



## Impact of Intellectual Capital Investment on Sustainable Competitive Advantage in Sudanese Pharmaceuticals

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أثر الاستثمار في رأس المال الفكري على الميزة التنافسية المستدامة في شركات الأدوية السودانية

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### Abstract

**Purpose:** The purpose of this study is to investigate the impact of intellectual capital (IC) components—human, structural, and customer capital—on sustainable competitive advantage (SCA) within the Sudanese pharmaceutical manufacturing industry.

**Design/methodology/approach** A cross-sectional survey design was employed, targeting employees in key managerial and technical positions with over five years of experience. Data were gathered from 50 valid questionnaires out of 60 distributed (a 91.7% response rate, with 83.3% usability). The conceptual model was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM) via Smart-PLS software.

**Findings:** The results indicate that human capital significantly influences the quality of products and services, while customer capital is a primary driver for efficiency and responsiveness. Conversely, structural capital showed no significant statistical effect on any dimension of competitive advantage. The integrated model explained 43% of the variance in responsiveness, 37% in innovation, 32% in quality, and 31% in efficiency, indicating a moderate to weak predictive power in this specific context.

**Originality:** This study contributes to the existing literature by providing empirical evidence from a developing economy (Sudan), specifically within the pharmaceutical sector. It highlights the non-uniform impact of IC components, suggesting that the value of intellectual assets is context-dependent.

**Practical implications:** Managers in Sudanese pharmaceutical firms should prioritize investments in human capital development and customer relationship management to enhance quality and operational responsiveness. The lack of impact from structural capital suggests a need for digital transformation and internal process restructuring to better leverage intellectual assets.

**Keywords:** Intellectual capital; human capital; structural capital; customer capital; sustainable competitive advantage; pharmaceutical industry; Sudan.

### المستخلص

**هدف الدراسة:** تهدف هذه الدراسة إلى استقصاء أثر مكونات رأس المال الفكري (رأس المال البشري، والهيكلية، والزبوني) على الميزة التنافسية المستدامة في قطاع صناعة الأدوية في السودان.

**المنهجية:** تم استخدام تصميم المسح العرضي (Cross-sectional survey)، حيث استهدف الموظفون في المناصب الإدارية والفنية الرئيسية ممن لديهم خبرة تزيد عن خمس سنوات. جُمعت البيانات من 50 استبانة صالحة للتحليل من أصل 60 وزعت (بمعدل استجابة بلغت نسبته 91.7%، وصلاحيته للاستخدام بنسبة 83.3%). واختُبر النموذج المفاهيمي للدراسة باستخدام نمذجة المعادلات الهيكلية بالمربعات الصغرى الجزئية (PLS-SEM) عبر برنامج Smart-PLS.

**النتائج:** تشير النتائج إلى أن رأس المال البشري يؤثر بشكل معنوي على جودة المنتجات والخدمات، بينما يُعد رأس المال الزبوني محركاً رئيسياً للكفاءة والاستجابة. وعلى العكس من ذلك، لم يظهر رأس المال الهيكلية أي أثر إحصائي معنوي على أي بُعد من أبعاد الميزة التنافسية. وفسر النموذج المتكامل ما نسبته 43% من التباين في "الاستجابة"، و37% في "الابتكار"،

و32% في "الجودة"، و31% في "الكفاءة"، مما يشير إلى قدرة تنبؤية تتراوح ما بين متوسطة إلى ضعيفة في هذا السياق المحدد.

**الأصالة/القيمة العلمية:** تساهم هذه الدراسة في الأدبيات العلمية الحالية من خلال تقديم أدلة تجريبية من اقتصاد نامٍ (السودان)، وتحديدًا من داخل قطاع الصناعات الدوائية. كما تسلط الضوء على الأثر غير المتجانس لمكونات رأس المال الفكري، مما يشير إلى أن قيمة الأصول الفكرية تعتمد بشكل كبير على السياق المحيط.

**الأثار التطبيقية:** يجب على المديرين في شركات الأدوية السودانية إعطاء الأولوية للاستثمار في تطوير رأس المال البشري وإدارة علاقات الزبائن لتعزيز الجودة والاستجابة العملياتية. كما يشير غياب أثر رأس المال الهيكلي إلى الحاجة الملحة للتحويل الرقمي وإعادة هيكلة العمليات الداخلية للاستفادة بشكل أفضل من الأصول الفكرية المتاحة.

**الكلمات المفتاحية:** رأس المال الفكري؛ رأس المال البشري؛ رأس المال الهيكلي؛ رأس المال الزبوني؛ الميزة التنافسية المستدامة؛ قطاع صناعة الأدوية؛ السودان.

## Introduction

In the contemporary knowledge-based economy, the limitations of conventional financial reporting have become increasingly apparent. Traditional reports, which emphasize tangible and physical assets, offer a narrow view of a company's true value, and fail to adequately support strategic decision-making or investor assessments. ICA ( Institute of Chartered Accountants in England and Wales, 2008) underscored this inadequacy, noting it as one of the contributing factors to the 2008 financial crisis, during which investors were unable to accurately evaluate risk due to poor disclosure of intangible assets.

This has driven a paradigm shift toward recognizing intellectual capital often referred to as cognitive capital as a foundational source of sustainable competitive advantage. Intellectual capital includes three core components: human capital, structural capital, and customer (or relational) capital, all of which contribute significantly to a firm's market value. According to (Rylander et al., 2000), these intangible resources explain the persistent gap between a firm's book value and its market valuation, making them strategic drivers of organizational performance (Rylander et al., 2000).

Recent studies continue to emphasize that intellectual capital is not only central to innovation but also a predictor of firm growth, productivity, and market leadership, especially in emerging economies. For instance, (Shubita, 2022) highlighted a significant correlation between the development of intellectual capital components and the performance of industrial firms, while (Wernerfelt, 1984) established the foundational principles of the resource-based view (RBV), which sees unique internal capabilities as sources of competitive advantage (Shubita, 2022, Wernerfelt, 1984). This theoretical lens positions cognitive capital as a non-replicable and valuable resource.

