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CRITICAL SUCCESS FACTORS FOR HYBRID CLOUD DATA INTEGRATION: A CASE STUDY IN THE CEMENT INDUSTRY

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Abstract. Data integration in hybrid cloud environments is a major challenge in the era of digital transformation due to the need to manage data efficiently across both public and private cloud environments. This study aims to identify and rank the Critical Success Factors (CSFs) for data integration in hybrid cloud environments, using a case study of PT XYZ, which is currently undergoing a cloud migration process. The study integrates three frameworks: TOE (Technology–Organization–Environment), HOT-fit (Human–Organization–Technology), and the IS Triangle, to form a holistic evaluation model with five dimensions. Twenty CSF factors were identified through a literature review and validated through interviews with five experts. Subsequently, the Analytical Hierarchy Process (AHP) method was applied to a questionnaire distributed to ten expert respondents to rank these factors. Of the five dimensions, the Business dimension was found to be the most important (weight 0.33), followed by Environment (0.18), Organization (0.17), Technology (0.17), and Human (0.15). These findings provide practical guidance for organizations implementing hybrid cloud data integration, particularly within the context of Indonesian regulations.

Keywords: Cloud Computing, Hybrid Cloud, Data Integration, Critical Success Factors, AHP, TOE, HOT-Fit

I. INTRODUCTION

Hybrid cloud adoption has become a dominant digital transformation strategy among large-scale organizations, primarily due to its ability to combine the flexibility of the public cloud with private cloud security and control [1],[3]. In its implementation, data integration between the two cloud environments is the most critical and failure-prone component, involving high technical, organizational, and regulatory complexity [9]. Data integration failures have a direct impact on an organization's operational continuity, information security, and business efficiency.

A number of studies have sought to identify the Critical Success Factors (CSF) in the adoption of cloud computing. Gangwar et al. [5] used the TAM-TOE framework and found that technological readiness and system compatibility were the dominant factors, but the research was limited to technology and organizational perspectives without taking into account the human resource dimension and the strategic justification of the business. Yusof et al. [6] through the HOT-fit framework reinforce the importance of human factor suitability in the adoption of information systems, but do not explore external environmental pressures and regulatory compliance. Alharbi et al. [7] integrated the IS Triangle to include a business perspective, but its application was limited to cloud adoption decisions in general without focusing on the specific challenges of hybrid cloud data integration. The most relevant study was conducted by Suhanto et al. [2] who examined the CSF of hybrid cloud data integration at PT Pos Indonesia using AHP based on the TOE framework.

However, Suhanto et al.'s study [2] has three fundamental limitations that open up significant research gaps. **First**, the TOE framework used does not include the human dimension and the business dimension, so factors such as the innovative role of the CIO and strategic financial analysis are not identified as CSFs. **Second**, the research was conducted on the logistics industry which has fundamentally different operational characteristics from the manufacturing industry, especially in terms of 24/7 operational patterns, massive volumes of production data, and reliance on complex ERP systems. **Third**, no study has simultaneously integrated the three complementary frameworks of TOE, HOT-fit, and IS Triangle to produce a CSF model that covers all relevant dimensions in a single rankable hierarchical structure.

This gap is significant considering that the manufacturing industry, especially the cement industry, is accelerating digital transformation by adopting hybrid cloud as a data infrastructure. Without a comprehensive understanding of the factors that determine its success, cloud migration investments are at high risk of implementation failure. This research fills this gap with three main contributions: (1)

proposing an integrated CSF model that combines TOE, HOT-fit, and IS Triangle simultaneously; (2) apply the Analytical Hierarchy Process (AHP) method to produce measurable and operationalable factor ratings; and (3) test the model in the context of the Indonesian cement manufacturing industry that has never been studied before.

Based on this background, this study formulates two research questions: (RQ1) What are the CSF factors that determine the success of hybrid cloud data integration in the cement manufacturing industry in Indonesia? and (RQ2) What is the relative ranking of the CSF factors based on the assessment of experts using the AHP method?

II. RESEARCH METHODS

Research Design

This study uses a mixed-method approach (quantitative and qualitative) with a three-stage procedure: (1) literature review to identify CSF factor candidates; (2) qualitative validation through semi-structured interviews with experts; and (3) quantitative ranking using the AHP method. A single case study was conducted on PT XYZ's cloud migration team, which in 2023 initiated the public cloud adoption process.

