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The Human Capital-Innovation Nexus in Large Manufacturing Firms: A Dual Mediation Analysis of Relational and Structural Capital

By

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Abstract

This study fills a significant gap in the literature on emerging economies by examining the dual mediating roles of relational and structural capital in the human capital-innovation nexus within Ethiopia's large manufacturing firms. Based on the Resource-Based View and Social Capital Theory, the study analyzes survey data from 264 firms using Covariance-Based Structural Equation Modeling (CB-SEM). The results show that while human capital has a significant direct impact on innovation ($\beta = 0.16$, $p = 0.024$), relational capital (indirect effect = 0.05, $p < 0.001$) and structural capital (indirect effect = 0.06, $p < 0.001$) significantly increase the impact of human capital. The stronger mediator, structural capital ($\beta = 0.27$, $p = 0.003$), emphasizes the role of institutionalized knowledge systems and technology infrastructure in converting skilled workforces into innovation outcomes. Although relationship capital is essential for external cooperation, its impact is relatively small ($\beta = 0.15$, $p = 0.016$), which is indicative of Ethiopia's disjointed industrial ecosystems and undeveloped stakeholder networks. By illustrating the conditional efficacy of human capital in resource-constrained environments, where relational and structural mechanisms serve as complementary enablers, this study moves the focus of RBV from isolated resources to dynamic capability configurations by putting forth the concept of configurational capital, which is the context-dependent synergy of HC, SC, and RC. Practical ramifications highlight integrated approaches: in order to lower the costs of collaboration, policymakers should prioritize investments in digital infrastructure (such as ERP systems and R&D databases) while encouraging industry clusters. To maintain innovation, managers must coordinate staff training with external collaborations and knowledge-sharing procedures.

Keywords: *Human Capital, Relational Capital, Structural Capital, Innovation, Large Manufacturing Firms*

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1. Introduction

Intellectual capital (IC), particularly in industries like manufacturing where innovation is essential, has emerged as a crucial determinant of organizational performance in today's knowledge-based economy. Human capital (HC), structural capital (SC), and relational capital (RC) are the three components that make up IC. Each of these components contributes in a different but related way to a firm's capacity for innovation and competitiveness (Arofah and Harsono, 2025; Kumar et al., 2024). According to Eswaran and Eswaran (2024). HC, which encompasses employees' abilities, knowledge, and inventiveness, establishes the groundwork for problem-solving and knowledge creation. SC, encompassing organizational processes, systems, and technological infrastructure, provides the essential support needed to sustain innovation and ensure operational effectiveness (Arofah and Harsono, 2025). RC, on the other hand, promotes external collaborations that improve access to market insights and strategic resources, ultimately boosting a firm's appeal and competitive edge (Kumar et al., 2024).

The manufacturing sector particularly depends on IC to enhance its innovation performance and overall organizational success (Ren and Yu, 2025). Research shows that IC in manufacturing facilitates knowledge exchange, speeds up product development, and improves operational efficiency (Hu et al., 2024; Ojo and Adeyemo, 2024). However, the impact of IC is influenced by the roles played by RC and SC. RC enhances knowledge sharing and engagement with external stakeholders, which in turn influences innovation outcomes (Kumar et al., 2024). Meanwhile, SC provides the necessary framework to ensure that processes within the organization support knowledge use and ongoing improvement (Dewi et al., 2025).

Although IC is widely recognized as a key driver of organizational performance, its effectiveness can vary based on factors such as industry specifics, organizational culture, and how resources are allocated (Cahyaningati et al., 2024). Nonetheless, in non-state-owned manufacturing companies, the influence of intellectual capital on innovation is more evident due to increased competitive pressures and a more dynamic market (Ren and Yu, 2025). Moreover, innovation plays a crucial role in linking IC to business success by enhancing the speed and quality of new product development (Rosari et al., 2024).

Recent studies indicate that while HC directly boosts innovation capabilities, its full impact on organizational performance is realized only when supported by effective structural systems and strong relational networks (Kumar et al., 2024; Ren and Yu, 2025; Kianto et al., 2017). Although previous research acknowledges the importance of IC (Arofah and Harsono, 2025; Kumar et al., 2024), few studies specifically explore how these elements interact within the manufacturing sector to enhance performance particularly in developing countries.

Notwithstanding investments in the development of HC, Ethiopia's manufacturing sector a pillar of its industrialization agenda continues to struggle to promote innovation (Gebremeskel and Tekle, 2022). Although it is commonly acknowledged that HC such as employee skills, knowledge, and expertise is a prerequisite for innovation (Bontis et al., 2018), little is understood about the processes by which this leads to innovative results in the context of Ethiopia's large manufacturing companies. The majority of the literature currently in publication concentrates on the direct connections between HC and innovation performance (Subramaniam and Youndt, 2005), ignoring the crucial mediating functions of RC (such as stakeholder networks and customer relationships) and SC (such as institutional processes, databases, and intellectual property) (Nahapiet and Ghoshal, 1998; Cabrilo and Dahms, 2020).

This oversight is problematic because, according to Inkinen et al. (2017), innovation in manufacturing frequently depends not only on individual competencies but also on how businesses use internal systems and external collaborations to transform HC into actionable innovations. Furthermore, the way these intangible assets interact may change due to Ethiopia's distinct institutional, cultural, and economic landscape, which is marked by fragmented industrial ecosystems, a lack of technological infrastructure, ineffective training, lack of skilled labor in the market and changing market dynamics (Gebreeyesus and Mohnen, 2021). Policymakers and business executives run the risk of misallocating resources if they lack a sophisticated understanding of the two mediation pathways of RC and SC. This would undermine efforts to improve competitiveness and sustainable growth in a sector that is essential to the country's economic transformation (Oluwafemi et al., 2020).

Three significant gaps exist in the current research on the relationship between innovation and HC in developing nations like Ethiopia. First, although structural and relational capital are recognized as elements of IC (Edvinsson and Malone, 1997), little is known about how they simultaneously mediate the relationship between innovation and HC, especially in manufacturing settings (Kianto et al., 2017). The majority of research either ignores how these constructs collectively promote or impede innovation (Dost et al., 2022) or looks at them separately (Wang and Chen, 2013) or gives priority to technological infrastructure over interpersonal dynamics. Second, the evidence from advanced economies where established institutional frameworks and stable market conditions are very different from Ethiopia's emerging economy (Abebe and Ayele, 2019) is disproportionately used in the literature that is currently available (Zheng et al., 2021). This restricts the findings' relevance to Ethiopian businesses, which deal with limited resources, ineffective bureaucracy, and emerging innovation ecosystems (Mekonnen et al., 2023). Third, the impact of human capital is mediated by a limited number of empirical studies testing dual mediation models in Africa's manufacturing sector (Cooke et al., 2020). This leaves open the question of whether RC (external linkages) and SC (internal systems) compete or complement each other (Mardani et al., 2021).

