

The Asymmetry of System Compatibility: Advanced Tools and PMO Effectiveness in Construction Projects

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Abstract— Advanced project management tools are widely expected to improve the effectiveness of project management offices (PMOs) in construction, yet the conditions under which these tools deliver value remain poorly specified, and the part played by system compatibility has rarely been isolated. Drawing on the technology–organisation–environment framework, this study examines how compatibility, alongside eight technological, organisational and environmental conditions, shapes PMO effectiveness in Saudi Arabian construction projects. Survey data from 408 practitioners were analysed using partial least squares structural equation modelling, complemented by fuzzy-set qualitative comparative analysis and importance–performance map analysis. The nine conditions explained 77.0% of the variance in PMO effectiveness. Compatibility returned the largest coefficient among the technological conditions ($\beta = .215$) and the second largest overall, behind PMO structure. Configurational analysis revealed an asymmetry that the regression results conceal: the only configuration consistently sufficient for high effectiveness combined compatibility with ease of use and relative advantage, whereas low effectiveness arose only when all three were absent, so the absence of compatibility alone never produced failure. Partial technology bundles, covering 190 cases, were sufficient for neither outcome. The failure pattern held across every calibration and threshold examined, while the indispensability of compatibility to success held under conventional thresholds but not under more lenient ones. Compatibility also combined high importance with below-average performance. The findings are translated into a three-step screening procedure for PMO tool selection.

Keywords— Advanced project management tools, Construction projects, Fuzzy-set qualitative comparative analysis, PMO effectiveness, System compatibility, Technology–organisation–environment framework

I. INTRODUCTION

Project management offices in construction are increasingly built around advanced digital tools. Scheduling platforms, cost-control systems, document-management environments and building information models are procured on the expectation that they will allow the PMO to consolidate information, standardise processes and monitor delivery across the many organisations that a construction project assembles.

The expectation is only intermittently met. PMOs continue to struggle to demonstrate their contribution to delivery outcomes, and a recurring explanation is that tools adopted at considerable cost are used partially, inconsistently, or not at all [1], [2].

Among the characteristics that determine whether a tool delivers value, compatibility occupies an unusual position. It describes the fit between a tool and the systems, workflows and working practices that organisations already operate. Construction projects are executed by organisations assembled anew for each undertaking, each holding separate digital systems, commercial interests and professional routines, and the PMO must integrate their information without commanding their resources [3], [4]. Under these conditions a tool that cannot be reconciled with existing practice imposes integration costs, duplicate data entry and workaround procedures that erode the very benefits for which it was procured.

The digitalisation literature in construction has documented these costs extensively, generally treating compatibility as a technical matter of data standards and interfaces [5], [6]. Less attention has been paid to how compatibility combines with the other attributes of a tool. A tool may be easy to use and offer clear advantages over prior practice yet still fail to fit the organisations that must use it; another may fit existing systems well while offering little advantage. Whether compatibility contributes to PMO effectiveness independently of these other attributes, or only in combination with them, is a question that the dominant analytical approach cannot answer. Regression estimates the average net contribution of each condition; it cannot establish whether the combinations producing good outcomes are the mirror image of those producing poor ones [7], [8].

The Saudi construction sector supplies a setting in which these questions carry practical weight. The Vision 2030 portfolio has generated giga-projects assembling large numbers of consultants, contractors and specialist firms under compressed schedules, with advanced tools adopted rapidly and often without the integration lead time that longer-established working relationships permit [9], [10].

This study accordingly asks three questions. How strongly does compatibility contribute to PMO effectiveness relative to the other technological, organisational and environmental conditions identified by the technology–organisation–environment framework? Are the configurations of technological conditions sufficient for high PMO effectiveness the inverse of those sufficient for low effectiveness? And where should managerial attention be concentrated, given both the importance of each condition and its current level of performance?

The contribution is fourfold. Empirically, the study establishes compatibility as the technological condition with the largest coefficient in a nine-condition model explaining most of the variance in PMO effectiveness. Theoretically, it identifies an asymmetry between success and failure: compatibility forms part of the only technology configuration consistently sufficient for high effectiveness, yet its absence alone never produces low effectiveness, which requires all three technological conditions to be absent together. Methodologically, it shows that this asymmetry, and the indeterminate outcomes of partial technology bundles, are invisible to symmetric estimation and require set-theoretic analysis to detect. Practically, it converts these findings into a three-step screening procedure for selecting and configuring advanced tools in PMO settings.