Respondent Profile

Two groups of respondents were involved in this study. The first group consists of five experts for factor validation through interviews. The second group consisted of ten experts including five from the first group for filling out the AHP questionnaire. All respondents have at least five years of professional experience in the field of hybrid cloud computing in Indonesia.

Table 1. Respondent Profile

No.	Departments	Experience	Participation
1	Cloud Engineer	≥ 6 years old	Interview + AHP
2	IT Cloud Platform Officer	≥ 7 years old	Interview + AHP
3	Cloud Engineer	≥ 5 years	Interview + AHP
4	Technical Operation Lead	≥ 5 years	Interview + AHP
5	Technical Account Manager	≥ 6 years old	Interview + AHP
6	Cloud Operations	≥ 5 years	AHP
7	IT Cloud Platform Officer	≥ 5 years	AHP
8	Cloud Engineer	≥ 5 years	AHP
9	Cloud Engineer	≥ 6 years old	AHP
10	Cloud Engineer	≥ 5 years	AHP

AHP Hierarchical Model

The AHP model in this study was operationalized through a paired comparison questionnaire distributed to ten expert respondents. The questionnaire is prepared based on the three-level hierarchical structure that has been proposed in Part II.E, including a comparison between dimensions at Level 2 and a comparison between factors at Level 3. The results of the questionnaire were processed using Microsoft Excel with the geometric mean method to consolidate the assessment of all respondents into one representative matrix. The priority weights are calculated through the normalization of the main eigenvector, and the validity of each matrix is verified using a Consistency Ratio (CR) with an acceptable limit of ≤ 0.1.

AHP Consistency Verification

The validity of the pairwise comparison matrix is verified through the calculation of the Consistency Index (CI) and Consistency Ratio (CR) for each matrix. Table 2 summarizes the CR value resulting from the consolidation of all respondents.

Table 2. Verification of Consistency Ratio (CR) of the Entire AHP Matrix

Matrix	Size(n)	λ Max	MT	RI	CR	Status
General Criteria (T-O-E-H-B)	5	5,158	0,040	1,120	0,035	✓ Consistent
Technology Sub-criteria	6	6,218	0,044	1,240	0,035	✓ Consistent
Organizational Sub-criteria	5	5,086	0,021	1,120	0,019	✓ Consistent
Environmental Sub-criteria	4	4,053	0,018	0,900	0,020	✓ Consistent
Human Sub-criteria	3	3,002	0,001	0,580	0,002	✓ Consistent
Business Sub-criteria	2	2,000	0,000	0,000	0,00	✓ Consistent

Note: The entire CR value ≤ 0.10 indicates an acceptable level of consistency. The CR value was calculated from a consolidated geometric mean matrix of 10 respondents using the eigenvector normalization method.

III. RESULT AND DISCUSSION

Processing of AHP data from ten respondents resulted in priority weights for all CSF dimensions and factors. Table 3 presents the weighting results at the general criterion level. Key findings show that the Business dimension ranks highest with a weight of 0.335, followed by Environment (0.176), Organization (0.171), Technology (0.170), and People (0.149). These results indicate that experts view strategic and financial justification as the most fundamental prerequisites before technical and human resources in the implementation of hybrid cloud data integration.

Table 3. Priority Weight Of General Criteria (CR = 0.035)

Rankings	Dimensions	T	O	E	H	B	Quantity	Priorities
4	Technology (T)	0,145	0,163	0,147	0,227	0,168	0,850	0,170
3	Organization (O)	0,145	0,144	0,290	0,123	0,150	0,853	0,171
2	Environment (E)	0,212	0,111	0,145	0,212	0,202	0,882	0,176
5	Human (H)	0,113	0,220	0,121	0,127	0,162	0,743	0,149

Volume 10, Number 02, Page 311-316
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Rankings	Dimensions	T	O	E	H	B	Quantity	Priorities
1	Business (B)	0,385	0,362	0,297	0,311	0,318	1,673	0,335

In the Technology dimension, the results of the weighting of the sub-criteria are presented in Table 4. Security (T5) ranks first with a weight of 0.279, reflecting that data security is a major concern in a hybrid environment that connects the private and public clouds simultaneously. Technology Readiness (T2, weight 0.219) and Compatibility (T3, weight 0.214) are in second and third positions, indicating that infrastructure readiness and system suitability are technical prerequisites that cannot be ignored. In contrast, Latency (T6, weight 0.055) ranks the lowest, indicating that network latency is seen as a more manageable challenge than the security and readiness aspects of the system.

