1	0	1	1	0	0	0
Dynamics of professional life	1	1	1	1	1*	0	1	0	1	0	1	1	0	0	0
Institutional support	1	1	1	1*	1*	1	1*	1	1	1	1	1	1	1	1
Departmental culture	1	1*	1*	1*	1*	0	1*	0	1	0	1	1*	0	0	0
Tenure and promotions	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Research-oriented culture	1	1*	1	1	1*	0	1*	0	1*	0	1	1*	0	0	0
Situational factors	1*	1*	1	1*	1*	0	1*	0	1	0	1	1	0	0	0
Electronic information resources	1	1*	1*	1*	1*	0	1*	0	1*	0	1	1*	1	0	0
Research funding	1	1	1*	1*	1*	0	1*	0	1*	0	1*	1*	0	1	0
Reward system	1*	1	1*	1*	1*	0	1*	0	1*	1	1	1*	0	1	1

* indicates transitivity.

Step 6: Construct level partitions.

Using Algorithm 1, each driving factor is assigned a level in the proposed hierarchical structure. The assignments are described in Table 5. It shows that 10 driving factors are positioned in Level 1, while only institutional support is assigned to Level IV.

Step 7: Draw the final interpretive structural map.

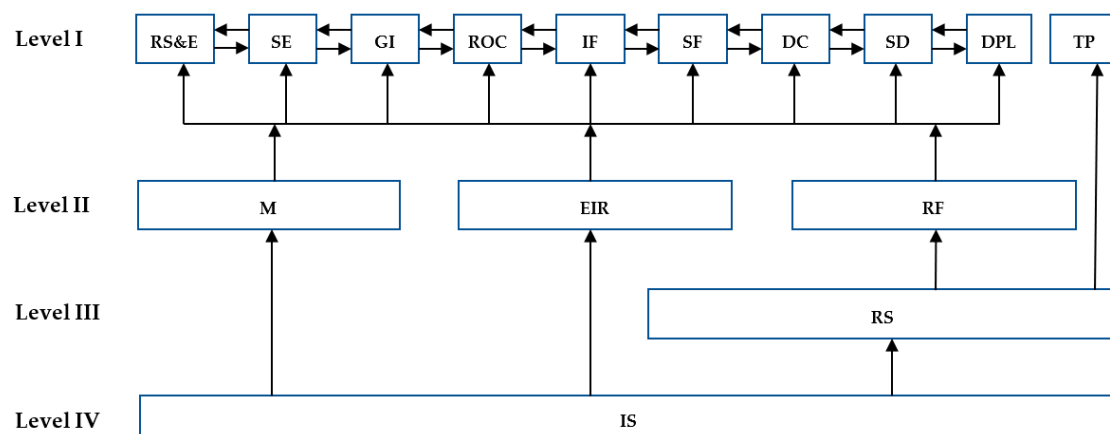
The final interpretive structural map is constructed using the level partitions in Step 6 and the initial reachability matrix in Table 3, as shown in Figure 1.

Step 8: Perform the MICMAC analysis.

Figure 2 shows the graphical representation of the driving factors of RP according to the autonomous, dependent, linkage, and independent clusters (see Step 10, Section 3 for the discussion). It reveals that nine driving factors belong to the linkage cluster; five are in the independent cluster, while tenure and promotion is the only factor in the autonomous cluster. The autonomous cluster contains no driving factor of RP.

Table 5. The partition leveling of research productivity driving factors.

Driving Factors	Reachability Set	Antecedent Set	Intersection Set	Level
Research skills and competence	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Self-efficacy	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Global innovativeness	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Individual factors	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Self-determination	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Mentoring	RS&C, SE, GI, IF, SD, M, DPL, DC, ROC, SF	M, IS	M	II
Dynamics of professional life	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Institutional support	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, TP, ROC, SF, EIR, RF, RS	IS	IS	IV
Departmental culture	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Tenure and promotions	TP	IS, TP, RS	TP	I
Research-oriented culture	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Situational factors	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	RS&C, SE, GI, IF, SD, M, DPL, IS, DC, ROC, SF, EIR, RF, RS	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF	I
Electronic information resources	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF, EIR	IS, EIR	EIR	II
Research funding	RS&C, SE, GI, IF, SD, DPL, DC, ROC, SF, RF	IS, RF, RS	RF	II
Reward system	RS&C, SE, GI, IF, SD, DPL, DC, TP, ROC, SF, RF, RS	IS, RS	RS	III

**Figure 1.** The interpretive structural model of the contextual relationships of research productivity driving factors.

