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Feasibility constraints in public works price adjustment weighting in Nepal

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Abstract

Price-adjustment clauses distribute construction cost fluctuations between public employers and contractors, but the weighting intervals written in bidding documents do not necessarily provide the discretion they appear to provide. This study audited 31 official Nepal e-GP works documents. Documents with exactly identical coefficient-range tuples were consolidated into 19 distinct specifications; similar but non-identical ranges were retained separately. The corpus is an analytical audit and is not used to estimate national prevalence. For each specification, the feasible combinations of labour, materials and equipment coefficients were derived under the contractual normalization constraint with a non-adjustable coefficient of 0.15. Seventeen specifications produced polygonal feasible regions, whereas two nominal interval sets collapsed to a single admissible weighting. Among polygonal specifications, feasible area in the labour-material coefficient plane ranged from 0.0012 to 0.0350, a 29-fold difference. Historical sensitivity was then evaluated for eight specifications whose index sources were compatible with Nepal Rastra Bank construction labour, construction materials, and machinery/equipment series. Under the 2022/23-2023/24 annual-average movement, the broadest specification permitted a 1.810 percentage-point spread in the adjustment factor, equivalent to about NPR 1.81 million per NPR 100 million of adjustment-eligible work. The results show that coefficient normalization should be checked explicitly when drafting and evaluating price-adjustment schedules.

Keywords: price adjustment; public procurement; construction contracts; coefficient weighting; Nepal; construction management

1. Introduction

Construction contracts extending over months or years are exposed to changes in wages, material prices and equipment costs. Price-adjustment clauses are intended to allocate part of this market risk through an agreed formula rather than forcing either party to absorb all subsequent cost movement. International procurement guidance therefore treats price adjustment as a risk-allocation mechanism and recommends formulas based on cost indices when contracts are materially exposed to inflation or deflation (Asian Development Bank [ADB], 2018; World Bank, 2020).

The common index formula combines a fixed, non-adjustable share with coefficients representing major cost inputs. In Nepal, standard public-works bidding documents use the same basic structure and generally identify labour, construction materials, and equipment or fuel as adjustable inputs. The Public Procurement Monitoring Office (PPMO) specifies that bidder-proposed weightings must remain within the employer's stated ranges, while the coefficient total, including the non-adjustable component, must equal one (Government of

Nepal, PPMO, 2026). This normalization requirement means that the allowable values of labour, materials, and equipment are mathematically coupled.

Previous work has established that price adjustment is important to contract administration and that formula design affects the distribution of escalation risk. Choi et al. (2006) emphasized the policy choices embedded in escalation systems, while more recent international research has shown that factor selection and coefficient weighting should reflect the actual cost structure of a project rather than a generic formula (Oliveira et al., 2025). Nepalese studies have examined price-adjustment formulas, trends in construction inputs, stakeholder perceptions, and disputes. Pokharel and Mishra (2020) compared price-adjustment practices in selected road projects; Mishra and Aithal (2020) examined ten construction contracts and different formula applications; Chaudhary and Sharma (2023) documented practices in bridge contracts; and Kayastha et al. (2024) examined price-adjustment claims during project time extension.

Those studies focus principally on formula choice, implementation, claims, project experience, or stakeholder perceptions. A narrower issue remains largely unexamined: whether the coefficient ranges advertised in bidding documents actually create the amount of bidder discretion suggested by the individual interval widths. If the required sum constraint is ignored, three apparently broad ranges can be read as three independent choices even though many combinations are impossible. In the limiting case, the ranges can collapse to a single feasible coefficient triplet. The novelty of the present study lies in treating the advertised coefficient intervals as a coupled feasible-set problem rather than evaluating the labour, materials, and equipment ranges independently. This differs from approaches such as Oliveira et al. (2025), which derive or adjust coefficient weights to reflect project-specific bill-of-quantities cost structure. The present analysis addresses an earlier contract-design question: whether the stated coefficient bounds mathematically create the degree of weighting choice they appear to provide.

This study therefore evaluates the geometric feasibility of labour, materials and equipment weightings in a contemporary audit of Nepalese public-works bidding documents. It asks two questions: (1) how much feasible weighting discretion remains after the contractual normalization condition is imposed, and (2) how large can the resulting difference in price adjustment become under identical observed index movements? The contribution is deliberately practical. It does not estimate national prevalence or contractor loss. Instead, it provides a reproducible check that procurement officers, consultants, and bidders can apply to the price-adjustment schedules used in public works.