Table 4. Priority weight of the technology sub-criteria (CR = 0.035)

Rankings	Factor	T1	T2	T3	T4	T5	T6	Quantity	Priorities
4	T1: Relative Advantage	0,152	0,135	0,170	0,164	0,130	0,148	0,900	0,150
2	T2: Technology Readiness	0,236	0,210	0,110	0,223	0,311	0,224	1,314	0,219
3	T3: Compatibility	0,157	0,337	0,176	0,253	0,109	0,250	1,282	0,214
5	T4: Complexity	0,075	0,076	0,056	0,081	0,093	0,121	0,501	0,084
1	T5: Security	0,322	0,187	0,447	0,241	0,276	0,199	1,671	0,279
6	T6: Latency	0,059	0,054	0,041	0,039	0,080	0,058	0,331	0,055

Table 5 presents the results of the weighting of the Organization dimension. Top Management Support (O1) dominates significantly with a weight of 0.429, almost double the weight of the second highest factor, namely Governance (O4, weight 0.219). This dominance confirms that commitment from the executive level is a fundamental enabler that determines the success of all aspects of implementation. Interestingly, Organizational Competency (O2) ranks lowest (weighted 0.080), indicating that experts assess organizational competency as a factor that can be built gradually after management commitments are formed, rather than as an initial prerequisite.

Table 5. Priority weighting of organizational sub-criteria (CR = 0.019)

Rankings	Factor	O1	O2	O3	O4	O5	Quantity	Priorities
1	O1: Top Management Support	0,445	0,408	0,463	0,482	0,345	2,143	0,429
5	O2: Organizational Competency	0,088	0,080	0,104	0,071	0,059	0,402	0,080
3	O3: Cost	0,164	0,131	0,171	0,185	0,204	0,856	0,171
2	O4: Governance	0,185	0,228	0,184	0,200	0,299	1,096	0,219
4	O5: Attitude Toward Change	0,119	0,153	0,077	0,062	0,092	0,503	0,101

As shown in Table 6, in the Environmental dimension, Regulation Compliance (E2) occupies the top position with a weight of 0.391. These findings stand out because they differ from previous studies that generally placed industry competitive pressures as a major environmental factor [5][10]. In the Indonesian context, compliance with regulations including Government Regulation No. 82/2012 on Electronic Systems and Transactions that regulates the placement of data on cloud infrastructure is a legal obstacle that cannot be compromised before data migration is carried out. Perceived Industry Pressure (E1, weight 0.290) ranks second, indicating that competitive pressures remain relevant but subordinate to regulatory certainty.

Table 6. Priority weight of environmental sub-criteria (CR = 0.020)

Rankings	Factor	E1	E2	E3	E4	Quantity	Priorities
2	E1: Perceived Industry Pressure	0,291	0,284	0,339	0,247	1,161	0,290
1	E2: Regulation Compliance	0,395	0,385	0,304	0,481	1,564	0,391
3	E3: Trading Partner's Support	0,147	0,217	0,171	0,131	0,665	0,166
4	E4: External Expertise	0,168	0,114	0,186	0,142	0,610	0,153

Table 7 shows the results of the Human dimension weighting. CIO Innovativeness (H1) dominates very strongly with a weight of 0.663 more than four times the weight of Internal Expertise (H2, 0.153). This pattern of dominance indicates that experts view the transformational leadership role of the CIO as the most determinant human factor, far beyond the technical expertise of the operational team. These findings are consistent with the digital transformation literature that emphasizes the role of *digital leadership* as a key catalyst for organizational change [8].