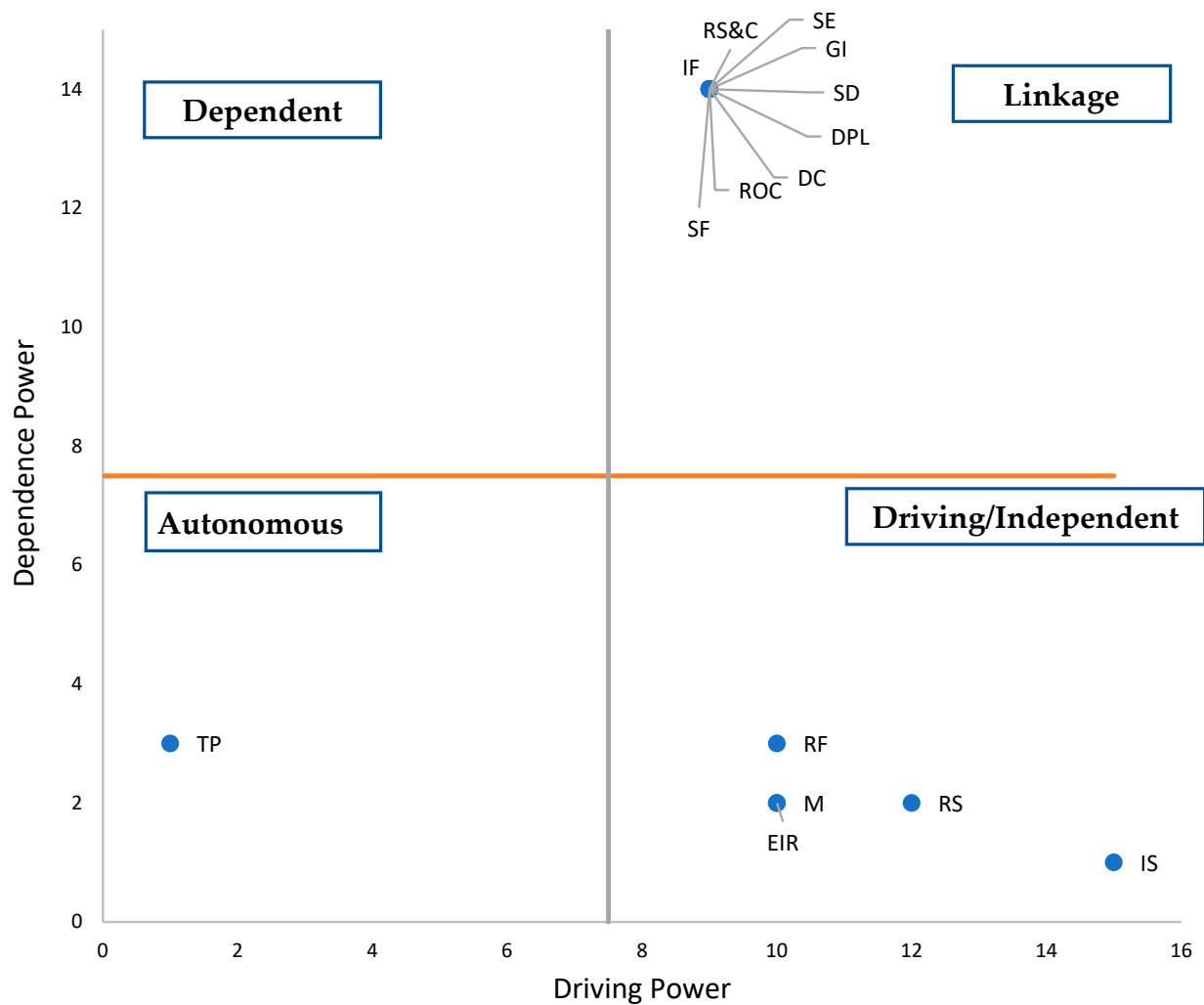


Figure 2. The MICMAC analysis.

