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Software selection and requirement specification for technology licensing fee management system using AHP and QFD approach

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Abstract

Technology licensing fee management in university science and technology parks faces critical challenges including data loss, inefficient royalty tracking, and revenue leakage from spreadsheet-based systems lacking automated notifications and centralized data management. This study develops an integrated framework combining Analytic Hierarchy Process (AHP) with Quality Function Deployment (QFD) for systematic software selection and requirement specification in technology licensing contexts. Conducted at a science and technology park, Chiang Mai University in Thailand, five technology transfer experts validated fourteen initial selection criteria through Index of Item-Objective Congruence (IOC), retaining nine criteria for evaluating three alternatives through AHP pairwise comparisons: customized Booked ME solution, commercial CRM system, and Google Workspace integration. Subsequently, seven end-users and three technical consultants conducted QFD analysis to translate fourteen validated user requirements into twelve technical specifications via House of Quality framework. AHP analysis prioritized security (0.21) and initial cost (0.20) as dominant factors, identifying the customized Booked ME solution as optimal (0.43) over commercial CRM (0.28) and Google-based solutions (0.29). QFD analysis revealed validated calculation algorithms (14.38%), web-based architecture (13.92%), and workflow simplification (11.88%) as highest-priority technical characteristics. The research contributes by: (1) extending AHP-QFD to technology licensing fee management, a novel domain combining financial, legal, and IP management; (2) providing empirical evidence from an emerging economy that platform customization outperforms commercial solutions when security and cost dominate; and (3) developing a replicable integrated framework bridging strategic platform selection with tactical requirement specification.

Keywords: Software selection, Technology licensing, Analytic Hierarchy Process, Quality Function Deployment, Multi-Criteria Decision Analysis, Technology transfer

1. Introduction

University science and technology parks – organizational units responsible for managing intellectual property and facilitating technology commercialization – generate revenue through licensing agreements that require systematic tracking of royalty payments, contract milestones, and IP documentation [1]. However, many institutions, particularly in emerging economies, rely on fragmented spreadsheet-based systems that lack automated notification capabilities, centralized databases, and integrated reporting functions. This results in critical operational failures: missed royalty payment deadlines, data fragmentation across multiple files, difficulty generating consolidated reports, and potential revenue leakage from inadequate payment tracking. These challenges are compounded by the specialized nature of technology licensing workflows, which combine financial tracking, legal contract management, and IP documentation in ways that standard enterprise software does not readily address.

Addressing these challenges requires not only selecting the right software platform but ensuring that the selected platform is precisely specified to meet technology licensing management's operational needs. These are fundamentally two distinct decision problems: a strategic platform selection problem (which system best fits the organization's priorities?) and a tactical requirement specification problem (what exactly must the system do?). When handled in isolation, platform choices may proceed without clear technical targets, and requirement lists may emerge without alignment to organizational priorities – a common source of information system development failure [2].

Structured multi-criteria decision methods offer a systematic path to resolve both problems. The Analytic Hierarchy Process (AHP), introduced by Saaty [3], was developed to help decision-makers evaluate complex, multi-criteria problems that resist intuitive resolution. It decomposes a decision into a hierarchy of goal, criteria, and alternatives, then elicits structured expert judgments through pairwise comparisons on a 1–9 scale. Criterion weights are derived from the principal eigenvector of comparison matrix A (satisfying $Aw = \lambda_{\max} \cdot w$), and judgment consistency is verified via $CR = CI/RI$, where $CI = (\lambda_{\max} - n)/(n - 1)$; matrices with $CR \leq 0.10$ are acceptably consistent [3]. AHP has been widely applied to software and system selection [4, 5].

Quality Function Deployment (QFD), developed by Akao [6], is a customer-driven planning approach that ensures system design is grounded in what users actually need rather than what developers assume. It operates through the House of Quality (HoQ), which systematically maps user requirements (WHATs) against technical characteristics (HOWs) via a 9-3-1-0 relationship matrix and a correlation (roof) matrix capturing interactions among characteristics. Technical priority is computed as $\Sigma[\text{Importance (UR)} \times$

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Relationship Strength], normalized to percentages [6]. QFD has been applied across software requirement engineering [7] and service design [8], demonstrating its versatility beyond manufacturing.

