



THE EFFECT OF HUMAN AND STRUCTURAL CAPITAL ON R&D PERFORMANCE THROUGH RESEARCH COMPETENCY AT THE NAVAL RESEARCH AND DEVELOPMENT AGENCY

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Abstract: This study examines the effects of Human Capital and Structural Capital on R&D Performance through Research Competency at the Naval Research and Development Agency (DISLITBANGAL). A quantitative explanatory design was employed using survey data collected from 266 personnel selected through purposive sampling. Data were collected using structured questionnaires and analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) with SmartPLS 4.0. The findings show that Human Capital positively influences Research Competency, whereas Structural Capital does not have a significant relationship with Research Competency. Structural Capital positively influences R&D Performance, while Human Capital does not have a significant direct effect on R&D Performance. Research Competency positively contributes to R&D Performance. The mediation analysis indicates that Research Competency mediates the relationship between Human Capital and R&D Performance, whereas it does not mediate the relationship between Structural Capital and R&D Performance. These findings demonstrate that human and structural resources contribute to R&D Performance through distinct pathways. The findings imply that DISLITBANGAL should strengthen research-specific competency development alongside organizational structures, systems, and resources that support R&D activities.

Keywords: Human Capital, Structural Capital, Research Competency, R&D Performance, Defence R&D

INTRODUCTION

The development of Industry 4.0, digital transformation, artificial intelligence, big data, the Internet of Things, autonomous technologies, and cyber systems has transformed how organizations generate and utilize knowledge. These changes are increasingly important for defence organizations because technological advances are accompanied by changing threat characteristics and growing demands for enhanced defence capabilities. Under these conditions, research and development (R&D) serves as a strategic instrument for generating innovation, strengthening technological capabilities, and supporting operational readiness. R&D Performance depends not only on budgets and facilities but also on the quality of human resources and the organization's ability to manage knowledge. Human Capital positions individual knowledge, skills, and

experience as organizational resources, whereas intellectual capital emphasizes the importance of organizational structures that enable knowledge to generate value (Becker, 1964; Bontis, 1998). Human capital development is also an important component of successful scientific research (Morrison et al., 2013).

These needs are particularly relevant to the Naval Research and Development Agency (DISLITBANGAL), which is responsible for research, development, testing, evaluation, application of science and technology, defence technology engineering, and innovation development. Its R&D roadmap covers vehicle technologies, weapon systems, sensors, electronics, information technology, materials, underwater technologies, and defence management. The diversity of these fields requires personnel with appropriate knowledge and experience, as well as organizational structures capable of preserving and transferring research knowledge. From this perspective, Human Capital provides knowledge and skill capacity, while Structural Capital provides the systems, procedures, documentation, and knowledge bases that support the continuity of research processes (Bontis, 1998; Davenport & Prusak, 1998; Yu & Jiang, 2025).

The need to strengthen these capabilities is reflected in DISLITBANGAL's human resource conditions. Personnel establishment data as of June 2026 indicate a requirement for 391 personnel, while only 267 personnel were available, representing 68.3% of the required strength and a shortfall of 124 personnel. This gap is relevant to R&D activities that require knowledge, skills, experience, and innovation capabilities aligned with specific research fields. Beyond personnel numbers, rotations, transfers, and assignments may affect knowledge continuity when research experience has not been optimally documented and transferred. In addition, the Chief of Naval Staff, through Decree No. Kep/495/II/2026, designated 84 personnel as members of the research professional corps, all of whom were commissioned officers, while enlisted personnel and civil servants performing research functions had not yet been designated as members of the research professional corps. These conditions highlight the importance of strengthening Human Capital and Research Competency to sustain DISLITBANGAL's research capacity (DISLITBANGAL, 2026a).

These challenges are also evident in the implementation of R&D programmes. DISLITBANGAL evaluation data for the 2020–2026 period indicate that the realization of activities has not always been proportional to the number of proposals. Of 67 proposals in 2020, 22 activities were implemented, representing 33%. Implementation rates subsequently reached 15% in 2021, 14% in 2022, 9% in 2023, 12% in 2024, 1% in 2025, and 5% in 2026 (DISLITBANGAL, 2026b). These differences do not in themselves indicate low R&D Performance because programme implementation is influenced by organizational priorities, budgetary

policies, and annual research priorities. However, the pattern indicates the need to strengthen the organization's capacity to manage resources and maintain continuity in research programmes. Structural Capital is therefore important because organizational structures and knowledge bases can facilitate knowledge integration and support innovation performance (Obeso et al., 2020; Yu & Jiang, 2025). Within R&D activities, effective knowledge management can also help organizations convert knowledge resources into productive outcomes (Darroch, 2005).

