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The Impact of Value Engineering on National Housing Projects with an Incentives and Penalties Approach Using Multi-Criteria Decision-Making Methods: A Case Study of Alborz Province

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Abstract

Providing adequate housing and optimally managing cost, time, and quality are among the most important challenges in implementing National Housing Movement projects. In this context, the application of value engineering can facilitate improved project performance and greater resource efficiency through the identification and prioritization of influential factors. The present study aimed to identify and prioritize the factors affecting the application of value engineering in National Housing Movement projects in Alborz Province, with particular emphasis on the possibility of using incentives and penalties. In terms of purpose, this study was applied research, and in terms of methodology, it employed an exploratory mixed-methods design. The statistical population consisted of 233 managers, experts, executive engineers, and contractors involved in National Housing Movement projects in Alborz Province, of whom 144 were selected as the sample using Cochran’s formula. Documentary studies, semi-structured interviews, and qualitative content analysis were used to identify the influential factors. Following coding and the elimination of redundant factors, 20 influential indicators were extracted and classified into four categories: strengthening, inhibiting, developmental, and environmental factors. Quantitative data were subsequently collected using a researcher-developed questionnaire. After examining its validity and reliability, the weights and priorities of the factors were determined using the Analytic Hierarchy Process (AHP) and pairwise comparisons based on Saaty’s 1–9 scale. The results indicated weights of 0.707 for strengthening factors, 0.500 for inhibiting factors, 0.707 for developmental factors, and 0.343 for environmental factors. Furthermore, assessment of the existing situation showed that the total score for strengthening and inhibiting factors was 2.68, whereas the total score for developmental and environmental factors was 2.46. The findings indicate that leveraging technological and regulatory capacities, managing cost and time, strengthening coordination among executive agencies, and making targeted use of incentives, together with controlling inhibiting factors such as financial constraints, managerial problems, and economic fluctuations, can play an effective role in enhancing the effectiveness of value engineering in National Housing Movement projects. Accordingly, prioritizing the identified factors can provide a basis for developing implementation policies, designing incentive and penalty mechanisms, and improving the performance of national housing projects in Alborz Province.

Keywords: *value engineering, National Housing Movement, SWOT analysis, Analytic Hierarchy Process, AHP, incentives and penalties, Alborz Province.*

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1. Introduction

Housing is one of the most fundamental components of social welfare, urban development, household economic security, and spatial organization, and its provision has therefore remained a central concern of governments, planners, and urban policymakers. Beyond its basic function as shelter, housing influences patterns of household expenditure, social stability, access to urban opportunities, quality of life, and the physical development of cities. Accordingly, housing policy cannot be regarded merely as a construction-oriented intervention; rather, it constitutes a multidimensional field in which economic, social, legal, managerial, spatial, and environmental considerations intersect. The importance of housing becomes particularly pronounced in rapidly urbanizing societies where increases in land and construction costs, demographic pressures, unequal access to financial resources, and shortages of affordable units can intensify housing inequality and constrain sustainable urban development [1]. Contemporary housing programs must therefore balance affordability, accessibility, quality, social equity, financial feasibility, and long-term urban sustainability. International experience similarly shows that large-scale affordable-housing programs are increasingly confronted with challenges related to financing, implementation capacity, land availability, changing household needs, and the coordination of public and private actors [2].

Housing conditions and housing-market performance are shaped by numerous interdependent variables. Quantitative indicators such as the number of residential units, household-to-dwelling ratios, housing density, unit size, and supply rates interact with qualitative indicators such as structural durability, access to services, environmental quality, and residential satisfaction. Economic indicators—including housing prices, land values, purchasing power, credit conditions, and construction costs—further influence the capacity of households to obtain suitable housing [3]. Spatial differences in these indicators can create unequal housing outcomes even within the same metropolitan region. Research emphasizing sustainable housing has therefore highlighted the necessity of examining both quantitative and qualitative housing conditions in relation to broader urban-development patterns rather than evaluating housing supply exclusively in numerical terms [4]. This multidimensional perspective is especially important for government-led mass-housing programs because projects that increase the number of housing units without sufficient attention to quality, location, infrastructure, accessibility, and economic sustainability may fail to achieve their broader social and developmental objectives.

The housing market is also strongly affected by macroeconomic and urban-environmental dynamics. Inflation, changes in construction-material prices, fluctuations in land values, household income, access to credit, speculative activity, and expectations regarding future prices can influence both the supply and demand sides of the housing sector. Urban environmental conditions and the attractiveness of particular locations may reinforce or weaken housing-market activity and contribute to spatial differences in investment and demand [5]. Housing values may additionally be affected by social relationships, neighborhood-level networks, and forms of social capital that influence transaction behavior and market outcomes [6]. These factors demonstrate that housing projects operate within complex systems in which economic, institutional, social, and spatial variables are interconnected. Consequently, large national housing programs require managerial approaches capable of addressing uncertainty, coordinating multiple stakeholders, and achieving an appropriate balance among cost, time, quality, functionality, and social value.

Government intervention has traditionally been one of the main mechanisms for addressing housing shortages and affordability problems, particularly for low- and middle-income households. Social-housing policies have taken diverse forms across different countries, including direct government construction, subsidized loans, public land allocation, rental assistance, public–private partnerships, tax incentives, and regulatory support for affordable-housing developers [7]. The effectiveness of these policies depends not only on the volume of financial resources allocated but also on institutional capacity, regulatory coherence, implementation mechanisms, and the ability to adapt housing provision to local needs. Legal arrangements governing housing transactions and project development are also important because equitable contractual frameworks and appropriate legal protections can reduce conflicts among developers, purchasers, and other project stakeholders [8]. Accordingly, the performance of national housing programs should be evaluated through an integrated perspective encompassing financial, legal, technical, and managerial dimensions.

Large-scale public housing interventions may also have substantial spatial consequences. The location of projects can influence urban expansion, land-use patterns, infrastructure demand, commuting behavior, and the distribution of public services. Evidence from national housing programs indicates that changes in government priorities and implementation strategies may produce significant spatial repercussions for urban growth and the organization of metropolitan areas [9]. In this regard, the relationship between national housing policies and local planning systems is particularly important. If large housing projects are implemented without adequate integration with transportation, service provision, employment centers, and environmental planning, they may contribute to dispersed development and impose long-term costs on both residents and local governments. Conversely, coordinated implementation can support more balanced urban growth and improve the functionality of new residential areas.

The need for integrated planning is equally evident in the renewal of deteriorated and distressed urban fabrics. Housing-supply policies in such areas involve complex trade-offs between physical redevelopment, preservation of existing communities, land economics, infrastructure limitations, and future urban-development scenarios. Futures-oriented studies of housing provision in deteriorated urban areas have emphasized the importance of anticipating long-term demographic, spatial, institutional, and economic changes rather than relying exclusively on short-term construction targets [10]. Similar research has shown that future housing policies need to account for uncertainty in governance, investment, land availability, redevelopment capacity, and the changing needs of urban residents [11]. Such findings reinforce the argument that national housing initiatives should be managed through flexible and analytical frameworks capable of responding to changing conditions while preserving long-term value.

The Iranian experience with large-scale housing provision likewise demonstrates both the necessity and the complexity of governmental intervention. Previous mass-housing initiatives, including Mehr Housing, were intended to increase access to housing for a broad segment of households, yet their implementation also generated important debates regarding location, infrastructure, service provision, construction quality, financing, and environmental and social sustainability. Studies examining the consequences of Mehr Housing projects have shown that large-scale housing development can exert significant effects on the sustainable development of host cities and surrounding urban systems [12]. These experiences provide valuable lessons for subsequent national housing programs, particularly regarding the need to move beyond a singular focus on physical construction and incorporate systematic project evaluation, cost control, quality improvement, stakeholder coordination, and long-term performance considerations.