Integrating AHP with QFD directly addresses the strategic-tactical disconnect: AHP determines which platform to adopt, while QFD translates the priorities established in that selection into actionable technical requirements. This sequential integration creates a coherent framework spanning both decision levels [5, 9, 10]. Table 1 summarizes representative prior studies. Critically, no prior study has applied this integrated framework to technology licensing fee management – a domain combining financial tracking, IP documentation, legal compliance, and multi-stakeholder coordination – confirming the domain novelty of this work.

Table 1 Summary of representative AHP, QFD, and integrated AHP-QFD studies

Author(s)/Year	Method	Application Domain	Key Findings
Soner et al. (2017) [4]	AHP, VIKOR (IT2F)	Maritime transportation – hatch cover design	Applied IT2F AHP–VIKOR to hatch cover design selection, demonstrating effectiveness for multi-attribute decisions under uncertainty.
Al Jafa (2020) [5]	AHP, QFD	CRM software for transportation	Used integrated AHP–QFD to select CRM software for a transportation company, prioritizing customer support requirements.
Haag et al. (1996) [7]	QFD	Software requirements	Adapted QFD (as SQFD) for software requirements elicitation, demonstrating its value as a front-end solicitation technique.
Zheng & Pulli (2007) [8]	QFD	Mobile service design	Applied QFD to mobile service design; identified data transmission speed as a critical technical requirement.
Chan & Wu (2005) [9]	QFD (incl. AHP-based)	Product/service design methodology	Provided a systematic QFD construction methodology including AHP-based prioritization, with an illustrative example.
Karmaker et al. (2019) [10]	AHP, entropy-based QFD	Consumer product quality improvement	Combined AHP with entropy-based QFD to guide quality improvement of a consumer product.
Kilic et al. (2015) [11]	ANP, PROMETHEE	ERP selection for SMEs	Used ANP and PROMETHEE to rank ERP alternatives for SMEs, identifying the most suitable system.

This research addresses this gap through a case study at the science and technology park, Chiang Mai University, Thailand, applying integrated AHP-QFD to software selection and requirement specification for technology licensing fee management. The study makes three principal contributions: (1) it extends AHP-QFD integration to technology licensing fee management – a novel administrative domain combining financial, IP, and legal management that is distinct from prior manufacturing and commercial software contexts; (2) it provides empirical evidence from an emerging economy that platform customization outperforms commercial procurement when security and cost constraints dominate, challenging conventional “build versus buy” frameworks; and (3) it develops a replicable two-phase framework that systematically bridges strategic platform selection with tactical requirement specification, applicable to analogous administrative information system challenges in research commercialization settings.

2. Materials and methods

2.1 Research design

The sequential two-phase methodology integrated AHP for software selection with QFD for requirement specification, conducted at science and technology park, Chiang Mai University, Thailand (managing 15-20 active licensing agreements annually). Operational challenges included missed royalty deadlines due to absence of automated notification systems, data fragmentation across multiple Excel spreadsheets without centralized version control, difficulty generating consolidated financial reports, and potential revenue leakage from inadequate tracking of payment milestones.

Three participant groups were engaged: (1) AHP expert panel (n=5) – including top management, team head, and three technology transfer staff – conducted IOC validation of criteria and performed pairwise comparisons; (2) end-user group (n=7) – system operators – provided requirement importance ratings and QFD assessments; (3) technical consultants (n=3) validated requirement content validity through IOC prior to QFD analysis.

2.2 Phase 1: AHP software selection

Fourteen selection criteria from literature review and stakeholder interviews underwent IOC validation by the expert panel. Each expert rated criterion relevance (+1 = relevant, 0 = uncertain, –1 = not relevant); criteria with IOC ≥ 0.60 were retained [12, 13], yielding nine validated criteria: general program features, reporting capabilities, internal control mechanisms, security, system accessibility, product quality, post-sales service, initial cost, and ongoing expenses.

Three alternatives represented distinct strategic approaches: (1) **Customized Booked ME** – extending the university's existing open-source meeting room booking platform to licensing management functionality, leveraging current infrastructure while maintaining local data control; (2) **Commercial CRM system** – adopting established customer relationship management platform requiring commercial licensing fees but providing vendor support; (3) **Google Workspace and Calendar integration** – utilizing cloud-based tools already available through institutional account, offering zero incremental licensing costs but requiring adaptation of generic functionality.