Human Capital and Structural Capital also need to be translated into Research Competency to generate R&D Performance. Research Competency encompasses the capabilities required to design research, conduct analysis, generate knowledge, solve problems, and develop research outputs. Research capability has been examined as an important component of research development and productivity, while research and teaching capabilities contribute to knowledge production (Brew, 2012; Kiley & Mullins, 2005). Previous studies have demonstrated the relationship between Human Capital and innovation and organizational performance (Demircioglu et al., 2025; Fonseca et al., 2019; Marchiori et al., 2022), while intellectual capital has been associated with innovation and organizational performance (Pigola et al., 2022; Wang et al., 2019; Yin et al., 2023). Research on Research Competency likewise demonstrates its relevance to research capability and productivity (Abella et al., 2024; G. ROMAN, 2021; Gillham & Schilling, 2023; León et al., 2025).

Although these relationships have been widely examined, research integrating Human Capital, Structural Capital, and Research Competency to explain R&D Performance in defence organizations remains limited. Previous studies have predominantly focused on universities, firms, or public organizations more broadly. Bonaccorsi et al. (2021) examined university research productivity, Bican & Brem (2020) investigated R&D performance measurement, while Lim et al. (2022) examined R&D performance in public research institutes. Strazzullo et al. (2024) further demonstrated the relationship between intellectual capital and R&D performance in public universities, while Han et al. (2021) examined workforce composition and R&D performance in government-funded research institutes. Recent research also shows that organizational structure and knowledge-based characteristics can shape innovation performance (Yu & Jiang, 2025). However, these studies have not explained Research Competency as a mechanism linking Human Capital and Structural Capital to R&D Performance in a defence research organization. Accordingly, this study contributes by integrating these three constructs within a mediation model applied to DISLITBANGAL.

Based on these phenomena and the identified research gap, this study examines the effects of Human Capital and Structural Capital on Research

Competency and R&D Performance, the relationship between Research Competency and R&D Performance, and the role of Research Competency in mediating the relationships of Human Capital and Structural Capital with R&D Performance at DISLITBANGAL. The study employs Partial Least Squares Structural Equation Modelling (PLS-SEM) to examine direct relationships and mediation mechanisms among the constructs (J. Hair & Alamer, 2022; J. F. Hair et al., 2019). Theoretically, this study extends research on Human Capital, Structural Capital, Research Competency, and R&D Performance in a defence organization. Practically, the findings provide empirical evidence to support the strengthening of personnel quality, organizational systems, research competency, and R&D capacity at DISLITBANGAL.

LITERATURE REVIEW

Human Capital and Research Competency

Human Capital refers to the knowledge, skills, experience, and individual capabilities that constitute organizational resources (Becker, 1964). In research organizations, human resource quality is important because research activities require the ability to understand problems, develop knowledge, conduct analysis, and generate solutions. Bontis (1998) positions human resources as an essential component of intellectual capital, while Morrison et al. (2013) demonstrate that human capacity development supports the successful implementation of scientific research. Previous studies have also linked Human Capital to innovation and organizational performance (Demircioglu et al., 2025; Marchiori et al., 2022). In this study, Human Capital is represented by knowledge, skills, experience, and individual capabilities relevant to research activities. As these resources become stronger, personnel are expected to be better able to perform research activities competently.

H1: Human Capital has a positive effect on Research Competency at DISLITBANGAL.

Structural Capital and Research Competency

Structural Capital is a component of intellectual capital that encompasses organizational structures and mechanisms through which individual knowledge can be stored, utilized, and developed for organizational purposes (Bontis, 1998). In research organizations, such structures include work systems, research procedures, documentation, knowledge bases, and mechanisms that facilitate knowledge exchange and utilization. Adequate structural support allows individual capabilities to be less dependent on particular personnel and to be retained when assignments change. Morrison et al. (2013) emphasize the importance of organizational capacity in supporting scientific research, while studies of

intellectual capital indicate its relationship with innovation and performance (Wang et al., 2019; Xu et al., 2019). In this study, Structural Capital is represented by work systems and procedures, knowledge documentation, information bases, and organizational infrastructure supporting research activities. Such structures are expected to enable personnel to conduct research in a more systematic and consistent manner, thereby strengthening Research Competency.