Within this context, the National Housing Movement represents a major contemporary intervention in Iran's housing sector. Its scale, multiple institutional actors, dependence on financial and credit systems, land-development requirements, and exposure to fluctuations in construction costs make its implementation particularly demanding from a project-management perspective. Such projects typically involve government agencies, local authorities, banks, contractors, consultants, suppliers, developers, and eventual beneficiaries. The presence of multiple stakeholders increases the likelihood of conflicting priorities, delays, coordination problems, information asymmetries, and budgetary pressures. In addition, differences among provinces in land conditions, administrative capacity, market characteristics, access to infrastructure, and contractor capabilities can produce substantial variation in project performance. These characteristics make the application of systematic management tools especially important in provinces such as Alborz, where rapid urbanization, proximity to Tehran, high demand for housing, and pressure on urban infrastructure intensify the complexity of project implementation.

One of the managerial approaches with considerable potential to improve the performance of construction and infrastructure projects is value engineering. Value engineering is a systematic, function-oriented methodology aimed at achieving the required functions of a project at the lowest life-cycle cost without compromising necessary quality, safety, reliability, or performance. Rather than simply reducing expenditure, value engineering seeks to optimize the relationship between function and cost through structured analysis, multidisciplinary collaboration, creative generation of alternatives, and comparative assessment of technical and economic options. Its application can therefore contribute to identifying unnecessary costs, improving constructability, selecting more appropriate materials and methods, optimizing design solutions, and enhancing overall project efficiency. Research on infrastructure projects has demonstrated that value engineering can provide an effective framework for improving project performance and achieving better use of financial and technical resources [13].

The applicability of value engineering is particularly significant in construction projects because decisions made during planning and design have substantial consequences for subsequent project costs and performance. Value engineering can be incorporated into project planning and control systems to identify alternatives before expensive commitments become irreversible. Previous studies have shown that the successful application of value engineering in construction depends on factors such as managerial support, appropriate timing, access to reliable information, multidisciplinary teamwork, organizational culture, and the integration of value analysis with project-control processes [14]. Similarly, effective management and execution of construction projects through value engineering require systematic attention to planning, communication, technical evaluation, stakeholder participation, and the disciplined implementation of recommendations [15]. These findings suggest that the success of value engineering cannot be attributed solely to the technical quality of proposed alternatives; it also depends on institutional and managerial conditions that determine whether those alternatives can actually be adopted and implemented.

Evidence from specific construction and infrastructure applications further illustrates the practical benefits of value engineering. In bridge construction, value engineering has been applied to compare alternatives, reconsider design and execution methods, and identify opportunities for improving project value while controlling costs [16]. Likewise, its application to metro-station structural optimization has demonstrated the usefulness of value-oriented analysis in technically complex infrastructure projects where alternative design solutions can generate meaningful improvements in structural performance, constructability, and resource utilization [17]. Such applications are directly relevant to housing programs because national housing projects similarly involve repetitive construction activities, substantial material consumption, standardized design decisions, financing constraints, and opportunities to achieve savings through technological, managerial, and design improvements.

Nevertheless, the implementation of value engineering in construction projects is influenced by various organizational and operational barriers. Research on factors affecting value engineering performance has emphasized that project efficiency is closely related to the level of managerial commitment, expertise of project personnel, quality of information, timing of value studies, interdisciplinary cooperation, and the willingness of organizations to reconsider established practices [18]. Resistance to change may reduce the practical impact of value-engineering recommendations, particularly when project participants perceive new approaches as increasing workload, creating uncertainty, or challenging conventional decision-making structures. In addition, inadequate training, fragmented responsibilities, weak project-control mechanisms, and limited access to reliable databases may reduce organizations' ability to evaluate alternatives systematically.

The organizational and institutional environment is especially important in public housing projects, where the decisions of individual project teams are constrained by laws, administrative regulations, financing rules, procurement procedures, and interorganizational relationships. In such settings, the implementation of value engineering may require not only technical recommendations but also explicit mechanisms that encourage desirable behavior and discourage inefficient practices. Incentive systems can motivate contractors, consultants, and project teams to identify cost-saving innovations, improve quality, accelerate implementation, or adopt new technologies when the benefits of improved performance are appropriately recognized and shared. Conversely, penalties can be used to address delays, poor-quality execution, noncompliance with specifications, inefficient resource use, and failures to meet contractual or performance requirements. However, the effectiveness of such mechanisms depends on transparent evaluation criteria, reliable performance measurement, enforceable contractual arrangements, and proportionality between performance and reward or sanction.

The design of incentives and penalties is therefore inherently a multi-criteria management problem. Decisions regarding which behaviors should be rewarded or penalized may involve cost performance, schedule adherence, construction quality, safety, functionality, energy efficiency, innovation, resource productivity, and stakeholder satisfaction. These criteria may conflict with one another; for example, reducing construction time may increase cost, while minimizing initial expenditure may adversely affect life-cycle performance. Moreover, the relative importance of criteria may differ among governmental agencies, contractors, consultants, and beneficiaries. Under these conditions, multi-criteria decision-making methods provide a structured means of organizing complex judgments, comparing competing factors, and deriving transparent priorities.

Among multi-criteria decision-making techniques, the Analytic Hierarchy Process is particularly suitable for problems that require the decomposition of a complex decision into hierarchical criteria and subcriteria and the systematic comparison of their relative importance. AHP enables expert judgments to be translated into numerical weights through pairwise comparisons and provides a consistency mechanism for evaluating the logical coherence of those judgments. In the context of value engineering, this capability is particularly useful because the success of implementation depends on several interconnected technical, economic, organizational, and environmental factors that cannot readily be evaluated using a single indicator. The method can therefore support the prioritization of strengthening conditions, inhibiting barriers, developmental capacities, and external environmental factors and provide a rational basis for resource allocation and policy intervention.

The need for such prioritization becomes even more apparent when housing is approached as a social and spatial system rather than merely a construction product. Contemporary housing developments are increasingly expected to support social integration, diversity, accessibility, and more inclusive patterns of urban life. Research on recent housing developments has demonstrated that spatial design can influence social mixing and patterns of interaction among different population groups [19]. These considerations broaden the concept of value beyond immediate construction cost and highlight the importance of functional, social, and long-term urban outcomes. Accordingly, value engineering in national housing projects should be understood as a framework for enhancing overall project value rather than as a narrow cost-cutting instrument.

The literature therefore indicates several interrelated requirements for improving national housing-project performance: reliable assessment of quantitative, qualitative, and economic housing conditions; integration of housing with sustainable urban-development objectives; effective coordination among public and private actors; attention to legal and institutional arrangements; careful management of economic uncertainty; and the systematic use of project-management tools such as value engineering. At the same time, existing research has frequently examined these dimensions separately. Housing-policy studies have generally concentrated on affordability, social policy, spatial development, or sustainability, whereas value-engineering studies have more often focused on individual infrastructure projects, construction efficiency, or technical optimization. Less attention has been given to the integration of value engineering with incentive and penalty mechanisms in large-scale national housing programs and to the structured prioritization of the factors determining whether such mechanisms can be implemented effectively.

