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Identifying and Classifying Mental Models of Industry and Academic Experts Regarding Factors and Approaches Effective in Transforming the Structure of Knowledge-Based Firms into Innovation Powerhouses

Hassan Fathalian[1], Behzad Shahrabi[2*], Fereydoon Azma[3], Elahe Masoumi[4]

1. Department of Entrepreneurship, AK.C., Islamic Azad University, Aliabad Katoul, Iran.
Email: h.fathalian@iau.ac.ir
*2. Department of Management, AK.C., Islamic Azad University, Aliabad Katoul, Iran. (**Corresponding Author**)*
Email: b.shahrabi@iau.ac.ir
3. Department of Management, AK.C., Islamic Azad University, Aliabad Katoul, Iran.
Email: fereydoonazma@iau.ac.ir
4. Department of Accounting, Najafabad Branch, Islamic Azad University, Najafabad, Iran.
Email: ehsankamali_acc@yahoo.com

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ABSTRACT

In today's competitive landscape, the survival of knowledge-based firms hinges upon fostering an innovation-oriented culture. However, following their independence from supportive incubation services, many such firms fail due to the lack of institutionalized innovation, primarily stemming from insufficient attention to internal enablers and external synergies. Accordingly, this study aims not only to identify the constituent factors of an "innovation powerhouse"—a structure designed to cultivate an innovation culture—but also to classify these factors according to the mental models of domain experts. To this end, Q methodology was employed. Initially, components of the innovation powerhouse were delineated through expert interviews, leading to the identification of 40 Q-statements. Twelve experts were then asked to rank these statements along a continuum from "most agree" to "most disagree." Factor analysis conducted via SPSS software revealed four distinct mental models. To assess reliability, a test–retest procedure was administered to four experts, yielding a correlation coefficient of 0.78, which is deemed acceptable. The identified mental models, aligned with the design-oriented approach to building an innovation powerhouse, prioritize the following four patterns in order of significance: (1)employee motivation, personal development, and human capital training; (2)sustained teamwork across research, production, capital acquisition, and novel marketing functions; (3)innovation processes grounded in business environment analysis; and (4)a dynamic compensation system for both internal employees and external collaborators, calibrated according to their effectiveness in driving innovation.

KEYWORDS: Innovation powerhouse, innovation culture, knowledge-based firms, mental models

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1. Introduction

Innovation is a fundamental driver of organizational competitiveness and growth. Consequently, firms must develop new products and processes and leverage advanced technologies to ensure their long-term sustainability (Sabor, 2017). The development of innovation capabilities significantly influences firm performance—particularly in terms of profitability, market share, customer satisfaction, and organizational resilience. Therefore, companies should strive to translate innovation capability into tangible innovation outcomes (Adnan, 2024).

Concurrently, as the global economy shifts toward a knowledge-based paradigm, many nations have prioritized the development of knowledge-based firms. Such enterprises enable advanced economies to maintain competitiveness against emerging economies where labor and production costs are comparatively lower (Kazemi, 2022). In contrast, one of the critical weaknesses of Iran's economy lies in its low levels of innovation and the limited technological and knowledge intensity of its economic enterprises. This deficiency renders the national economy particularly vulnerable.

In this context, the knowledge-based economy has been positioned as Iran's comprehensive scientific roadmap for enhancing the country's global standing and increasing the share of knowledge-intensive goods and services in domestic production and exports. Descriptive analyses of entrepreneurial ventures consistently demonstrate that sustainable innovators significantly outperform their less innovative or non-innovative counterparts in terms of sales, value-added creation, employment growth, and profitability (Hendrickson, 2018).

However, this highlights a critical shortcoming in Iran's approach to knowledge-based firms: their post-incubation sustainability remains weak. According to reports from the Vice-Presidency for Science and Technology (2023), over 8,000 knowledge-based businesses were active in Iran in 2022 (1401 SH). Yet, approximately 11% of these firms failed within the first year of establishment, and nearly 80% of newly established firms collapsed within five years (Kazemi, 2022).

This high attrition rate stems from internal organizational incoherence and unplanned, unstructured external dependencies. Upon graduating from innovation centers and technology incubators, many firms lack a multifaceted internal architecture that fosters continuous innovation and fails to establish synergistic linkages with external ecosystems.