H2: Structural Capital has a positive effect on Research Competency at DISLITBANGAL.

Research Competency and R&D Performance

Research Competency refers to the capabilities required to conduct research effectively, including problem formulation, research design, methodological application, analysis, and the production and communication of knowledge. Sondari et al. (2016) conceptualize research competency as a set of capabilities that underlie faculty research productivity, while G. ROMAN (2021) provides empirical evidence that research competency predicts research productivity. Brew (2012), Kiley and Mullins (2005) further emphasize research capabilities as important components of knowledge creation and development. More recent studies by Gillham & Schilling (2023) and Arboleda et al. (2024) further demonstrate the relevance of research capability to research performance and development. In this study, Research Competency is represented by the ability to formulate and design research, apply research methods, conduct analysis, generate knowledge or solutions, and communicate research findings. These competencies enable organizational resources to be translated into higher-quality research processes and outputs. Accordingly, stronger Research Competency is expected to enhance the organization's ability to achieve R&D Performance aligned with research objectives.

H5: Research Competency has a positive effect on R&D Performance at DISLITBANGAL.

Human Capital, Structural Capital, and R&D Performance

R&D Performance reflects an organization's ability to generate research and development outputs that create organizational value and address relevant organizational needs. Such performance is influenced not only by individual capabilities but also by organizational resources that enable knowledge to be developed into research outputs. Previous studies have linked Human Capital to innovation and organizational performance (Demircioglu et al., 2025; Marchiori et al., 2022), while research on intellectual capital demonstrates its relationship with innovation and performance (Pigola et al., 2022; Wang et al., 2019; Yin et al., 2023). In R&D performance research, Bican & Brem (2020) emphasize the importance of performance measurement in managing research and development

activities, while Strazzullo et al. (2024) demonstrate the relationship between intellectual capital and improvements in R&D Performance. In this study, R&D Performance is represented by research outputs, research quality, the relevance of research findings to organizational needs, and the ability to generate innovations or solutions that can be utilized. Accordingly, stronger Human Capital and Structural Capital are expected to support R&D Performance through knowledge resources, organizational systems, and the effective utilization of research resources.

H3: Human Capital has a positive effect on R&D Performance at DISLITBANGAL.

H4: Structural Capital has a positive effect on R&D Performance at DISLITBANGAL.

Research Competency as a Mediator

The relationships among Human Capital, Structural Capital, and R&D Performance can be further explained through Research Competency. Human Capital provides knowledge, skills, experience, and other individual capabilities, while Structural Capital provides organizational systems, knowledge repositories, and infrastructure that support the use and retention of these resources. However, these resources may not automatically generate research outputs unless they are translated into effective research processes and capabilities. Research Competency therefore represents a mechanism through which individual capabilities and organizational resources can be transformed into research activities and outputs. Research on human capital and innovation (Demircioglu et al., 2025; Marchiori et al., 2022), intellectual capital and innovation and performance (Pigola et al., 2022; Wang et al., 2019; Yin et al., 2023), and research competency (G. ROMAN, 2021; Gillham & Schilling, 2023; Sondari et al., 2016) provides a basis for this proposed mechanism. Accordingly, Research Competency is expected to have a direct relationship with R&D Performance and to mediate the relationships of Human Capital and Structural Capital with R&D Performance.

H6: Research Competency mediates the relationship between Human Capital and R&D Performance at DISLITBANGAL.