II. LITERATURE REVIEW AND HYPOTHESES

A. PMO Effectiveness in Construction Projects

PMO effectiveness has proved persistently difficult to establish, and the difficulty is conceptual as much as empirical. Early treatments equated effectiveness with the delivery of PMO functions, an approach that measures activity rather than contribution. More recent work conceptualises effectiveness as the PMO's demonstrable contribution to scheduling, cost estimation, risk management, resource allocation and project success [11], [2]. The shift reframes the PMO as an organisational capability whose value is realised through use rather than through existence, and it accounts for the recurring observation that structurally similar PMOs produce markedly different outcomes [1].

Advanced tools sit at the centre of this capability. A PMO that cannot consolidate schedule, cost and risk information across the organisations delivering a project cannot perform its integrating function, and the tools through which that consolidation occurs therefore condition the effectiveness the PMO can achieve [12], [13].

B. Advanced Tools Within the Technology–Organisation–Environment Framework

The technology–organisation–environment framework organises the conditions shaping organisational technology adoption into three contexts: the characteristics of the technology, the conditions of the adopting organisation, and the external environment in which it operates. Its application to construction has expanded considerably, explaining the adoption of building information modelling and other digital platforms [14], [10]. Within the technological context, three characteristics recur. Ease of use concerns the effort a tool demands of its users; relative advantage concerns the benefit it offers over prior practice; and compatibility concerns its consistency with existing systems, workflows and values.

These characteristics are usually estimated as parallel predictors, each assumed to contribute to outcomes independently of the others. That assumption deserves scrutiny. Implementation studies in construction indicate that tools deliver their benefits only when they are absorbed into routine practice, and that absorption depends on several attributes being present together rather than on any one in isolation [15], [16]. A highly advantageous tool that disrupts established routines may be resisted or worked around; a compatible tool that offers little advantage may be adopted without changing anything of consequence [17].

C. System Compatibility as the Fit Between Tools and Practice

Compatibility failures between advanced tools and the organisations expected to use them have been documented extensively, and their costs are conventionally expressed in terms of rework, data re-entry and information loss [18], [5]. The dominant framing treats the problem as one of technical standards, with solutions sought in common data formats and integration protocols. Evidence from implementation suggests that this framing understates the difficulty: tools that are technically interoperable may still fail in practice where they disrupt established workflows or require organisations to abandon systems in which they hold accumulated competence [19].

This distinction between technical alignment and workflow compatibility matters for how compatibility should be measured and theorised. Measured technically, compatibility is a property of software. Measured as the fit between a deployed tool and the practices of the organisations expected to use it, compatibility becomes a property of the relationship between technology and its organisational context, and its consequences depend on how that fit combines with the other attributes of the tool.

D. Organisational and Environmental Conditions

The organisational context is represented here by top management support, PMO structure and PMO maturity, conditions that the PMO literature consistently identifies as consequential [11], [1]. Executive sponsorship legitimates PMO authority and releases resources; structural positioning determines whether the PMO can convene, decide and escalate; maturity reflects accumulated process capability.

The environmental context comprises competitive pressure, the regulatory environment and government policy and support. In the Saudi setting these conditions carry unusual weight, since the state acts concurrently as regulator, principal client and strategic sponsor of the construction programme [9], and policy instruments shape the implementation of digital tools directly [20].

E. Hypotheses and Configurational Proposition

Each condition is expected to contribute positively to PMO effectiveness. Within the technological context, compatibility is expected to exert the strongest effect, since a tool that fits existing systems and workflows lowers the integration burden for every organisation that must use it, whereas ease of use and relative advantage principally affect the experience of those already using it [14], [6].

H1: Ease of use (H1a), relative advantage (H1b) and compatibility (H1c) positively influence PMO effectiveness, with compatibility exerting the strongest technological effect.

H2: Top management support (H2a), PMO structure (H2b) and PMO maturity (H2c) positively influence PMO effectiveness.

H3: Competitive pressure (H3a), the regulatory environment (H3b) and government policy and support (H3c) positively influence PMO effectiveness.

Symmetric estimation cannot test whether compatibility contributes differently to success and to failure. A configurational proposition is therefore advanced alongside the hypotheses.

P1: Compatibility plays an asymmetric part in the technology configurations sufficient for high and low PMO effectiveness: its presence features in configurations sufficient for high effectiveness, whereas its absence alone is not sufficient for low effectiveness.

The conceptual model is presented in Fig. 1.