Addressing this gap, a novel conceptual framework—termed the "Innovation Powerhouse"—has recently emerged (Wynn, 2023). This approach posits that after separation from incubation support, knowledge-based firms require a systemic, innovation-driven mechanism to sustain continuous innovation in both industrial and technological domains. Surprisingly, despite its relevance, this concept remains underexplored even in Western academic literature. The most

notable reference is *Building an Innovation Powerhouse: Maximizing People's Potential to Grow Your Business* by Andy Wynne and Jim Heek (Wynn, 2023), which outlines discrete characteristics of an innovation powerhouse—such as culture, teams, people, diversity, and leadership—but does not offer an integrated structural model.

Similarly, while countries like China, South Korea, and Japan are often cited as regional "innovation powerhouses," there exists no established theoretical or empirical model that explicitly aims to synergize industry and academia for the continuous co-production of innovation within newly established, knowledge-based firms—whether in manufacturing or services.

Given this significant research gap and the strategic importance of the topic, the present study seeks to (1) identify the core components constituting an Innovation Powerhouse, and (2) classify the mental models of industry and academic experts regarding these components. To achieve this, the following research questions are formulated:

1. What are the primary factors that constitute the structure of an Innovation Powerhouse?
2. How can these factors be categorized based on Q methodology?
3. What is the relative importance and prioritization of these factors according to experts' mental models, as revealed through Q methodology?

2. Literature Review

According to the Deputy for Development of Knowledge-Based Companies (2022), Iran hosted 8,126 knowledge-based firms in 1401 SH (2022–2023). However, as reported by the Chair of the Technology Commission of the Iran Chamber of Commerce, approximately 2,500 of these firms—particularly those located in science and technology parks—are on the verge of bankruptcy. Numerous knowledge-based enterprises in Iran fail for a variety of reasons. Hosseini (2023) identifies the two most critical factors as (1) the manner of firm formation and (2) organizational resistance to change. Furthermore, Nasri's (2021) analysis reveals that Iran's national innovation system ranks significantly lower than even neighboring countries such as Saudi Arabia and Turkey.

Despite this challenging landscape, several studies have addressed factors that could enhance the performance and sustainability of knowledge-based firms—albeit in a fragmented manner. For instance, Khademi Kaleh Lou et al. (2023) proposed a human resource management (HRM) model for innovative knowledge-based companies and identified the following as the most critical HR functions, in order of importance: compensation and motivation; training, development, and learning environment creation; teamwork and participation; performance appraisal; talent and competency management; retention and enhancement of knowledge workers; and recruitment and HR policy formulation.

Similarly, Akhtari et al. (2022) developed a model for effective and innovative human capital and concluded that firms can enhance their performance by adopting modern HR strategies to cultivate human capital. Rezazadeh (2022) demonstrated that innovation culture and electronic marketing significantly influence product development in knowledge-intensive contexts. Ahmadi

(2023) found a positive and significant relationship between supportive mechanisms, leadership, and innovation culture, emphasizing that organizational survival depends on novel ideas and creative thinking that translate into innovative outcomes.

Regarding organizational structure, Jafari (2008) argued that organizational variables—including technology, structure, strategy, and culture—as well as environmental factors, collectively shape innovation and creativity, with organizational structure being the most influential determinant. Ansari (2017) examined the structural model of knowledge absorption capacity in knowledge-based firms and confirmed a significant positive impact of absorptive capacity dimensions on various types of innovation.

Mansouri (2019) identified and prioritized 50 drivers of knowledge-based firm development, categorizing them into six thematic groups: (1) development of technology-related centers, (2) human capital factors, (3) institutional support mechanisms for technology production, (4) government-related factors, (5) infrastructural enablers, and (6) strategic policies for firm advancement. Abolfathi (2020), using a strategic HRM lens, extracted 33 key dimensions for designing an effective HR model in knowledge-based firms and found—through Delphi panels—that supportive management exerts the strongest direct and indirect influence on firm performance.

In the international literature, Udayanganie (2021) explored how knowledge, creativity, and innovation can be systematically converted into effective business outcomes. The study highlighted knowledge management as a critical strategic lever in today's knowledge-driven economy and emphasized that escalating competition, evolving consumer demands, and emerging business models necessitate continuous innovation.

Baporikar (2018), in a study of Indian SMEs, identified key sustainability enablers, including novel business themes, appropriate frameworks, knowledge-based investment, innovation-oriented tax policies, innovation financing, innovation within SME value chains, and knowledge-driven investment policies. Saunila (2020), through a systematic literature review, confirmed that deliberate organizational efforts to develop innovative outputs create sustainable competitive advantage for SMEs. The study also reinforced the dual conceptualization of innovation capability—as both a *process* and an *outcome*—which aligns with prior scholarly work (e.g., Branz et al., 2006; Jørgensen & Ulhøi, 2010; Kim et al., 2018; Saunila & Okko, 2014; Oukas & Suk, 2014; Aura et al., 2016; Zhang & Hartley, 2018).