H7: Research Competency mediates the relationship between Structural Capital and R&D Performance at DISLITBANGAL

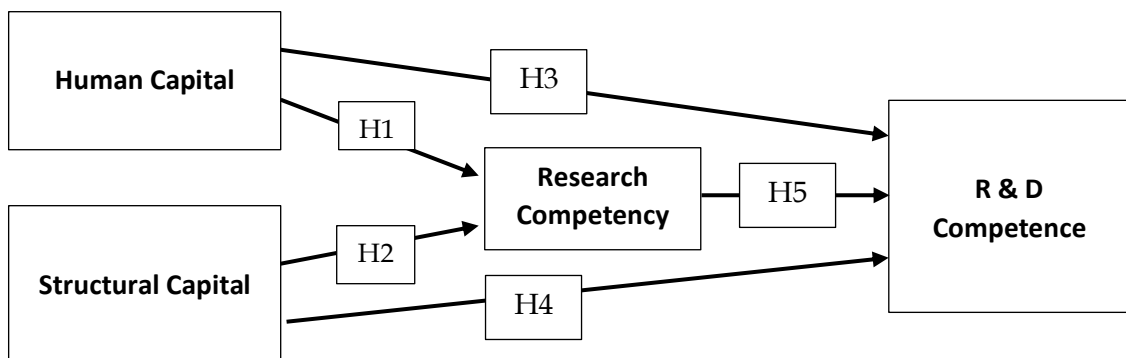


Figure 1. Research Model

Source: Author's own work.

The research model (figure 1) illustrates the direct relationships among Human Capital, Structural Capital, Research Competency, and R&D Competence. Research Competency is positioned as a mediating variable between intellectual capital and R&D Competence. The mediation hypotheses (H6 and H7) examine the indirect effects of Human Capital and Structural Capital on R&D Competence through Research Competency.

METHODS

This study employed a quantitative approach with an explanatory design to examine the effects of Human Capital and Structural Capital on R&D Performance through Research Competency as a mediating variable at the Naval Research and Development Agency (DISLITBANGAL), Jakarta. The study was conducted from 2025 to July 2026 and involved 266 personnel using a saturated sampling technique. Primary data were collected through a five-point Likert-scale questionnaire, while secondary data were used as supporting information. The four constructs were each measured using eight indicators developed through a synthesis of relevant theories and previous studies. Human Capital comprised knowledge, skills, experience, creativity, innovation, continuous learning, adaptability, and competency development. Structural Capital comprised organizational systems and procedures, organizational culture, knowledge management, information technology, databases, infrastructure, and support for innovation. Research Competency comprised problem identification, research methodology, data analysis, scientific writing, communication, collaboration, technology utilization, and research competency development. R&D Performance comprised quality, productivity, innovation, utilization of research outputs, effectiveness, collaboration, organizational contribution, and sustainability of R&D activities.

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through SmartPLS 4.0. PLS-SEM was employed to

examine latent constructs and both direct and indirect relationships through mediation (Hair et al., 2019; Hair & Alamer, 2022). The measurement model was assessed using outer loadings, average variance extracted (AVE), Composite Reliability, Cronbach's Alpha, and the heterotrait-monotrait ratio (HTMT). The structural model was evaluated using R^2 , f^2 , and Q^2 . Hypotheses were tested using the bootstrapping procedure based on path coefficients, t-statistics, and p-values, while the mediating effect of Research Competency was assessed using specific indirect effects (J. Hair & Alamer, 2022; J. F. Hair et al., 2019).

RESULTS AND DISCUSSION

Results

Descriptive Statistics and PLS-SEM Model

Table 1. Descriptive Statistics

Construct	N	Minimum	Maximum	Mean	SD
Human Capital	266	1.00	5.00	3.710	0.832
Structural Capital	266	1.00	5.00	3.775	0.945
Research Competency	266	1.00	5.00	3.509	0.940
R&D Performance	266	1.00	5.00	3.796	0.897

Source: Authors' analysis based on primary survey data, 2026

The descriptive statistics indicate that the four constructs were generally perceived positively by respondents. Table 1 shows that Human Capital had a mean of 3.710, Structural Capital 3.775, Research Competency 3.509, and R&D Performance 3.796. The relatively higher mean of R&D Performance indicates that respondents tended to provide favorable assessments of research and development performance within the organization. Descriptive statistics provide an initial overview of the distribution and central tendency of the observed constructs before assessing the measurement and structural models (J. F. Hair et al., 2019).

The PLS-SEM model was subsequently evaluated through the measurement and structural models. All four constructs were specified as reflective constructs and each was measured using eight indicators. The assessment follows established PLS-SEM procedures for evaluating indicator reliability, construct reliability, convergent validity, discriminant validity, and the structural model (J. Hair & Alamer, 2022; J. F. Hair et al., 2019).