Table 7. Human Sub-Criterion Priority Weight (CR = 0.002)

Rankings	Factor	H1	H2	H3	Quantity	Priorities
1	H1: CIO Innovativeness	0,662	0,678	0,648	1,988	0,663
3	H2: Internal Expertise	0,146	0,149	0,163	0,459	0,153
2	H3: Prior Technology Experience	0,193	0,172	0,189	0,554	0,185

In the Business dimension, which is the most important dimension overall, Table 8 shows the dominance of Hard Financial Analysis (B1) with a weight of 0.797. The nearly 4:1 ratio between B1 and Soft Financial Analysis (B2) confirms that experts prioritize quantitative justification based on ROI and TCO over non-financial considerations. These findings are practically relevant: in the context of the manufacturing industry, IT infrastructure investment decisions must be financially accountable to the board of directors, so that *hard financial analysis* becomes the first gate that must be passed before technical implementation begins.

Table 8. Priority Weighting of Business Sub-Criteria (CR = 0.000)

Rankings	Factor	B1	B2	Quantity	Priorities
1	B1: Hard Financial Analysis	0,797	0,797	1,595	0,797
2	B2: Soft Financial Analysis	0,203	0,203	0,405	0,203

Overall, Table 9 summarizes the top CSF factors of each dimension along with their weights. The pattern that emerged from all the results of this study shows that the success of hybrid cloud data integration is not determined primarily by technical readiness, but rather by a series of non-technical prerequisites: strong financial justification (B1), assured regulatory compliance (E2), top management commitment (O1), and innovative digital leadership (H1). The technical aspect, in this case system security (T5), only becomes the focus of implementation after the four prerequisites are met.

Table 9. Summary of Top CSF Factors by Dimension

Dimensions	Weight Dimensions	Top Factors	Weight Factor	Global Ranking
Business	0,335	B1: Hard Financial Analysis	0,797	1
Environment	0,176	E2: Regulation Compliance	0,391	2
Organisasi	0,171	O1: Top Management Support	0,429	3
Technology	0,170	T5: Security	0,279	4
Humans	0,149	H1: CIO Innovativeness	0,663	5

Of the five dimensions evaluated, the Business dimension received the highest weight of 0.335. These results differ from previous cloud computing adoption studies that predominantly placed technology factors as the main determinants [5][7][10]. This difference is not surprising when considering the context of the cement industry: as a capital-intensive industry with continuous operations and a high reliance on ERP systems, any infrastructure investment decision including hybrid cloud data integration must first be financially viable. The dominance of Hard Financial Analysis (B1, 0.797) in this dimension reinforces the findings of Naveed et al. [8] about the importance of financial justification, but with a higher weight than the study, likely due to the sensitivity of the manufacturing industry to the risk of production disruptions.

Security (T5) got a weight of 0.279 and ranked first in the Technology dimension. Security has been identified as an important factor in cloud computing [5][12][13], but it has become more critical in hybrid clouds as data moves through two different infrastructures through gateway APIs, middleware, and synchronization mechanisms, each of which opens up new vulnerabilities. This means that the security challenge here is not just about protecting stored data, but also includes *data security in transit* and consistency of cross-platform access policies. Interestingly, while Security dominates the sub-criteria, the overall Technology dimension ranks fourth, indicating that technical readiness is seen as a relevant prerequisite, but not an early trigger for implementation decisions.

In the Organization dimension, Top Management Support (O1) gained a weight of 0.429, almost double the Governance (O4) in second place. The literature has long identified top management support as a key factor [7][13], but its relevance is greater in hybrid cloud because its implementation involves cross-functional coordination between IT infrastructure, information security, *compliance*, and external vendor teams simultaneously. In a manufacturing industry with tight integration between production systems and enterprises, the silo barriers between functions become real and can only be overcome with executive authority. The high weight of Governance (O4) complements this: cross-platform governance in hybrid clouds is much more complex than *on-premises* systems, requiring a clear structure from the start.

Regulation Compliance (E2, 0.391) dominates the Environment dimension, surpassing Perceived Industry Pressure (E1, 0.290) which is prevalent in other cloud adoption studies [5][10]. These findings are more in line with research examining the regulatory environment [6][11]. In Indonesia, Government Regulation No. 82/2012 on Electronic Systems and Transactions regulates the placement of data on public cloud infrastructure and is *mandatory* rather than a competitive option. For organizations operating under this kind of regulation, legal compliance is an obstacle that must be resolved earlier than technical and competitive considerations.