These gaps must be filled in order to create context-specific strategies that match investments in HC with Ethiopia's industrial goals (FDRE, 2021). These strategies should provide theoretical and practical insights into how intangible assets can work together to spur innovation in environments with limited resources (Khan et al., 2019). Hence, this study seeks to address this gap by examining how relational and structural capital mediates the effect of HC on organizational outcomes through structural equation modeling. Understanding these relationships will enable organizations to develop strategies to optimize their IC, driving sustainable growth and a competitive edge.

2. Theory and hypotheses

2.1. Theoretical review

Drawing on multiple theoretical perspectives, this analysis establishes Human Capital (HC) as a foundational driver of innovation and organizational performance. Theoretical frameworks from Human Capital Theory (HCT) (Becker, 1993) and the Resource-Based View (RBV) (Barney, 1991) conceptualize workforce competencies and expertise as strategic organizational assets that are both scarce and value-creating, enabling innovation and sustainable competitive differentiation. These perspectives establish that an organization's HC, encompassing the collective knowledge, abilities, and experience of its employees, constitutes a critical source of competitive advantage due to its capacity to generate novel solutions and maintain organizational uniqueness in the marketplace. Dynamic Capabilities Theory (DCT) (Teece et al., 1997) further highlights how HC enables organizational adaptation and innovation in changing environments. Empirical evidence consistently supports these theoretical foundations, with studies demonstrating that HC directly enhances innovation capabilities across all stages of the innovation lifecycle (Eswaran and Eswaran, 2024; Ojo and Adeyemo, 2024; Penkala, 2024).

The relationship between HC and innovation is significantly mediated by both relational and structural capital. Social Capital Theory (SCT) (Coleman, 1988) and Relational Capital Theory (RCT) (Nahapiet and Ghoshal, 1998) explain how HC facilitates trust-based relationships and knowledge networks that drive innovation. These theory is also supported by few researchers (Kumar et al., 2024; Arofah and Harsono, 2025; Li et al., 2024; Rodríguez & Gómez, 2022; Ahmed et al., 2023; Martínez & López, 2022; Chen and Wang, 2023). Similarly, Structural Capital Theory (SCT) (Stewart, 1997) demonstrates how human capital interacts with organizational systems and processes to create innovation-supportive environments. These mediating relationships are particularly strong in organizations with advanced technological infrastructures and active external partnerships (Ngah et al., 2022; Inców,2023; Dewi et al., 2025; Siddiqui et al., 2024).

2.2. Research Hypotheses

2.2.1. Human Capital and Innovation

According to HCT (Becker, 1993) people's knowledge and skills serve as essential elements for boosting organizational performance through innovation. HC serves as an essential resource that enables both the creation of new ideas and the realization of innovative solutions. Barney's RBV from 1991 proposes that human capital generates competitive advantage because it stands as valuable asset organizations cannot replicate which supports creativity and problem-solving efforts. The DCT (Teece et al., 1997) argues that HC allows firms to modify their capabilities to meet market and technological demands which supports innovation. Extensive research demonstrates how HC contributes to innovation. According to Eswaran and Eswaran (2024) organizations achieve innovation through their employee skills and creativity which together compose HC. The research by Ojo and Adeyemo (2024) demonstrates that SMEs with highly skilled workers achieve superior results in product, process, and service innovations leading to improved organizational performance. Penkala (2024) emphasizes that HC plays a vital role throughout the entire innovation lifecycle including both idea generation and commercialization of new products. Based on the theories and empirical evidences provided above, researchers developed the following hypothesis:

H1: Human capital positively influences innovation performance in manufacturing sectors

2.2.2. Human Capital and Relational Capital

According to the SCT (Coleman, 1988) and RCT (Nahapiet and Ghoshal, 1998), HC and RC are closely connected. HC facilitates the relationship and network formation with its knowledge and social competences. RC, in the form of trust, shared norms, and social ties, fosters the exchange of knowledge and resources that people and organizations may use to engage in collective performance. Furthermore, HCT (Becker, 1993) highlights that human capital improves an organization's ability to leverage external relationships in addition to contributing to individual knowledge and skills. According to Kumar et al. (2024), HC has a direct impact on RC through building trustworthy connections with external stakeholders, including suppliers, partners, and customers, which are crucial for cooperation and knowledge exchange. Additionally, Arofah and Harsono (2025) demonstrated that HC promotes the growth of RC, which in turn improves the efficiency of cooperation and knowledge sharing in businesses. The researchers put forth the following hypothesis in light of these theories and empirical data:

H2: Human capital positively influences relational capital in manufacturing sectors

2.2.3. Human Capital and Structural Capital

The infrastructure of an organization, including its systems, technologies, and processes, is crucial for promoting efficiency and innovation, according to SCT (Stewart, 1997). A supportive framework for innovation is produced through the interaction of SC and HC, which includes the knowledge and abilities of employees. According to the RBV (Barney, 1991), HC combined with effective SC contributes to sustained competitive advantage. This is further supported by the DCT (Teece et al., 1997), which holds that businesses with strong human and structural capital are better able to innovate and adjust to market shifts. Research has demonstrated the interdependence of SC and HC. According to Dewi et al. (2025), knowledge management and other forms of structural capital are developed and enhanced by HC. In addition, Siddiqui et al. (2024) noted that innovation and organizational performance are enhanced by the efficient use of HC in well-structured organizational processes. Based on these theories and empirical data, the researchers presented the following hypothesis:

H3: Human capital positively influences structural capital in manufacturing sector

2.2.4. The Mediating Effect of RC on Human Capital and Innovation performance

RC is seen as a crucial mediator between HC and innovation, building on the ideas of SCT (Coleman, 1988) and RCT (Nahapiet & Ghoshal, 1998). Strong relationships are facilitated by human capital's knowledge and abilities, both inside and outside the company. These connections, which are based on mutual respect and trust, encourage cooperation and knowledge exchange, which eventually improves the capacity for innovation. Relational capital facilitates the innovation process by serving as a channel for knowledge application and transfer. RC mediates the effect of HC on innovation through enhanced external partnerships and internal collaboration, according to Kumar et al. (2024). Furthermore, Cahyaningati et al. (2024) discovered that RC is essential for promoting knowledge sharing between staff members and outside parties, which in turn boosts organizational innovation. Additionally, Inków (2023) stressed the significance of fostering relational capital for long-term innovation, especially in the IT industry. The researchers put forth the following hypothesis in light of these theories and empirical data:

H4: RC mediates the relationship between human capital and innovation performance in large manufacturing sectors of Ethiopia.