2. Method

2.1. Procurement document audit

The study used publicly accessible works bidding documents from Nepal's official electronic government procurement portal. The audit was assembled on 29 August 2026 through targeted retrieval of official works records containing price-adjustment schedules; it was designed as an analytical audit rather than a time-bounded census or probability sample. A document was retained only when its price-adjustment schedule stated the non-adjustable coefficient *A* and explicit lower and upper bounds for labour *(b)*, materials *(c)*, and equipment or equivalent equipment-use *(d)*. Records without a usable price-adjustment schedule or without explicit bounds for all three adjustable coefficients were not eligible. The retained corpus comprised 31 document instances. To prevent repeated templates from inflating the structural comparison, documents were consolidated only when the complete coefficient tuple (A , b_{min} , b_{max} , c_{min} , c_{max} , d_{min} , d_{max}) was exactly identical; similar but non-identical ranges were retained as separate specifications. This yielded 19 distinct specifications, which form the primary unit of structural analysis. Because the corpus is not a probability sample, the counts are descriptive and are not interpreted as national prevalence estimates. The accompanying reproducibility workbook records the source URL, extracted coefficient bounds, specification identifier, duplicate frequency, feasibility classification, and index-source eligibility for every retained document.

2.2. Feasible weighting geometry

For the audited specifications, the non-adjustable coefficient was A = 0.15. An admissible coefficient triplet therefore had to satisfy the employer's advertised bounds together with the normalization condition:

$$A + b + c + d = 1.00, \quad so \quad b + c + d = 0.85$$

For each specification, feasibility was represented in the b-c plane. Because d = 0.85 - b - c, the equipment interval becomes a diagonal strip bounded by 0.85 - d_{max} <= b + c <= 0.85 - d_{min}. The feasible set is the intersection of this strip with the advertised b and c intervals. Exact intersections were obtained from boundary-line vertices. A specification was classified as a unique point if only one coefficient triplet satisfied all constraints, as a polygon if a two-dimensional feasible region remained, or as empty if no triplet was admissible. Polygon area in the b-c plane was used as a dimensionless measure of the geometric extent of permitted weighting choice. It is not a measure of project value or economic importance. Table 1 summarizes the data and analytical definitions used throughout the study.

Table 1. Data and analytical definitions used in the study

Element	Operational definition	Use in analysis
Procurement corpus	31 official e-GP works document instances with usable price-adjustment schedules.	Audit corpus; no national prevalence inference.
Structural unit	19 distinct coefficient-range specifications after exactly repeated range designs were consolidated	Primary denominator for feasibility analysis.
Normalization	A = 0.15 and A + b + c + d = 1.00.	Couples the three adjustable coefficient ranges.
Feasible set	Intersection of coefficient bounds with b + c + d = 0.85.	Classified as unique point, polygon, or empty.
Feasible area	Area of the admissible polygon in the b-c plane.	Compares geometric discretion across range designs.
Historical sensitivity	Minimum and maximum p_n over feasible vertices for fixed NRB index ratios.	Restricted to index-source-compatible specifications.

2.3. Historical sensitivity scenarios

The second part of the analysis translated feasible coefficient choice into price-adjustment sensitivity. The standard multiplier was evaluated as:

$$p_n = A + b(L_n/L_0) + c(M_n/M_0) + d(E_n/E_0)$$

where L, M and E denote construction labour, construction materials, and machinery/equipment indices. Annual-average values were taken from Nepal Rastra Bank (NRB) for 2022/23, 2023/24 and 2024/25. The corresponding ratios were 1.02638, 0.97337 and 1.03734 for labour, materials and machinery/equipment in the 2022/23-2023/24 scenario, and 1.02130, 0.98326 and 1.01327 in the 2023/24-2024/25 scenario (Nepal Rastra Bank [NRB], 2026). Because some bidding documents use diesel or alternative equipment indices, monetary translation was restricted to the subset with verified NRB machinery/equipment indexing: nine document instances representing eight distinct specifications.