Measurement Model Assessment

Table 2. Indicator Loadings and Construct Reliability

Construct	Indicators	Loading Range	Cronbach's α	Composite Reliability	AVE
Human Capital	HC1-HC8	0.891-0.915	0.970	0.974	0.824
Structural Capital	SC1-SC8	0.901-0.949	0.978	0.981	0.867
Research Competency	RC1-RC8	0.920-0.958	0.982	0.985	0.889
R&D Performance	KL1-KL8	0.913-0.938	0.978	0.981	0.867

Source: Authors' analysis based on SmartPLS 4.0, 2026

All 32 indicators were retained because their outer loadings exceeded 0.70. As presented in Table 2, the loading values ranged from 0.891 to 0.958, indicating strong indicator reliability. Composite reliability and Cronbach's alpha values also exceeded the recommended level, while the AVE values were above 0.50 for all constructs. These results indicate adequate indicator reliability, internal consistency, and convergent validity of the measurement model, consistent with established PLS-SEM assessment procedures (J. Hair & Alamer, 2022; J. F. Hair et al., 2019).

Discriminant validity was assessed using the Fornell-Larcker criterion and HTMT. The results in Table 3 show that the diagonal values in the Fornell-Larcker matrix, representing the square root of AVE, were higher than the correlations between constructs, supporting discriminant validity. This indicates that each construct shares greater variance with its own indicators than with the other constructs in the model (J. F. Hair et al., 2019).

Table 3. Fornell-Larcker Criterion

	Human Capital	R&D Performance	Research Competency	Structural Capital
Human Capital	0.908	0.718	0.813	0.709
R&D Performance	0.718	0.930	0.685	0.765
Research Competency	0.813	0.685	0.943	0.635
Structural Capital	0.709	0.765	0.635	0.931

Source: Authors' analysis based on SmartPLS 4.0, 2026

The HTMT ratios were below 0.85 for all construct pairs. As shown in Table 4, the values ranged from 0.647 to 0.833, providing additional evidence that the constructs are empirically distinguishable. Together with the Fornell-Larcker results, these findings support discriminant validity of the measurement model.

Table 4. Heterotrait-Monotrait Ratio (HTMT)

	Human Capital	R&D Performance	Research Competency	Structural Capital
Human Capital	—			
R&D Performance	0.736	—		
Research Competency	0.833	0.699	—	
Structural Capital	0.727	0.782	0.647	—

Source: Authors' analysis based on SmartPLS 4.0, 2026

Structural Model Assessment

The structural model demonstrates that Human Capital and Structural Capital jointly explained 66.8% of the variance in Research Competency, while Human Capital, Structural Capital, and Research Competency explained 66.2% of the variance in R&D Performance. Table 5 summarizes the R^2 , adjusted R^2 , and Q^2 values, with corresponding adjusted R^2 values of 0.666 and 0.658. The Q^2 values of 0.590 for Research Competency and 0.564 for R&D Performance indicate predictive relevance of the structural model. These measures are consistent with the recommended evaluation of explanatory and predictive performance in PLS-SEM (J. Hair & Alamer, 2022; J. F. Hair et al., 2019).

Table 5. Structural Model Evaluation

Endogenous Construct	R^2	Adjusted R^2	Q^2
Research Competency	0.668	0.666	0.590
R&D Performance	0.662	0.658	0.564

Source: Authors' analysis based on SmartPLS 4.0, 2026

Multicollinearity was examined using the inner VIF values. As shown in Table 6, the values ranged from 2.011 to 3.616, indicating that collinearity was not a critical concern in the structural model. All values remained below the commonly applied threshold, supporting the adequacy of the model for subsequent hypothesis testing.

Table 6. Inner VIF

Relationship	VIF
Human Capital → Research Competency	2.011
Structural Capital → Research Competency	2.011
Human Capital → R&D Performance	3.616
Structural Capital → R&D Performance	2.052
Research Competency → R&D Performance	3.013

Source: Authors' analysis based on SmartPLS 4.0, 2026

Effect sizes were assessed using f^2 to evaluate the substantive contribution of each predictor to the corresponding endogenous construct. As shown in Table 7, Human Capital had a large effect on Research Competency ($f^2 = 0.799$), while Structural Capital had a medium effect on R&D Performance ($f^2 = 0.345$). The remaining relationships showed small effects. These results provide additional information on the relative contribution of the predictors beyond statistical significance.