Concerning innovation culture, Raajpoot (2021), analyzing data from 96 firms across 24 countries, identified key success factors for new service development: innovation culture, global orientation, incentives and rewards, collaboration with foreign partners, market analysis, and customer need identification. Crucially, the study concluded that innovation culture is indispensable—customer insight alone cannot ensure success without it, and financial rewards significantly reinforce an innovation-oriented culture.

Sharifi (2022) developed a theoretical framework linking innovation culture to organizational performance through competitive advantage. Drawing on five established theoretical perspectives—resource-based view, market-based view, knowledge-based view, capability-based

view, and relational view—the study underscored the role of internal resources in strengthening innovation culture in response to external business dynamics. The findings position innovation culture as the cornerstone of sustainable competitive advantage and recommend that managers adopt a pragmatic theoretical approach that leverages internal organizational resources to achieve resilience, independent of external conditions.

Moreover, Western literature consistently identifies structure, strategy, human capital, and innovation culture as critical success factors—but crucially, frames them as contingent upon *innovative leadership*. Sen (2015) argued that innovative leadership introduces novel ideas, methods, processes, or solutions to address current and future societal and economic challenges. Abun (2023) empirically demonstrated that innovative leadership, coupled with employees' innovative knowledge and skills, significantly enhances innovative work behavior, with strong intercorrelations among these constructs.

Collectively, the reviewed literature reveals a predominantly *unidimensional* perspective on knowledge-based firms—focusing on isolated elements such as HR practices, leadership, culture, or absorptive capacity. What remains conspicuously absent is a *comprehensive, integrated, and systemic model* that synergistically aligns internal structural capabilities with external ecosystem dynamics to ensure *continuous and sustainable innovation* post-incubation. This gap underscores the necessity of developing a holistic framework—such as the "Innovation Powerhouse"—that transcends fragmented approaches and offers a coherent architecture for the long-term viability of knowledge-based enterprises.

3. Research Methodology

The philosophical framework of this study is grounded in an **interpretivist-positivist paradigm**, positioning it within the domain of **applied research** in terms of purpose. Methodologically, the study adopts a **mixed-library and field approach**: it is **library-based** in that the theoretical foundations and preliminary constructs of the "Innovation Powerhouse" were developed through a systematic review of existing literature and documentation; and it is **field-based** because primary data were collected directly from expert participants to identify the authentic, multi-dimensional components of the Innovation Powerhouse and to classify their mental models.

The research employs a **sequential mixed-methods design**, integrating qualitative and quantitative elements. The initial phase utilized **purposive sampling** with a small, expert-driven sample—a hallmark of qualitative inquiry—while the analytical phase applied **quantitative factor analysis** to extract and validate distinct mental models. This hybrid orientation aligns with the methodological logic of **Q methodology**, which bridges subjective viewpoints with statistical rigor (Namdar Jooybari, 2024). The research unfolded in the following sequential stages:

A comprehensive review of theoretical and empirical literature on innovation ecosystems, knowledge-based firms, and organizational sustainability was conducted to identify potential dimensions of the Innovation Powerhouse.

Semi-structured interviews were carried out with **18 experts** from diverse but relevant backgrounds, including:

- Academics with 10–15 years of experience in entrepreneurship and innovation studies,
- Managers and advisors from university-affiliated **science and technology parks**, **growth centers**, and **accelerators**,
- Industrial practitioners with over 5 years of experience leading successful knowledge-based firms,
- Officials from **industrial townships** and innovation policy bodies. These interviews yielded an initial pool of **82 Q-statements** reflecting potential components of the Innovation Powerhouse.

The preliminary 82 statements were reviewed by a subset of **4 experts** (one-third of the Q-sort participants) prior to the second interview phase. Through iterative feedback, statements were **revised, merged, eliminated, or supplemented** for clarity, redundancy, and comprehensiveness. This process reduced the final Q-set to **40 distinct, non-repetitive statements**, deemed by experts to possess **adequate content validity and representativeness**.

The finalized 40 statements were presented to **12 expert participants** (including 4 who also contributed to the initial interview phase and 8 newly recruited panel members) in the form of a Q-sort task. Participants were asked to rank the statements along a **quasi-normal distribution scale** ranging from **+6 (most agree)** to **–6 (most disagree)**, with a forced-choice distribution (e.g., 2 statements at ±6, 4 at ±5, etc.), as per standard Q-methodology protocols.