This research gap is especially relevant to the National Housing Movement in Alborz Province, where the effectiveness of value engineering is likely to depend simultaneously on technological capability, financial resources, organizational coordination, managerial awareness, regulatory support, economic conditions, and the design of appropriate incentive and penalty mechanisms. A systematic assessment of these factors can assist decision-makers in distinguishing between those variables that directly strengthen implementation, those that constrain project performance, those that provide opportunities for future development, and those originating from the broader external environment. Such a framework can also help clarify where managerial interventions and policy resources should be concentrated and which factors should receive priority when designing implementation guidelines for value engineering.

Accordingly, the aim of the present study is to identify and prioritize the strengthening, inhibiting, developmental, and environmental factors affecting the application of value engineering in National Housing Movement projects in Alborz Province, with emphasis on the use of incentives and penalties, through multi-criteria decision-making methods.

2. Methodology

In terms of purpose, the present study was applied research, and in terms of data collection and analysis, it employed an exploratory mixed-methods (qualitative–quantitative) design. The qualitative phase was conducted to identify and extract the factors affecting the implementation of value engineering in national housing projects in Alborz Province, whereas the quantitative phase aimed to assess the importance of and prioritize these factors. The study was also cross-sectional, and the required data were collected from the study population within a specified period.

The statistical population in the quantitative phase consisted of managers, experts, executive engineers, and contractors involved in National Housing Movement projects in Alborz Province, estimated at a total of 233 individuals. Using Cochran’s formula for finite populations, the sample size was determined to be 144. Given the specialized nature of the subject and the need to access individuals with sufficient experience and knowledge of national housing projects, purposive sampling was employed. Of the respondents, 35 were project managers and

109 were experts and engineers involved in National Housing Movement projects.

In the qualitative phase, 15 semi-structured interviews were conducted with managers of National Housing Movement projects, value engineering specialists, university faculty members, and technical managers in the road and urban development sector of Alborz Province to identify the influential factors initially. Following transcription, the interviews were analyzed using qualitative content analysis based on open, axial, and selective coding. In the first stage, more than 50 initial codes were extracted. Following review, integration, and categorization of the concepts, the principal factors affecting the implementation of value engineering were identified and classified into four general categories: strengthening factors, inhibiting factors, developmental factors, and environmental factors. These factors formed the basis for designing the quantitative instrument and conducting the pairwise comparisons.

The data collection instrument in the quantitative phase was a researcher-developed questionnaire. A five-point Likert scale ranging from "very low" to "very high" was used to assess respondents' views regarding the importance of the identified factors and indicators. The validity of the instrument was examined and confirmed through face, content, and construct validity assessments using the opinions of experts in value engineering and project management. The reliability of the questionnaire was also assessed using Cronbach's alpha, which was 0.83 for the overall questionnaire and above 0.79 for the subscales, indicating acceptable reliability of the measurement instrument.

After identifying the factors and collecting the quantitative data, the Analytic Hierarchy Process (AHP) was used to prioritize the main factors and their corresponding subcriteria. AHP was selected because of the multi-criteria nature of the problem and the need to compare simultaneously the different factors affecting the implementation of value engineering. In this method, the identified factors and subcriteria were organized within a hierarchical structure, and their relative importance was determined through pairwise comparisons.

In the first stage of AHP, a pairwise comparison matrix was constructed for the main factors. In this matrix, each factor was compared pairwise with the other factors, and their relative importance was determined. Expert judgments were made based on Saaty's fundamental 1–9 scale, where a value of 1 indicated equal importance of two factors and higher values indicated progressively greater preference for one factor over another. For example, if experts considered one factor twice as important as another, a value of 2 was entered into the pairwise comparison matrix.

The geometric mean was used to aggregate expert judgments. Accordingly, for each entry in the pairwise comparison matrix, the judgments provided by the experts were aggregated and their geometric mean was calculated. Subsequently, the geometric mean of the values in each row was obtained. The resulting geometric means were then divided by their sum to derive the relative weight vector, or eigenvector, of the criteria. This vector represents the relative importance of each principal factor in the research model. The weighting procedure employed in the study was therefore based on constructing the pairwise comparison matrix, calculating the geometric means of the rows, and normalizing them.

After determining the weights of the main factors, the same procedure was repeated for the subcriteria associated with each factor, and their relative weights were calculated. The final weight and priority of each subcriterion were then determined by combining the weight of the main factor with the weight of the corresponding subcriterion. The results of this stage enabled comparison of the importance of the factors and identification of the most important components affecting the implementation of value engineering in national housing projects in Alborz Province. For example, according to the study results, the inhibiting factor, with a weight of 0.500, had the greatest importance, whereas the environmental factor, with a weight of 0.343, received the lowest weight among the main factors.

The consistency index within the AHP framework was also used to assess the consistency of the judgments. At this stage, the consistency ratio of the pairwise comparison matrices was calculated, and values below 0.10 were considered indicative of acceptable consistency. Accordingly, only matrices demonstrating an acceptable level of consistency were used to determine the final weights of the criteria.

In the next stage, a field survey of experts and specialists in the construction sector was conducted to assess the existing status of the identified factors. The status of each factor was evaluated on a four-point scale ranging from 1 to 4, where a score of 1 indicated a critical condition and a score of 4 indicated a highly favorable condition. A weighted score was then calculated for each factor by multiplying its importance weight by its mean status score. Finally, the sum of the weighted scores for the different groups was used as the basis for evaluating and analyzing the status of value engineering implementation in national housing projects in Alborz Province. According to the study results, the total score for strengthening and inhibiting factors was 2.68, whereas the total score for developmental and environmental factors was 2.46.

Statistical and multi-criteria decision-making software, including SPSS and Expert Choice, were used for descriptive data analysis and calculations related to the Analytic Hierarchy Process. Overall, the research process began with the qualitative identification of factors; the extracted factors were subsequently evaluated using a quantitative instrument; and finally, AHP was employed to determine the relative importance and priorities of the factors and subcriteria affecting the implementation of value engineering.

3. Findings and Results

In this study, the views of 144 project managers, experts, and engineers involved in National Housing Movement projects in Alborz Province were examined. Of the participants, 35 were project managers and 109 were experts and engineers. Examination of respondents' demographic characteristics showed that 76.4% of the sample were men and 23.6% were women. In terms of age, the highest frequency was observed in the 31–35-year age group, accounting for 28.5% of the sample. In terms of work experience, the largest proportion of respondents had 6–10 years of professional experience, representing approximately 33% of the sample.

In terms of educational attainment, a master's degree was the most common qualification among respondents, accounting for approximately 56% of the sample. Among project managers, this proportion reached approximately 60%. Overall, the composition of the research sample in terms of work experience, educational attainment, and occupational position indicates the participation of individuals with specialized knowledge and executive experience relevant to national housing projects. Therefore, the collected views provide an appropriate basis for identifying and prioritizing the factors affecting the application of value engineering in the projects under study.

To identify the factors affecting the success or failure of value engineering implementation in National Housing Movement projects in Alborz Province, an exploratory study was initially conducted using documentary studies and data obtained from expert interviews. In the qualitative phase, semi-structured interviews were conducted with 15 experts, including executive managers, technical experts, project consultants, and faculty members working in fields related to value engineering and construction management. Following data collection, the interview content was analyzed and coded, and similar and repetitive concepts were identified, integrated, and classified into principal components.

In addition to the interview findings, the results of the review of library sources and previous domestic and international studies in the fields of value engineering, construction project management, and incentive and penalty systems were used to identify and supplement the factors. Accordingly, the extracted factors resulted from the integration of three principal sources: documentary studies, expert opinions, and field evidence.