5. Results and Discussion

The ISM and MICMAC analysis were implemented with the steps provided in Section 4. First, five SSIMs from the expert group were constructed, corresponding to Step 2. Following Step 3, the SSIMs were transformed into initial reachability matrices. Afterward, these individual initial reachability matrices were aggregated via a defined aggregation procedure that appropriately captures the knowledge and experience of the experts on RP in academic institutions. Step 4 generates the aggregate initial reachability matrix. The final reachability matrix, which encompasses the indirect relationships of the driving factors, was obtained to contain transitive relationships (i.e., represented by elements with “1” in Table 4) following the implementation of Step 5. The hierarchical ordering of the driving factors, which makes the construction of the digraph more interpretive, was obtained using Step 6 and is presented in Table 5. Subsequently, the digraph was drawn from the final reachability matrix, as suggested in Step 7. The digraph, which also represents the interpretive structural model, is shown in Figure 1. The MICMAC analysis is carried out using Step 8, where the driving and dependence powers are used to assign the challenges into four clusters, as presented in Figure 2.

Figure 1 depicts the digraph showing the relationships among the 15 identified driving factors of RP. Driving factors are arranged in four levels in a hierarchical structure. Those at the lower level of the hierarchy drive the factors at the upper levels. As illustrated in Figure 1, driving factors such as research skills and competence, self-efficacy, global innovativeness, research-oriented culture, individual factors, situational factors, departmental

culture, tenure and promotion, self-determination, and dynamics of professional life are found at Level I. Driving factors belonging to Level II include mentoring, electronic information resources, and research funding, while reward system is the only factor belonging to Level III. Institutional support, which can be categorized as an organizational resource, is the most elementary driver of RP and is located at Level IV. The ISM-MICMAC analysis also suggests that no dependent driving factor emerges, implying that although some factors may have tendencies to be dependent on other factors, they have more driving power than dependence power.

Autonomous driving factors both have low driving power and dependence power, resulting in their relative disconnection from the system. Results indicate that the tenure and promotion factor is considered autonomous. Based on Figure 1, it is only affected by two other driving factors, namely institutional support and research funding, and it does not impact other driving factors. This finding implies that while efficient tenure and promotion schemes promote RP, without institutional support and research funding that would support the provisions of the tenure and promotion guidelines of an organization, its potential may be insufficient to hold significant ground. Cunningham-Williams et al. [114] argued that the relatively higher requirements of tenure and promotion schemes (e.g., research areas) have a perverse effect on the motivation of academics to pursue more research goals. This relationship may be aggravated by the presence of no financial funding and supportive policies that would foster an environment for academics to achieve tenure and promotion requirements. Thus, decision-makers and research managers must focus their initiatives on advancing institutional support and research funding when the development of tenure and promotion provisions aims to maximize research outputs.

The results also reveal nine (9) factors that belong to the linkage cluster: research skills and competence, self-efficacy, global innovativeness, individual factors, self-determination, dynamics of professional life, departmental culture, research-oriented culture, and situational factors. All driving factors in the linkage cluster have a strong driving power of 9 and a strong dependence power of 14, as presented in Figure 2. These driving factors are unstable, and any decision taken in response to them will affect others and feedback on themselves. The first six driving factors (i.e., research skills and competence, self-efficacy, global innovativeness, individual factors, self-determination, and the dynamics of professional life) influence the individual's inherent ability to achieve significant academic career progress. On the other hand, the other three factors (i.e., departmental culture, research-oriented culture, and situational factors) pertain to the institution's means of support to increase research performance. These factors providing a robust environment of research quality were considered the most influential predictors of RP [154,155]. However, as our findings suggest, they are significantly impacted by other driving factors, and so the initiatives designed to address them may not be efficient.