However, effective leverage of intellectual capital requires proper disclosure and governance. (Pike et al., 2002) observed that most organizations still lack robust reporting mechanisms for intangible assets, thereby undermining strategic alignment and investor transparency (Pike et al., 2002). The role of cognitive capital is further reinforced in dynamic and innovation-driven sectors. For example, (Suryantini et al., 2023) demonstrated how technology adoption and strategic flexibility mediate the link between intellectual capital and sustained competitiveness, particularly in small and medium-sized enterprises.

Empirical research across diverse geographic and industry contexts—including China and Pakistan has established that investing in intellectual capital can lead to superior strategic outcomes such as improved responsiveness, innovation, efficiency, and customer satisfaction (Lu et al., 2021, Bontis et al., 2000, Altarawneh, 2017). Welbourne (2008) also emphasized the significance of relational capital for SMEs, identifying it as a crucial factor in negotiation, stakeholder collaboration, and market resilience (Welbourne and Pardo-del-Val, 2009).

Despite widespread recognition of its value, many organizations still struggle to measure the return on investment (ROI) in knowledge-based assets. A cross-sectoral study, found that only a small fraction of international firms had systems in place to track the value created by knowledge management efforts, despite acknowledging the cost of missed opportunities due to ineffective practices (Wen Chong et al., 2000). This finding echoes in (Mundra et al., 2011), who argue that competitive advantage in the IT sector is increasingly derived from knowledge innovation and management capability rather than traditional asset accumulation.

Within the pharmaceutical sector, the stakes are even higher. It is a domain heavily reliant on knowledge transfer, regulatory compliance, and continuous innovation making intellectual capital not just important, but essential. In a focused study on Jordanian pharmaceutical companies, found that all three components of intellectual capital had significant effects on competitive outcomes (Altarawneh and Albloush, 2023). Similarly, according to few studies, entrepreneurial growth in knowledge-intensive industries is strongly tied to the effective use of intellectual resources (Altarawneh, 2017, Crupi et al., 2021).

Moreover, scholars have provided evidence from Italian and Vietnamese contexts, respectively, supporting the claim that intellectual capital is a core determinant of firm valuation and strategic competitiveness (Forte et al., 2019, Thang and Phong, 2023). Still, (Kamukama et al., 2011) cautioned that competitive advantage does not

emerge from intellectual capital automatically; it is often mediated by other organizational capabilities such as adaptability and strategic foresight.

Despite the robust global evidence, the Sudanese pharmaceutical industry remains underrepresented in academic discourse. The present study aims to fill this gap by exploring the extent to which investment in human, structural, and customer capital impacts the four critical dimensions of competitive advantage efficiency, quality, innovation, and responsiveness within Sudanese pharmaceutical manufacturing companies. This focus is particularly relevant given Sudan's challenging business environment, which necessitates reliance on resilient, non-physical assets to navigate instability and pursue sustainable growth.

While prior research has modeled links between intellectual capital and firm performance in developed markets like Korea, limited empirical work exists that applies such frameworks in the Sudanese context or among pharmaceutical firms operating in fragile economies (Xu and Wang, 2018). Therefore, this study not only addresses a scholarly gap but also provides practical insights for managers and policymakers seeking to enhance competitive advantage through strategic intellectual capital development.

## **Literature Review**

A systematic review of intellectual capital (IC) research provides a valuable framework for understanding how intangible assets drive firm performance and competitive advantage. This section synthesizes the academic evolution of cognitive capital and its components like human, structural, and customer capital within the broader resource-based view (RBV).

### **Theoretical Foundations**

The resource-based view posits that firms derive competitive advantage from resources that are valuable, rare, inimitable, and non-substitutable. Intellectual capital fits this profile, serving as a key internal asset for sustaining long-term competitiveness (Barney, 1991b), (Barney, 1991a), (Abualoush et al., 2018). According to Xu and Wang (Xu and Wang, 2018), intellectual capital directly influences firm performance and sustainable growth in manufacturing environments. (Ujwary-Gil, 2017) highlights its role in value creation through knowledge-centric business models, while (Xu and Li, 2022) confirm a statistically significant relationship between IC and firm performance in Chinese manufacturing.

The concept of intellectual capital has evolved considerably. Early definitions focused on the surplus between market value and book value, recognizing it as “unaccounted capital” in traditional systems (Barney, 1991b), (Abeysekera and Guthrie, 2005). However, as (Abhayawansa et al., 2021) noted, a lack of consensus on definitions led to inconsistent application. Scholars such as (Marr and Moustaghfir, 2005) and (Marr and Chatzkel, 2004) called for harmonized classification systems, while Bellucci et al. (Bellucci et al., 2021) urged a shift toward dynamic models that address emerging themes like innovation, agility, and sustainability.

### **Intellectual Capital: Key Components**

#### ***Human Capital***

Human capital includes employee knowledge, expertise, innovation capacity, and skills development (Bontis, 1998). It is widely considered the most crucial component of intellectual capital, especially in knowledge-driven industries like pharmaceuticals. (Kalkan et al., 2014) emphasized its impact on innovation and strategic orientation, while (Faruq et al., 2023) linked it to performance in financial institutions.

Empirical research confirms its relevance in pharmaceutical contexts. (Gunawan, 2019) found that human capital enhances responsiveness and compliance in regulated industries. (Masadeh, 2021), in a case study of Jordanian pharmaceutical companies, showed that skilled human capital significantly boosts competitive positioning across multiple dimensions.

Human capital also acts as a foundation for other resources, driving innovation, supporting structural systems, and enabling responsive customer strategies (Stewart, 2010; Arsawan et al., 2022a).

#### ***Structural Capital***

Structural capital comprises organizational routines, patents, intellectual property, information systems, and formalized procedures (Beltramino et al., 2020; Chen, 2004). It persists beyond individual employees and underpins the operational efficiency and scalability of firms.

(Beltramino et al., 2020) noted that in SMEs, well-developed structural capital strongly correlates with innovation outcomes. Stewart [34] described it as the “infrastructure of knowledge,” while emphasized its role in transforming individual knowledge into organizational assets.