The multiplier is linear in b, c and d. Accordingly, its minimum and maximum over a convex feasible polygon occur at polygon vertices; every feasible vertex was evaluated directly. The spread was reported in percentage points as 100(p_max - p_min). To make the scale understandable without implying an observed claim, the spread was also multiplied by NPR 100 million of adjustment-eligible work. This is an illustrative exposure amount, not an estimate of contractor profit, loss, or certified payment.

3. Results and Discussion

3.1. Nominal ranges do not equal feasible discretion

Unique-point specifications.

The 31 audited document instances yielded 19 distinct coefficient-range specifications. Seventeen specifications retained polygonal feasible regions, two reduced to unique feasible points, and none produced an empty feasible set. The unique-point cases demonstrate that displaying three numerical intervals does not necessarily provide three independent choices. For example, S10 advertises $b = 0.15 - 0.25$, $c = 0.25 - 0.40$, and $d = 0.15 - 0.20$. Because the upper bounds themselves sum to the required adjustable total of 0.85, the only feasible triplet is $(b, c, d) = (0.25, 0.40, 0.20)$. S07 behaves similarly. Thus, the normalization rule can remove all effective weighting discretion even when each component is displayed as an interval.

Variation among polygonal specifications.

Among the 17 polygonal specifications, feasible area ranged from 0.0012 for S18 to 0.0350 for S17; the median polygon area was 0.0050. The largest area was therefore about 29.2 times the smallest nonzero area. Fig 1 summarizes the full ranking. This variation is substantial even before any price index is introduced: the contract schedules themselves differ markedly in how much coefficient choice they permit. This 29-fold difference describes the geometric size of the admissible coefficient set only. It does not imply a 29-fold difference in financial exposure, because monetary sensitivity also depends on the relative movements of the labour, materials and equipment indices.

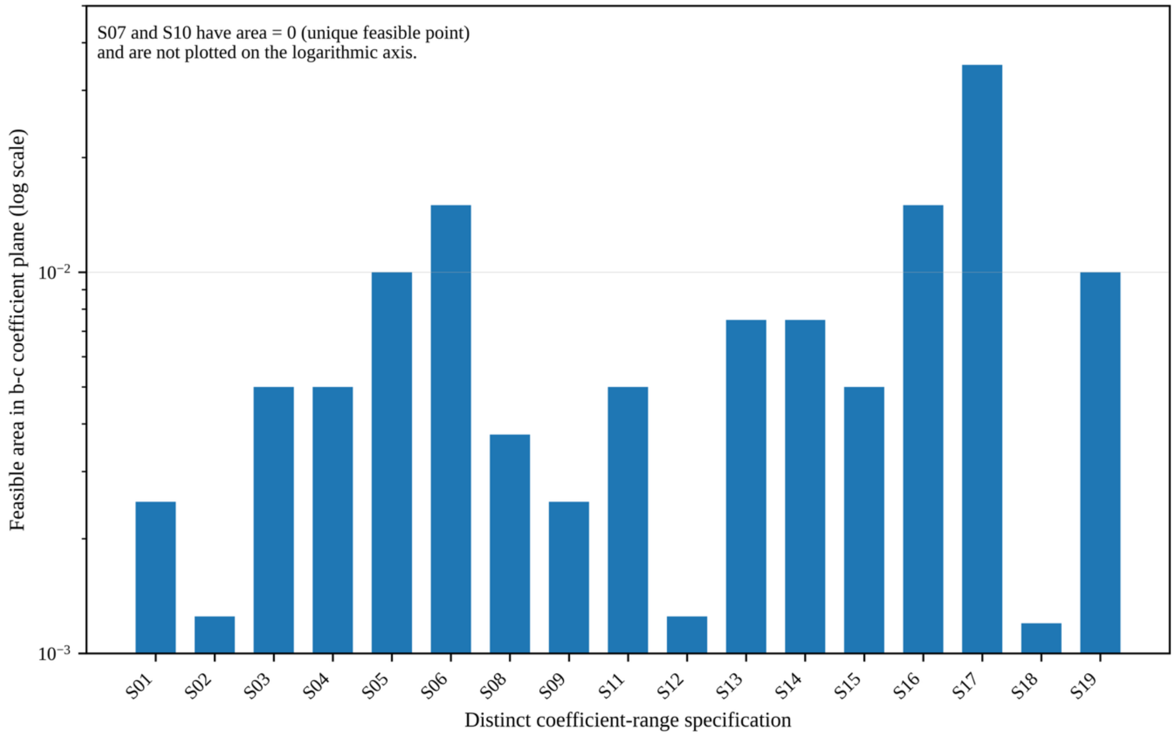

Fig 1. Feasible areas of the 17 polygonal coefficient-range specifications on a logarithmic scale. S07 and S10 have zero area because each reduces to a unique feasible point and therefore cannot be plotted on the logarithmic axis.