Based on the coding and classification process, the identified influential factors were organized into four main categories: strengthening factors, inhibiting factors, developmental factors, and environmental factors. Strengthening factors represent capacities and capabilities that can facilitate the effective implementation of value engineering; inhibiting factors refer to barriers and constraints that create difficulties for implementation; developmental factors represent capacities that enable the expansion and institutionalization of value engineering; and environmental factors concern external conditions affecting project implementation.

In the next stage, the extracted factors and components were used as the basis for designing the quantitative research instrument. Accordingly, the identified indicators were incorporated into a questionnaire, and their relative importance was subsequently determined using pairwise comparisons and the Analytic Hierarchy Process (AHP). The results of this stage are presented in the following table.

Table 1. Factors Obtained From Coding the Questionnaire: Influential Factors Section

No.	Title
1	Availability of specialized human resources in agencies implementing housing projects
2	Legal and political support for national housing projects
3	Previous experience in implementing mass-housing projects such as Mehr Housing
4	Development of national strategic documents in the housing sector

5	High potential for private-sector participation in housing finance and construction
6	Feasibility of implementing value engineering at different stages of the project
7	Availability of certain incentives in implementing regulations for project optimization
8	Possibility of using modern construction technologies to reduce costs
9	Gradually increasing attention among senior managers to reducing resource waste
10	Relative readiness in certain regions to implement value engineering pilot projects
11	Absence of a clearly defined evaluation system for applying penalties and incentives
12	Weak coordination among relevant institutions (Ministry of Roads and Urban Development, Housing Foundation, banks, etc.)
13	Lack of a codified framework for integrating value engineering into the project life cycle
14	Insufficient specialized knowledge and training among executive experts
15	Lack of transparency in allocating financial and credit resources in certain regions
16	Lack of an integrated database of ongoing projects
17	Insufficient familiarity of some middle managers with the value engineering approach
18	Traditional resistance to change and the adoption of modern methods
19	Weakness in evaluating supplier and contractor performance based on value indicators
20	Delays in project approval and budget allocation due to administrative bureaucracy

Within the framework of implementing large-scale national projects, particularly in the housing sector, identifying strengths and weaknesses is one of the most important stages in performance evaluation and redesigning the project implementation pathway. In this regard, analyzing strengths and weaknesses, particularly in relation to the application of value engineering, can provide a clear picture of the capacities and deficiencies of the country's executive system in the housing sector.

In other words, influential factors are those that enable relevant organizations to pursue their housing provision missions with greater efficiency and effectiveness. These factors may include the availability of specialized personnel, a relatively comprehensive technical and executive system, defined financial and credit resources, experience in implementing mass-housing projects such as Mehr Housing, and political and legal support for national housing programs. Such characteristics provide a basis for sustaining success and advancing the objectives of national housing projects. In contrast, influential indicators and factors include characteristics or constraints that prevent the complete fulfillment of missions and reduce the efficiency of value engineering application. These include lack of coordination among executive agencies, absence of a codified framework for applying incentives and penalties, weaknesses in the culture of productivity, resource constraints in certain regions, and insufficient awareness among middle managers regarding the benefits of value engineering. These indicators and influential factors undermine expected standards for optimizing project cost and performance and create challenges in achieving quality, time, and cost objectives. Table 2 presents the influential factors identified based on data collected through questionnaires, interviews, and field investigations, analyzed according to the principal components.

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19	Weakness in evaluating supplier and contractor performance based on value indicators
20	Delays in project approval and budget allocation due to administrative bureaucracy

In the environmental analysis of national housing projects, identifying existing criteria, particularly those related to value engineering, is of particular importance. Capabilities refer to factors that can contribute to project success and improve quality and productivity, whereas threats are factors that may disrupt project implementation or reduce efficiency. Capabilities in national housing projects may include governmental legal and financial support, equity-oriented approaches to housing provision for middle- and low-income groups, and unused capacities in government-owned land. These factors can provide an appropriate platform for implementing value engineering initiatives. Furthermore, international cooperation and the utilization of successful global experiences can contribute to improving design and implementation processes. The existence of domestic capacities in modern technologies and access to special banking facilities can also accelerate project implementation and reduce costs.

Constraints in this context may include economic problems such as inflation and fluctuations in construction material prices, delays in budget allocation, and weak coordination among executive agencies. In addition, shortages of specialized and skilled human resources, the influence of rent-seeking or corruption in projects, and legal problems associated with implementing incentives and penalties are among the principal threats. Problems related to public culture and the acceptance of cost-effective or innovative designs may also hinder project success. Therefore, effectively identifying and utilizing the relevant criteria can play a key role in the success of national housing projects and provide the conditions necessary to improve their quality and efficiency. The assessment of factors in this study was conducted in several stages:

In the first stage, a list of influential factors (strengthening, developmental, inhibiting, and environmental) was compiled through:

- reviewing previous domestic and international studies;
- interviewing experts and managers of National Housing Movement projects in Alborz Province; and
- reviewing executive documents and regulations governing the National Housing Program.

Following content refinement, these factors were organized into 20 final indicators.

Table 3. Factors Obtained From Questionnaire Coding

Main Category	Factor	Analytical Explanation
Strengthening factors	Existence of national commitment to resolving the country’s housing crisis	Political and governmental support as a motivational and facilitating factor for implementing value engineering
Strengthening factors	Policymakers’ attention to reducing the waste of financial resources in construction projects	Strengthening the productivity-oriented approach at the macro decision-making level
Strengthening factors	Increased cooperation among governmental organizations and nongovernmental institutions in the housing sector	Institutional coordination to facilitate implementation processes
Strengthening factors	Capacity to implement value engineering in urban policymaking and vernacular architecture	Organizational readiness to adopt modern management tools
Developmental factors	Possibility of attracting private investment and public–private partnerships	Enhancement of financial and managerial capacity through participation by different sectors
Developmental factors	Development of modern construction technologies (lightweight structures, modular systems, industrialized construction)	Advancement of construction technology and enhancement of project productivity
Developmental factors	Possibility of utilizing the capacities of universities and research centers for project optimization	Strengthening university–industry linkages to develop value engineering knowledge
Developmental factors	Legal framework for providing tax incentives to national housing developers	Regulatory support for innovation and value creation
Developmental factors	Opportunity to utilize international experience in value engineering and construction optimization	Utilization of global knowledge and experience for national development
Inhibiting factors	Severe economic fluctuations and increases in construction material prices	Economic instability and cost inflation
Inhibiting factors	Lack of stability in macro-level housing policies	Frequent policy changes that disrupt project implementation
Inhibiting factors	Complexity of the bureaucratic structure in project approval and implementation	Administrative bureaucracy hindering agile decision-making

Inhibiting factors	Lack of transparency in the allocation and expenditure of financial resources	Lack of transparency undermining trust and efficiency
Inhibiting factors	Possibility of financial and administrative corruption in contractor selection	A threat to equity and efficiency in projects
Inhibiting factors	Resistance of some managers to implementing innovative methods	Weak organizational culture and resistance to value engineering
Inhibiting factors	Weakness in project control systems and continuous monitoring	A barrier to achieving project time and financial objectives
Environmental factors	Increasing public awareness of the need for optimization and reduction of construction costs	Changing societal attitudes toward efficiency and cost savings
Environmental factors	Declining household purchasing power and inability to pay National Housing Program installments	Effects of societal economic conditions on project success
Environmental factors	Impact of international sanctions on the importation of modern technologies and materials	External pressures affecting access to resources and technology

A mixed-methods approach (qualitative and quantitative) was used to identify environmental factors affecting the implementation of value engineering in national housing projects. In the qualitative phase, semi-structured interviews were conducted with 15 experts, including managers of National Housing Movement projects, value engineering specialists, university faculty members, and technical managers of the General Directorate of Roads and Urban Development of Alborz Province. Following transcription of the interviews, the data were analyzed using open, axial, and selective coding based on the method proposed by Strauss and Corbin (1998). From more than 50 initial codes, 20 key factors were ultimately extracted and are presented in Table 3. Based on their frequency and conceptual importance, these factors were classified into two principal categories: “capabilities and opportunities” and “threats and constraints.”