The driving factors such as mentoring, institutional support, electronic information resources, research funding, and reward system are identified as having independent characteristics (see Figure 3). These factors have high driving power but low dependence power. Thus, these are substantial driving factors and may be treated as crucial of all driving factors, considering that they are the most important causative agents affecting RP in an institution. For emphasis, Figure 3 shows these main driving factors of RP. Mentoring, with a driving power of 10 and a dependence power of 2, directly involves six driving factors (i.e., research skills and competence, self-efficacy, global innovativeness, departmental culture, research-oriented culture, and situational factors). On the other hand, the electronic information resources, having a driving power of 10 and a dependence power of 2, directly affects two driving factors (i.e., research skills and competence and research-oriented culture). The findings in this study are consistent with others in the literature, particularly highlighting that mentoring directly improves the soft and technical skills of academics [92] and enhances their self-efficacy [91]. Furthermore, the utilization of electronic information resources also improved the competency of the researchers [127].

Thus, the provision of electronic information resources and mentoring opportunities is crucial in improving RP in academic institutions.



Figure 3. The main driving factors of research productivity.

Meanwhile, institutional support, with a driving power of 15 and a dependence power of 1, has a direct effect on 11 driving factors (i.e., research skills and competence, self-efficacy, global innovativeness, mentoring, departmental culture, tenure, and promotion, research-oriented culture, situational factors, electronic information resources, research funding, and reward system). Similar to the findings of White et al. [103], high institutional support impacts research performance through its positive influence on a faculty's cultural setting, work characteristics, and personal factors. Furthermore, institutions with an effective management approach generate faster growth in RP [104]. Policies that support research-related activities enforced in the institution have a contributing factor [106], especially on the time utilized for productive research endeavors an academic can spend. Research funding, on the other hand, has a driving power of 10 and a dependence power of 3. It directly affects two driving factors (i.e., research skills and competence and self-efficacy). As evident from the results of Hooi and Wang [129], the provision of research funds leads to a higher level of RP. Adequate funds for cutting-edge tools and resources needed for specific research outputs can support the academics working in institutions unable to provide such resources. Lastly, the reward system, having a driving power of 12 and dependence power of 2, directly affects four driving factors (i.e., self-efficacy, tenure and promotion, research-oriented culture, and research funding). Positive and direct enforcement of a reward system (e.g., monetary incentive) to an individual faculty significantly impacts scientific and publication performance, as apparent in the work of Quan et al. [139]. Given the interconnected and relevant relationships of the driving factors of RP under the independent cluster to other driving factors, stakeholders and decision-makers should focus on providing and improving research funding schemes, reward systems, and institutional support for the faculty members in their respective institutions, as its driving factors have a significant influence over other factors in the system.

6. Policy Insights

The findings of the ISM-MICMAC analysis offer invaluable insights for decision-makers of HEIs. In this section, the main driving factors (see Figure 3) are emphasized since they are considered the key driving factors affecting the productivity of research academics in institutions. Investments in these driving factors would yield an efficient allocation of organizational resources. One of the main factors of RP is institutional support, which is the institution's initiative to provide support in producing research outputs. Vision and mission statements must pronounce such direction of achieving increased RP, along with strategic action plans to attain them. A collaborative planning approach that integrates the interests of academics is pivotal in ensuring their involvement with the strategic directions set forth by the institution, including knowledge creation, research publication outputs, and intellectual property assets, among others. Along with these strategic directions is the necessary support that the institution promises to the academics. If addressed, institutional support may enhance most driving factors, which would be beneficial to the efforts of HEIs in advancing their RP. For instance, since institutional support drives self-efficacy, research academics may be more determined and confident in completing research-related tasks. Thus, decision-makers must design appropriate measures that ensure institutional support in all aspects of research academics. Institutional support may be demonstrated in various forms. Here, we identify three forms: (1) financial, (2) infrastructural, and (3) human capital. Providing research funds to carry out research works is straightforward for obvious reasons. A sizable portion of the institution's overall budget may be allocated to producing research outputs regarding funding the operational expenses of research projects and research dissemination costs. Infrastructural support may include putting up more research centers, laboratories, and co-working spaces and promoting more academic flexibility (e.g., allowing more time for research), faster lanes, and streamlined transactions. The provision of this kind of institutional support would encourage and allow academics to pursue cutting-edge research works. Finally, investments in human capital as one form of institutional support may be further explored as it promotes self-efficacy, research skills and competence, and global innovativeness, as the findings of this work suggest. These investments should support training and workshops in research career advancements, research and graduate fellowships, and organizing research conferences.