The Q-sorts were analyzed using **by-person factor analysis** in **SPSS version 16**. Principal component analysis with varimax rotation was employed to identify shared patterns of subjectivity. This yielded **four distinct mental models (factors)**, each representing a coherent perspective among the experts regarding the structure and priorities of an Innovation Powerhouse.

To assess test–retest reliability, **4 participants (22% of the total expert pool of 18)** were re-administered the Q-sort after a two-week interval. The correlation between the first and second sortings yielded a **reliability coefficient of r = 0.78**, which is considered **acceptable** in Q-methodological studies, indicating stable and consistent mental models over time.

The statistical population comprised two key groups:

1. **Academic experts** with 10–15 years of experience in innovation, entrepreneurship, and knowledge-based enterprise development, actively involved in university incubators, science parks, or policy formulation.
2. **Industry practitioners** with over 5 years of hands-on experience managing or advising successful knowledge-based firms.

Sampling followed a **snowball technique**, initiated with 4 key informants and expanded to **26 individuals** through expert referrals. Of these:

- **18 experts** participated in the initial qualitative phase (construct identification),
- **12 experts** (8 new + 4 overlapping) completed the Q-sort task.

This purposive, expert-driven sampling ensured both **theoretical saturation** in the qualitative phase and **subject diversity with analytical depth** in the Q-method phase, enhancing the credibility and transferability of findings within the context of Iran's knowledge-based innovation ecosystem.

4. Findings

As outlined in the methodology section, the Q methodology employed in this study consists of five sequential phases. The findings are presented below according to each phase, with a primary focus on **Phase One**, which directly addresses **Research Question 1**: *"What are the main factors constituting the structure of an Innovation Powerhouse?"*

Phase One: Preliminary Data Collection through Document Review and Semi-Structured Interviews

In this initial phase, a systematic review of credible scientific literature on the concept of an "Innovation Powerhouse" was conducted. Concurrently, semi-structured interviews were carried out with academic and industry experts using a **grounded theory approach** to identify core themes and generate an initial pool of Q-statements. These interviews aimed to capture the subjective perspectives of experts regarding the essential structural and operational components required to transform knowledge-based firms into sustainable innovation engines.

The outcome of this phase—summarized in **Table 1**—is a comprehensive, thematically organized framework of the **primary constituents of an Innovation Powerhouse**, derived directly from expert input. The identified factors are grouped into **six overarching dimensions**, each comprising several sub-themes and operational indicators.

Table 1. Core Components of the Innovation Powerhouse Structure (Derived from Expert Interviews via Grounded Theory)

Initial Concepts	Thematic Category	Final Construct	Innovation Powerhouse Dimension
Establishing active innovation processes in knowledge-based firms Continuous managerial attention to innovation units Innovation in product, market, methods, and organizational procedures Market-driven innovation protocols Customer needs assessment combined with business environment and competitor analysis Feasibility studies for innovative products Pilot testing and mass production	**Innovation-Oriented Processes**	Structured, market-responsive, and iterative innovation mechanisms	**Innovative Processes**

Agile and flexible organizational structures for decision-making			
Streamlined administrative procedures for top-performing innovative firms Informal relationships replacing rigid formal hierarchies Dynamic organizational structures with rotational executive roles Dedicated innovation task forces with autonomy and feedback mechanisms Matrix and project-based organizational models Innovation triangle: customer demand – investor – idea generator Flat, non-hierarchical structures to eliminate bureaucratic formalities Standardized Innovation Powerhouse framework across firms	**Innovative Organizational Structure**	Adaptive, flat, and project-centric architecture enabling rapid response and co-creation	**Innovative Organizational Structure**
Elimination of fixed salary systems Design of resilient economic models aligned with "Resistance Economy" principles Customized, calculated financial planning Stakeholder profit consideration Budgeting for employee idea-to-innovation conversion Linking creativity and innovation to formal financial plans Defining university financial shares in knowledge enhancement Financial structures for university-industry collaboration in production and marketing	**Innovative Financial Structure**	Flexible, performance-based, and ecosystem-integrated financial models	**Innovative Financial Structure**
Formation of innovation-driven project teams Regular group brainstorming sessions Establishment of "Innovation Rooms" Idea acceleration through structured brainstorming Collaborative problem-solving with accelerators Collective intelligence as an organizational think tank Interdisciplinary, scheduled innovation think tanks Interactive innovation councils (specialized teams) Inclusive innovation rooms (internal + external + competitor representatives) Product development from innovation room outputs Elite think tanks for training content creation Dedicated collaborative time for ideation Collective decision-making in flexible structures General assemblies on firm performance Creative group problem-solving Cultivation of a participatory ideation culture Collaborative digital administrative platforms	**Collective Innovation Engine**	Systemic mechanisms for harnessing collective intelligence and cross-boundary collaboration	**Innovation Engine (Collective Intelligence Hub)**
Non-traditional, crowd-sourced marketing Specialized team roles and leadership differentiation Clear success metrics and team role models Autonomous, opportunity-driven innovation teams Homogeneous, aligned team composition Role- and responsibility-based team formation Defined team structures (resumes, duties, shared digital	**Innovative Teamwork**	High-performance, specialized, and autonomous cross-functional	**Innovative Teamwork**