In manufacturing sectors like pharmaceuticals, structural capital includes SOPs, ISO systems, automated production lines, and digital platforms such as ERP or SCADA. Such systems reduce production variance, enhance decision-making, and align internal processes to strategic goals (Youndt et al., 2004).

### ***Customer (Relational) Capital***

Customer capital, or relational capital, refers to the network of external relationships clients, regulators, suppliers, and brand advocates that contribute to organizational stability and growth (Bontis, 1998), (Kohli and Jaworski, 1990). It includes customer loyalty, satisfaction, trust, and brand reputation, all of which drive long-term profitability.

(Crupi et al., 2021) found that relational capital supports entrepreneurial expansion by ensuring access to markets and strategic partners. (Yaseen et al., 2016, Kaleka and Morgan, 2017) showed its positive influence on competitive advantage in both financial and telecom sectors. Furthermore, (Chatzoglou and Chatzoudes, 2018) highlighted that relationship quality predicts international market performance.

Customer capital is particularly important in pharmaceuticals, where companies must maintain trusted ties with pharmacists, physicians, hospitals, and consumers. This trust enhances responsiveness to market shifts and regulatory changes (Henkel et al., 2014, Kamukama, 2013).

### **Intellectual Capital and Competitive Advantage**

Numerous studies demonstrate that IC drives competitive advantage across sectors (Kamukama et al., 2011), (Gunawan, 2019), (Krishnan, 2021). The literature outlines multiple theoretical perspectives from Porter's cost-leadership and differentiation models to dynamic capabilities theory and market orientation frameworks (Jardon and Susana Martos, 2012), (Bontis, 2001), (Mohammad Shafiee, 2022). Competitive advantage itself has been linked to several strategic dimensions, including cost efficiency, product quality, responsiveness, innovation, and agility (Jafari et al., 2023, Kallel et al., 2017). (Allal-Chérif et al., 2023) emphasized the role of capability transformation in maintaining flexibility, while (Jafari et al., 2023) identified innovation as the most consistent driver of long-term advantage. Recent empirical models integrate intellectual capital directly into competitive advantage frameworks. For example, (Yang et al., 2021) showed how business intelligence and IC drive supply chain performance through enhanced agility. (Krishnan, 2021) proposed mindfulness as a complementary intangible resource for sustainable advantage.

In the pharmaceutical industry, intellectual capital serves as the strategic anchor for achieving both regulatory compliance and innovation-led growth. (Krishnan, 2021) described IC as the "invisible asset" shaping firm competitiveness in resource-constrained environments. Yang et al. (Bontis, 2001) and (Porter and Kramer, 2006) highlighted the role of IC in facilitating digital transformation and open innovation. (Asiaei and Bontis, 2020) categorized competitive advantage into four primary dimensions efficiency, quality, innovation, and responsiveness suggesting that these elements are universally applicable across industries. (Kallel et al., 2017, Jardon and Martos, 2021) further validated this model in the context of Latin American SMEs, aligning closely with the dimensions tested in the present study.

### **Hypotheses**

Themes (relationships between variables):

H1: There is a statistically significant relationship between human capital and the achievement of sustainable competitive advantage in pharmaceutical manufacturing companies.

H2: There is a statistically significant relationship between structural capital and sustainable competitive advantage in pharmaceutical manufacturing companies.

H3: There is a statistically significant relationship between customer capital and sustainable competitive advantage in pharmaceutical manufacturing companies.

Sub-presumptions (can be used to test each dimension of competitive advantage separately):

#### ***Human capital relation to the competitive advantage dimensions:***

H1a: There is a positive impact of human capital on efficiency.

H1b: There is a positive impact of human capital on quality.

H1c: There is a positive impact of human capital on creativity.

H1d: There is a positive impact of human capital on the response.

#### ***Structural capital relation to the competitive advantage dimensions:***

H2a: There is a positive effect of structural capital on efficiency.

H2b: There is a positive impact of structural capital on quality.

H2c: There is a positive impact of structural capital on creativity.

H2d: There is a positive impact of structural capital on the response.

#### ***Customer capital relation to the competitive advantage dimensions:***

H3a: There is a positive effect on efficiency of customer capital.

H3b: There is a positive impact of customer capital on quality.

H3c: There is a positive impact of customer capital on creativity.

H3d: There is a positive impact of customer capital on the response.

### Methodology

The Field Study was conducted with a view to knowing the relationship between cognitive capital and the competitive advantage of Sudanese pharmaceutical manufacturing companies, this section describes how the field study was implemented and the methodology used in field data analysis, where it contains a description of the study community and its designation, how the study tool and actions taken to ensure its honesty and consistency, how it is applied and the statistical methods used for data analysis and extraction of results, and this section will be presented as follows:

### Study procedure

The Field Study aims to collect data on research researchers' views, by responding to the terms of the independent variable of human capital, structural capital, customer capital, and the dimensions of the variable of sustainable competitive advantage, efficiency, quality, creativity and response.

### Dimensions of Intellectual Capital and Sustainable Competitive Advantage

The study examines the relationship between dimensions of Intellectual Capital and Sustainable Competitive Advantage (see Tables 1 and 2). Data were collected from the study population and analyzed using Smart-PLS to assess the measurement and structural models.

**Table 1:** Dimensions of Intellectual Capital.

Variable	Code
Human Capital	HC
Structural Capital	SC
Customer Capital	CC

**Table 2:** Dimensions of Sustainable Competitive Advantage.

Variable	Code
Efficiency	E
Quality	Q
Creativity	C
Responsiveness	R

### Study Population and Sample

The field study population was determined by identifying individuals involved in pharmaceutical manufacturing companies listed on the Khartoum Stock Exchange.

*\*Note: These procedures were completed prior to the recent war in Sudan.*

A purposive sample of 50 individuals was selected from the general study population. The researcher distributed 60 questionnaires, out of which 55 were returned, giving a response rate of 91.7%. A total of 50 questionnaires were valid for analysis.

To ensure the results were as accurate as possible, the researcher ensured the sample was diverse in terms of gender, age, education level, specialization, years of service in the company, job position, department, and number of training courses completed.