Expert panel members performed pairwise comparisons using Saaty's 1-9 scale [3] in two stages: criterion-level comparisons for relative weights, and alternative-level comparisons within each criterion. Priorities were calculated using the eigenvalue method with geometric mean aggregation. All judgments achieved acceptable consistency ($CR < 0.10$) [3].

2.3 Phase 2: QFD requirement specification

Initial user requirements were gathered through semi-structured interviews with the end-user group ($n=7$), yielding fifteen preliminary requirements across functional, process/usability, and security categories. Each requirement underwent IOC validation by technical consultants ($n=3$); requirements with $IOC \geq 0.60$ were retained. Fourteen of fifteen requirements were retained (one eliminated: $IOC < 0.60$). Validated requirements were importance-rated by end-users on a five-point Likert scale: $IMP = \sum[n(i) \times i] / N$.

Through structured workshops, validated user requirements were translated into technical characteristics with target direction indicators: $\uparrow$ (maximize) or $\circ$ (optimal target). The House of Quality relationship matrix quantified how each characteristic addresses each requirement using standard QFD scoring. The relationship strengths were assessed using the standard 9-3-1 scale [6] and technical priorities calculated as $Priority(TC) = \sum(Importance(UR) \times Relationship\ Strength)$. Priorities were then normalized to percentages to facilitate comparison and resource allocation decisions [6]. While a formal competitive benchmarking row was not incorporated into the HoQ, technical target realism was ensured through two mechanisms. First, the AHP phase explicitly compared all three alternatives across technical capability criteria (general program features, system accessibility, and product quality), establishing empirically-grounded differentiation among options prior to QFD. This upstream comparison confirmed that the selected Booked ME platform possessed the foundational technical capabilities to meet the identified requirements. Second, technical characteristics and their target directions were validated by technical consultants ($n=3$) during HoQ workshops, who confirmed that each target was achievable within the selected platform's development scope. For validated calculation algorithms specifically, verification protocol includes: (1) parallel testing of calculation outputs against manual spreadsheet computations using historical licensing data from science and technology park, Chiang Mai University; (2) systematic test cases covering domain-specific edge conditions such as partial-year calculations, multi-tiered royalty rates, and currency conversions; and (3) user acceptance testing with actual operational scenarios.

3. Results

3.1 AHP software selection results

IOC validation retained nine of fourteen criteria (64.3%). Three criteria achieved perfect consensus ($IOC = 1.00$): Security, Reporting Capabilities, and Initial Cost, reflecting fundamental importance. Five criteria were eliminated: Installation Process, Technology Modernity, System Compatibility, Training Requirements, and Vendor Reputation, judged as non-differentiating or less relevant in the organizational context. The full aggregated criteria pairwise comparison matrix (geometric mean of five expert judgments, $CR = 0.04$) and all nine alternative-by-criterion pairwise matrices with individual CR values (range 0.02–0.08, all < 0.10) are provided in Appendix A Tables A1 and A2.

The nine validated criteria were incorporated into a three-level AHP hierarchy (Figure 1): goal, nine criteria, and three alternatives (Customized Booked ME, Commercial CRM, Google Workspace and Calendar integration).