CIO Innovativeness (H1) dominates the Human dimension with a weight of 0.663, well above Internal Expertise (H2, 0.153) and Prior Technology Experience (H3, 0.185). The CIO's digital leadership is recognized as important in organizational transformation [8][14], but hybrid cloud provides an additional dimension: decisions about *workload placement*, vendor dependency management, and legacy system integration strategies require someone who is able to strategically connect business needs to architectural choices. The technical expertise of the operational team is required for execution, but the direction of the decision is in the hands of the CIO.

Overall, the Business–Environment–Organization–Technology–People priority order illustrates that the success of hybrid cloud data integration depends more on strategic, regulatory, and organizational readiness than on technical readiness. This pattern also justifies the TOE + HOT-fit + IS Triangle integration approach: all three have gaps that cover each other, and this study shows that all five are relevant to different degrees of importance.

Practical Implications

The weight of AHP in this study not only describes important factors, but also provides a sequence of priorities that can be used as a guide for managerial decisions.

Referring to the dominance of the Business dimension, *a business case* that includes calculations of ROI, TCO, and operational efficiency projections must be finalized before technical decisions are made [8][13]. Hybrid cloud investments that are not preceded by strong financial justification risk losing support in the middle of implementation.

Regulation Compliance as a dominant factor in the Environmental dimension requires that data classification policies and workload placement rules be established from the architecture design stage, rather than adjusting in the implementation phase considering the inherent legal consequences.

The high weight of Top Management Support and Governance suggests that organizations need to ensure active executive involvement in cross-functional coordination, not just formal approval. A clear governance structure needs to be established before the integration takes place.

On a technical level, *a workload segmentation strategy* that separates critical systems in *the private cloud* from elastic *workloads* in *the public cloud* allows organizations to balance security controls with cost efficiency simultaneously.

The dominance of CIO Innovativeness shows that investing in the development of CIO's digital leadership capabilities has a greater impact than strengthening the team's technical expertise alone. CIOs need to have the ability to manage the *trade-offs* between security, *compliance*, and agility simultaneously [8][14].

The weight of AHP produced in this study can be used directly as a managerial prioritization framework. The sequence of the Business, Environment, Organization, Technology, Human dimensions provides a sequential guide to decision-making that distinguishes AHP-based research from typical adoption studies: it not only identifies important factors, but also determines in what order managerial attention should be directed.

Theoretical Implications

This study provides four contributions to the literature on the adoption of cloud computing and information systems.

The dominance of the Business dimension provides empirical evidence that a theoretical framework focused on technology readiness is insufficient to explain hybrid cloud adoption decisions. In a context with high architectural complexity and strategic consequences, hybrid cloud adoption is more appropriately conceptualized as a strategic investment decision, rather than a technical one, a perspective that needs to be considered in the development of theoretical models going forward.

The relevance of the five dimensions of the three different frameworks provides empirical support for the integrative theoretical approach. The complementary limitations of TOE [5], HOT-fit [6], and IS Triangle [7] suggest that multi-dimensional phenomena such as hybrid cloud data integration cannot be adequately explained by a single framework.

The difference in findings with cloud adoption studies with different industry and regulatory backgrounds indicates that CSF configurations are contextual. Generalization of the CSF model across industries or jurisdictions needs to take into account variations in operational characteristics and the intensity of applicable regulations.

Methodologically, this study shows the value of the AHP approach in the IS study to produce a more operational prioritization framework. Unlike the regression or SEM approach that examines causal relationships, AHP generates priority weights that can be directly translated into managerial decision-making guidelines of relevant contributions to research that aim to generate a decision framework, rather than simply test hypotheses.

IV. CONCLUSIONS

This study identified and ranked 20 CSF factors for hybrid cloud data integration at PT XYZ using the AHP method with the integration of TOE, HOT-fit, and IS Triangle frameworks. Of the five dimensions analyzed, the Business dimension was found to be the most important (weighted 0.33), followed by Environment (0.18), Organization (0.17), Technology (0.17), and People (0.15). The top factors in each dimension are: Security (Technology), Top Management Support (Organization), Regulation Compliance (Environment), CIO Innovativeness (People), and Hard Financial Analysis (Business).

The finding that the non-technology dimension is the most important factor is a significant contribution that distinguishes this study from previous studies that generally place technical factors as the top priority. This indicates that in the context of Indonesia's cement industry, the success of hybrid cloud adoption is determined more by strategic and financial justification than by technical readiness alone.

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