Table 7. Effect Size (f^2)

Relationship	f^2	Effect Size
Human Capital → Research Competency	0.799	Large
Structural Capital → Research Competency	0.021	Small
Human Capital → R&D Performance	0.031	Small
Structural Capital → R&D Performance	0.345	Medium
Research Competency → R&D Performance	0.045	Small

Source: Authors' analysis based on SmartPLS 4.0, 2026

The largest effect size was observed for Human Capital on Research Competency ($f^2 = 0.799$), whereas Structural Capital showed a medium effect on R&D Performance ($f^2 = 0.345$). The remaining structural relationships demonstrated small effect sizes, providing additional information about the relative contribution of each predictor to the endogenous constructs (J. F. Hair et al., 2019).

Hypothesis Testing

Table 8. Direct Effects and Hypothesis Testing

Hypotheses	Relationship	β	t-statistic	p-value	Decision
H1	Human Capital → Research Competency	0.730	9.894	< 0.001	Supported
H2	Structural Capital → Research Competency	0.117	1.565	0.118	Not supported
H3	Human Capital → R&D Performance	0.196	1.677	0.094	Not supported
H4	Structural Capital → R&D Performance	0.489	6.508	< 0.001	Supported
H5	Research Competency → R&D Performance	0.215	2.047	0.041	Supported

Source: Authors' analysis based on SmartPLS 4.0, 2026

Hypotheses were tested using the bootstrapping procedure in SmartPLS 4.0. The results indicate that three of the five direct relationships were statistically supported. Table 8 shows that Human Capital had a positive relationship with Research Competency ($\beta = 0.730$, $t = 9.894$, $p < 0.001$), supporting H1. In contrast, the relationship between Structural Capital and Research Competency was not statistically supported ($\beta = 0.117$, $t = 1.565$, $p = 0.118$), leading to the non-support of H2.

Human Capital showed a positive but statistically unsupported relationship with R&D Performance ($\beta = 0.196$, $t = 1.677$, $p = 0.094$), whereas Structural Capital demonstrated a positive and statistically supported relationship with R&D Performance ($\beta = 0.489$, $t = 6.508$, $p < 0.001$). Research Competency also had a positive and statistically supported relationship with R&D Performance ($\beta = 0.215$, $t = 2.047$, $p = 0.041$). These findings indicate that the direct structural relationships vary across the proposed pathways.

Table 9. Indirect Effects and Mediation Testing

Hypotheses	Indirect Relationship	β	t-statistic	p-value	95% CI	Decision
H6	Human Capital → Research Competency → R&D Performance	0.157	2.059	0.040	[0.012, 0.312]	Supported
H7	Structural Capital → Research Competency → R&D Performance	0.025	1.082	0.279	[-0.002, 0.084]	Not supported

Source: Authors' analysis based on SmartPLS 4.0, 2026

The indirect effects are summarized in Table 9, including the bootstrapped confidence intervals used to assess the mediation paths. H6 is supported, as Human Capital has a statistically supported indirect relationship with R&D Performance through Research Competency ($\beta = 0.157$, $t = 2.059$, $p = 0.040$, 95% CI [0.012, 0.312]). The confidence interval does not include zero, confirming the presence of an indirect effect. Since the direct relationship between Human Capital and R&D Performance is not statistically supported, the result indicates an indirect-only mediation pattern, consistent with the assessment of specific indirect effects in PLS-SEM mediation analysis (J. Hair & Alamer, 2022; J. F. Hair et al., 2019).

In contrast, H7 is not supported, as the indirect relationship between Structural Capital and R&D Performance through Research Competency is not statistically supported ($\beta = 0.025$, $t = 1.082$, $p = 0.279$, 95% CI [-0.002, 0.084]). The confidence interval includes zero, indicating that Research Competency does not transmit the effect of Structural Capital to R&D Performance. Although Structural Capital has a statistically supported direct relationship with R&D Performance, its relationship with Research Competency is not statistically supported. This finding suggests that organizational systems, procedures, knowledge management, technological infrastructure, and other structural resources are more directly associated with R&D Performance rather than operating through Research Competency as the mediating mechanism.