### Descriptive Analysis of the Study Sample

Table 3 is a detailed overview of the demographic characteristics of the study participants, as qualitative variables likely to influence the study outcomes:

**Table 3:** Frequency and Percentage Distribution of Respondents by Demographics.

Variable	Category	Frequency	Percentage
Gender	Male	37	74%
	Female	13	26%
	<b>Total</b>	<b>50</b>	<b>100%</b>
Age Range	Under 25	1	2%

	25–35	15	30%
	36–45	20	40%
	46–55	10	20%
	Over 55	4	8%
	<b>Total</b>	<b>50</b>	<b>100%</b>
<b>Educational Qualification</b>	Intermediate Diploma	1	2%
	Bachelor's Degree	27	54%
	Higher Diploma	8	16%
	Master's Degree	11	22%
	Ph.D.	3	6%
	<b>Total</b>	<b>50</b>	<b>100%</b>
<b>Specialization</b>	Pharmacy	13	26%
	General Chemistry	9	18%
	Biochemistry	4	8%
	Chemical Engineering	6	12%
	Chemistry Laboratory	5	10%
	Marketing	4	8%
	Human Resources	3	6%
	Accounting	5	10%
	Other	1	2%
	<b>Total</b>	<b>50</b>	<b>100%</b>
<b>Years of Service</b>	Less than 5 years	5	10%
	5–10 years	15	30%
	11–15 years	21	42%
	16–20 years	8	16%
	Over 20 years	1	2%
	<b>Total</b>	<b>50</b>	<b>100%</b>
<b>Job Position</b>	Department Manager	7	14%
	Chemical Analyst	9	18%
	Quality Officer	13	26%
	General Supervisor	9	18%
	Marketing Executive	6	12%
	Other (e.g., Accountant, Auditor)	6	12%
	<b>Total</b>	<b>50</b>	<b>100%</b>
<b>Department</b>	Manufacturing	14	28%
	Quality Control	15	30%
	Marketing & Sales	11	22%
	Public Relations	2	4%
	Finance & Accounting	4	8%
	Human Resources	4	8%
	<b>Total</b>	<b>50</b>	<b>100%</b>
<b>Training Courses</b>	Less than 2 courses	6	12%
	2–5 courses	20	40%
	More than 5 courses	23	46%
	No training courses	1	2%
	<b>Total</b>	<b>50</b>	<b>100%</b>

*Source: Study Data Analysis Results, 2024*

The data in Table 3 highlights several key insights:

- Quality Officer was the most common job title (26%), followed by Chemical Analyst and General Supervisor (18% each), and Department Manager (14%). This indicates strong representation from quality assurance roles, which are essential in pharmaceutical manufacturing.
- The wide range of job functions and departments suggests a broad and representative participation across administrative and operational levels, supporting the study's goal of understanding how various roles contribute to sustainable competitive advantage.
- The most represented age group was 36–45 years (40%), and most participants held a bachelor's degree or higher, indicating a workforce with strong intellectual capital potential.
- The most common range of experience was 11–15 years (42%), and most respondents had taken specialized training courses, showing a high level of professional expertise.
- These patterns suggest that building and sustaining competitive advantage in pharmaceutical companies relies on a combination of experience, education, and diverse functional expertise key pillars of intellectual capital.

### **Field Study Instrument**

The researcher utilized a questionnaire as the primary data collection tool for the field study. The questionnaire consisted of two parts:

- Part One included demographic information (personal data).
- Part Two focused on measuring the study variables.

Participants responded to all items using a five-point Likert scale: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree. Nominal variables were converted into quantitative variables by assigning weights from 5 to 1, respectively.

The questionnaire comprised 44 items related to the research topic. Participants were asked to indicate their response to each item. These items were distributed across the following seven dimensions:

- Human Capital (10 items)
- Structural Capital (10 items)
- Customer Capital (10 items)
- Efficiency (4 items)
- Quality (3 items)
- Creativity (3 items)
- Responsiveness (4 items)

### **Statistical Methods Used**

To analyze the data, we utilized Smart-PLS 3, along with Microsoft Excel and Microsoft Word, to apply various statistical methods. Frequencies and percentages were used to describe the distribution of demographic variables and responses to questionnaire items. The Cronbach's Alpha coefficient was calculated to assess the reliability of the study instrument. Weighted means were computed for responses to the six main variables, and frequency tables for each item were generated, along with averages of the weighted means, to identify participant opinions and tendencies based on the five-point Likert scale. Finally, Smart-PLS 3 was employed to test the relationships between variables and determine effect sizes.