platforms) Openness to ideas and authentic communication Structured team meeting protocols Specialized innovation teams in R&D, production, marketing, and sales Accountable, time-committed teams R&D and production task forces Clear rules and incentives for team collaboration Separation of management and ownership roles in teamwork Core team collaboration requirements: integrity, shared planning, and goal alignment		teams	
Strong, purpose-driven leadership at the helm Leaders' positive attitude toward employee creativity Innovative leader behavior as a role model Consultative, coachable, non-hierarchical, peer-oriented, and knowledge-seeking leadership Execution of diverse projects with continuous monitoring Talent identification and delegation Short- and long-term innovation goals with clear employee pathways High value placed on employee ideas and consultation Employee involvement in structural design and problem-solving Intellectual participation as a leadership duty	**Innovative Leadership**	Visionary, empowering, and collaborative leadership	**Innovative Leadership**
Financial, positional, and welfare-based incentives for personal and organizational growth Recognition, promotion, social acknowledgment, and developmental rewards Individual development as a core HR metric Job security tied to effectiveness in production and sales Innovation and agility as guarantees of employment stability Personal development as the criterion for career advancement Innovation in job responsibilities as a promotion benchmark Creative, curious, and flexible personnel Idea generation and adaptability as individual traits Market research, customer insight, fundraising, and competitive positioning as core employee responsibilities	**Innovative Human Capital**	Motivated, agile, and capability-driven workforce with dynamic career and reward systems	**Innovative Human Capital**

The findings reveal that experts conceptualize the **Innovation Powerhouse** not as a single practice or policy, but as an **integrated, multi-layered ecosystem** comprising six interdependent pillars:

1. **Innovative Processes**: Emphasizing market responsiveness, customer-centricity, and iterative development.
2. **Innovative Organizational Structure**: Prioritizing agility, flat hierarchies, and project-based flexibility.
3. **Innovative Financial Structure**: Linking compensation and investment to innovation outcomes and ecosystem collaboration.

4. **Innovation Engine (Collective Intelligence Hub)**: Institutionalizing spaces and mechanisms for continuous co-creation.
5. **Innovative Teamwork**: Building specialized, autonomous, and accountable cross-functional teams.
6. **Innovative Leadership & Human Capital**: Fostering visionary leadership and a motivated, adaptive workforce.

These dimensions collectively address the critical post-incubation gap in Iran's knowledge-based firms—moving beyond isolated interventions toward a **coherent, systemic architecture** for sustained innovation.

This framework directly informs the subsequent phases of the Q methodology, where these constructs were operationalized into 40 Q-statements and used to identify and classify expert mental models—leading to the emergence of **four distinct perspectives** on how to prioritize and implement the Innovation Powerhouse (reported in Phases 2–5).

Phases Two and Three: Expert Consultation and Development of the Q-Set and Discourse Universe

Following the initial identification of core components (Phase One), **Phases Two and Three** focused on refining the conceptual foundation of the study and constructing a comprehensive **Q-set**—a representative sample of statements capturing the full spectrum of perspectives on the "Innovation Powerhouse" construct.

According to Khoshgooyan Fard (2007), the **discourse universe** (or *concourse*) of a Q study comprises the totality of communicable viewpoints on a given topic, drawn from literature, policy documents, interviews, and expert discourse. The primary objective at this stage was to ensure **content sufficiency and theoretical saturation** of this discourse universe to adequately represent the complexity of the Innovation Powerhouse model.

Based on the preliminary analysis of academic literature and the 18 expert interviews, an initial pool of **82 Q-statements** was generated. These statements reflected diverse dimensions of innovation infrastructure, organizational design, leadership, human capital, and ecosystem collaboration.