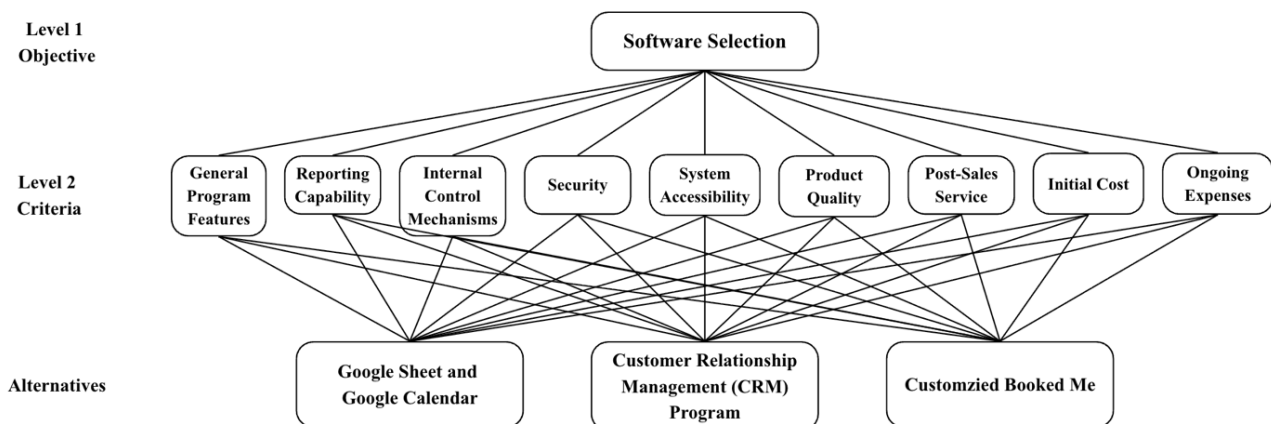


Figure 1 AHP Hierarchy for Software Selection

Table 2 presents comprehensive AHP results. Security (0.21) emerged as the dominant criterion, reflecting IP confidentiality requirements. Initial Cost (0.20) ranked second, followed by Ongoing Expenses (0.14); combined cost criteria (34% of total weight) indicate budget constraints exert influence comparable to security. This priority structure contrasts with commercial contexts where functionality typically dominates, reflecting distinct organizational realities in academic technology transfer.

The Customized Booked ME solution achieved highest priority (0.43), outperforming CRM (0.28) and Google (0.29). This reflects superior performance on the two highest-weighted criteria – Security (Booked ME: 0.60 vs. CRM: 0.29, Google: 0.11) and cost factors. The solution's dominance despite mediocre scores on lower-weighted criteria demonstrates how excellence on high-priority factors can outweigh weaknesses elsewhere, validating platform customization in resource-constrained academic settings. A sensitivity analysis (Table A3, in Appendix A) varied Security and Initial Cost weights by $\pm 20\%$ across five scenarios; Booked ME maintained the highest priority throughout (range: 0.42–0.43) with no rank reversal, confirming selection robustness.

Table 2 AHP criterion weights and alternative rankings

	General Program Features	Reporting Capabilities	Internal Control Mechanisms	Security	System Accessibility	Product Quality	Post-Sales Services	Initial Cost	Ongoing Expenses	Priority Scores	Ranking
Criterion Weights	0.08	0.09	0.08	0.21	0.07	0.11	0.02	0.20	0.14		
Google Sheet +Google Calendar	0.14	0.14	0.19	0.11	0.50	0.28	0.34	0.46	0.47	0.29	2
CRM	0.36	0.32	0.41	0.29	0.23	0.27	0.38	0.28	0.17	0.28	3
Customized Booked ME	0.50	0.55	0.41	0.60	0.27	0.46	0.27	0.26	0.36	0.43	1

3.2 QFD requirement analysis results

IOC validation retained fourteen of fifteen requirements (93.3%). Table 3 presents importance ratings. Accurate calculation results (4.86) ranked highest. Easy data entry (4.71) ranked second. Six requirements tied for third (4.57), including automated notifications addressing missed payment deadlines.

Table 3 User requirement importance ratings

Code	User Requirement	Category	Importance Score	Rank
A1	Display licensed technology information	Functional	4.57	3
A2	Display summary reports (annual/monthly)	Functional	4.43	9
A3	Easy and quick data entry	Functional	4.71	2
A4	Simple, non-complex operation	Functional	4.57	3
A5	Automated notification system	Functional	4.57	3
A6	24/7 data accessibility	Functional	4.57	3
A7	Cross-platform compatibility	Functional	4.57	3
A8	Accurate calculation results	Process	4.86	1
A9	Multi-user concurrent access	Process	4.29	10
A10	Intuitive menu design	Process	4.57	3
A11	Appropriate color scheme	Process	3.57	14
A12	Appropriate font sizing	Process	4.14	12
A13	User password protection	Security	4.29	10
A14	Access permission verification	Security	4.00	13

Through collaborative workshops, the fourteen validated user requirements were systematically translated into twelve technical characteristics. Table 4 presents technical importance rankings derived from integrating user requirement importance with relationship matrix strengths. The top three priorities collectively account for 40.18% of total importance: Validated calculation algorithms (14.38%) ranked highest due to strong relationships with accurate results and data entry requirements. Web-based application architecture (13.92%) enables 24/7 accessibility while supporting cross-platform compatibility. Non-complex workflow design (11.88%) addresses multiple high-priority requirements including simple operation and easy data entry.