Table 2 lists the 19 distinct range designs and their feasible-set geometry. Repetition across document instances is retained only as a document count; structural comparisons use each specification once.

Table 2. Feasibility geometry of the distinct coefficient-range specifications

Spec.	Docs	b interval	c interval	d interval	Feasible set	Area
S01	1	0.100-0.150	0.400-0.600	0.150-0.200	Polygon	0.00250
S02	2	0.100-0.200	0.200-0.400	0.150-0.300	Polygon	0.00125
S03	1	0.100-0.200	0.500-0.600	0.150-0.250	Polygon	0.00500
S04	1	0.100-0.200	0.600-0.700	0.050-0.150	Polygon	0.00500
S05	1	0.100-0.250	0.300-0.500	0.150-0.250	Polygon	0.01000
S06	2	0.100-0.300	0.300-0.600	0.050-0.150	Polygon	0.01500
S07	1	0.125-0.130	0.650-0.690	0.025-0.030	Unique point	0.00000
S08	3	0.150-0.200	0.400-0.500	0.150-0.250	Polygon	0.00375
S09	2	0.150-0.200	0.400-0.600	0.100-0.150	Polygon	0.00250
S10	4	0.150-0.250	0.250-0.400	0.150-0.200	Unique point	0.00000
S11	5	0.150-0.250	0.300-0.400	0.200-0.300	Polygon	0.00500
S12	1	0.150-0.250	0.400-0.500	0.050-0.150	Polygon	0.00125
S13	1	0.150-0.250	0.400-0.500	0.150-0.250	Polygon	0.00750
S14	1	0.150-0.250	0.500-0.600	0.050-0.150	Polygon	0.00750
S15	1	0.150-0.250	0.500-0.600	0.100-0.200	Polygon	0.00500
S16	1	0.150-0.300	0.300-0.600	0.150-0.250	Polygon	0.01500

Spec.	Docs	b interval	c interval	d interval	Feasible set	Area
S17	1	0.150-0.350	0.300-0.600	0.100-0.300	Polygon	0.03500
S18	1	0.200-0.250	0.370-0.420	0.230-0.270	Polygon	0.00120
S19	1	0.200-0.300	0.400-0.700	0.100-0.300	Polygon	0.01000

3.2. Geometry explains why similar-looking schedules behave differently

Fig 2 uses S17, the broadest specification in the audit, to illustrate the feasible-set construction directly. The advertised labour and materials intervals form the rectangular $b - c$ bounds, while the equipment interval restricts $b + c$ through $d = 0.85 - b - c$. For S17, $d = 0.10 - 0.30$ creates the two diagonal boundaries shown in the figure. Their intersection with the advertised b and c limits produces the actual feasible region. The figure therefore illustrates why apparently independent coefficient intervals must be evaluated jointly; Table 2 reports the corresponding geometry for all 19 specifications.

This geometric feasibility question is distinct from selecting economically representative coefficient weights. Oliveira et al. (2025), for example, developed price-adjustment weights from project-specific bill-of-quantities information. The present analysis addresses the preceding contract-design question: whether the advertised bounds themselves generate the intended choice set. A schedule that unintentionally collapses to a point offers no bidder weighting discretion, while a very broad polygon may allow materially different allocations of the same construction cost risk.