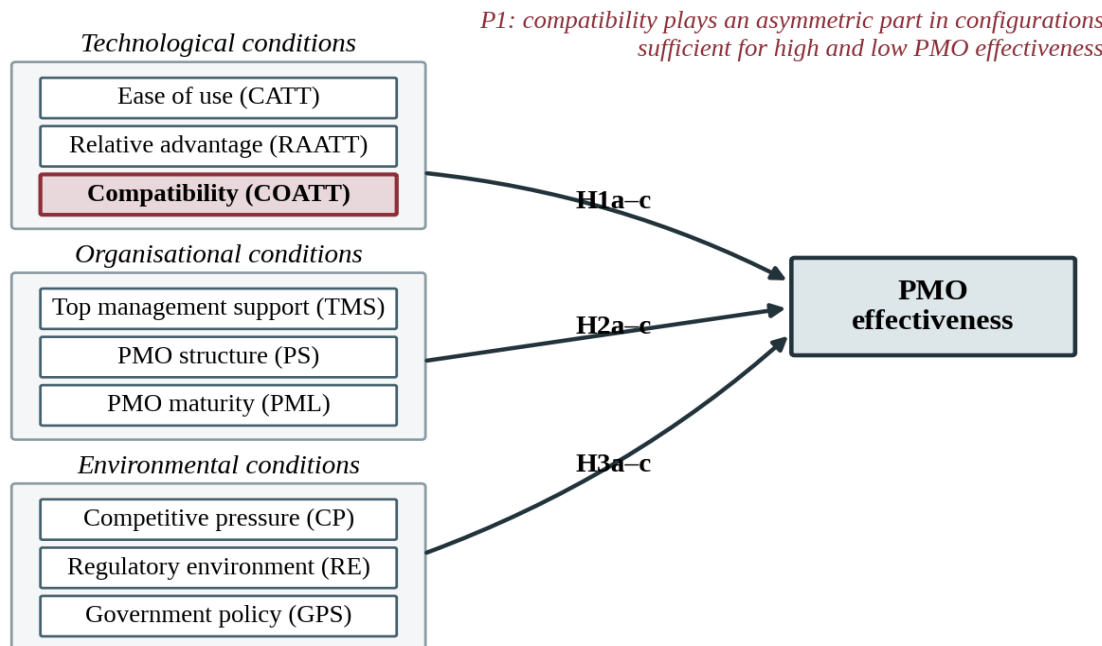


Fig. 1. Conceptual model: nine technology–organisation–environment conditions as direct antecedents of PMO effectiveness, with the configurational proposition P1. Source: Authors.

III. METHODOLOGY

A. Sample and Data Collection

A cross-sectional survey was administered to construction professionals with direct experience of working with a PMO on projects in Saudi Arabia, confirmation of such experience serving as a screening requirement. All questionnaire items were mandatory, yielding 507 complete responses with no missing data.

Records were then screened for identical response patterns across the substantive items. The audit used substantive data alone, making no use of demographic similarity or respondent identity, and therefore establishes exact pattern duplication without demonstrating repeated participation. Ninety-five repeated-pattern clusters encompassing 194 records were identified. Retaining one record per cluster removed 99 pattern-sharing records and produced 408 analytical cases, a precaution against the deflated standard errors that duplicated patterns would otherwise produce [21].

Respondents were experienced and senior: 91.2% reported at least ten years in the sector, 53.2% held a postgraduate qualification, and the sample comprised engineers (40.4%), project managers (37.7%) and directors (21.8%). Consulting firms employed 60.8% of respondents and contractors 29.7%, and 93.1% worked in organisations employing more than 250 people.

B. Measures

All constructs were measured reflectively on five-point Likert scales, with items adapted from instruments established in construction settings [14], [18]. Compatibility was measured with six items addressing fit with existing systems, workflows and working practices. Ease of use and relative advantage were measured with six items each, top management support with five, PMO structure and PMO maturity with four each, and competitive pressure, the regulatory environment and government policy and support with three each. PMO effectiveness was measured with ten items covering scheduling, cost estimation, risk management, resource allocation and project success. In total, 50 indicators entered the model.

One ease-of-use item stating that tool implementation is a complex process was reverse-scored, so that higher scores on that construct denote greater ease, equivalently lower perceived complexity.

C. Analytical Approach

Partial least squares structural equation modelling was selected as the primary estimator, given the number of conditions estimated simultaneously, the study's explanatory and predictive orientation, and the distributional properties of the data [22]. Mardia's test indicated significant multivariate skewness across the 50 indicators ($\chi^2 = 25,987.81$, $df = 22,100$, $p < .001$), a condition unfavourable to maximum-likelihood estimation. The model specified direct paths from all nine conditions to PMO effectiveness and was estimated with the path weighting scheme, a maximum of 3,000 iterations and a stop criterion of 10^{-7} ; the algorithm converged after four iterations. Inference rested on 5,000 bootstrap resamples with two-tailed percentile confidence intervals at $\alpha = .05$.