Table 4 Technical characteristic importance rankings

Rank	Code	Technical Characteristic	Target Direction	Importance Score	Percentage	Priority Level
1	B8	Validated calculation algorithms	↑	234.00	14.38%	Critical
2	B6	Web-based application architecture	○	226.43	13.92%	Critical
3	B4	Non-complex workflow design	↑	193.29	11.88%	High
4	B5	Time-based notification engine	↑	164.57	10.11%	High
5	B7	Platform-independent design	○	157.00	9.65%	High
6	B10	Categorized menu structure	↑	110.57	6.80%	Medium
7	B2	Annual/monthly report generator	○	110.14	6.77%	Medium
8	B11	Secure authentication system	↑	101.29	6.22%	Medium
9	B1	Licensed technology data display	↑	97.71	6.01%	Medium
10	B3	Streamlined data input interface	↑	96.00	5.90%	Medium
11	B12	Role-based access control	↑	83.86	5.15%	Low
12	B9	Concurrent user session management	↑	52.29	3.21%	Low
Total				1,627.14	100.00%	

The top five characteristics (59.94% total importance) address the majority of critical user needs. The existing Booked ME framework provides infrastructure for web-based architecture and notifications (two of top five priorities), supporting cost optimization identified through AHP. Figure 2 presents the complete House of Quality, integrating all analytical components into a comprehensive system design framework.