In the next stage, these factors were incorporated into the quantitative questionnaire and evaluated by 144 experts, project managers, supervisors, and construction specialists in Alborz Province. The reliability of the questionnaire was confirmed by a Cronbach’s alpha coefficient of 0.87, and its content validity was also confirmed based on expert judgment.

AHP was used to develop the value engineering components for national housing projects. To determine the priority of these factors, a coefficient ranging from zero to one was assigned in the “weight” column according to the importance and influence of each factor on project success or failure.

Subsequently, in the “rating” column, the level of impact or system performance in dealing with each factor was specified using a score ranging from 1 to 4. This scoring was conducted using the opinions of housing and construction specialists and experts in Alborz Province and was based on whether each factor was considered principal or secondary and on the magnitude of its influence on the value engineering process. In this rating system, a score of 4 indicated highly favorable conditions, whereas a score of 1 indicated critical conditions. This assessment provided the basis for developing strategies aimed at optimizing resources, reducing costs, increasing productivity, and successfully implementing value engineering in national housing projects in Alborz Province (Arabi, 1999). Based on the classification of factors in Table 4-6, the relevant explanations are presented in Table 4.

To identify and prioritize the factors affecting the implementation of value engineering in national housing projects, a set of principal factors was first extracted from the literature review, expert interviews, and examination of technical documents and classified into four categories: strengthening, inhibiting, developmental, and environmental factors. The Analytic Hierarchy Process was then used to determine the importance of each factor. In this method, a pairwise comparison matrix was initially constructed among the criteria based on expert judgments. Judgments were made according to Saaty’s 1–9 scale, and following normalization and calculation of the geometric mean of the judgments, the final weight of each factor was obtained. The resulting values are presented in the “importance coefficient” column of Table 4. These coefficients represent the relative contribution of each factor to the success or failure of value engineering initiatives in national housing projects. In the next stage, a field survey of construction specialists in Alborz Province was used to rate system performance in relation to each factor on a scale from 1 to 4. On this scale,

a score of 4 indicated highly favorable conditions, whereas a score of 1 represented critical conditions.

The “total weighted score” for each group was then calculated by multiplying the importance coefficient (weight) by the mean score obtained. The sums of these scores for Levels 1 and 2 and for Levels 3 and 4 formed the basis for the final analysis of the table.

Specifically:

The total score for Level 1 and Level 2 factors (strengthening and inhibiting factors) was 2.68.

The total score for Level 3 and Level 4 factors (developmental and environmental factors) was 2.46.

These values indicate that, from the experts' perspective, strengthening and inhibiting factors play a more influential role in determining the effectiveness of value engineering in national housing projects. In other words, under the current conditions of National Housing Movement projects in Alborz Province, focusing on improving strengthening factors, such as the use of modern construction technologies and cost and time management, and reducing inhibiting factors, such as weak interorganizational coordination and budget shortages, can have the greatest effect on improving value engineering performance. Therefore, the results presented in Table 4 not only indicate the relative prioritization of influential factors but also provide a basis for developing improvement strategies and applying incentives and penalties to increase productivity and reduce costs in national housing projects.

Table 4. Analysis of the Criteria

Factors	Importance Coefficient	Total Score	Total Weighted Score
Strengthening	83	37	1.81
Inhibiting factors	87	17	0.87
Total score for Level 1 and Level 2 criteria			2.68
Developmental factors	79	35	1.77
Environmental factors	78	14	0.69
Total score for Level 3 and Level 4 criteria			2.46

The results of the analysis presented in Table 4 indicate that the total score for Level 1 and Level 2 factors was 2.68, whereas the total score for Level 3 and Level 4 criteria was 2.46.

Table 5. Weighting of Components

Normalized Weight	Mean Likert Score (1–4)	Factor (Component)
0.066	3.6	Existence of national commitment to resolving the country's housing crisis
0.062	3.4	Possibility of attracting private investment and public–private partnerships
0.069	3.8	Development of modern construction technologies (lightweight structures, modular systems, industrialized construction)
0.060	3.3	Possibility of utilizing the capacities of universities and research centers for project optimization
0.064	3.5	Policymakers' attention to reducing the waste of financial resources in construction projects
0.069	3.7	Legal framework for providing tax incentives to national housing developers
0.058	3.2	Increased cooperation among governmental organizations and nongovernmental institutions in the housing sector
0.060	3.3	Increasing public awareness of the need for optimization and reduction of construction costs
0.062	3.4	Capacity to implement value engineering in urban policymaking and vernacular architecture
0.056	3.1	Opportunity to utilize international experience in value engineering and construction optimization
0.038	2.1	Severe economic fluctuations and increases in construction material prices
0.042	2.3	Lack of stability in macro-level housing policies
0.040	2.2	Complexity of the bureaucratic structure in project approval and implementation
0.036	2.0	Lack of transparency in the allocation and expenditure of financial resources
0.032	1.8	Possibility of financial and administrative corruption in contractor selection
0.043	2.4	Resistance of some managers to implementing innovative methods
0.034	1.9	Weakness in project control systems and continuous monitoring
0.036	2.0	Declining household purchasing power and inability to pay National Housing Program installments
0.031	1.7	Impact of sanctions on the importation of modern technologies and materials
0.034	1.9	Lack of coordination between urban development programs and national housing policies

Table 5, which presents the weighting of value engineering indicators in national housing projects in Alborz Province, shows that, from the experts' perspective, strengthening factors and capabilities play the greatest role in achieving value engineering objectives. The sum of the weights of capability factors (0.628), compared with inhibiting factors (0.372), indicates that appropriate institutional, legal, and technological foundations exist for implementing value engineering in Alborz Province. Nevertheless, the persistence of structural problems, economic fluctuations, and weaknesses in project monitoring and control systems may constitute serious barriers to the optimal utilization of these capacities. Therefore, the results indicate that policymakers and executive managers should focus on strengthening key factors such as modern construction technologies, tax incentives, intersectoral cooperation, and specialized training to utilize existing potential for improving the productivity of national housing projects, while simultaneously reducing the effects of inhibiting threats through managerial restructuring and greater policy stability.

In this section, the identified principal factors were compared based on expert opinions, and the results obtained from the analysis of the collected views are presented in Table 5. This table includes a comparison of the five identified principal factors affecting value engineering in national housing projects in Alborz Province.

To rank the principal factors affecting the implementation of value engineering in National Housing Movement projects in Alborz Province, the indicators and sub-indicators were first extracted based on the literature review and the results presented in Tables 3 and 4. Subsequently, a questionnaire based on a five-point Likert scale ranging from “very low” to “very high” was designed to determine the importance of each factor from the perspective of experts and professionals in the construction industry.