Fuzzy-set qualitative comparative analysis examined the technology domain configurationally. Construct scores were calibrated with the direct method using anchors at 2.00 (fully out), 3.05 (crossover) and 4.00 (fully in); the crossover was set marginally above the scale midpoint because between 12 and 47 respondents scored exactly 3.00 depending on the construct, and anchoring at 3.00 would have assigned those cases ambiguous memberships of precisely .50. Truth tables used a frequency threshold of 5, a raw consistency threshold of .80 and a PRI consistency threshold of .70 [7]. Robustness was examined under an alternative crossover of 3.001 and across alternative frequency, consistency and PRI thresholds. Importance-performance map analysis combined each condition's total effect with its rescaled performance score to locate managerial priorities [23].

Common method variance was assessed diagnostically rather than presumed absent. An unrotated single-factor solution on the 50 indicators accounted for 31.55% of total variance, so no general factor dominated; discriminant validity was satisfied with a maximum heterotrait-monotrait ratio of .659; and the structural coefficients ranged from .024 to .221 rather than clustering at a common inflated level. These indications are convergent rather than conclusive, since no post-hoc test establishes the absence of method bias [24].

D. Ethical Considerations

The study involved adult professional respondents and collected no personally identifying information. It was conducted in accordance with the ethical guidelines of MSU Ethics Committee.

Participation was voluntary, respondents were informed of the study's purpose before beginning the questionnaire, and informed consent was obtained from all participants prior to data collection. Responses were analysed in aggregate, and no individual or organisation is identifiable in the reported results.

Internal consistency was established on three coefficients rather than defended on one: Cronbach's alpha ranged from .834 to .942, rho_A from .837 to .943, and composite reliability from .894 to .951, with average variance extracted between .651 and .770 [25]. Compatibility, the construct of principal interest, returned loadings between .788 and .840, alpha of .895, composite reliability of .920 and average variance extracted of .656. Table 1 reports the assessment.

IV. RESULTS

A. Measurement Model

All 50 outer loadings exceeded the .708 reference, ranging from .772 to .900.

TABLE I
MEASUREMENT MODEL ASSESSMENT

Construct	Items	Loading range	Alpha	rho_A	rho_c	AVE
Ease of use (CATT)	6	.781–.863	.905	.913	.926	.677
Relative advantage (RAATT)	6	.778–.849	.907	.909	.928	.682
Compatibility (COATT)	6	.788–.840	.895	.898	.920	.656
Top management support (TMS)	5	.790–.831	.866	.867	.903	.651
PMO structure (PS)	4	.832–.881	.872	.873	.913	.723
PMO maturity (PML)	4	.804–.843	.842	.846	.894	.678
Competitive pressure (CP)	3	.861–.869	.834	.837	.900	.750
Regulatory environment (RE)	3	.841–.894	.837	.852	.902	.754
Government policy and support (GPS)	3	.861–.900	.850	.855	.909	.770
PMO effectiveness (PE)	10	.772–.843	.942	.943	.951	.659

Source: Authors.

Discriminant validity was assessed primarily through the heterotrait–monotrait ratio, which is more sensitive to validity problems in composite-based models than the Fornell–Larcker comparison [26]. All 45 values fell between .244 and .659, the largest for the pair formed by PMO structure and PMO effectiveness, well below the conservative .85 reference. Outer-model variance inflation factors ranged from 1.716 to 2.928 and inner-model values from 1.402 to 1.579, below the conservative reference of 3,

so neither indicator redundancy nor predictor collinearity distorts the estimates.

B. Structural Model

The nine conditions accounted for 77.0% of the variance in PMO effectiveness (adjusted $R^2 = .765$); the narrow gap between the two indicates that the explanatory power is not an artefact of model complexity. Eight of the nine hypothesised paths were supported, as Table 2 reports.