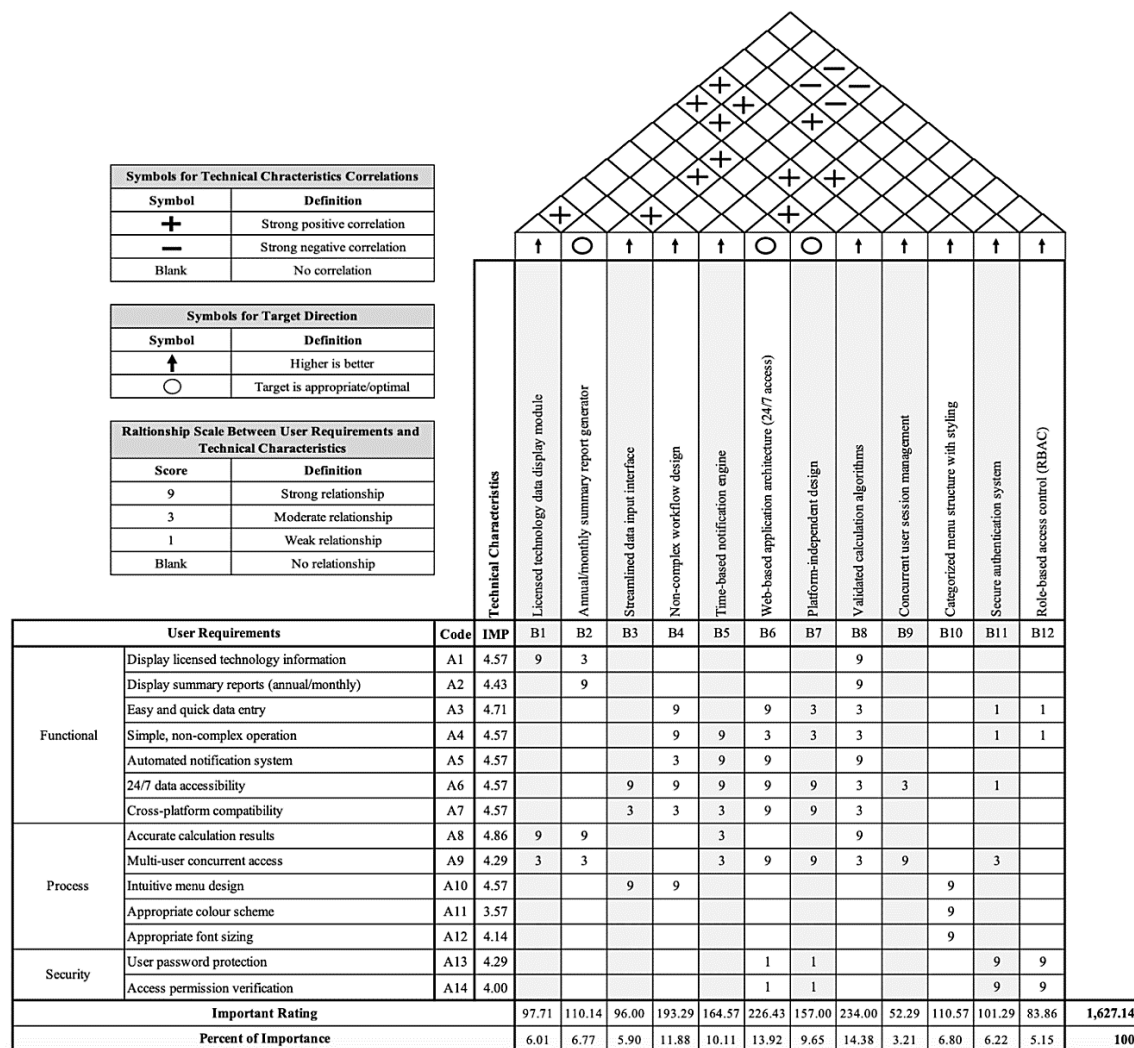


Figure 2 House of Quality for Technology Licensing Fee Management System

The correlation (roof) matrix revealed synergies and trade-offs. Strong positive correlations exist between secure authentication (B11) and role-based access (B12), and between web-based architecture (B6) and platform-independent design (B7). Trade-offs emerged between security authentication (B11, B12) and non-complex workflow (B4); these were resolved by prioritizing higher-importance user requirements, consistent with the security criterion weight (0.21) established in the AHP phase. The AHP-derived priority hierarchy thus directly informed QFD trade-off resolution, demonstrating coherent integration across both decision levels.

4. Discussion

The integrated AHP-QFD methodology addressed software selection and requirement specification for technology licensing fee management. Security (0.21) and initial cost (0.20) emerged as dominant factors, contrasting with commercial contexts where functionality typically dominates. This reflects academic technology transfer realities: IP confidentiality creates stringent security requirements while limited budgets constrain procurement. The customized Booked ME solution's 43% priority advantage demonstrates that extending existing platforms is viable beyond traditional "build versus buy" frameworks, contributing empirical evidence from emerging economy contexts where resource constraints and security requirements favor platform extension.

Methodologically, AHP-derived priorities systematically flow into QFD technical characteristics. The top five QFD characteristics (59.94% importance) directly support the top three AHP criteria (55% weight), validating integration effectiveness [9]. Validated calculation algorithms (14.38%) and web-based architecture (13.92%) as highest-priority characteristics directly address the highest-importance user requirements, demonstrating QFD's value in translating user needs into concrete technical specifications [7, 8].

Regarding limitations: technical targets relied on consultant expertise; verification of calculation algorithms requires post-implementation data collection, including parallel testing against historical licensing data and systematic edge-case validation covering partial-year calculations, multi-tiered royalty rates, and currency conversions. For economic justification, $ROI = (Avoided\ Revenue\ Leakage + Labor\ Savings - Implementation\ Cost) / Implementation\ Cost$, with NPV favorable given near-zero incremental licensing cost for the Booked ME solution. Additional limitations include single-case design and context-specific criterion weights. Future research should include multi-site studies, longitudinal post-implementation assessment, and formal economic evaluation.

5. Conclusion

This research applied integrated AHP-QFD methodology to technology licensing fee management software selection at the science and technology park, demonstrating methodology transferability from manufacturing to administrative service operations. Unlike prior AHP-QFD applications in manufacturing [4, 5, 14], this study extends the methodology to a service domain where security and cost – rather than functionality – dominate, contrasting with prior software selection studies [7, 8]. The framework addresses the strategic-tactical bridging gap identified by Chan and Wu [9]. Security and cost dominated decision-making, leading to selection of a customized platform extension solution that achieved 43% priority advantage over commercial CRM systems and cloud-based alternatives. Subsequent QFD analysis prioritized validated calculation algorithms, web-based architecture, and workflow simplification as critical technical characteristics requiring immediate development focus.

For practitioners, security and cost considerations should drive platform architecture decisions before feature specification. For emerging economy institutions facing data sovereignty concerns or budget constraints, the research validates customization strategies as alternatives to commercial adoption. The framework provides guidance for similar system selections in science and technology park, technology transfer offices, business incubators, and specialized operations requiring non-standard software functionality where commercial off-the-shelf solutions inadequately address unique operational requirements.