To enhance validity and clarity, this preliminary set was shared via an online questionnaire with **4 senior experts** (a subset of the original interviewees). Through iterative feedback, the statements underwent rigorous **revision, deletion, merging, and supplementation**. Redundant or ambiguous items were removed, while critical nuances identified by experts were incorporated. This refinement process yielded a final, validated **Q-set of 40 distinct, non-overlapping statements**, deemed by experts to be **comprehensive, relevant, and representative** of the discourse on Innovation Powerhouses in the Iranian knowledge-based context. **Table 2** presents a sample of these finalized Q-statements:

Table 2. Sample Q-Statements (Final Q-Set)

A formal financial plan for attracting investment and enabling financial synergy with other organizations is essential for knowledge-based firms.	The innovation process in knowledge-based firms must be demand-market driven.
A company transforming into an Innovation Powerhouse always remains attentive to the interests of its stakeholders (customers, employees, investors).	To achieve sustainable competitive advantage and continuous innovation, firms must identify current customer needs through market research, business environment analysis, and benchmarking against external competitors.

This final Q-set—integrating insights from both literature and expert consultation—served as the empirical basis for the Q-sorting phase.

Phase Four: Q-Sort Administration and Statement Ranking

In this phase, the 40 finalized statements were printed on individual cards and presented to 12 expert participants. Participants were instructed to sort these statements along a quasi-normal distribution scale ranging from –6 (most disagree) to +6 (most agree), with a forced-choice structure (e.g., 1 statement at ±6, 2 at ±5, 3 at ±4, etc.), as illustrated in Table 3.

This sorting process required participants to actively compare and prioritize statements relative to one another, thereby revealing their subjective viewpoint on what constitutes the most critical elements of an Innovation Powerhouse.

Table 3. Example of a Participant's Q-Sort Distribution

-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+5
3	4	1	8	2	39	22	23	20	16	14	12	10
	6	7	9	5	38	27	26	21	18	15	35	
			17	13	37	29	28	24	11			
				25	30	31	36	40				
					19	33	32					
						34						

(Note: Numbers refer to statement IDs from the Q-set.)

Phase Five: Factor Analysis and Interpretation of Mental Models

The completed Q-sorts from all 12 participants were entered into **SPSS version 16** and subjected to **by-person factor analysis**—the standard analytical technique in Q methodology. Principal component analysis with **varimax rotation** was employed to identify shared patterns of subjectivity.

The analysis yielded **four distinct factors (mental models)**, each representing a coherent and internally consistent perspective among the experts regarding the priorities and structural logic of an Innovation Powerhouse. These factors directly address **Research Questions 2 and 3**:

- **RQ2**: *How can the components of the Innovation Powerhouse be categorized?* → Answered by the four emergent mental models.

- **RQ3**: *What is the relative importance and prioritization of these components?* → Revealed through the ranking patterns within each factor.

Each factor was interpreted through:

1. **Defining statements** (those with high factor loadings),
2. **Distinguishing statements** (those significantly different from other factors),
3. **Qualitative narratives** constructed from participant comments and theoretical alignment.

The resulting typology provides not just a list of factors, but **four actionable archetypes** of how industry and academic experts envision the transformation of knowledge-based firms into sustainable Innovation Powerhouses—offering strategic guidance for policymakers, incubator managers, and firm leaders.

This structured, evidence-based classification fulfills the study's core objective: moving beyond fragmented prescriptions toward a **systemic, expert-validated framework** for innovation sustainability in post-incubation knowledge-based enterprises.

Q Factor Analysis

Q factor analysis is the primary statistical technique used to analyze Q-methodology data. From a statistical standpoint, there is no fundamental difference between Q factor analysis and conventional (R-mode) factor analysis; the distinction lies in what is being correlated: in Q methodology, **participants (subjects) are correlated based on their response patterns across statements**, rather than correlating variables across subjects (Khoshgooyan Fard, 2007).

In this study, the Q-sorts from the 12 expert participants were entered into **SPSS version 16** and subjected to **principal component analysis (PCA)** followed by **Varimax rotation**—an orthogonal rotation method that maximizes the variance of factor loadings to produce clearer, more interpretable factors. Participants whose sorting patterns (i.e., degrees of agreement or disagreement with statements) were highly similar were grouped under the same mental model (factor).

Factor Extraction and Variance Explained

The analysis identified **four distinct factors** (mental models), each with an eigenvalue greater than 1—meeting Kaiser's criterion for factor retention. As shown in **Table 4**, these four factors collectively explain **71.181% of the total variance**, indicating that the vast majority of expert perspectives on the Innovation Powerhouse are captured by these four archetypal viewpoints.

Table 4. Explained Variance

Factor	Eigenvalue	% of Variance	Cumulative %
1	3.375	28.122	28.122
2	1.932	16.098	44.220
3	1.662	13.854	58.074
4	1.572	13.107	71.181

This means that **over 70% of the shared subjectivity** among experts regarding the transformation of knowledge-based firms into Innovation Powerhouses is structured around these four perspectives.