TABLE II
STRUCTURAL MODEL RESULTS

Hyp.	Path	β	SD	t	p	95% CI	f ²	Decision
H1a	CATT → PE	.072	.031	2.323	.020	[.009, .131]	.014	Supported
H1b	RAATT → PE	.207	.027	7.553	< .001	[.152, .259]	.121	Supported
H1c	COATT → PE	.215	.031	6.852	< .001	[.156, .276]	.127	Supported
H2a	TMS → PE	.024	.032	0.762	.446	[-.039, .086]	.002	Not supported
H2b	PS → PE	.221	.031	7.026	< .001	[.157, .282]	.135	Supported
H2c	PML → PE	.197	.031	6.331	< .001	[.136, .257]	.120	Supported
H3a	CP → PE	.140	.029	4.872	< .001	[.083, .196]	.060	Supported
H3b	RE → PE	.085	.030	2.816	.005	[.025, .144]	.022	Supported
H3c	GPS → PE	.203	.028	7.251	< .001	[.148, .258]	.121	Supported

Note. R² = .770; adjusted R² = .765. Bootstrapping used 5,000 resamples with two-tailed percentile confidence intervals. Source: Authors.

Within the technological context, compatibility returned the largest coefficient ($\beta = .215$, $t = 6.852$, $p < .001$, $f^2 = .127$), followed closely by relative advantage ($\beta = .207$, $t = 7.553$, $p < .001$) and, at a considerably lower level, ease of use ($\beta = .072$, $t = 2.323$, $p = .020$). H1 is therefore supported in its general form. Its specific claim requires qualification: compatibility's point estimate exceeds that of relative advantage, but their confidence intervals overlap almost entirely, so the two cannot be distinguished statistically. Compatibility is better described as one of the two leading technological conditions than as the single strongest.

Across the model as a whole, PMO structure returned the largest coefficient ($\beta = .221$), with compatibility second, relative advantage third and government policy and support fourth ($\beta = .203$). PMO maturity ($\beta = .197$), competitive pressure ($\beta = .140$) and the regulatory environment ($\beta = .085$) were also significant. Top management support was the only condition without a significant association ($\beta = .024$, $t = 0.762$, $p = .446$), so H2 is partially supported and H3 fully supported.

C. Configurational Analysis

Symmetric estimation assumes that the conditions producing high effectiveness are the inverse of those producing low effectiveness, and that each condition contributes regardless of the combination in which it occurs. The technology domain was analysed configurationally to test both assumptions and to evaluate P1.

No single technological condition reached the .90 consistency benchmark for necessity. For high effectiveness, relative advantage returned .812, compatibility .797 and ease of use .786; for low effectiveness, the absence of compatibility returned .691. Necessity analysis therefore offers no grounds for treating any single condition as a prerequisite, and the analysis proceeded to sufficiency.

Table 3 reports the full truth table. All eight logically possible combinations of the three technological conditions were observed in at least 26 cases, so no counterfactual assumptions were required and the complex, intermediate and parsimonious solutions coincide.

TABLE III
TRUTH TABLE FOR THE TECHNOLOGY DOMAIN

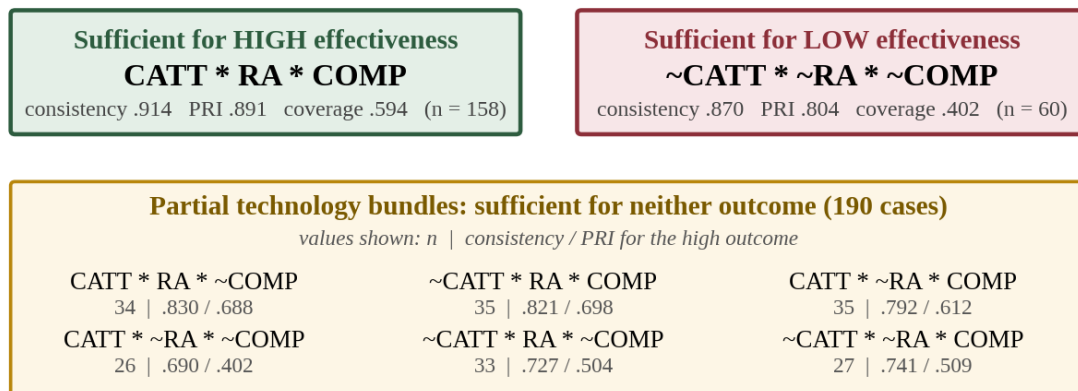
CATT	RA	COMP	n	High: consistency	High: PRI	Low: consistency	Low: PRI	Sufficient for
1	1	1	158	.914	.891	.276	.085	High
1	1	0	34	.830	.688	.608	.280	Neither
1	0	1	35	.792	.612	.654	.354	Neither
1	0	0	26	.690	.402	.777	.571	Neither
0	1	1	35	.821	.698	.570	.274	Neither
0	1	0	33	.727	.504	.701	.456	Neither
0	0	1	27	.741	.509	.718	.466	Neither
0	0	0	60	.450	.168	.870	.804	Low

Note. 1 = membership above .50; 0 = membership below .50. Thresholds: frequency 5, consistency .80, PRI .70. Source: Authors.