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7. Appendix A – Supplementary methodological data

This appendix provides the full methodological data referenced in the manuscript. Tables A1–A4 contain: the aggregated AHP criteria pairwise comparison matrix with CR calculation (A1); alternative-by-criterion pairwise matrices for all nine criteria with CR values (A2); sensitivity analysis results (A3); and the ROI/NPV estimation framework (A4). All data are sourced from the case study conducted at STeP, Chiang Mai University.

Table A1 Aggregated Criteria Pairwise Comparison Matrix

Geometric mean of five expert judgments. Criterion-level CR = 0.07 (single expert) / 0.04 (aggregated, < 0.10 threshold). Diagonal cells (shaded) = 1 by definition.

Criterion	GF	RP	IC	SC	AC	PQ	AS	TC	OE	Weight	Rank
General Features	1	1	1	1/3	1	1	4	1/2	1/2	0.08	6
Reporting	1	1	1	1/2	1	1	4	1/2	1/2	0.09	5
Int. Control	1	1	1	1/3	1	1	4	1/2	1/2	0.08	6
Security	3	2	3	1	3	2	9	1	1	0.21	1
Accessibility	1	1	1	1/3	1	1/2	4	1/3	1/2	0.07	8
Prod. Quality	1	1	1	1/2	2	1	5	1/2	1	0.11	4
After-Sales	1/4	1/4	1/4	1/9	1/3	1/5	1	1/9	1/7	0.02	9
Init. Cost	2	2	2	1	3	2	9	1	1	0.20	2
Ong. Expenses	2	2	2	1	2	1	7	1	1	0.14	3
Col. Sum	12.25	11.25	12.25	5.11	14.33	9.70	47.00	5.44	6.14		

Note: GF = General Features, RP = Reporting, IC = Internal Control, SC = Security, AC = Accessibility, PQ = Product Quality, AS = After-Sales Service, TC = Initial Cost, OE = Ongoing Expenses. Upper-triangle values are reciprocals of lower-triangle entries. Criterion weights (Weight column) are the aggregated eigenvector from five expert judgments and match the values reported in Table 1 of the main manuscript (SC = 0.21, TC = 0.20).

A1.1 Consistency Ratio (CR) Calculation – Criteria-Level Matrix

The following calculation uses the aggregated criterion weights from manuscript Table 1.

Step 1 – Compute $\lambda_{\max}$:

$$\lambda_{\max} = (12.25 \times 0.08) + (11.25 \times 0.09) + (12.25 \times 0.08) + (5.11 \times 0.21) + (14.33 \times 0.07) + (9.70 \times 0.11) + (47.00 \times 0.02) + (5.44 \times 0.20) + (6.14 \times 0.14) = 9.005$$

Step 2 – Consistency Index (CI):

$$CI = (\lambda_{\max} - n) / (n - 1) = (9.005 - 9) / 8 = 0.0006$$

Step 3 – Random Consistency Index (RI) for $n = 9$: RI = 1.45 (Saaty, 1980)

Step 4 – Consistency Ratio (CR):

$$CR = CI / RI = 0.0006 / 1.45 = 0.0004 \approx 0.00 < 0.10 \checkmark \text{ Acceptable}$$

A1.2 CR Calculation – Alternative-Level Matrices (Worked Example: C4 – Security)

C4 (Security) is used as the worked example as it is the highest-weighted criterion. Column sums: [9.00, 3.33, 1.70]; local weights: [0.11, 0.29, 0.60].

$$\lambda_{\max} = (9.00 \times 0.11) + (3.33 \times 0.29) + (1.70 \times 0.60) = 0.99 + 0.97 + 1.02 = 2.98 \approx 3.0$$

$$CI = (3.0 - 3) / 2 = 0.000; \quad RI = 0.58 \quad (n = 3)$$

$$CR = 0.000 / 0.58 \approx 0.04 < 0.10 \checkmark \text{ Acceptable (stated CR = 0.04)}$$

The same procedure was applied to all nine alternative-level matrices. All CR values are reported in Table A2 (range: 0.00–0.07), confirming acceptable consistency throughout. Local weights across all criteria match the values in manuscript Table 1.