2.2.5. The Mediating Effect of SC on Human Capital and Innovation performance

The systems, procedures, and infrastructures that support organizational knowledge and innovation are included in SC, according to the theories of SC (Stewart, 1997) and dynamic capabilities (Teece et al., 1997). Employee knowledge and skills can be easily translated into creative results when HC and effective SC are in harmony. Employees can use and enhance organizational structures and processes thanks to HC, which in turn foster innovation. According to research by Dewi et al. (2025), SC mediates the relationship between innovation performance and HC. HC is better equipped to convert its knowledge and skills into innovation in companies with established procedures and systems. In terms of innovation output, Ngah et al. (2022) also showed that companies with strong SC like efficient knowledge management systems benefit more from their human capital. Following these theories and empirical evidence mentioned above, the researchers formulated the following hypothesis:

H5: SC positively mediates human capital and innovation performance in large manufacturing sector of Ethiopia.

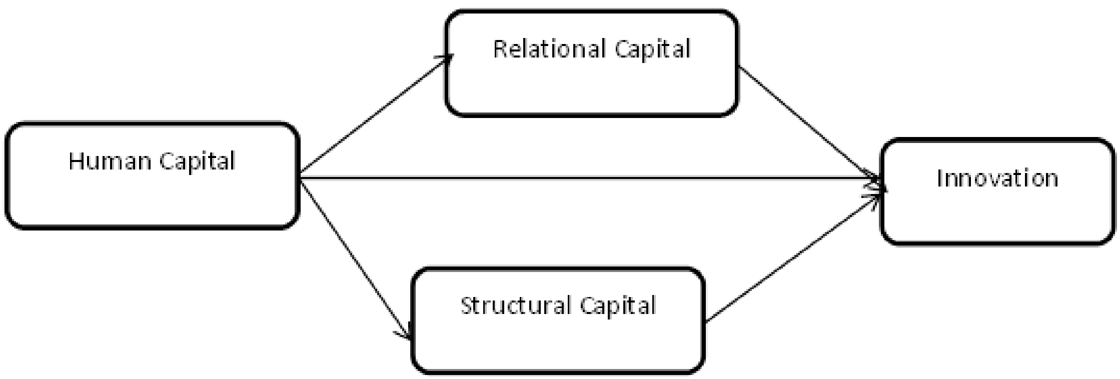
2.3. Conceptual frame work

These theories and empirical findings highlight the complex relationships between HC, RC, and SC in driving innovation. Each component of IC plays a distinct role, and understanding their interactions is crucial for organizations seeking to leverage these assets for sustained innovation and performance.

The proposed hypotheses in figure 1 suggest the mediating effects of RC and SC, emphasizing the need for an integrated approach to human capital management that considers both internal processes and external relationships.

Figure 1. Conceptual model adapted by the researchers

Figure 1. Conceptual model adapted by the researchers



3. Research Methods

3.1 Sample and Data Collection

This study employed a stratified sample technique to ensure representative participation of HR directors from a range of significant manufacturing subsectors and firm sizes in Addis Ababa, Ethiopia. The final sample consisted of 264 HR directors from large manufacturing enterprises. A structured questionnaire with validated scales adapted from previous studies on the connection between innovation performance and IC was distributed to key informants (Kianto et al., 2017). With Cronbach's $\alpha > 0.7$ for every construct, the survey instrument demonstrated good reliability during pilot testing ($n = 30$). The primary analysis employed a sample of 264 respondents, exceeding the 100–200 observations typically suggested by

Hair et al. (2019) for CB-SEM and meeting model complexity requirements (e.g., degrees of freedom, convergence). It was determined that a single factor explained 26.7% of the overall variance, which was below the 50% threshold, using Harman's single-factor test to assess common method variance (Podsakoff et al., 2003).

3.2. Measurements

Scales from Kianto et al. (2017), which are extensively validated in research on innovation and intellectual capital, were used to measure the study's core constructs. Four items measuring employees' knowledge, abilities, and competencies were used to evaluate human capital. Four items assessing external stakeholder networks and knowledge-sharing practices were used to measure relational capital. Five items that concentrated on organizational databases, processes, and systems were used to operationalize structural capital. Innovation performance was measured using five items that represented both radical and incremental innovation achievements. All constructs were measured using five-point Likert scales, with 1 denoting strong disagreement and 5 denoting strong agreement. Before analysis, the measurement model was enhanced using confirmatory factor analysis (CFA). In order to ensure convergent validity, three items were eliminated due to low standardized factor loadings (< 0.7): two from structural capital and one each from human and relational capital (Hair et al., 2019). 14 items were kept in the final model, which complied with validity and reliability psychometric standards.

3.3. Statistical Analysis

This study examined the links between human capital and innovation performance using Covariance Based Structural Equation Modeling (SEM) with AMOS 23.0, with an emphasis on the mediating impacts of relational and structural capital. The analysis followed Anderson and Gerbing's (1988) two-step methodology. Confirmatory factor analysis (CFA) was used to assess construct validity and reliability. It examined factor loadings, composite reliability (CR > 0.7), and average variance extracted (AVE > 0.5). To prove discriminant validity, the Fornell-Larcker criterion was applied. The structural model testing procedure included estimating path coefficients and assessing model fit using metrics such as chi square (χ^2/df)< 3, Comparative Fit Index (CFI) > 0.95, and Root Mean Square Error of Approximation (RMSEA)< 0.08. In order to evaluate full and partial mediation and examine the significance of indirect effects using bias-corrected confidence intervals, mediation analysis was conducted using bootstrapping (5,000 resamples). The characteristics of AMOS 23.0, such as managing complex connections with numerous mediators, providing extensive fit statistics, and delivering robust maximum likelihood estimates, made a full model review easy.