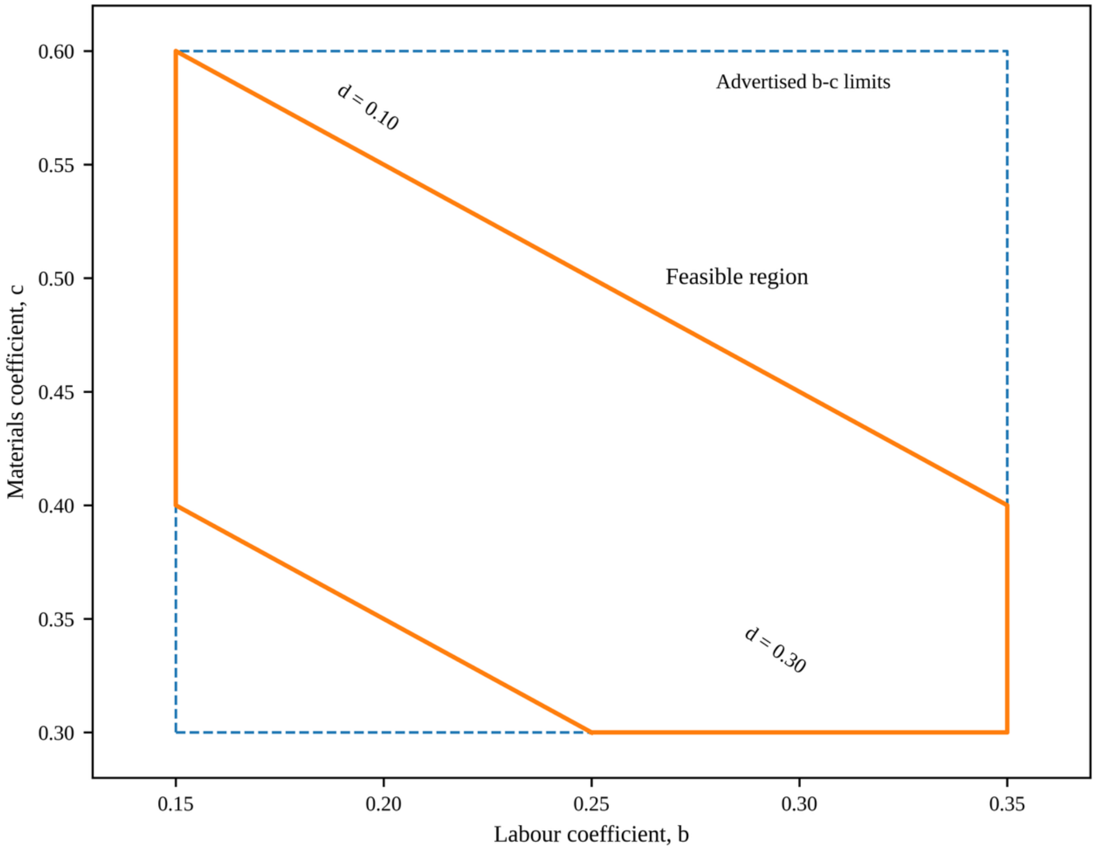

Fig 2. Feasible labour-material coefficient region for S17 after imposing $b + c + d = 0.85$ and the advertised equipment-coefficient bounds. The dashed outline shows the advertised $b - c$ limits and the solid boundary shows the admissible set.

3.3. Historical adjustment sensitivity

The geometric analysis above uses all 19 distinct specifications. The historical monetary sensitivity analysis is deliberately separate and narrower because index-source compatibility is required. Only eight distinct specifications, represented by nine document instances, were retained for the NRB machinery/equipment scenarios. Accordingly, Table 3 and Fig 3 describe only this source-compatible subset and should not be interpreted as monetary results for the remaining specifications. Table 3 reports the minimum and maximum multiplier over the feasible vertices for both annual-average scenarios.

Table 3. Historical price-adjustment sensitivity for NRB source-compatible specifications

Spec.	Area	p min S1	p max S1	Spread S1 (pp)	Spread S2 (pp)	NPR/100m S1
S01	0.00250	0.992258	0.998108	0.585	0.340	584,941
S03	0.00500	0.992258	0.998656	0.640	0.380	639,758
S08	0.00375	0.997559	1.003957	0.640	0.340	639,758
S11	0.00500	1.003409	1.009806	0.640	0.380	639,758
S12	0.00125	0.997011	1.000210	0.320	0.190	319,879
S15	0.00500	0.991710	0.998108	0.640	0.380	639,758
S17	0.03500	0.991710	1.009806	1.810	1.061	1,809,641
S18	0.00120	1.002678	1.005767	0.309	0.190	308,916

S1 = 2022/23 to 2023/24 annual-average NRB index movement; S2 = 2023/24 to 2024/25. NPR/100m S1 is an illustrative amount for NPR 100 million of adjustment-eligible work.