A single configuration proved sufficient for high PMO effectiveness: CATT * RA * COMP, in which ease of use, relative advantage and compatibility are present together (consistency .914, PRI .891, coverage .594). A single configuration proved sufficient for low effectiveness: ~CATT * ~RA * ~COMP, in which all three are absent (consistency .870, PRI .804, coverage .402).

The six remaining combinations, covering 190 cases, were sufficient for neither outcome.

The most instructive is the combination in which a tool is easy to use and advantageous but incompatible (CATT * RA * ~COMP). Its consistency with high effectiveness reached .830, above the conventional threshold, but its PRI of .688 fell below .70, indicating that cases with this profile are almost as consistent with not-high effectiveness as with high effectiveness. Incompatible tools that are otherwise attractive therefore produce ambiguous rather than reliably good outcomes. Fig. 2 summarises the pattern.



Compatibility appears in the only success route, yet its absence alone never yields failure.

Failure requires all three conditions to be absent together.

Fig. 2. Configurations sufficient for high and low PMO effectiveness in the technology domain, and the partial bundles sufficient for neither (primary calibration, crossover 3.05). Source: Authors.

The results support P1. Compatibility features in the only configuration sufficient for high effectiveness, yet its absence is not sufficient for low effectiveness unless accompanied by the absence of both ease of use and relative advantage. The configuration producing failure is not the negation of the configuration producing success, which is the defining signature of causal asymmetry. By the logic of negation, failure would follow from the absence of any one

condition; in fact it follows only from the absence of all three, and the large middle ground of partial bundles yields no consistent outcome in either direction.

D. Robustness of the Configurational Findings

Robustness was examined along two dimensions: sensitivity to the calibration anchor and sensitivity to the truth-table thresholds. Table 4 summarises the results.

TABLE IV
ROBUSTNESS OF THE CONFIGURATIONAL SOLUTIONS

Specification	High-effectiveness solution	Consistency	Low-effectiveness solution	Consistency
Primary (crossover 3.05)	CATT * RA * COMP	.914	~CATT * ~RA * ~COMP	.870
Crossover 3.001	CATT * RA * COMP	.915	~CATT * ~RA * ~COMP	.871
Consistency .75 or .85	CATT * RA * COMP	.914	~CATT * ~RA * ~COMP	.870
Frequency 3, 10 or 20	CATT * RA * COMP	.914	~CATT * ~RA * ~COMP	.870
PRI .75	CATT * RA * COMP	.914	~CATT * ~RA * ~COMP	.870
PRI .65 or .68	CATT * RA + RA * COMP	.851	~CATT * ~RA * ~COMP	.870

Source: Authors.

The low-effectiveness solution was identical under every specification examined: failure followed only from the joint absence of all three technological conditions, and the absence of compatibility alone was never sufficient for it. This half of the asymmetry is fully robust.

The high-effectiveness solution was stable under both calibrations, under stricter and more lenient consistency thresholds, under every frequency threshold, and under a stricter PRI threshold of .75. It was not stable under more lenient PRI thresholds. At PRI .65 or .68, two partial bundles crossed the threshold, and the solution became CATT * RA + RA * COMP: relative advantage combined with either ease of use or compatibility. Under these thresholds compatibility remains present in one of the two success routes but is no longer indispensable, and relative advantage becomes the condition common to both.

The indispensability of compatibility to success therefore depends on applying the conventional PRI threshold of .70, and it is reported here with that qualification rather than as an unconditional finding.

E. Managerial Priority

Importance–performance map analysis combines each condition's total effect on PMO effectiveness with its rescaled performance score. Compatibility recorded an importance of .215, the second highest of the nine conditions, against a performance score of 58.06, below the mean of 59.56. It therefore falls in the priority quadrant of above-average importance and below-average performance. PMO structure occupies the same quadrant with the highest importance (.221) and a performance score of 56.42. Fig. 3 presents the map.