Discussion

Human Capital and Research Competency

The strongest relationship in the structural model is between *Human Capital* and *Research Competency* ($\beta = 0.730$, $p < 0.001$), supporting H1. The finding indicates that research capability at DISLITBANGAL is closely rooted in personnel knowledge, skills, and experience. This supports Becker (1964) view of human capital as a productive resource and Bontis (1998) intellectual capital perspective. It is also consistent with research emphasizing the role of human capabilities in scientific research and organizational performance (Demircioglu et al., 2025; Fonseca et al., 2019; Marchiori et al., 2022; Morrison et al., 2013). Research competency studies further indicate that individual knowledge and capabilities are important foundations of research competence and research performance (G. ROMAN, 2021; Gillham & Schilling, 2023; Sondari et al., 2016). The present finding extends this view by positioning Research Competency as a research-specific capability through which Human Capital becomes relevant to R&D activities.

Structural Capital and Research Competency

The relationship between *Structural Capital* and *Research Competency* is not statistically supported in H2 ($\beta = 0.117$, $p = 0.118$). This suggests that

organizational systems and research infrastructure alone do not necessarily strengthen individual research capabilities. Bontis (1998) and Davenport & Prusak (1998) emphasize the role of organizational structures and knowledge mechanisms in storing, transferring, and utilizing knowledge, yet such resources may support research activities without developing the methodological and analytical capabilities of personnel. This distinction is consistent with studies linking structural resources to innovation and organizational performance (Darroch, 2005; Obeso et al., 2020; Pigola et al., 2022; Wang et al., 2019), while research on *Research Competency* emphasizes individual capabilities in conducting and developing research (Abella et al., 2024; G. ROMAN, 2021; Gillham & Schilling, 2023; León et al., 2025; Sondari et al., 2016). H2 therefore qualifies the intellectual capital perspective by showing that, at DISLITBANGAL, Structural Capital primarily provides organizational support rather than directly developing individual research capability.

Human Capital and R&D Performance

The direct relationship between Human Capital and R&D Performance is not statistically supported in H3 ($\beta = 0.196$, $p = 0.094$). This finding indicates that knowledge, skills, experience, and adaptability do not necessarily translate directly into organizational research outcomes. The result differs from studies associating Human Capital with innovation and organizational performance (Demircioglu et al., 2025; Fonseca et al., 2019; Marchiori et al., 2022). However, it is consistent with research suggesting that the value of human capital depends on how individual capabilities are developed and translated into productive activities (Dimand et al., 2023; Habicht et al., 2021; Martin-Sardesai & Guthrie, 2018). Together with the supported indirect relationship in H6, the finding suggests that Human Capital may influence R&D Performance through the development of Research Competency. Thus, individual knowledge and skills may need to be translated into research-specific capabilities before they can generate measurable organizational research outcomes.

Structural Capital and R&D Performance

Structural Capital presents a different pattern. H4 is supported, with a positive relationship with R&D Performance ($\beta = 0.489$, $p < 0.001$). This finding is consistent with the intellectual capital perspective of Bontis (1998) and empirical evidence linking intellectual capital with innovation and organizational performance (Pigola et al., 2022; Wang et al., 2019; Yin et al., 2023). It is also supported by research in public and research-oriented organizations, particularly Strazzullo et al. (2024), which demonstrates the relevance of intellectual capital to R&D performance. Yu & Jiang, (2025) further show that organizational structure and knowledge-based characteristics are relevant to innovation performance. The present finding

extends this literature by indicating that, at DISLITBANGAL, structural resources can contribute directly to R&D Performance, even though their relationship with Research Competency is not statistically supported. Systems, knowledge repositories, information infrastructure, and established procedures may therefore provide an organizational foundation for coordinating, documenting, and executing research activities, thereby supporting the generation of research outputs and other R&D outcomes.