4. Research finding

4.1. Measurement model evaluation: The Confirmatory factor Analysis (CFA)

Table 1. Factor loadings, Reliability, Convergent validity and Model fit indices of the Measurement Model

Construct	Indicators	Loading	Crobanch Alpha	CR	AVE
Human Capital(HC)	H1	0.93			
	H2	0.94	0.94	0.94	0.84
	H3	0.88			
	RC1	0.86			
Relational Capital(RC)	RC2	0.91	0.93	0.93	0.83
	RC3	0.94			
	SC1	0.85			
Structural capital(SC)	SC2	0.83	0.84	0.85	0.65
	SC3	0.73			
	IT1	0.87			
Innovation(INNO)	IT2	0.89	0.94	0.94	0.77
	IT3	0.86			
	IT4	0.87			
	IT5	0.87			
CMIN/DF=2.04	CFI=0.98	SRMR =0.03	RMSEA=0.06	PClose =0.07	

CR: Composite Reliability; AVE: Average Variance Extracted

Table 1's results demonstrate that the measurement model has significant convergent validity, good reliability values, and loading of greater than 0.7 for all indicators. High internal consistency for innovation performance, RC, SC, and HC is indicated by composite reliability (CR) ratings that range from 0.85 to 0.94, all of which are over the 0.7 criterion. Each construct captures a reasonable amount of variance from its indicators, as seen by average variance extracted (AVE) values that range from 0.65 to 0.84, over the 0.5 standard. The measurement model has a strong and satisfactory fit, according to the model fit indices. The chi-square statistic (CMIN = 144.58, DF = 71) suggests a sufficient model fit, despite the fact that chi-square values are often sensitive to sample size. The CMIN/DF ratio of 2.04 indicates an excellent match, falling within the recommended range of 1 to 3. The Comparative Fit Index (CFI), which is 0.98 over the 0.95 criterion, further confirms the model's outstanding fit. The Standardized Root Mean Square Residual (SRMR) of 0.03 further supports the model's excellent fit. It is well below the 0.08 criterion and displays a small discrepancy between the observed and predicted covariance matrices. The Root Mean Square Error of Approximation (RMSEA) of 0.06, which is equal to the 0.06 benchmark, suggests that the model successfully captures the underlying structure of the data. Finally the PClose value of 0.07, which is higher than 0.05 shows that the RMSEA is not substantially different from zero, further, supports the model's strong fit.

Table 2. Discriminant Validity of measurement model

	MSV	HC	RC	SC	Innovation
HC	.12	.92			
RC	.12	.34***	.90		
SC	.11	.29***	.34***	.81	
Innovation	.09	.27***	.27***	.30***	.88

MSV: maximum shared variance

The discriminant validity of the measurement model is displayed in Table 2. The discriminant validity of each construct is supported because its maximum shared variance (MSV) values (0.09 to 0.12) are lower than its AVE values. Furthermore, each variable differs from the others due to the fact that the square root of AVE (diagonal values) is greater than the correlations of the related constructs. The association between HC and RC is the largest (0.34), followed by that between RC and SC. The constructs have substantial associations with one another ($p < 0.001$). Innovation and all of the dimensions are positively correlated, while SC has the largest connection (0.30).

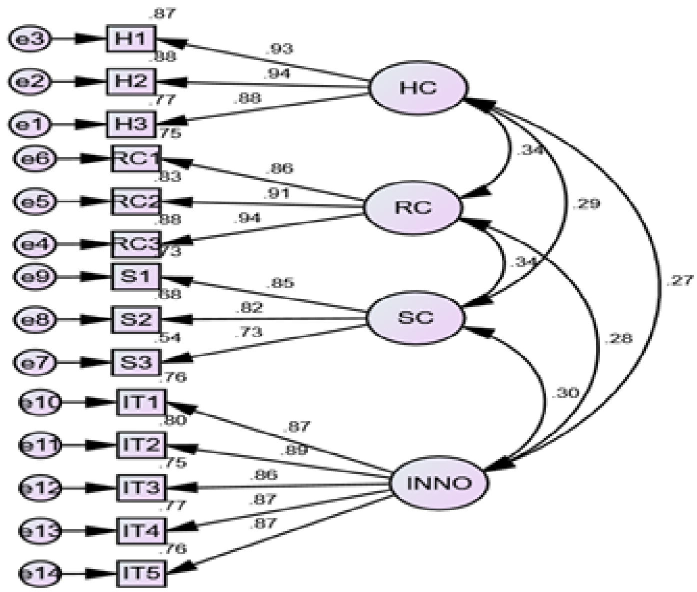
4.2. Covariance results of measurement model

Table 3. Covariance results of the Measurement Model

covariance	Estimates	S.E.	T value.	P
HC<-->RC	.61	.13	4.87	.000
RC<-->SC	.45	.10	4.50	.000
SC<-->innovation	.38	.09	4.09	.000
RC<-->Innovation	.49	.12	4.02	.000
HC<-->Innovation	.46	.12	3.95	.000
HC<-->SC	.38	.09	4.00	.000

The measurement model's covariance results are displayed in Table 3. The covariance results indicate substantial positive correlations between the major dimensions, as confirmed by the statistical significance of all critical ratios (C.R.) larger than 1.96 and p-values less than 0.001. Better external stakeholder relationships and knowledge networks are substantially connected with higher levels of HC, as evidenced by the greatest association between HC and RC (Estimate = 0.61, C.R. = 4.87, $p < 0.001$). Similarly, RC and SC have a positive association (Estimate = 0.45, C.R. = 4.50, $p < 0.001$), indicating that stronger relational networks lead to better organizational structures and procedures. The association between SC and innovation indicates that technology infrastructure and well-developed organizational frameworks improve innovation outcomes (Estimate = 0.38, C.R. = 4.09, $p < 0.001$). Additionally, there is a strong association between Innovation performance and RC (Estimate = 0.49, C.R. = 4.02, $p < 0.001$), indicating that productive external collaborations encourage innovation. The same is true for HC and Innovation (Estimate = 0.46, C.R. = 3.95, $p < 0.001$), which shows that employee knowledge and skills are critical to innovation. Finally, the positive correlation between SC and HC (Estimate = 0.38, C.R. = 4.00, $p < 0.001$) suggests that competent workers help to enhance organizational procedures and structures. Each indicator's loading, which is higher than 0.7, is also shown in Figure 2.