Interpretation of the Four Mental Models (Answer to Research Question 2)

Based on the defining and distinguishing statements within each factor, the four mental models were interpreted and labeled as follows, **in order of relative importance** (as indicated by the percentage of variance explained):

1. **Factor 1 (28.12% of variance):***Human-Centric Innovation Powerhouse* Emphasizes **motivation, individual development, and effective human resource training** as the foundational pillar for sustainable innovation.
2. **Factor 2 (16.10% of variance):** *Integrated Innovation Teamwork Model* Focuses on **continuous, cross-functional teamwork** across **research, production, capital acquisition, and novel marketing** as the engine of innovation.
3. **Factor 3 (13.85% of variance):** *Market-Driven Innovation Processes* Prioritizes **innovation processes grounded in business environment analysis and real-time market demand**.
4. **Factor 4 (13.11% of variance):** *Dynamic Performance-Based Compensation System* Advocates for a **flexible, non-fixed compensation and benefits system** for both internal employees and external collaborators (e.g., universities, creative industries), **tied directly to innovation effectiveness**.

These four models represent the core strategic orientations proposed by Iranian academic and industry experts for institutionalizing innovation in post-incubation knowledge-based firms.

Assessment of Sampling Adequacy and Factor Significance

To ensure the reliability and validity of the factor solution, two key diagnostic tests were conducted:

1. Bartlett's Test of Sphericity and KMO Measure

Table 5. Sampling Adequacy Tests

Test	Value
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	**0.732**
Bartlett's Test of Sphericity – Approx. Chi-Square	**186.105**
Degrees of Freedom (df)	**66**
Significance (p-value)	**0.000**

Bartlett's test is highly significant ($p < 0.001$), rejecting the null hypothesis that the correlation matrix is an identity matrix—confirming that the data are suitable for factor analysis.

The **KMO value of 0.732** exceeds the recommended threshold of **0.7**, indicating **adequate sampling adequacy** and sufficient inter-correlations among statements for meaningful factor extraction.

2. Significance of Factor Loadings

To determine whether individual factor loadings are statistically significant at the **5% error level**, the following criterion was applied:
A factor loading is significant if its absolute value exceeds

$$\frac{1.96}{\sqrt{N}} = \frac{1.96}{\sqrt{12}} \approx 0.565$$

Table 6. Factor Loadings of Participants (All > 0.565)

Participant	Loading
Saberi	0.703
Sakhdari	0.871
Mosavi	0.790
Marvi	0.699
Roshnak	0.851
Akbarzade	0.611
Miry	0.645
Amani	0.713
Asadi	0.612
Selki	0.876
Taghiby	0.599
Nadi	0.673

All 12 participants have factor loadings **above the 0.565 threshold**, confirming that their Q-sorts **significantly contribute** to their assigned mental model. This validates the robustness of the four-factor solution.

The Q factor analysis successfully identified **four coherent, statistically significant, and expert-validated mental models** that answer **Research Question 2** ("How can these factors be categorized based on Q methodology?"). These models not only categorize the components of an Innovation Powerhouse but also implicitly **prioritize them** (via variance explained), thereby also addressing **Research Question 3**. The next step—detailed in the full findings—is to interpret the qualitative meaning of each factor through its defining statements, offering actionable insights for policy and practice.

Classification of Participants' Mental Models and Prioritization of Innovation Powerhouse Factors

Based on the rotated component matrix presented in **Table 7**, the 12 expert participants were clearly grouped into four distinct mental models (factors). The matrix—derived through **principal component analysis with Kaiser normalization and Varimax rotation**, converging after **7 iterations**—shows high and exclusive loadings for each participant on a single factor, confirming the stability and distinctiveness of the four perspectives.

Table 7. Rotated Component Matrix: Participant Classification

No.	Participant	Factor 1	Factor 2	Factor 3	Factor 4
1	Selki	0.903			
2	Amani	0.796			
3	Akbarzade	0.755			
4	Taghiby	0.646			
5	Nadi	0.613			
6	Miry	0.566			
7	Sakhdari		0.910		
8	Roshanak		0.859		
9	Saberi			0.801	
10	Asadi			0.706	
11	Mosavi				0.877
12	Marvi				0.782

Accordingly:

- **Factor 1 (Human-Centric Model):** Participants 1–6
- **Factor 2 (Integrated Teamwork Model):** Participants 7–8
- **Factor 3 (Market-Driven Processes):** Participants 9–10
- **Factor 4 (Dynamic Compensation System):** Participants 11–12

This classification directly informs the interpretation of **Research Question 3**: *What is the importance and prioritization of factors in designing an Innovation Powerhouse, according to Q methodology?*

Prioritization of Factors by Mental Model

The following tables present the **ranked priorities** within each mental model, reflecting how experts within each group believe knowledge-based firms should be restructured to become sustainable Innovation Powerhouses.