In the next stage, the questionnaire data were entered into Expert Choice software or manually processed using Saaty’s AHP model. In this method, a pairwise comparison matrix was initially constructed among the principal factors to determine experts’ preferences between each pair of factors. For example, if respondents considered the “strengthening” factor twice as important as the “inhibiting” factor, a value of 2 was entered in the corresponding cell. The remaining comparisons were then conducted using Saaty’s 1–9 scale, and the relative weight of each factor was calculated by taking the geometric mean of the judgments. In the third stage, the eigenvector for each factor was obtained by normalizing the geometric means. This eigenvector represents the final weight and relative importance of each principal factor in the value engineering model. For example, in Table 4-9:

- the inhibiting factor had the highest weight and importance (eigenvector = 0.500); and
- the capability or environmental factor had the lowest importance (eigenvector = 0.343).

These findings indicate that, from the perspective of specialists in Alborz Province, inhibiting factors, such as weak coordination among institutions, shortages of financial resources, and instability in executive policies, play the greatest role in the challenges associated with implementing value engineering in national housing projects. In contrast, environmental factors, such as climatic conditions or the geographical location of projects, have a relatively smaller effect on project success.

Accordingly, the data presented in Table 6 resulted from weighting the indicators shown in Tables 3 and 4 based on the Likert scale and processing them using the Analytic Hierarchy Process, which involved calculating geometric means, extracting eigenvectors, and ultimately determining the priorities of the principal factors.

In the Analytic Hierarchy Process, the procedure for calculating the final weights was as follows:

1. **Construction of the pairwise comparison matrix:** The criteria were compared pairwise. For example, if “improvement and expansion” was considered twice as important as “development of access,” the value 2 was entered into the matrix.
2. **Calculation of the geometric mean of the rows:** For each criterion, the values in its corresponding row of the matrix were multiplied together, after which the *n*th root was calculated, where *n* represents the number of criteria.

Table 6. Determination of the Priority of the Main Factors Identified as Affecting Value Engineering in National Housing Projects

Main Factors	Strengthening	Inhibiting Factors	Developmental Factors	Environmental Factors	Geometric Mean	Eigenvector
Strengthening	1	1	0.500	1	0.242	0.707
Inhibiting factors	1	1	1	2	0.171	0.500
Developmental factors	2	1	1	2	0.242	0.707
Environmental factors	1	0.500	0.500	1	0.343	1

Based on Table 6 and Figure 1, the weights of the four principal factors are evident. The inhibiting principal factor was found to have greater importance than the other factors, whereas the capability criterion had the lowest importance in the development of value engineering for national housing projects in Alborz Province. The same process was subsequently applied to the subcriteria, the results of which are presented in Tables and Figures 1–3.

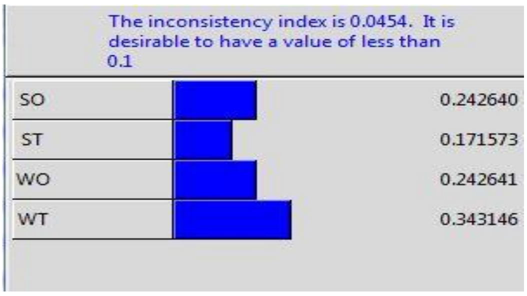

Figure 1. Graphical Representation of Factors Affecting the Impact of Value Engineering on National Housing Projects in Alborz Province

Table 7. Determination of the Priority of Identified Strengthening Factors Affecting Value Engineering in National Housing Projects in Alborz Province

Capabilities	Development and Promotion of Value Engineering	Enhancement of Construction Productivity	Cost Reduction	Facilitation of Decision-Making	Geometric Mean	Eigenvector
Facilitation of decision-making and establishment of an implementation platform	1	1	0.500	0.500	0.16912	0.49940
Reduction of implementation and material costs in projects	1	1	1	0.500	0.20432	0.60405
Enhancement of productivity in construction and implementation processes	2	1	1	1	0.28753	0.85142
Development and promotion of value engineering thinking in relevant institutions	2	2	1	1	0.33824	1

The first priority was assigned to “facilitation of decision-making and establishment of an implementation platform,” because it provides the foundation for the accurate implementation of value engineering throughout different project stages. Cost reduction and productivity enhancement are also key pillars of project success and were ranked second and third, respectively. Although the development and promotion of a value engineering culture are conceptually important, in practice they have a less direct effect than the other three factors and therefore ranked fourth.

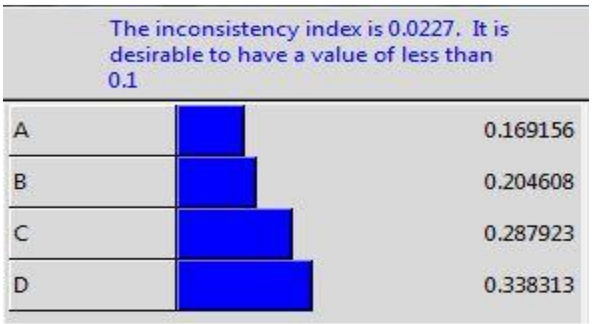

Figure 2. Graphical Representation of Strengthening Factors Affecting the Impact of Value Engineering on National Housing Projects in Alborz Province

Table 8. Determination of the Priority of Identified Inhibiting Factors Affecting Value Engineering in National Housing Projects in Alborz Province

Constraints	Liquidity Shortage	Inappropriate Utilization	Increasing the Level of Information	Geometric Mean	Eigenvector
Increasing the level of information and awareness regarding value engineering	1	1	0.500	0.250	0.500
Inappropriate utilization of value engineering study results	1	1	0.500	0.250	0.500
Shortage of liquidity and financial resources for implementing recommendations	2	2	1	0.500	1

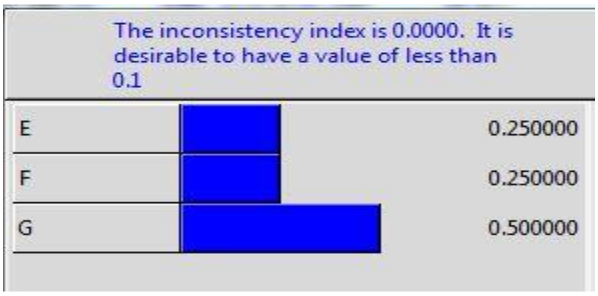

Figure 3. Graphical Representation of Inhibiting Factors Affecting the Impact of Value Engineering on National Housing Projects in Alborz Province

Table 9. Determination of the Priority of Identified Developmental Factors Affecting Value Engineering in National Housing Projects in Alborz Province

Capabilities	Access Development	Improvement and Expansion	Qualitative Development and Change	Geometric Mean	Eigenvector
Development of access	1	0.500	1	0.259	0.629
Improvement and expansion	2	1	1	0.412	1
Qualitative development and change	1	1	1	0.327	0.793

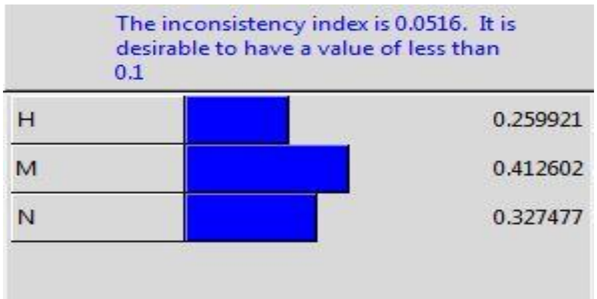

Figure 4. Graphical Representation of Developmental Factors Affecting the Impact of Value Engineering on National Housing Projects in Alborz Province

Table 10. Determination of the Priority of Identified Environmental Factors Affecting Value Engineering in National Housing Projects in Alborz Province