Under the 2022/23-2023/24 annual-average NRB scenario, the broadest source-compatible specification, S17, produced p_n values from 0.991710 to 1.009806, a spread of 1.810 percentage points. On NPR 100 million of adjustment-eligible work, the spread corresponds to about NPR 1.81 million. The two extremes were generated by different admissible weightings under identical index movements. At the low end, (b, c, d) = (0.150, 0.600, 0.100); at the high end, (0.250, 0.300, 0.300). Because construction materials fell in this annual-average comparison while labour and machinery/equipment increased, assigning more weight to materials reduced the multiplier and assigning more weight to the increasing components raised it.

The direction of adjustment is particularly informative. For S17 in the first scenario, one permissible weighting gives an adjustment of about -0.829%, while another gives approximately +0.981%. Thus, the same market movement can produce either a downward or upward adjustment depending solely on the permissible coefficient selection. In the 2023/24-2024/25 scenario, S17 again spans both sides of unity, from approximately -0.552% to +0.509%, although the spread narrows to 1.061 percentage points.

Fig 3 shows that the sensitivity is not uniform across the eight source-compatible specifications. Narrower feasible regions such as S12 and S18 limit the spread to roughly 0.31-0.32 percentage points in the first scenario, whereas S17 permits substantially more variation. Feasible area and economic spread are related but not identical: the eventual monetary sensitivity also depends on the relative movements of the selected indices. A large feasible region matters most when the component indices diverge.

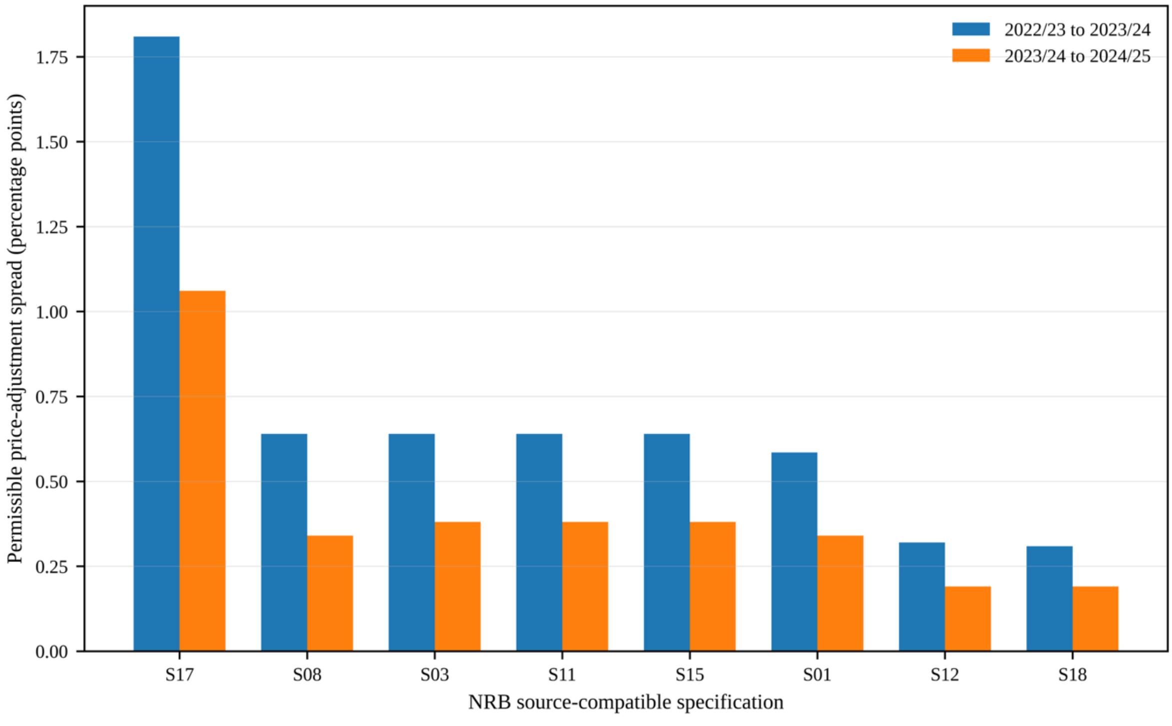

Fig 3. Permissible price-adjustment spread under the two NRB annual-average scenarios for source-compatible specifications.