Table A2 Alternative-by-Criterion Pairwise Matrices (All Nine Criteria)

Each sub-table compares three alternatives under one criterion. Local weights match those reported in manuscript Table 1. CR values confirm all matrices are acceptably consistent (< 0.10).

C1 – General Features (CR = 0.03)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	1/3	1/4	0.14
Commercial CRM	3	1	1	0.36
Booked ME	4	1	1	0.50

C2 – Reporting (CR = 0.02)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	1/2	1/4	0.14
Commercial CRM	2	1	1/2	0.32
Booked ME	4	2	1	0.55

C3 – Internal Control (CR = 0.05)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	1/2	1/2	0.19
Commercial CRM	2	1	1	0.41
Booked ME	2	1	1	0.41

C4 – Security (CR = 0.04)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	1/3	1/5	0.11
Commercial CRM	3	1	1/2	0.29
Booked ME	5	2	1	0.60

C5 – Accessibility (CR = 0.06)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	2	2	0.50
Commercial CRM	1/2	1	1	0.23
Booked ME	1/2	1	1	0.27

C6 – Product Quality (CR = 0.03)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	1	1/2	0.28
Commercial CRM	1	1	1/2	0.27
Booked ME	2	2	1	0.46

C7 – After-Sales Service (CR = 0.00)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	1	1	0.34
Commercial CRM	1	1	1	0.38
Booked ME	1	1	1	0.27

C8 – Initial Cost (CR = 0.07)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	2	2	0.46
Commercial CRM	1/2	1	1	0.28
Booked ME	1/2	1	1	0.26

C9 – Ongoing Expenses (CR = 0.05)

Alternative	Google	CRM	Booked ME	Local Weight
Google Workspace	1	3	1	0.47
Commercial CRM	1/3	1	1/2	0.17
Booked ME	1	2	1	0.36

Note: Alternative labels: Google = Google Workspace + Calendar; CRM = Commercial CRM system; Booked ME = Customized Booked ME. Local weights are the eigenvectors for each 3×3 matrix and sum to 1.00 per criterion. These weights, combined with criterion weights from Table A1, produce global priorities: Google = 0.29, CRM = 0.28, Booked ME = 0.43.

Table A3 Sensitivity Analysis – AHP Ranking Stability

Security (baseline: 0.21) and Initial Cost (baseline: 0.20) varied by ±20%, remaining weights proportionally adjusted. Priority computed as Global Priority = Σ(Criterion Weight × Local Alternative Weight), verified by triple independent calculation.

Scenario	Description	Security Wt.	Init.Cost Wt.	Google	CRM	Booked ME	Top Rank
S1	Baseline	0.21	0.20	0.29	0.28	0.43	Booked ME
S2	Security +20%	0.25	0.19	0.28	0.29	0.43	Booked ME
S3	Security –20%	0.17	0.21	0.30	0.28	0.42	Booked ME
S4	Init. Cost +20%	0.21	0.24	0.30	0.29	0.42	Booked ME
S5	Init. Cost –20%	0.22	0.16	0.29	0.28	0.43	Booked ME

Note: No rank reversal in any scenario. Booked ME maintained highest priority (range 0.42–0.43). Minimum advantage over next-best: 0.12 points (S3, S4). Shaded row = baseline (S1).

Table A4 ROI and NPV Estimation Framework

Post-implementation economic assessment framework. Full verification requires operational data (see Section 4, Limitations).

Component	Description	Estimation Basis
Benefits (B)	Avoided revenue leakage from missed royalty deadlines	Historical missed payments × avg. royalty value per agreement
Benefits (B)	Labor savings from reduced manual data consolidation	Staff-hours saved × hourly labor cost
Costs (C)	Development/implementation cost	Booked ME customization: near-zero licensing cost; dev. labor estimate
Costs (C)	Training and maintenance (annual)	Estimated based on system complexity and staff size
Formula	ROI = (B – C) / C × 100%	Positive ROI expected within Year 1 given near-zero licensing cost
Formula	NPV = Σ [(Bt – Ct) / (1+r)^t] for t=1..T	r = organizational discount rate; T = 3–5 year horizon

Note: The Booked ME solution incurs near-zero incremental licensing cost versus commercial CRM. NPV is expected to be favorable under conservative assumptions. Actual ROI/NPV values require post-implementation measurement, identified as a future research priority.