### **Hypotheses Testing**

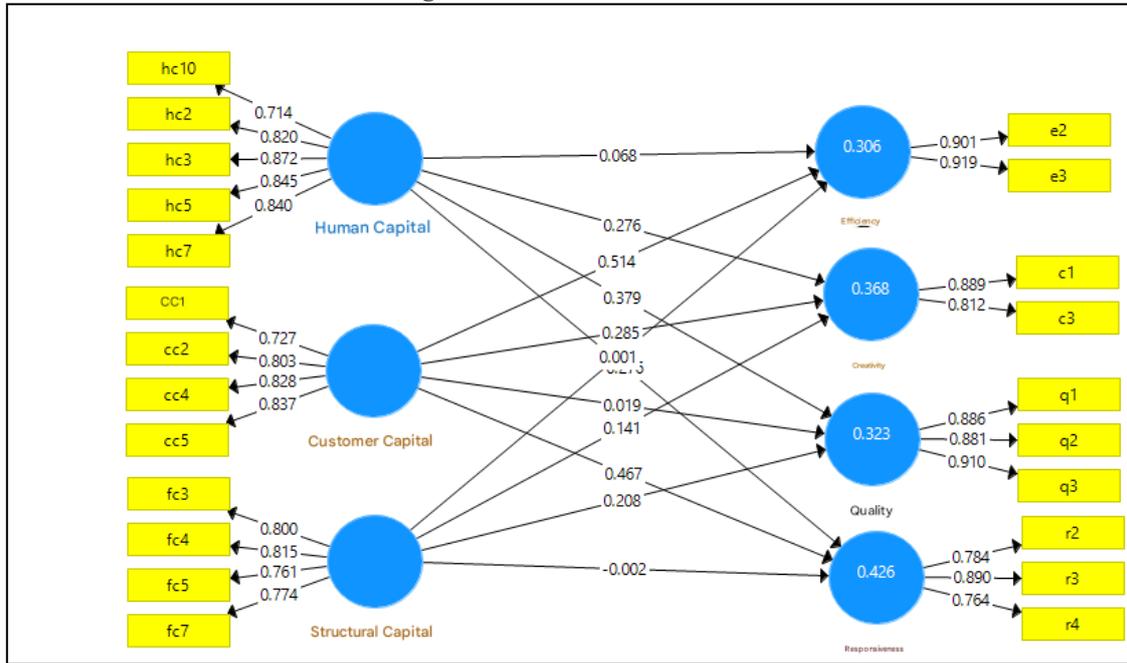
To test the hypotheses of the study, Smart-PLS version 3.3.7 was employed to examine the relationships between the dimensions of the independent variable and the dependent variable, as well as to calculate effect sizes. To ensure accurate application of the program, the analysis followed two main steps. First, the measurement model was constructed and validated by assessing convergent validity, including individual item reliability with factor loadings greater than 0.70, composite reliability above 0.70, and average variance extracted (AVE) exceeding 0.50. Discriminant validity was also examined using cross-loadings and the square root of AVE for variable correlations. Second, the structural model was constructed and assessed by evaluating the coefficient of determination ( $R^2$ ), effect size ( $F^2$ ), predictive relevance ( $Q^2$ ), goodness of fit (GoF), and path coefficients to test the proposed hypotheses.

## **Results**

### **Development and Testing of the Study Model Measures**

All factor loadings exceed 0.70, CR values are greater than 0.70, and AVE values exceed 0.50. Items with low factor loading or AVE were removed. This confirms that the items effectively measure their intended constructs.

**Figure 1: Measurement Model.**



Source: Study Data Analysis Results, 2024

**Table 4: Convergent Reliability Results.**

Variable	Item	Factor Loading	CR	AVE
Human Capital	Statement 2	0.82		
	Statement 3	0.87	0.91	0.67
	Statement 5	0.84		
	Statement 7	0.84		
Structural Capital	Statement 10	0.71		
	Statement 3	0.80		
	Statement 4	0.81	0.87	0.62
	Statement 5	0.76		
Customer Capital	Statement 7	0.77		
	Statement 1	0.73		
	Statement 2	0.80	0.88	0.64
	Statement 4	0.83		
Efficiency	Statement 5	0.84		
	Statement 2	0.90		
Quality	Statement 3	0.92	0.91	0.83
	Statement 1	0.89		
Creativity	Statement 2	0.88	0.92	0.80
	Statement 3	0.91		
	Statement 1	0.89		
Responsiveness	Statement 3	0.81	0.84	0.73
	Statement 2	0.78		
	Statement 3	0.89	0.85	0.66
	Statement 4	0.76		

Source: Study Data Analysis Results (2024)

The convergent reliability of the constructs was assessed using factor loadings, composite reliability (CR), and average variance extracted (AVE), as presented in Table 4. All factor loadings exceeded the recommended

threshold of 0.70, demonstrating adequate item reliability. The CR values for all constructs ranged from 0.84 to 0.92, and AVE values ranged from 0.62 to 0.83, indicating good internal consistency and convergent validity. Discriminant validity was evaluated through cross-loadings (Table 5), which showed that each item loaded more strongly on its intended construct than on any other construct. These results confirm that the measurement model possesses both strong convergent and discriminant validity, ensuring that each set of items effectively measures its intended dimension.

**Table 5: Cross-Loading Results.**

	Creativity	Quality	Efficiency	Customer Capital	Structural Capital	Human Capital
Responsiveness	0.81	0.44	0.30	0.51	0.61	0.52
Creativity	0.85	0.47	0.42	0.51	0.53	0.53
Quality	0.89	0.35	0.34	0.52	0.55	
Efficiency	0.91	0.55	0.36	0.34		
Customer Capital	0.80	0.59	0.52			
Structural Capital	0.79	0.79				
Human Capital	0.82					

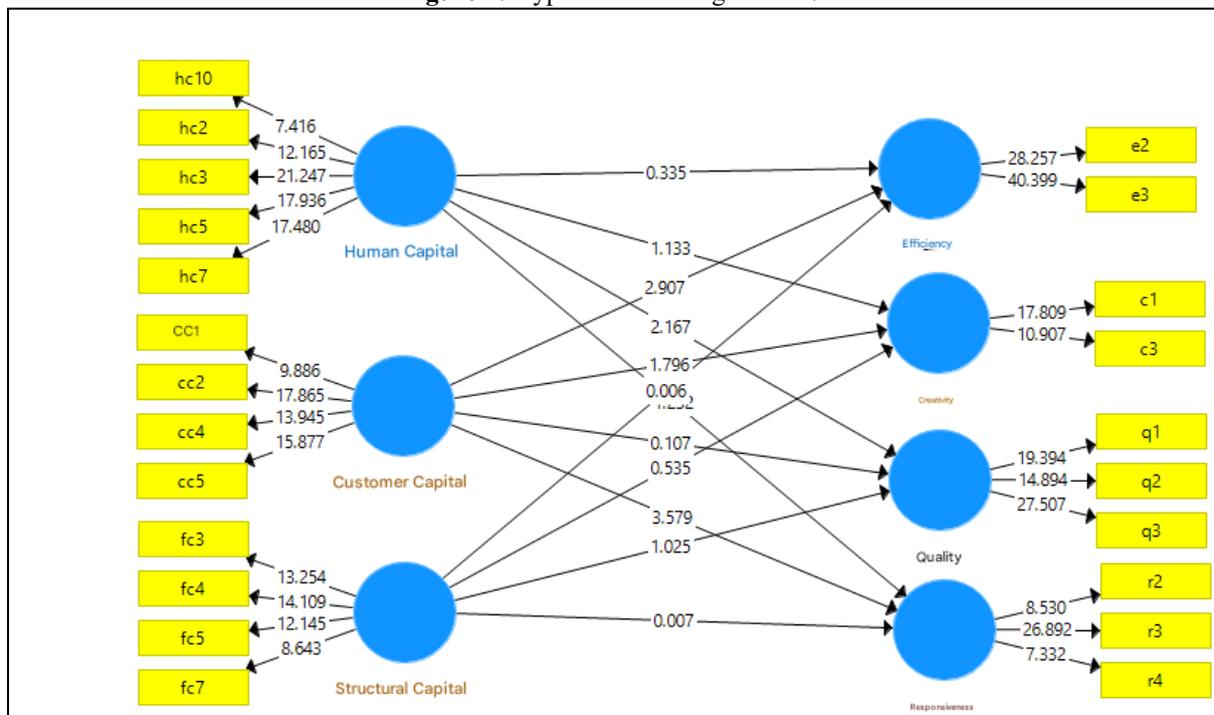
Source: Study Data Analysis Results (2024)