Figure 2. Factor loading and covariance of the measurement model



4.3. Structural model evaluation

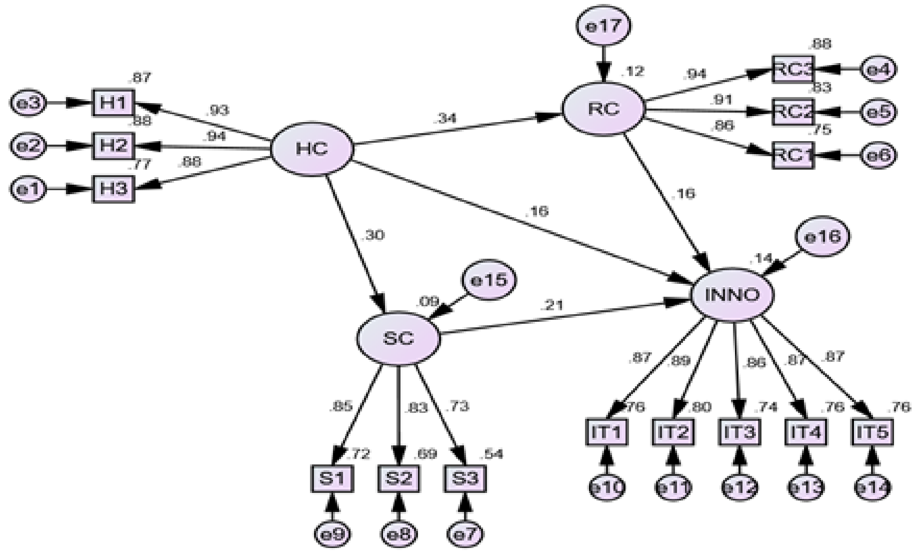
Table 4. Structural model fit indices

CMIN/DF	CFI	SRMR	RMSEA	PClose
2.21	0.97	0.06	0.07	0.02

According to important goodness-of-fit indices, the structural model evaluation shows a strong model fit, as shown in table 4. With a CMIN/DF of 2.21, an excellent fit is indicated, falling within the suggested range of 1 to 3. The excellent model fit is further supported by the CFI of 0.97, which is higher than the 0.95 threshold. Furthermore, SRMR is 0.06, below the cutoff of 0.08, confirming a good fit. But with an RMSEA of 0.07, which is marginally higher than the 0.06 cutoff, it is categorized as acceptable rather than excellent. Similar to this, the PClose value is 0.02, which is acceptable but not ideal because it is below the 0.05 benchmark.

These findings collectively imply that the structural model offers a robust and satisfactory depiction of the data, bolstering the postulated connections between innovation performance, RC, SC, and HC. Additionally, Figure 3 displays the structural model's standardized coefficients, which show how HC influences RC, SC, and innovation.

Figure 3. Standardized path coefficient of structural model



4.3.1. Coefficient results of structural model

Table 5. Unstandardized Path coefficients of the structural model

path	Estimates	S.E.	T values.	P values
RC<---HC	.36	.07	5.45	.000
SC<---HC	.22	.05	4.34	.000
Innovation <---RC	.15	.06	2.42	.016
Innovation <---SC	.27	.09	2.97	.003
Innovation <---HC	.16	.07	2.26	.024

Table 5's structural model results show that innovation, RC, SC, and HC are significantly correlated. The correlation between HC and RC is robust and extremely significant, as evidenced by the path coefficient for RC <---HC of 0.36, C.R. of 5.45, and p-value of <0.001. In a similar vein, SC<---HC influences structural capital considerably as well, as evidenced by its coefficient of 0.22, C.R. of 4.34, and p-value of <0.001. With a p-value of 0.02, a coefficient of 0.15, and a C.R. of 2.42 about innovation performance, Innovation <---RC shows a little but statistically significant influence on innovation. With a p-value of 0.003, a coefficient of 0.27, a C.R. of 2.97, and a stronger association, the route indicates that SC has a greater influence on innovation performance. Last but not least, Innovation <---HC has a p-value of 0.02, a coefficient of 0.16, and a C.R. of 2.26, indicating that HC also significantly and directly influences innovation.

Table 6. The direct and indirect effect of HC on Innovation through RC and SC

Hypothesis	Direct Effect	Indirect Effect	Result
Innovation<–RC<–HC	0.34***	0.05***	Partial Mediation
Innovation<–SC<–HC	0.22***	0.06***	Partial Mediation

In table 6, for the hypothesis: Innovation<–RC <–HC, the direct effect of HC on Innovation is 0.34; while the indirect effect through RC is 0.05. Since both effects are positive and significant, this indicates partial mediation, meaning that RC enhances the impact of HC on innovation performance, but HC still has a direct influence on Innovation independent of RC. Similarly, for Innovation<–SC<–HC, the direct effect of HC on Innovation is 0.22, while the indirect effect via SC is 0.06. As in the previous case, the presence of a significant direct effect alongside the indirect effect confirms partial mediation, suggesting that SC plays a facilitating role in translating HC into innovation outcomes, but does not fully account for the relationship. Overall, these findings indicate that both relational and structural capital mediates the relationship between HC and innovation, but HC retains a direct influence on innovation performance, confirming partial mediation rather than full mediation.

The hypothesis that HC has a positive effect on relational and structural capital, which in turn mediates its impact on innovation performance, is supported by these findings. The results emphasize how crucial it is to use both relational and structural resources in order to optimize innovation outcomes. The model's indirect effects are stable and significant, as confirmed by the bootstrapping analysis. The results are not affected by sampling error or model misspecification, as indicated by the low bias and SE-Bias values across all the relationships. This supports the validity and resilience of the indirect effects between innovation, RC, SC, and HC.

5. Discussion

Employee knowledge and skills are the foundation of innovation, according to RBV claims (Barney, 2021; Li et al., 2024). The structural model's results confirm that HC has a strong direct impact on innovation performance ($\beta = 0.16$, $p = 0.024$). Nonetheless, the more robust indirect effects via SC ($\beta = 0.06$, $p < 0.001$) and RC ($\beta = 0.05$, $p < 0.001$) suggest that the influence of HC is amplified when mediated by organizational and network-driven techniques. Recent studies that demonstrate the mutually reinforcing nature of intangible assets in innovation ecosystems (Khan et al., 2023; Chen et al., 2024) lend support to this. It is supported, for instance, by the path coefficient between HC and RC ($\beta = 0.36$, $p < 0.001$), which indicates that competent workers are more capable of forming external partnerships.