Another main driver of RP that decision-makers need to focus on is the reward systems. In general, organizations use reward systems to manage the performance of an individual or a group, which could build job satisfaction, productive behavior, and positive retention. It is considered necessary for an institution to gain leverage in a competitive environment and is linked with goal setting, character development, competency measures, and team performance. Hence, institutions need to adopt an attractive performance-based incentive plan with periodic monitoring, assessment, and evaluation to address changing needs over time. Some HEIs in the Philippines, for instance, take the initiative in providing an incentive scheme in a form of monetary reward and assigning impact factors to journals as a basis for awarding academics who are publishing academic papers. HEIs may also organize periodic recognition ceremonies and testimonials for productive researchers. A proactive reward system nurtures a healthy research environment in HEIs as it helps achieve positive motivation among academics. Research funding pertains to the monetary provision of an institution or external organization to conduct research activities. It is one of the main driving factors policymakers need to focus on. The completion of a research output relies heavily on the availability of necessary resources. Hence, it is crucial for decision-makers to (1) develop programs that will set internal fund allocation for excellent research proposals that would benefit the institution and (2) partner with external organizations that would grant funding for the research proposals crafted by their respective academics. To monitor the provision of funding, decision-makers can consider evaluating the academic's performance against the amount of funding allocated.

On the other hand, mentoring is another main driver of RP that decision-makers need to highlight in their institutional measures. Mentoring is promoted when an experienced

researcher takes the initiative to guide and teach those with less experience. The big brother, small brother (BB/SB) approach could serve as a benchmark, wherein the big brother serves as the role model to develop a proper research mindset for “small brother” researchers in actively engaging themselves in the mentoring process. This approach also serves as an agent of change in generating a pool of human resources trained to efficiently implement research projects and consequently increases RP. Another example is the adoption of a commitment policy in the development process to expand the opportunities for all promising researchers in the institution for substantial involvement in research initiatives. It is considered essential in gaining expanded networks and collaborations for more interdisciplinary research projects. In the empirical case reported by Elkbuli et al. [156] among burn surgeons, those who have been mentored are more likely to publish and receive grants. It finds that a well-established mentoring support system from the university builds a strong research foundation and profound professional relationships in the research ecosystem. Thus, an institution needs to build a mentoring support system that assists ongoing initiatives, including training for mentors in building better professional relationships and promoting productive conversations. Finally, electronic information resources are a crucial driver of RP. The provision of these resources (e.g., online databases, infrastructures, and the Internet) allows academics to access a wide range of resources efficiently and accurately on various subjects. Such access is deemed essential in promoting impactful and cutting-edge research works necessary for the institutions to gain a competitive advantage while minimizing communication costs. Electronic information resources are necessary for institutions to gain an advantage in a competitive climate. Subscription to academic and research databases that would allow access to research articles is deemed an essential lifeline in promoting impactful and cutting-edge research works. With mobile access, institutions minimize some relevant costs. In the efforts of increasing institutional support, reward systems, research funding, mentoring, and EIR, the corresponding dependent factors are effectively addressed, thereby increasing the RP of the institution.

7. Conclusions and Future Work

Research productivity plays an important role in knowledge transfer and innovation. Due to its significant impact on socio-economic development, the current literature has examined how certain factors influence RP. A comprehensive list of the factors that drive RP has been established up until the present. However, the possible relationships between the identified driving factors have not been explored in the literature domain. While empirical evidence reported that these factors influence RP, it is essential to consider that these driving factors may impact other driving factors due to their loosely defined boundaries, which is crucial in developing insights for policy-making in HEIs to maximize research outputs. Such a gap serves as the main departure of this work.