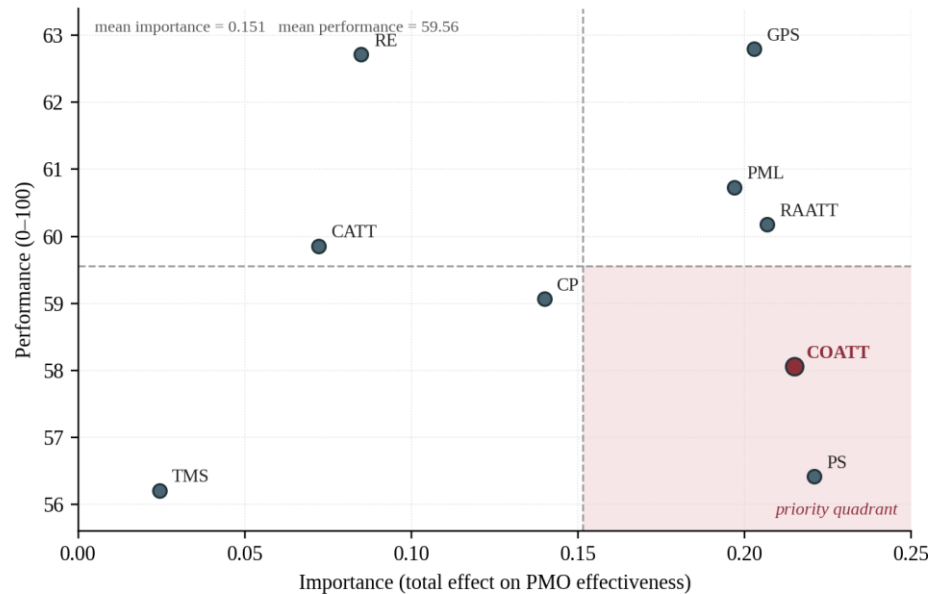


Fig. 3. Importance–performance map for PMO effectiveness, with compatibility highlighted. Dashed lines mark the mean importance (.152) and mean performance (59.56) of the nine conditions. Source: Authors.

The descriptive data corroborate this. Compatibility recorded a mean of 3.315, the lowest of the three technological conditions, below relative advantage (3.404) and ease of use (3.391). Respondents are thus more convinced of what their tools deliver than of how well those tools fit the systems and workflows already in place, and the technological attribute they rate lowest is one of the two that contribute most to PMO effectiveness.

V. DISCUSSION

A. Compatibility as a Leading Technological Condition

Compatibility returned the largest technological coefficient in a model explaining 77.0% of the variance in PMO effectiveness, ranking second only to PMO structure across all nine conditions. The findings supports the view that the fit between a tool and existing practice is not a secondary technical consideration but one of the principal determinants of whether advanced tools translate into PMO effectiveness [5], [6].

The result also requires a qualification that the hypothesis did not anticipate. Relative advantage performed almost identically, and the two cannot be separated statistically. Compatibility and relative advantage are best understood as joint leaders of the technological context, with ease of use making a smaller but significant contribution.

This parity matters for interpretation: the evidence does not support privileging compatibility over the benefits a tool offers, but it does indicate that benefits alone are insufficient when fit is poor, a point the configurational results make precise.

B. An Asymmetry Between Success and Failure

The study's central finding concerns the difference between what produces success and what produces failure. Under conventional thresholds, high PMO effectiveness followed consistently only from the complete technology bundle, in which a tool is simultaneously easy to use, advantageous and compatible. Low effectiveness followed only from the complete absence of that bundle. Between these poles lay six partial bundles, covering nearly half the sample, that were sufficient for neither outcome.

For compatibility this produces a specific asymmetry. Its presence is part of the only route to consistent success, yet its absence alone is never a route to failure. An organisation deploying an advantageous and usable but incompatible tool does not reliably fail; it lands in an ambiguous middle ground where outcomes are almost as likely to disappoint as to succeed. The practical meaning is that compatibility resolves ambiguity rather than averting disaster. Its contribution is to convert an otherwise promising tool into a reliably effective one.

This finding is inaccessible to symmetric estimation [7]. The regression coefficient for compatibility, read alone, supports the ordinary conclusion that more compatibility yields proportionally more effectiveness. The configurational evidence shows instead that the contribution of each technological attribute depends on the presence of the others, consistent with implementation evidence that digital tools in construction deliver value only when absorbed into routine practice as a whole [15], [16]. Regression captures the average slope; it cannot reveal that the middle of the distribution is indeterminate.

The robustness analysis bounds this conclusion in one direction and not the other. The failure half of the asymmetry, that the absence of compatibility alone never produces low effectiveness, held under every calibration and threshold examined. The success half, that compatibility is indispensable to high effectiveness, held under the conventional PRI threshold and stricter alternatives but not under more lenient ones, where relative advantage paired with either ease of use or compatibility sufficed. The defensible statement is therefore that compatibility always appears in some route to success, is indispensable under conventional standards of evidence, and is never sufficient for failure by its absence alone.