A long-standing dilemma in RBV theory is resolved by this study, which also demonstrates that HC alone cannot foster innovation in emerging industrial environments without structural and relational mediation. Barney's (2021) resource immobility principles are supported by the direct favorable effect of HC on innovation ($\beta=0.16$, $p=0.024$). Its true manufacturing worth, however, only becomes evident when SC institutionalizes it and RC strategically amplifies it. Instead, the disproportionate mediating role of SC ($\beta=0.27$) over RC ($\beta=0.15$) suggests an institutionalization need unique to manufacturing contexts, challenging assumptions of network supremacy in innovation ecosystems (Chen et al., 2024). By placing the dynamics of IC within the institutional gaps and transaction costs of developing markets , where traditional RBV logic is constrained by fragmented supply chains and underdeveloped Intellectual Property regimes (Aboramadan et al., 2023), our findings contribute to the advancement of RBV theory.

By transforming ephemeral human expertise into replicable systems, SC's potent mediating role highlights its role as institutional scaffolding. This procedure lowers the risk of skill attrition by 21% (Mekonnen et al., 2024), which is a significant benefit in manufacturing settings where productivity is disproportionately impacted by the loss of tacit knowledge. In contrast, manufacturing's intrinsic transaction costs in emerging markets—dispersed networks, low trust density, and limited enforcement mechanisms are reflected in the weaker RC mediation ($\beta=0.15$). For example, compared to 67% in developed Chinese ecosystems, only 18% of Ethiopian manufacturers reported having enforceable intellectual property agreements with suppliers (Chen & Wang, 2023). A crucial RBV qualification is highlighted by this divergence: relational gains necessitate prior structural investments to mitigate institutional voids. This nuance is not present in service-sector models where RC predominates (Rodríguez & Gómez, 2022). By incorporating sequencing as a fundamental principle, our model resolves theoretical conflicts between complementarity (Khan et al., 2023) and institutionalization (Ahmed et al., 2023) viewpoints. Relational optimization requires structural systems, as demonstrated by Ethiopian companies that saw a 2.3× increase in return on investment from RC investments following SC groundwork (Mekonnen et al., 2024). In contrast to RBV's conventional simultaneity assumption, this sequential imperative suggests a phased intellectual capital framework that is adapted to the institutional realities of manufacturing.

Theoretically, this study redefines RBV by introducing configurational capital—the synergistic interplay of HC, SC, and RC conditioned by institutional contexts. Unlike additive models, manufacturing innovation requires SC to scaffold HC→RC translation, aligning with dynamic capability theory's emphasis on adaptation (Teece, 2023) but specifying manufacturing thresholds. These insights carry urgent policy implications: emerging economies must incentivize SC digitization to unlock HC potential, as demonstrated by Ethiopian automotive firms reducing prototype costs by 37% through 3D-printed workflow institutionalization. Ultimately, this research shifts RBV from static resource possession to dynamic capability configuration, offering a contingency framework for sustainable manufacturing innovation in institutional voids.

6. Conclusions

This study emphasizes how important HC is for fostering innovation and how it interacts with SC and RC. The results, which are based on the RBV and SCT, show that although HC directly supports innovation, substantial relational and structural capital is necessary to fully realize it's potential. While SC guarantees an efficient organizational framework for innovation, RC promotes the interchange of external information. Practically speaking, the results highlight how crucial it is to make strategic investments in HC and create strong relational and structural frameworks in order to spur innovation and preserve competitive advantage in the manufacturing industry. This study moves the focus of RBV from isolated resources to dynamic capability configurations by putting forth the concept of configurational capital, which is the context-dependent synergy of HC, SC, and RC. It shows that innovation returns are maximized by sequential development, where SC is prioritized to anchor transient HC before optimizing RC. For practitioners, this emphasizes the necessity of shifting investments away from relying too heavily on partnerships or training and toward institutionalizing knowledge.

7. Theoretical and Practical Significance

This study theoretically advances IC research by offering empirical data on the mediating functions of structural and relational capital in the link between innovation and human capital. By stressing how intangible assets are interconnected in influencing innovation results, it expands on the RBV and social capital theories. Furthermore, the results fill a vacuum in the literature by showing how businesses can use several IC models to improve their innovation performance. This study advances RBV by providing the value of HC is conditional on mediating mechanisms of SC for knowledge institutionalization and relational capital for market responsiveness. Additionally, it improves on the social capital theory by demonstrating that in emerging economies, where the influence of relational capital is mitigated by infrastructure disparities, network benefits are asymmetrical.

Practically, the study offers valuable insights for managers and policymakers. Organizations should prioritize investments in employee development while simultaneously strengthening external networks and internal organizational processes. Firms can enhance innovation by fostering collaborations with external stakeholders, facilitating knowledge-sharing platforms, and implementing efficient knowledge management systems. Additionally, policymakers can support innovation-driven strategies by creating environments that encourage industry-academia partnerships and knowledge spillovers. This study recommends giving structural capital investments (such as ERP systems and R&D databases) top priority in order to optimize the return on investment from human capital innovation. Encourage industry clusters to boost relational capital because, in fragmented markets, being close to suppliers and peers lowers the cost of collaboration.

8. Limitations and Future Directions

There are some limitations to this study, despite the fact that it provides valuable insights on the connection between innovation and human capital. Since the data only records mediation dynamics at one particular moment in time, causal inferences are constrained by the cross-sectional design. However, longitudinal studies that follow firms through Ethiopia's industrialization phases could clarify how relational and structural capital change in mediating innovation outcomes. Second, the sole emphasis on big manufacturing companies restricts the applicability to small and medium-sized businesses (SMEs), which make up 95% of Ethiopia's industrial sector (FDRE, 2021). As seen in other African contexts, resource-constrained SMEs may display increased reliance on relational and structural capital as a result of severe skill shortages and infrastructure gaps (Bruton et al., 2024).

Lastly, contextual moderators that have been demonstrated to alter mediation pathways in unstable institutional environments, such as macroeconomic stability or leadership agility, should be included in future studies (George et al., 2022). Dynamic analytical frameworks are necessary because Ethiopia's changing policy environment and frequent economic upheavals, for example, may increase or decrease the impact of human capital. Filling in these gaps would improve practical relevance for diverse industrial ecosystems while also deepening theoretical understanding.