3.4. Implications for procurement practice

Price adjustment is intended to share market risk more predictably. ADB (2018) notes that well-designed adjustment provisions can allow bidders to price contracts more realistically. International standard documents similarly emphasize cost-element coefficients, appropriate indices, and a total weighting of 1.00 (World Bank, 2020, Section IV, Appendix to Bid, pp. 60–

63). In that context, the present findings suggest three straightforward checks for Nepalese public works.

First, the employer should test the feasible set before issuing a bidding document. A simple normalization check can identify whether the lower and upper bounds create a meaningful region, a line-like restriction, a single point, or no solution. Second, where bidder discretion is intended, the allowed region should be consistent with the likely cost structure of the work. Merely widening one interval may have little effect if the other bounds and the coefficient sum remain binding. Third, index sources should be specified consistently. The audit encountered machinery/equipment schedules as well as fuel-based alternatives; these should not be treated as interchangeable in sensitivity or payment calculations because their market movements can differ.

These controls address a different stage of the problem from the claim and administration issues reported in earlier Nepalese studies. Pokharel and Mishra (2020) and Mishra and Aithal (2020) documented differences in formulas and implementation, while Kayastha et al. (2024) showed how ambiguous or delayed index selection can contribute to disputes during time extension. The present analysis indicates that ambiguity can also be embedded earlier, in the geometry of the coefficient ranges themselves. Making the feasible set explicit would improve transparency without changing the underlying price-adjustment formula.

The study has limitations. The 31 documents were selected for an analytical audit and are not a statistically representative sample of all public-works procurement in Nepal. Repeated specifications may reflect deliberate standardization rather than error. Feasible area is a geometric measure and does not establish whether a specific bidder weighting is economically appropriate. The historical scenarios use annual-average NRB indices for transparent sensitivity illustration; actual payment certificates use contract-specific base and current dates and may use different approved indices. Finally, the NPR translation is illustrative and should not be read as evidence of actual overpayment, underpayment, profit or loss.

4. Conclusion

This study examined an overlooked property of price-adjustment schedules in Nepalese public works: the feasible coefficient set created after advertised labour, materials and equipment ranges are combined with the mandatory normalization condition. Thirty-one official e-GP document instances yielded 19 distinct range specifications. Seventeen retained polygonal feasible regions, while two nominal sets of intervals collapsed to a single admissible weighting. No empty specification was found in the audit.

The degree of genuine weighting discretion varied sharply. Feasible polygon area ranged from 0.0012 to 0.0350, a roughly 29-fold difference. In the source-compatible historical analysis, the broadest specification generated a 1.810 percentage-point difference in the price-adjustment multiplier under 2022/23-2023/24 annual-average NRB index movements, equivalent to about NPR 1.81 million per NPR 100 million of adjustment-eligible work. The permissible alternatives could even place the multiplier on opposite sides of 1.00 under the same observed index movement.

The practical recommendation is simple: coefficient intervals should be checked as a coupled feasible set before a bidding document is issued or evaluated. Procurement templates can retain the familiar price-adjustment formula, but the employer should verify that the stated ranges provide the intended degree of choice and that their index sources are unambiguous.

This small mathematical check can improve transparency at bid preparation and reduce avoidable ambiguity during contract administration.

This check can be operationalized in a simple spreadsheet or e-procurement validation tool that applies the normalization condition, computes the feasible intersection of the advertised coefficient bounds, and flags unique-point or empty specifications before a tender is issued.

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Disclosure statement

The authors declare no competing interests.

Author contributions

Prasanna Jibi Ghimire: Conceptualization, methodology, data curation, formal analysis, visualization, and writing - original draft. Prerana Khatiwada: Validation, literature review, interpretation, and writing - review and editing. Both authors reviewed and approved the final manuscript.

Data availability

The source procurement documents are publicly accessible through the Government of Nepal electronic procurement system, and the construction input indices used for the historical scenarios are publicly available from Nepal Rastra Bank. The compiled analytical dataset, source audit, feasible-set calculations, and scenario calculations are provided in Supplementary File 1 (NuCE_Reproducibility_Workbook_R1_FINAL.xlsx).

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