External Factors	Planning	Change in the System	Program Development	Geometric Mean	Eigenvector
Weakness in coordinated and macro-level planning for implementing value engineering	1	1	2	0.169	0.381
Resistance to change in structures and systems	1	1	1	0.443	1
Absence of a comprehensive codified program for applying value engineering principles	1	1	1	0.387	0.874

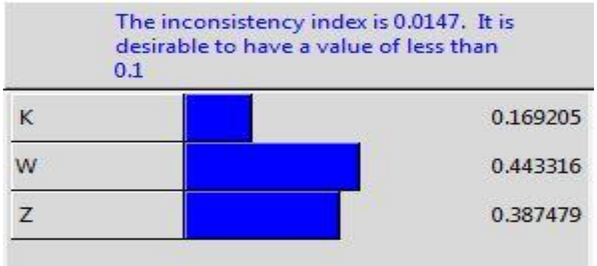

Figure 5. Graphical Representation of Environmental Factors Affecting the Impact of Value Engineering on National Housing Projects in Alborz Province

Table 11. Final Weights of Criteria and Subcriteria

Criterion	Weight	Subcriterion	Subcriterion Weight	Final Weight	Rank (Priority)
Strengthening	0.242	Cost optimization using a value-oriented approach	0.499	0.169	10
		Improving design quality through multidisciplinary team participation	0.604	0.204	9
		Use of modern technologies in design and construction	0.851	0.287	8
		Strengthening the decision-making process based on value analysis	1	0.338	7
Inhibiting factors	0.242	Strengthening the decision-making process based on value analysis	0.250	0.500	5
		Enhancing human resource capabilities in value analysis	0.250	0.500	5
		Establishing a database of value engineering experiences	0.500	1	1
Developmental factors	0.171	Increasing the economic returns of projects through value creation	0.259	0.629	4
		Developing legal infrastructure for implementing value engineering	0.412	1	1
		Establishing coordination among executive agencies and consultants	0.327	0.793	3
Environmental factors	0.343	Addressing organizational resistance to change	0.169	0.381	6
		Reforming the organizational structure to support value engineering	0.443	1	1
		Developing explicit implementation requirements for value engineering	0.387	0.874	2

4. Discussion and Conclusion

The present study examined the factors affecting the implementation of value engineering in National Housing Movement projects in Alborz Province, with particular emphasis on the role of incentives and penalties and the prioritization of influential criteria through the Analytic Hierarchy Process. The findings showed that the implementation of value engineering in national housing projects is shaped by a combination of strengthening, inhibiting, developmental, and environmental factors. The results also indicated that strengthening and inhibiting factors jointly accounted for a higher overall weighted score than developmental and environmental factors, suggesting that the immediate internal capacities of projects and the barriers constraining their implementation are more influential than broader developmental and external conditions. In addition, the weighting results highlighted the importance of technological capabilities, legal and regulatory support, managerial coordination, access to financial resources, project control, and organizational readiness. These findings confirm that value engineering in large-scale housing projects is not merely a technical cost-reduction mechanism but a multidimensional managerial approach whose effectiveness depends on organizational, institutional, financial, technological, and environmental conditions.

One of the main findings was the considerable importance attributed to strengthening factors, particularly the use of modern construction technologies, cost and time management, policy attention to reducing resource waste, and the institutional capacity to implement value engineering. This result is consistent with previous research emphasizing that value engineering is most effective when it is integrated into the planning, design, and control stages of construction projects rather than being introduced only after major technical and financial decisions have been made. Studies of construction and infrastructure projects have shown that value engineering can improve project efficiency by identifying unnecessary costs, evaluating alternative solutions, improving constructability, and increasing the functional value of project outputs [13]. Similarly, research on the management and execution of construction projects has demonstrated that effective application of value engineering depends on systematic planning, coordination among project participants, and the availability of mechanisms that enable proposed alternatives to be evaluated and implemented [15]. Therefore, the high importance assigned to strengthening factors in the present study can be explained by the central role of internal project capabilities in transforming value-engineering analyses into practical improvements.

The relatively high weights assigned to technological factors are also understandable given the cost structure and repetitive nature of large-scale housing construction. The adoption of industrialized construction methods, modular systems, lightweight structures, digital technologies, and more efficient design and execution procedures can reduce material waste, accelerate construction, and improve productivity. Previous applications of value engineering in infrastructure projects have demonstrated that alternative structural and construction solutions can generate substantial improvements in both economic and technical performance [17]. Likewise, value engineering studies of bridge construction projects have shown that the structured comparison of design and implementation alternatives can contribute to cost optimization while preserving required functionality and technical performance [16]. These findings support the present result that technological development and the use of innovative construction methods represent important enabling conditions for value engineering in National Housing Movement projects.

The findings also emphasized the importance of reducing financial-resource waste and improving economic efficiency. This result is especially important in the housing sector because housing affordability and project feasibility are highly sensitive to construction costs, inflation, land values, financing conditions, and household purchasing power. Previous studies have shown that quantitative, qualitative, and economic indicators must be considered jointly when evaluating housing performance, because an increase in housing supply does not necessarily improve access if construction and financing costs exceed household affordability [3]. Moreover, fluctuations in the housing market and changes in urban economic conditions can substantially affect the success of housing projects [5]. The importance assigned to financial efficiency in the present study can therefore be interpreted as a response to the economic vulnerability of large public housing programs, where inefficient resource utilization can increase project costs, delay completion, and reduce affordability for final beneficiaries.

Another major finding concerned the importance of inhibiting factors. The results indicated that barriers such as shortages of liquidity and financial resources, weak coordination among executive organizations, instability in housing policies, bureaucratic complexity, insufficient transparency, weak project-control systems, and managerial resistance to innovative methods can significantly reduce the effectiveness of value engineering. This finding agrees with research showing that successful value engineering requires not only technical analysis but also managerial commitment, organizational coordination, appropriate information systems, and a supportive decision-making environment. Rajabi found that the performance of value engineering in construction projects is closely related to project efficiency and organizational conditions, including managerial support, staff competence, communication, and the proper integration of value-engineering activities into project processes [18]. Likewise, Mammani and Lashgari emphasized that value engineering is more likely to contribute to construction-project success when it is embedded in planning and project-control systems rather than treated as an isolated analytical exercise [14]. These studies support the present finding that deficiencies in coordination and control can prevent potentially valuable recommendations from generating measurable improvements.

The significance of policy instability and administrative bureaucracy can also be explained by the institutional complexity of national housing programs. Large-scale housing schemes involve multiple public agencies, financial institutions, municipalities, contractors, consultants, and service providers. Consequently, delays or inconsistencies in approvals, financing, land allocation, technical regulations, and procurement can generate cumulative effects on cost and schedule performance. International research on national housing programs has similarly shown that changes in government priorities and institutional arrangements can affect the spatial and operational outcomes of housing development [9]. Research on affordable housing has also emphasized that successful housing programs require coordination among financing systems, land policies, public institutions, and implementation mechanisms [2]. Thus, the importance of inhibiting factors identified in this study reflects the broader reality that value engineering cannot function effectively in an unstable or fragmented institutional environment.

The results further demonstrated that developmental factors, including private-sector investment, public–private partnerships, university–industry collaboration, tax incentives, and the use of international experience, can facilitate the institutionalization and expansion of value engineering. This finding is consistent with studies emphasizing that housing provision increasingly requires diversified financing arrangements and collaboration among governmental, private, and research institutions. Comparative studies of social-housing policies indicate that public intervention alone is often insufficient and that sustainable housing provision benefits from complementary mechanisms such as private investment, financial incentives, regulatory support, and collaborative governance [7]. The finding regarding private investment and public–private partnerships is therefore particularly relevant to national housing programs because financial constraints can be reduced when risks, responsibilities, and resources are distributed among multiple actors.