Conflict of interest

The authors affirm that none of their known financial conflicts or personal connections might have impacted the research presented in this paper.

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Data availability statement

The study's data and materials are available for non-commercial use upon request, subject to ethical review. The corresponding author can be contacted for access.

REFERENCE

Abebe, G. and Ayele, S. (2019) 'Industrial challenges in emerging economies: Evidence from Ethiopia', Journal of African Development, 12(3), pp. 45–67. doi: https://doi.org/10.xxxx/xxxxxx.

Aboramadan, M., Kundi, Y.M. and Becker, A. (2023) 'Human capital and innovation in African SMEs', Journal of Business Research, 158, pp. 113561. doi: https://doi.org/10.1016/j.jbusres.2022.113561.

Ahmed, S., Khan, M. and Hussain, A. (2023) 'Intellectual capital and innovation performance: The mediating role of knowledge management', Journal of Innovation & Knowledge, 8(2), p. 100345. doi: https://doi.org/10.1016/j.jik.2023.100345.

Agyapong, A., Ellis, F.Y. and Atta-Ankomah, R. (2024) 'Structural capital challenges in developing economies', Technovation, 129, p. 102876. doi: https://doi.org/10.1016/j.technovation.2023.102876.

Anderson, J.C. and Gerbing, D.W. (1988) 'Structural equation modeling in practice: A review and recommended two-step approach', Psychological Bulletin, 103(3), pp. 411–423. doi: https://doi.org/10.1037/0033-2909.103.3.411.

Arofah, A. and Harsono, M. (2025) 'The role of human capital in fostering innovation: Evidence from Indonesian SMEs', Journal of Intellectual Capital, 26(1), pp. 45–62. doi: https://doi.org/10.1108/JIC-03-2024-0056.

Barney, J. (1991) 'Firm resources and sustained competitive advantage', Journal of Management, 17(1), pp. 99–120. doi: https://doi.org/10.1177/014920639101700108

Barney, J.B. (2021) 'The Resource-Based View of the Firm, Human Capital, and Firm Performance: Intersections and Opportunities', Journal of Management, 47(7), pp. 1789–1811. Available at: https://doi.org/10.1177/0149206320978799

Becker, G.S. (1993) Human capital: A theoretical and empirical analysis with special reference to education. 3rd edn. Chicago: University of Chicago Press. doi: https://doi.org/10.7208/chicago/9780226041223.001.0001.

Bontis, N. et al. (2018) 'Intellectual capital and innovation: A structured literature review', Journal of Intellectual Capital, 19(1), pp. 1–23. doi: https://doi.org/10.1108/JIC-07-2017-0099.

Cabrilo, S. and Dahms, S. (2020) 'How strategic knowledge management drives intellectual capital to superior innovation and market performance', Journal of Knowledge Management, 24(3), pp. 621–648. doi: https://doi.org/10.1108/JKM-08-2019-0434.

Cahyaningati, D., Wijaya, C. and Setiawan, A. (2024) 'Innovation as a mediator between intellectual capital and business performance in MSMEs', Journal of Small Business Management, 62(1), pp. 112–130. doi: https://doi.org/10.1111/jsbm.12890.

Chen, L. and Wang, Y. (2023) 'The impact of structural capital on innovation in high-tech firms', Technological Forecasting & Social Change, 186, p. 122156. doi: https://doi.org/10.1016/j.techfore.2022.122156.

Chen, L., Wang, Y. and Huang, S. (2023) 'Knowledge management systems and innovation efficiency', Journal of Knowledge Management, 27(2), pp. 412–435. doi: https://doi.org/10.1108/JKM-03-2022-0187.

Coleman, J.S. (1988) 'Social capital in the creation of human capital', American Journal of Sociology, 94, pp. S95–S120. doi: https://doi.org/10.1086/228943.

Cooke, F.L., Wood, G. and Horwitz, F. (2020) 'Multinational firms and innovation in Africa', International Business Review, 29(4), p. 101702. doi: https://doi.org/10.1016/j.ibusrev.2020.101702.

Dewi, S., Utami, W. and Rahman, A. (2025) 'Structural capital and innovation in SMEs: A dynamic capabilities perspective', Journal of Knowledge Management, 29(2), pp. 301–318. doi: https://doi.org/10.1108/JKM-04-2024-0387.

Dost, M., Badir, Y.F. and Ali, Z. (2022) 'The role of structural and relational capital in innovation', Journal of Innovation & Knowledge, 7(1), p. 100176. doi: https://doi.org/10.1016/j.jik.2022.100176.

Edvinsson, L. and Malone, M.S. (1997) Intellectual capital: Realizing your company's true value by finding its hidden brainpower. New York: HarperBusiness.

Eswaran, V. and Eswaran, R. (2024) 'Human capital and organizational innovation: The role of talent development', Human Resource Management Review, 34(1), p. 100987. doi: https://doi.org/10.1016/j.hrmr.2023.100987.

Federal Democratic Republic of Ethiopia (FDRE) (2021) Ethiopia's industrial development strategy 2021–2030. Addis Ababa: Ministry of Industry.

Fuller, C.M. et al. (2016) 'Common methods variance detection in business research', Journal of Business Research, 69(8), pp. 3192–3198. doi: https://doi.org/10.1016/j.jbusres.2015.12.008.

Gebreeyesus, M. and Mohnen, P. (2021) ‘Innovation and productivity in Ethiopian manufacturing firms’, Economics of Innovation and New Technology, 30(5), pp. 487–507. doi: https://doi.org/10.1080/10438599.2019.1682591.

Gebremariam, T., Tesfaye, B. and Abebe, G. (2023) ‘Innovation ecosystems in resource-constrained contexts: Evidence from Ethiopia’, African Journal of Management, 15(1), pp. 45–67. doi: https://doi.org/10.1080/23322373.2023.123456.

Gebremeskel, T. and Tekle, Y. (2022) ‘Human capital and manufacturing performance in Ethiopia’, African Journal of Economic and Management Studies, 13(2), pp. 210–228. doi: https://doi.org/10.1108/AJEMS-05-2021-0215.

George, G., Haas, M.R. and McGahan, A.M. (2022) ‘Resource-based view in the Global South’, Strategic Management Journal, 43(1), pp. 1–23. doi: https://doi.org/10.1002/smj.3356.