As shown, each variable loads more strongly on itself than on others, indicating good discriminant validity each set of items measures only the intended construct.

**Model Structure Testing**

*Path Coefficient – Hypothesis Testing*

**Figure 2: Hypotheses Testing Results.**



Source: Study Data Analysis Results, 2024

**Table 6: Path Coefficient Results.**  
 ✓ = Significant relationship (P-value < 0.05)  
 Source: Study Data Analysis Results (2024)

Relationship	Std. Beta	S.E.	T-value	P-value
Human Capital → Creativity	0.28	0.24	1.13	0.26
Human Capital → Responsiveness	0.28	0.22	1.23	0.22
Human Capital → Quality	0.38	0.17	2.17	0.03 ✓
Human Capital → Efficiency	0.07	0.20	0.34	0.74
Customer Capital → Creativity	0.29	0.16	1.80	0.07
Customer Capital → Responsiveness	0.47	0.13	3.58	0.00 ✓
Customer Capital → Quality	0.02	0.18	0.11	0.92
Customer Capital → Efficiency	0.51	0.18	2.91	0.00 ✓
Structural Capital → Creativity	0.14	0.26	0.54	0.59
Structural Capital → Responsiveness	-0.00	0.21	0.01	0.99
Structural Capital → Quality	0.21	0.20	1.02	0.31
Structural Capital → Efficiency	0.00	0.22	0.01	1.00

The structural model was assessed using path coefficients, standard errors, t-values, and p-values to test the hypothesized relationships between the dimensions of Intellectual Capital and Sustainable Competitive Advantage. As shown in Table 6, Human Capital had a significant positive effect on Quality ( $\beta = 0.38$ ,  $t = 2.17$ ,  $p = 0.03$ ), while its relationships with Creativity, Responsiveness, and Efficiency were not significant. Customer Capital significantly influenced Responsiveness ( $\beta = 0.47$ ,  $t = 3.58$ ,  $p < 0.01$ ) and Efficiency ( $\beta = 0.51$ ,  $t = 2.91$ ,  $p < 0.01$ ), but not Quality or Creativity. In contrast, Structural Capital did not exhibit any significant effects on the dependent variables. The coefficient of determination ( $R^2$ ) indicates the explanatory power of the independent variables for each outcome, with values interpreted as high, moderate, weak, or unacceptable according to conventional thresholds. These results suggest that Human Capital and Customer Capital are the primary drivers of certain dimensions of Sustainable Competitive Advantage, while Structural Capital does not significantly contribute in this context.

**Table 7: R<sup>2</sup> Results.**

Dependent Variable	R <sup>2</sup> Value	Interpretation
Creativity	0.37	Moderate
Responsiveness	0.43	Moderate
Quality	0.32	Weak
Efficiency	0.31	Weak

Source: Study Data Analysis Results (2024)

The coefficient of determination ( $R^2$ ) was examined to assess the explanatory power of the independent variables on the dependent variables. As shown in Table 7, the independent variables explained 37% of the variance in Creativity and 43% in Responsiveness, both of which are considered moderate. The  $R^2$  values for Quality (32%) and Efficiency (31%) indicate a weak but acceptable level of explanatory power. These results suggest that while Human Capital and Customer Capital substantially influence certain dimensions of Sustainable Competitive Advantage, other factors may also contribute to these outcomes.

#### Effect Size ( $F^2$ )

The effect size ( $F^2$ ) was assessed to determine the relative contribution of each independent variable to the dependent variables. According to Table 8, Structural Capital demonstrated a medium effect on Efficiency ( $F^2 = 0.25$ ) and Responsiveness ( $F^2 = 0.25$ ). In contrast, the effects of Human Capital and Customer Capital on all dependent variables were small or negligible, with  $F^2$  values ranging from 0.00 to 0.08. These findings suggest that while Structural Capital moderately influences certain dimensions of Sustainable Competitive Advantage, Human Capital and Customer Capital exert weaker individual effects in this model.

**Table 8: F<sup>2</sup> Results.**

Independent Variable	Efficiency	Quality	Responsiveness	Creativity
Human Capital	0.00	0.08	0.05	0.05
Structural Capital	0.25	0.00	0.25	0.08
Customer Capital	0.00	0.02	0.00	0.01