In this work, a comprehensive list of 15 relevant driving factors was obtained through a literature review. Due to the subjectivity of the identified driving factors and the notion that the evaluation of the interrelationships reflects an expert judgment, ISM and MICMAC analyses were adopted to determine the possible relationships between them. ISM portrays a clear overview of the complex relationships of the driving factors of RP in a manner that establishes a hierarchical structure that determines those significant factors. With the ISM-MICMAC analysis, results reveal that most driving factors are categorized as linkage variables that decision-makers must oversee in their policy-making agenda. As these driving factors both have high dependence and driving powers, compromising one driver in this category changes the overall structure of the RP network of driving factors. Furthermore, five driving factors (i.e., institutional support, reward system, research funding, mentoring, and electronic information resources) identified as independent variables are determined highly important since addressing these driving factors would address other driving factors. On the other hand, only the tenure and promotion factor has autonomous characteristics, while no dependent variable has been identified.

The results of this work contribute significantly to the literature as it provides meaningful insights that would help better understand the overall structure of RP. These results would aid decision-makers, especially in HEIs, in resource allocation, human resource pooling, and the design of appropriate initiatives. Based on the findings, HEIs should (1) provide research funds and mentoring programs, (2) offer efficient monetary award incentive schemes, (3) develop programs that would set internal fund allocation for highly potential research proposals beneficial to the institution, and (4) collaborate with external organizations to grant funding for research proposals.

However, this work has its limitations. The limited number of experts may be the groundwork for future studies. Since the decision-makers are all from the Philippines, their judgments may not well reflect other institutions with different cultures, resources, bureaucracies, and educational systems. Moreover, due to the subjectivity of the response being explored, an empirical analysis of the interrelationships between the driving factors of RP has not been investigated. For future works, statistical modeling (i.e., factor analysis, structural equation modeling) can be adopted to validate the subjective relationships between the driving factors as discussed in this work. Finally, a closely similar analysis that would adopt the decision-making trial and evaluation laboratory (DEMATEL) in examining the causal relationships of these driving factors is an important future agenda to further reinforce the insights of this work.

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Appendix A

Table A1. The final list of driving factors of research productivity.

Code	Driving Factors	Brief Description	References
RS&C	Research skills and competence	Refers to the set of skills associated with research training and experience of the faculty to achieve desirable research outputs.	Prado [11]
SE	Self-efficacy	Refers to the belief system of the individual faculty member on their ability to carry out a research project.	Garnasih et al. [12]
GI	Global innovativeness	Refers to the degree to which a person is open to new ideas and independently makes innovative decisions.	Rubin and Callaghan [13]
IF	Individual factors	Refers to how the attributes of an individual become factors in the perception of their involvement and interest in conducting research works.	Ghabban et al. [10]
SD	Self-determination	Refers to the internally produced autonomous encouragement, motivation, and adaptive attributes crucial to research initiatives.	Peng and Gao [14]
M	Mentoring	Refers to the initiative wherein the experienced faculty member will act as a guide, role model, and teacher for those with less research experience.	Sorkness et al. [15]

Table A1. Cont.

Code	Driving Factors	Brief Description	References
DPL	Dynamics of professional life	Refers to the academic's superiority in his or her graduate training program, the impact of sponsorship, and the stratification of the academic profession.	Kozhakhmet et al. [16]
IS	Institutional support	Refers to the institution's provision of training and support in enhancing research productivity.	Nygaard [17]
DC	Departmental culture	Refers to developing and maintaining a distinct culture of the department unit and its frequent communication to enhance research culture among faculty members.	Ductor [18]
TP	Tenure and promotions	Refers to how research productivity is integrated and institutionalized within the tenure and promotions guidelines of the university.	Scott et al. [19]
ROC	Research-oriented culture	Refers to the broad set of customs and traditions of an organization wherein administrators and faculty members are trained to become outstanding researchers during post-graduate training.	Scott et al. [19]
SF	Situational factors	Refers to the working condition, positive group climate, and organizational communication among faculties of the university.	Dapiton and Canlas [20]
EIR	Electronic information resources	Refers to electronic resources or databases, which allow faculty members to access a wide range of accurate and timely information on various subjects.	Bhagwatwar et al. [22]
RF	Research funding	Refers to funds allocated to support research projects, recruit research staff, and other similar initiatives.	Iqbal and Mahmood [157]
RS	Reward system	Refers to the set of mechanisms that promote encouragement toward research and academic productivity.	Chang and Mills [136]

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