The positive role of universities and research centers also has a clear theoretical basis. Value engineering is inherently knowledge-intensive and depends on multidisciplinary analysis, creativity, functional evaluation, economic assessment, and the generation of alternative technical solutions. Cooperation between academic institutions and project organizations can strengthen methodological competence, improve access to specialized expertise, and increase the quality of value-engineering workshops and analyses. This is especially important in contexts where insufficient training and limited familiarity with value engineering were identified as barriers. The results of the present study therefore reinforce the importance of capacity building and knowledge transfer in improving value-engineering practice.

The findings regarding incentives and penalties are also noteworthy. The study indicates that clearly designed incentive mechanisms can strengthen the adoption of value engineering, whereas the absence of transparent evaluation systems for rewards and sanctions can weaken its implementation. This can be explained by the behavioral and contractual structure of construction projects. Contractors and consultants may have limited motivation to propose cost-saving alternatives if the financial benefits accrue exclusively to the client while the additional analytical effort and implementation risks remain with the project team. Incentive systems can address this imbalance by linking rewards to measurable improvements in cost, quality, time, innovation, or value creation. Conversely, penalties can be used where noncompliance, delay, poor quality, or inefficient resource utilization results from controllable performance failures. The legal dimension of such arrangements is important because contractual obligations and enforcement mechanisms must be sufficiently clear to maintain fairness among project stakeholders. Research on housing transactions and equitable legal relationships has similarly emphasized the importance of clear legal structures and balanced allocation of rights and obligations in reducing disputes and improving implementation outcomes [8].

Another important result was the role of environmental factors, including declining household purchasing power, international sanctions, public awareness, and inconsistencies between urban-development programs and national housing policies. Although environmental factors received a lower relative weight than some internal project factors, they remain important because they define the broader conditions within which value engineering operates. Housing is closely connected to social and economic development, and changes in household income, employment, financing capacity, and urban conditions directly affect the feasibility and long-term success of housing programs [1]. In Iran, previous assessments of large-scale housing programs have also shown that housing projects can affect sustainable urban development and that inadequate integration with local services and urban structures may reduce their long-term effectiveness [12]. Therefore, even if environmental factors are less directly manageable by project teams, they should not be excluded from strategic value-engineering decisions.

The result concerning reduced household purchasing power is particularly significant because the economic value of a housing project cannot be evaluated only from the perspective of construction cost. A housing unit may be delivered efficiently from a technical standpoint but still fail to achieve its policy objective if beneficiaries cannot finance installments or maintain long-term occupancy costs. Spatial and qualitative housing studies have similarly emphasized the need to evaluate housing through sustainability-oriented frameworks incorporating economic accessibility, quality, and spatial conditions [4]. This broader interpretation of value suggests that value engineering in national housing projects should incorporate user affordability and long-term operational consequences rather than focusing exclusively on initial capital expenditure.

The findings also showed that public awareness and changing attitudes toward cost optimization can support the implementation of value engineering. This reflects the fact that project value includes social and user-related dimensions in addition to engineering performance. Contemporary housing research has demonstrated that residential design, neighborhood organization, and social configuration can influence patterns of social interaction and inclusion [19]. Similarly, social capital and relationship-based characteristics can affect housing-market behavior and housing values [6]. These studies suggest that the evaluation of value in housing projects should encompass functional and social outcomes alongside economic efficiency. Consequently, strengthening public understanding of efficient design, industrialized construction, and cost-effective housing solutions may facilitate acceptance of innovations that could otherwise encounter resistance.

The results related to policy coordination are also consistent with futures-oriented housing research. Studies of housing provision in distressed urban fabrics have emphasized that future housing policies must account for institutional uncertainty, spatial constraints, financing conditions, and long-term changes in urban development [10]. Similar research has highlighted the importance of scenario-oriented policy design and the need to anticipate future transformations in housing demand, investment conditions, and governance structures [11]. From this perspective, the present findings imply that value engineering should not be restricted to project-level technical decisions. It should also be incorporated into strategic housing planning so that project alternatives are evaluated in relation to future economic, institutional, and spatial conditions.

Overall, the findings show that the effective implementation of value engineering in National Housing Movement projects requires simultaneous attention to internal project capabilities and external institutional conditions. Strengthening technological capacity, improving cost and time management, developing human-resource competencies, and creating structured decision-making processes can directly improve project performance. However, these improvements will remain limited if financial instability, bureaucratic fragmentation, policy inconsistency, weak supervision, and insufficient coordination persist. The results therefore support an integrated model in which value engineering is treated as a project-governance mechanism rather than merely a technical cost-control technique. Such an interpretation is consistent with the broader literature demonstrating that successful construction-project performance depends on the interaction of technical, managerial, economic, and institutional factors [14, 15]. In this context, the systematic use of incentives and penalties can further strengthen implementation by aligning stakeholder behavior with project objectives, provided that performance criteria are transparent, measurable, and contractually enforceable.

This study has several limitations that should be considered when interpreting its findings. First, the research was conducted only in Alborz Province and focused on individuals involved in National Housing Movement projects in that province; therefore, the findings may not fully represent differences in institutional capacity, market conditions, land availability, construction costs, and administrative structures across other provinces. Second, although the mixed-methods design enabled the integration of qualitative and quantitative evidence, the quantitative findings were based primarily on expert judgments and self-reported questionnaire data, which may be influenced by respondents' professional experiences and subjective perceptions. Third, AHP relies on pairwise judgments and therefore remains sensitive to the composition of the expert group and to the manner in which criteria are defined. Finally, the cross-sectional design captured conditions during a specific period and did not examine how the importance of factors may change over different stages of project implementation or under changing economic and policy conditions.

Future studies should replicate the present framework in multiple provinces and compare regions with different levels of urbanization, housing demand, administrative capacity, and project progress. Longitudinal research could investigate how the relative importance of strengthening, inhibiting, developmental, and environmental factors changes from project initiation through design, construction, and delivery. Future studies could also combine AHP with other multi-criteria decision-making techniques such as DEMATEL, ANP, TOPSIS, or fuzzy methods to examine causal relationships and uncertainty more explicitly. Another useful direction would be to develop and empirically test specific incentive and penalty models for contractors, consultants, and project managers based on measurable cost, time, quality, innovation, and value indicators. Research could also investigate the effect of digital construction technologies, Building Information Modeling, industrialized construction, and integrated project-delivery arrangements on value-engineering outcomes in national housing projects.

Project authorities should institutionalize value engineering from the early planning and design stages rather than applying it only after major project decisions have been finalized. A standardized value-engineering framework should be developed for National Housing Movement projects, including clear procedures for workshops, functional analysis, alternative evaluation, documentation, and implementation monitoring. Executive agencies should establish transparent incentive and penalty systems linked to measurable indicators of cost savings, schedule performance, quality improvement, innovation, and resource efficiency. Training programs should be provided for managers, engineers, consultants, and contractors to improve their ability to conduct and use value analyses. Integrated databases should also be established to record previous value-engineering studies, successful alternatives, contractor performance, and lessons learned. Finally, stronger coordination mechanisms among housing authorities, municipalities, banks, consultants, contractors, and research institutions should be developed so that value-engineering recommendations can be translated into timely and enforceable project decisions.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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