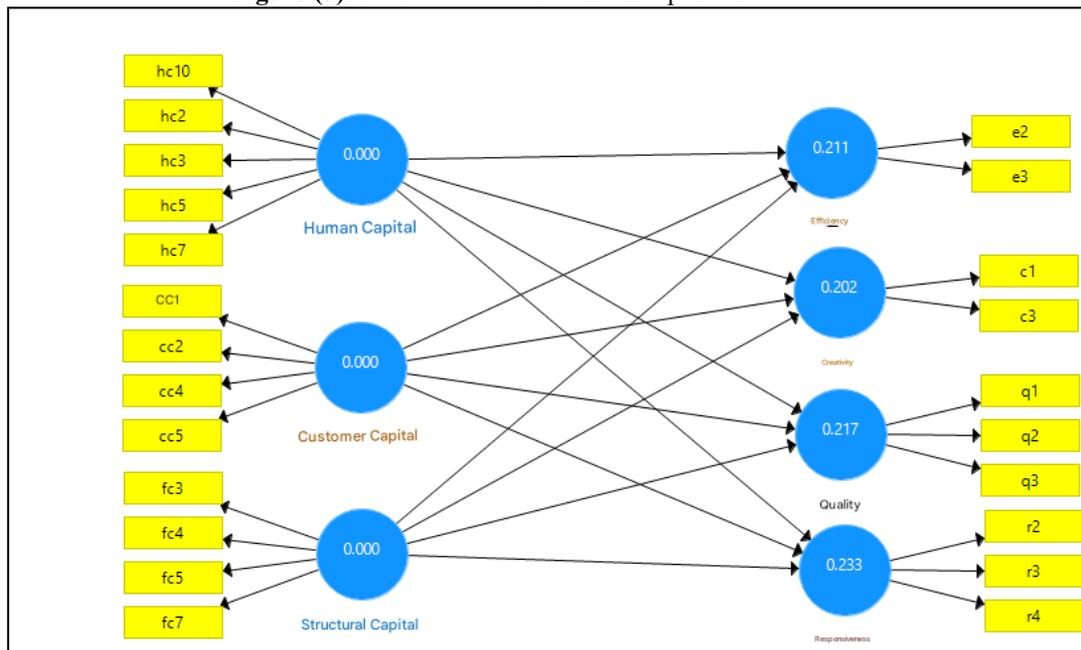
*Source: Study Data Analysis Results (2024)*

The effect size (F<sup>2</sup>) was evaluated to determine the strength of each independent variable’s contribution to the dependent variables. According to the results presented in Table 8, Structural Capital exhibited a medium effect on Efficiency and Responsiveness, while its effect on Creativity and Quality was weak or negligible. The impact of Human Capital on Creativity, Responsiveness, and Quality was small, with no observed effect on Efficiency. Customer Capital had a weak effect on Quality and negligible effects on the other dependent variables. These findings highlight that while Structural Capital plays a moderate role in certain dimensions of Sustainable Competitive Advantage, Human and Customer Capital generally exert weaker influences. It is important to interpret these results alongside other statistical findings, such as path coefficients and R<sup>2</sup> values, to draw meaningful and significant conclusions about the relationships between variables.

**Q<sup>2</sup> Test**

This test evaluates the ability of independent variables to predict the dependent variable. A Q<sup>2</sup> value must be greater than zero.

**Figure (3): Predictive Power of the Independent Variables.**



*Source: Study Data Analysis Results (2024)*

The predictive relevance (Q<sup>2</sup>) of the model was examined to evaluate how well the independent variables forecast the dependent variables. As shown in Figure 3, Human Capital, Structural Capital, and Customer Capital collectively predict Efficiency (Q<sup>2</sup> = 0.211), Creativity/Innovation (Q<sup>2</sup> = 0.202), Quality (Q<sup>2</sup> = 0.217), and Responsiveness (Q<sup>2</sup> = 0.233). These Q<sup>2</sup> values indicate that the model possesses adequate predictive relevance, suggesting that the dimensions of Intellectual Capital can reasonably forecast variations in Sustainable Competitive Advantage outcomes.

**GoF Test**

The Goodness of Fit (GoF) was calculated to assess the overall fit and reliability of the model using the formula  $\sqrt{(\text{average } R^2 \times \text{average AVE})}$ . As shown in Table 9, the GoF values for Innovation (0.51), Responsiveness (0.55), Quality (0.48), and Efficiency (0.47) all exceed the threshold of 0.36, indicating high reliability according to

established criteria (Ganguly et al., 2019). These results suggest that the model demonstrates a strong overall fit, confirming that the constructs and relationships included in the analysis adequately represent the underlying theoretical framework.

**Table 9: GoF Test Analysis.**

Dimension	R <sup>2</sup> Value	AVE	GoF Value	Interpretation
Innovation	0.37	0.71	0.51	High reliability
Responsiveness	0.43	0.71	0.55	High reliability
Quality	0.32	0.71	0.48	High reliability
Efficiency	0.31	0.71	0.47	High reliability

Source: Study Data Analysis Results (2024)

## Discussion

### The Intellectual Capital Influence on Competitive Advantage

The dynamic and unpredictable nature of today's business environment imposes constant pressure on organizations to enhance performance and achieve sustainable competitive advantage (SCA). In knowledge-intensive industries such as pharmaceuticals, these challenges are further amplified by rapid technological transformation, globalization, and market volatility. Firms must therefore mobilize internal resources, particularly intellectual capital (IC), as a strategic lever to adapt and outperform competitors (Cahyanti, Ganguly et al., 2019). This study contributes to the Resource-Based View (RBV) by empirically examining how the IC components human capital, structural capital, and customer capital influence the strategic dimensions of competitive advantage, namely efficiency, quality, innovation, and responsiveness (Henseler, 2018, Arsawan et al., 2022b, Dženopoljac et al., 2016).

### Human capital (HC)

Based on the hypothesis testing results (Table 6), human capital (HC) was found to have a statistically significant effect only on quality (H1b:  $\beta = 0.38$ ,  $t = 2.17$ ,  $p = 0.03$ ). Therefore, Hypothesis H1b is supported, indicating that skilled and knowledgeable employees positively influence the quality of products and services. This finding aligns with prior studies demonstrating that employee expertise and capabilities are critical for improving quality in knowledge-driven industries (Lu et al., 2021, Cahyanti, Bontis et al., 2015).

However, human capital did not have a significant impact on other dimensions of competitive advantage: innovation (H1c:  $\beta = 0.26$ ,  $t = 1.13$ ,  $p = 0.24$ ), responsiveness (H1d:  $\beta = 0.22$ ,  $t = 1.23$ ,  $p = 0.28$ ), and efficiency (H1a:  $\beta = 0.20$ ,  $t = 0.34$ ,  $p = 0.74$ ). Therefore, Hypotheses H1a, H1c, and H1d are not supported. These results suggest underutilization of employee skills in operational agility and research and development. Contributing factors may include managerial rigidity, lack of incentives for innovation, and insufficient knowledge-sharing mechanisms (Jin and Shao, 2022, Ying et al., 2019, Sayed, 2022). Compared with high-performing global pharmaceutical firms, Sudanese companies may lack systems to capture tacit knowledge and encourage cross-functional collaboration (Barney, 1991a, Dženopoljac et al., 2016). This indicates that while human capital is a valuable resource, its potential is not fully leveraged to achieve all dimensions of competitive advantage.