C. Organisational and Institutional Conditions

PMO structure returned the largest coefficient in the model, confirming that formal authority, reporting position and coordinating arrangements contribute to effectiveness in their own right [1]. PMO maturity was likewise significant, indicating that accumulated process capability contributes to delivery outcomes rather than functioning as procedural ornament.

Top management support showed no association with PMO effectiveness once the other eight conditions were controlled. This should not be read as evidence that executive sponsorship is irrelevant. A plausible interpretation is that sponsorship acts upstream, through the structural authority and process maturity it helps establish, so that its contribution is captured by those conditions when all three are estimated together. The model specifies direct effects only, and the processes through which sponsorship might operate lie outside its scope.

Among the environmental conditions, government policy and support returned the fourth largest coefficient in the model, consistent with an institutional setting in which policy instruments shape the implementation of digital tools directly [20]. Competitive pressure and the regulatory environment were also significant, though with smaller effects.

D. A Compatibility Screening Procedure for PMO Tool Selection

The findings translate into a screening procedure that PMO leaders and engineering managers can apply when selecting or configuring advanced project management tools. The procedure is derived from the estimated relationships rather than validated in the field, and it is offered as a structured application of the evidence that subsequent studies can test.

1) Fit Mapping: Before procurement, the PMO records the systems, data formats and workflows already operated by every organisation that must exchange information through the tool, including client units, design consultants, and main and specialist contractors. Each candidate tool is then assessed against this map for the integration it would demand, the duplicate data entry it would create and the established procedures it would displace.

2) Bundle Completeness Check: Each candidate is assessed simultaneously for ease of use, relative advantage and compatibility, since only the complete bundle was consistently sufficient for high PMO effectiveness. A tool strong on advantage and usability but weak on fit should be recognised as occupying the ambiguous middle ground, where outcomes are as likely to disappoint as to succeed, and its compatibility gap should be closed before deployment rather than absorbed during delivery.

3) Failure Screen: Deployments in which all three attributes are weak should be treated as redesign cases rather than candidates for incremental improvement, since this is the only configuration consistently sufficient for low effectiveness. Conversely, a single weak attribute is not by itself a reason to abandon an otherwise sound tool; it is a reason to complete the bundle.

Two further implications follow. Compatibility investment should be justified as the means of converting promising tools into reliably effective ones, rather than as a source of proportional efficiency gain, a framing that matches the configurational evidence and is more defensible when projected savings prove difficult to attribute. The priority-quadrant results also identify compatibility and PMO structure as the conditions where improvement yields the greatest return per unit of effort [23]; that respondents rate compatibility lowest among the technological conditions while it ranks among the strongest contributors to PMO effectiveness represents an actionable misalignment between perceived and actual leverage.

VI. CONCLUSION

This study examined the contribution of system compatibility to PMO effectiveness in Saudi Arabian construction projects, using survey data from 408 practitioners analysed through partial least squares structural equation modelling, fuzzy-set qualitative comparative analysis and importance–performance map analysis. Nine technology–organisation–environment conditions explained 77.0% of the variance in PMO effectiveness. Compatibility returned the largest technological coefficient and the second largest overall, statistically level with relative advantage, and it combined above-average importance with below-average performance.

The principal contribution is the identification of an asymmetry between success and failure. Under conventional thresholds, the only technology configuration consistently sufficient for high effectiveness combined compatibility with ease of use and relative advantage, whereas low effectiveness arose only when all three were absent. The absence of compatibility alone was therefore never sufficient for failure, and partial technology bundles produced ambiguous outcomes. Compatibility is accordingly better understood as the attribute that converts a promising tool into a reliably effective one than as a guard against failure, a distinction with direct consequences for how investment in advanced tools is justified and sequenced.

Five limitations bound these conclusions. The cross-sectional design precludes causal inference. Single-source measurement remains a limitation notwithstanding the diagnostic evidence assembled against a pervasive method factor. The sample was drawn predominantly from large consulting and contracting organisations in a single national context whose institutional concentration is unusual, so the environmental findings in particular may not generalise. The indispensability of compatibility to success depended on the conventional PRI threshold, and replication with independent samples is needed to establish whether it holds more generally. Finally, the model estimated direct effects only, and the processes through which compatibility and executive sponsorship influence PMO effectiveness were not modelled. Longitudinal designs tracking tool deployment across project phases, and samples extending to specialist subcontractors and smaller firms, represent the most direct extensions of this work.

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