Research Competency and R&D Performance

Research Competency also contributes to R&D Performance, supporting H5 ($\beta = 0.215$, $p = 0.041$). The finding is consistent with research emphasizing research capabilities as important elements in knowledge production and research development (Brew, 2012; Kiley & Mullins, 2005). It also accords with empirical studies connecting research competency with research capability and productivity (Abella et al., 2024; G. ROMAN, 2021; Gillham & Schilling, 2023; León et al., 2025; Sondari et al., 2016). This result complements R&D research identifying organizational, knowledge-based, and capability-related determinants of research outcomes. Bonaccorsi et al., (2021) demonstrate the importance of research productivity, while Bican & Brem (2020) emphasize the role of performance measurement in managing R&D activities. Lim et al., (2022) further highlight organizational and design-related factors in public R&D performance, while Strazzullo et al. (2024) demonstrate the relevance of intellectual capital to R&D performance. Research Competency therefore functions as a capability through which organizational and human resources can be translated into meaningful R&D outputs.

Research Competency as a Mediating Mechanism

The findings identify two distinct pathways through which organizational resources are related to R&D Performance. Human Capital does not demonstrate a statistically supported direct relationship with R&D Performance, but its indirect relationship through Research Competency is supported. In contrast, Structural Capital demonstrates a significant direct relationship with R&D Performance, while its indirect relationship through Research Competency is not supported. These findings suggest that individual capabilities and organizational structures contribute to R&D outcomes through different mechanisms.

H6 is supported because Human Capital has a significant indirect relationship with R&D Performance through Research Competency ($\beta = 0.157$, $p = 0.040$, 95% CI [0.012, 0.312]), while its direct relationship with R&D Performance is not statistically supported. This pattern indicates indirect-only mediation and extends the human capital perspective of Becker (1964) and the intellectual capital perspective of Bontis (1998) by

identifying Research Competency as a mechanism through which individual capabilities can be translated into R&D outcomes. The finding is also consistent with evidence linking Human Capital to innovation and organizational performance (Demircioglu et al., 2025; Dimand et al., 2023; Fonseca et al., 2019; Hafiluddin & Widiastuti, 2025; Marchiori et al., 2022; Martin-Sardesai & Guthrie, 2018; Yumhi et al., 2025). At DISLITBANGAL, therefore, the contribution of Human Capital to R&D Performance appears to depend on its translation into research-specific competency.

H7, however, is not supported ($\beta = 0.025$, $p = 0.279$, 95% CI [-0.002, 0.084]). Because Structural Capital is not significantly related to Research Competency and its indirect effect is unsupported, Research Competency does not transmit the effect of Structural Capital to R&D Performance. This finding distinguishes the role of organizational infrastructure from that of individual research capability. While knowledge management and intellectual capital studies emphasize the contribution of structural resources to organizational outcomes (Darroch, 2005; Obeso et al., 2020; Pigola et al., 2022; Wang et al., 2019), the present findings indicate that Structural Capital at DISLITBANGAL is more directly associated with R&D Performance through systems, knowledge resources, infrastructure, and procedures that facilitate research activities. This interpretation is consistent with Strazzullo et al. (2024) and Yu & Jiang (2025).

CONCLUSION

This study demonstrates that Human Capital, Structural Capital, and Research Competency contribute to R&D Performance through distinct pathways at the Naval Research and Development Agency (DISLITBANGAL). Human Capital is positively associated with Research Competency, while Structural Capital does not show a statistically supported relationship with Research Competency. Structural Capital has a significant direct relationship with R&D Performance, whereas Human Capital does not show a statistically supported direct relationship with R&D Performance. Research Competency is positively associated with R&D Performance and mediates the relationship between Human Capital and R&D Performance, but not the relationship between Structural Capital and R&D Performance.

These findings contribute to the intellectual capital literature by demonstrating that intangible resources influence R&D outcomes through different mechanisms. Human Capital contributes primarily through Research Competency, whereas Structural Capital contributes directly to R&D Performance. This distinction integrates the intellectual capital and research competency perspectives and provides a differentiated explanation of how individual capabilities and organizational resources support R&D performance in a public-sector defence R&D organization.

SUGGESTIONS

For DISLITBANGAL, personnel development should be aligned with research-specific competency development, particularly in research methodology, data analysis, scientific writing, mentoring, and continuous professional development. The organization should also strengthen the structural foundation supporting R&D activities through effective research procedures, knowledge management systems, research databases, information technology, infrastructure, and collaboration mechanisms. These priorities can strengthen both research capabilities and the organizational resources that support R&D performance.

Future research may examine these relationships using longitudinal designs and broader organizational settings to assess how Human Capital, Structural Capital, and Research Competency develop over time and whether the identified pathways remain consistent across different public-sector R&D organizations.

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