### Structural Capital (SC)

Contrary to expectations, structural capital exhibited no statistically significant effect on any of the four competitive advantage dimensions (H2a–H2d:  $P > 0.05$ ). Consequently, all hypotheses H2a, H2b, H2c, and H2d are rejected. This outcome contrasts with prior studies emphasizing the role of structural mechanisms such as IT systems, SOPs, patents, and digital infrastructure in supporting organizational agility, operational excellence, and innovation (Cepeda and Arias-Pérez, 2019, Vu and Nguyen, 2022, Allal-Chérif et al., 2023).

Several factors may explain this lack of significance. Sudanese pharmaceutical firms demonstrate limited investment in digital infrastructure, such as ERP, SCADA, and MES systems (Alhloul, 2023), absence of automated production lines and advanced R&D facilities, and weak knowledge management practices with poor institutionalization of learning processes (Ying et al., 2019, Sayed, 2022). These structural deficiencies hinder the translation of individual knowledge into organizational assets and prevent scalability, which is essential for resilience in highly regulated sectors (Pan et al., 2021). Therefore, the results highlight that structural capital, in its current state, does not contribute significantly to competitive advantage.

### Customer Capital (CC)

Customer capital emerged as a strong predictor of responsiveness (H3d:  $\beta = 0.47$ ,  $t = 3.58$ ,  $p = 0.00$ ) and efficiency (H3a:  $\beta = 0.51$ ,  $t = 2.91$ ,  $p = 0.00$ ). Accordingly, Hypotheses H3d and H3a are supported, confirming the strategic importance of relational and trust-based assets in markets where loyalty and customer relationships influence performance outcomes. These findings align with Pan et al. (Qalati et al., 2021) and Cepeda & Arias-Pérez (Allal-Chérif et al., 2023), who argue that strong customer relationships improve market sensing, reduce lead times, and

enhance operational responsiveness. In the pharmaceutical sector, close ties with doctors, hospitals, and distributors enable critical feedback loops and support just-in-time production capabilities. Conversely, customer capital did not significantly influence quality (H3b:  $\beta = 0.18$ ,  $t = 0.11$ ,  $p = 0.92$ ) or innovation (H3c:  $\beta = 0.16$ ,  $t = 1.80$ ,  $p = 0.07$ ). Hence, Hypotheses H3b and H3c are not supported. This suggests that while relational capital aids efficiency and responsiveness, it is not sufficiently leveraged to foster co-innovation or continuous improvement, possibly due to weak mechanisms for integrating customer feedback into product development and innovation strategies (Zhang et al., 2023).

### **Explanatory Power of the Model**

The explanatory power of the model, as indicated by  $R^2$  values (Table 7), was moderate for responsiveness (0.43) and innovation (0.37), and relatively weak for quality (0.32) and efficiency (0.31). These findings indicate that while IC explains a meaningful proportion of variance in certain strategic outcomes, additional factors such as digital transformation, organizational learning, and green innovation practices may further enhance the model's explanatory capability (Henseler, 2018). High Goodness-of-Fit (GoF) values confirm the robustness and internal validity of the model in line with Smart-PLS standards (Barney, 1991a).

### **Strategic Implications**

The study reinforces that intellectual capital is a cornerstone of sustainable competitive advantage, particularly in knowledge-intensive sectors that demand regulatory compliance, continuous innovation, and high responsiveness. However, the results highlight several critical gaps: human capital is underutilized in driving innovation and operational adaptability; structural capital investments are insufficient to support long-term scalability; and customer capital is leveraged tactically rather than strategically. Managers should focus on cross-functional knowledge sharing, invest in digital infrastructure, and implement customer co-creation mechanisms to maximize the value of IC (Arsawan et al., 2022b, Zhang et al., 2023). Embedding open innovation practices and strategic agility into IC management can further enhance firm performance, especially in turbulent and resource-constrained environments (Henseler, 2018).

### **Conclusion**

The study concludes that investing in intellectual capital produces different effects on achieving sustainable competitive advantage within Sudanese pharmaceutical firms, highlighting distinct roles for its various components. Among these, customer capital emerged as the most influential, playing a particularly critical role in enhancing the firms' responsiveness to market demands and operational efficiency, thereby directly contributing to competitive positioning. Human capital, while showing a more limited impact compared to customer capital, demonstrated a positive influence on the quality of products and services, indicating that skilled and knowledgeable employees can incrementally support performance improvements. In contrast, structural capital appeared to have no significant effect across any of the measured dimensions, suggesting that the formal processes, organizational routines, and knowledge management systems currently in place may not be sufficient on their own to drive sustainable advantages. Overall, the findings underscore the differential importance of intellectual capital components, emphasizing that building strong relationships with customers and investing in employee capabilities are more critical drivers of competitive sustainability than structural systems in the context of Sudanese pharmaceutical firms.

### **Recommendations**

Based on the study's findings, it is recommended that Sudanese pharmaceutical firms focus on enhancing customer relationship strategies to strengthen responsiveness and operational efficiency, as customer capital has been shown to be the most influential driver of competitive advantage. Simultaneously, firms should invest more intensively in human capital by providing professional training programs that are closely aligned with innovation and strategic growth objectives, ensuring that employees' skills and knowledge contribute effectively to organizational performance. Additionally, structural capital should be restructured by improving knowledge management systems and incorporating modern digital technologies, which can help optimize internal processes and support long-term competitiveness. Collectively, these recommendations not only offer practical guidance for firms seeking to leverage intellectual capital more effectively but also contribute to the academic understanding of its role in achieving sustainable competitive advantage within Sudan's pharmaceutical industry, while paving the way for future research to explore similar dynamics in other industrial sectors.

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