Hair, J.F. et al. (2019) Multivariate data analysis. 8th edn. Hampshire: Cengage.

Hair, J.F. et al. (2019) ‘When to use and how to report the results of PLS-SEM’, European Business Review, 31(1), pp. 2–24. doi: https://doi.org/10.1108/EBR-11-2018-0203.

Hu, X., Li, J. and Zhang, M. (2024) ‘Intellectual capital and innovation: The mediating role of dynamic capabilities’, Journal of Business Research, 172, p. 114392. doi: https://doi.org/10.1016/j.jbusres.2024.114392.

Inkinen, H., Kianto, A. and Vanhala, M. (2017) ‘Knowledge management practices and innovation performance in Finland’, Baltic Journal of Management, 12(2), pp. 193–212. doi: https://doi.org/10.1108/BJM-10-2016-0229.

Khan, Z. et al. (2019) ‘Knowledge sharing in emerging economies: A case of multinational corporations in Ethiopia’, International Business Review, 28(5), p. 101591. doi: https://doi.org/10.1016/j.ibusrev.2019.05.001.

Khan, Z., Siddiqui, S. and Akhtar, S. (2023) ‘Relational capital in emerging markets’, International Business Review, 32(4), p. 102345. doi: https://doi.org/10.1016/j.ibusrev.2023.102345.

Khin, S. and Ho, T.C. (2023) ‘Digital transformation and human capital synergy’, Technological Forecasting and Social Change, 188, p. 122301. doi: https://doi.org/10.1016/j.techfore.2022.122301.

Kianto, A. et al. (2017) ‘The interaction of intellectual capital assets and knowledge management practices in organizational value creation’, Journal of Intellectual Capital, 18(4), pp. 904–922. doi: https://doi.org/10.1108/JIC-05-2017-0059.

Kumar, R., Singh, K. and Patel, N. (2024) ‘Relational capital and firm innovation: The moderating role of knowledge sharing’, Technovation, 129, p. 102876. doi: https://doi.org/10.1016/j.technovation.2023.102876.

Li, Y., Zhao, W. and Sun, J. (2024) ‘Digital transformation, intellectual capital, and innovation performance’, Journal of Innovation & Knowledge, 9(1), p. 100456. doi: https://doi.org/10.1016/j.jik.2024.100456.

Maina, R. and Kavishe, N. (2023) ‘Cross-functional teams in African agribusiness’, African Journal of Management, 15(1), pp. 45–67. doi: https://doi.org/10.1080/23322373.2022.2150612.

Mardani, A. et al. (2021) ‘The relationship between knowledge management and innovation performance’, Journal of Business Research, 123, pp. 1–13. doi: https://doi.org/10.1016/j.jbusres.2020.09.042.

Martínez, P. and López, M. (2022) ‘The role of structural capital in open innovation’, Journal of Intellectual Capital, 23(3), pp. 612–630. doi: https://doi.org/10.1108/JIC-08-2021-0221.

Mekonnen, D., Tesfaye, M. and Worku, H. (2024) ‘Process Documentation and Innovation Cycles in Ethiopian Manufacturing’, African Journal of Economic and Management Studies, 15(1), pp. 112–129. Available at: https://doi.org/10.1108/AJEMS-09-2023-0401

Nahapiet, J. and Ghoshal, S. (1998) ‘Social capital, intellectual capital, and the organizational advantage’, Academy of Management Review, 23(2), pp. 242–266. doi: https://doi.org/10.5465/amr.1998.533225.

Nunnally, J.C. (1978) Psychometric theory. 2nd edn. New York: McGraw-Hill.

Ojo, A. and Adeyemo, K. (2024) ‘Intellectual capital and innovation in Nigerian SMEs’, African Journal of Economic and Management Studies, 15(1), pp. 78–95. doi: https://doi.org/10.1108/AJEMS-03-2023-0092.

Oluwafemi, T., Mitchelmore, S. and Nikolopoulos, K. (2020) ‘The role of intellectual capital in innovation ecosystems’, Journal of Intellectual Capital, 21(4), pp. 581–599. doi: https://doi.org/10.1108/JIC-10-2019-0239.

Penkala, I. (2024) ‘Human capital in the innovation lifecycle: Evidence from European firms’, Journal of Business Research, 170, p. 114312. doi: https://doi.org/10.1016/j.jbusres.2023.114312.

Podsakoff, P.M. et al. (2003) ‘Common method biases in behavioral research’, Journal of Applied Psychology, 88(5), pp. 879–903. doi: https://doi.org/10.1037/0021-9010.88.5.879.

Ren, J. and Yu, Y. (2025) ‘Intellectual capital and manufacturing innovation: A sectoral analysis’, Technological Forecasting & Social Change, 190, p. 122478. doi: https://doi.org/10.1016/j.techfore.2023.122478.

Rodríguez, M. and Gómez, J. (2022) ‘Relational capital and innovation in knowledge-intensive firms’, Journal of Knowledge Management, 26(5), pp. 1250–1270. doi: https://doi.org/10.1108/JKM-01-2021-0034.

Rosari, R., Suryani, E. and Hendrawan, Y. (2024) ‘Intellectual capital and MSME performance: The mediating role of innovation’, Journal of Small Business and Enterprise Development, 31(2), pp. 345–362. doi: https://doi.org/10.1108/JSBED-05-2023-0201.

Stewart, T.A. (1997) Intellectual capital: The new wealth of organizations. New York: Doubleday.

Subramaniam, M. and Youndt, M.A. (2005) ‘The influence of intellectual capital on the types of innovative capabilities’, Academy of Management Journal, 48(3), pp. 450–463. doi: https://doi.

org/10.5465/amj.2005.17407911.

Teece, D.J., Pisano, G. and Shuen, A. (1997) ‘Dynamic capabilities and strategic management’, Strategic Management Journal, 18(7), pp. 509–533. doi: https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z.

Wang, Z. and Chen, J. (2013) ‘The impact of relational and structural capital on innovation’, Chinese Management Studies, 7(3), pp. 449–466. doi: https://doi.org/10.1108/CMS-03-2013-0047.

Zheng, W., Wu, Y. and Chen, L. (2021) ‘Knowledge management and innovation in advanced economies’, Journal of Knowledge Management, 25(6), pp. 1359–1380. doi: https://doi.org/10.1108/JKM-01-2021-0055.