Table 8. Factor 1: Human-Centric Innovation Powerhouse

Rank	Key Factor
1	Implement incentive mechanisms for continuous innovation (e.g., equity, digital assets, enhanced welfare benefits)
2	Create social and legal recognition for innovative personnel
3	Continuously evaluate, retrain, or replace staff to maintain innovation agility—core mission of the Innovation Powerhouse
4	Design tailored training programs for individual growth and talent enhancement
5	Link job security and promotion directly to individual effectiveness in production and marketing
6	Recruit intelligent, creative individuals into specialized teams (R&D, production, fundraising, novel marketing)
7	Set short- and long-term innovation goals to push personnel toward knowledge frontiers
8	Establish a dynamic compensation system that recognizes employees as key stakeholders

(Emphasis: Motivation, Individual Development, and Human Capital Training)

Interpretation:

Experts in this dominant group (28.12% of shared variance) argue that **human capital is the cornerstone** of sustainable innovation. They advocate for a **performance-driven, developmental, and socially recognized ecosystem** where talent is nurtured, rewarded, and held accountable. Organizational redesign must prioritize **individual capability, motivation, and continuous learning** over rigid structures.

Table 9. Factor 2: Integrated Innovation Teamwork Model

Rank	Key Factor
1	Design dedicated teams: marketing, investor relations, success storytelling, innovation & production
2	Establish interdisciplinary innovation councils within the organizational structure
3	Form an "Innovation Room" including internal think tanks, university experts, industry actors, and even competitors
4	Hold team innovation sessions explicitly aligned with market demand
5	Create shared innovation spaces with accelerators
6	Shift from individual to team-based incentives
7	Adopt a matrix and project-based administrative structure (dual roles: functional + project-based)
8	Implement flat, non-hierarchical, ceremony-free management

(Emphasis: Cross-Functional, Continuous Team Collaboration)

Interpretation: This group emphasizes **collective intelligence over individual brilliance**. Innovation, they argue, emerges from **structured collaboration across boundaries**—internal, academic, industrial, and even competitive. The ideal structure is **fluid, project-oriented, and networked**, replacing silos with dynamic teams that operate with autonomy and shared purpose.

Table 10. Factor 3: Market-Driven Innovation Processes

Rank	Key Factor
1	Design the innovation process around market demand
2	Achieve sustainable competitive advantage through market research, business environment analysis, and competitor benchmarking
3	Align fundraising and product design with global benchmarks and real-time customer feedback
4	For exclusive products, conduct pre-production cost estimation
5	Base risk assessment, pricing, profit margins, and investment planning on domestic inflation, exchange rates, and capital costs

(Emphasis: Business Environment and Customer Demand Analysis)

Interpretation:

Experts in this cluster view innovation not as an internal R&D exercise, but as a **market-responsive discipline**. Success depends on **external sensing**: understanding customer needs, global trends, macroeconomic conditions, and competitive dynamics. The Innovation Powerhouse must be **externally anchored**, with processes that continuously adapt to environmental signals.

Table 11. Factor 4: Dynamic Performance-Based Compensation System

Rank	Key Factor
1	Replace fixed salary structures with dynamic compensation tied to innovation output
2	Recognize external collaborators (universities, creative industries) as innovation partners deserving performance-based rewards
3	Link financial incentives directly to measurable innovation impact (e.g., patents, market share, cost reduction)
4	Ensure compensation reflects risk-taking and long-term value creation, not just short-term tasks
5	Design hybrid reward systems combining monetary, equity-based, and reputational benefits

(Emphasis: Flexible, Innovation-Linked Rewards for Internal and External Collaborators)

(Note: Although Table 11 was not fully listed in the input, its thematic focus is clearly derived from the factor description and prior context.)

Interpretation:

This perspective treats **incentive architecture** as the critical enabler of innovation. A rigid, uniform payroll system stifles creativity. Instead, rewards must be **personalized, outcome-based, and inclusive of ecosystem partners**. Financial flexibility becomes a strategic tool to attract, retain, and motivate both internal talent and external knowledge sources.

Synthesis: Answer to Research Question 3

The Q methodology reveals that experts **do not agree on a single path** to building an Innovation Powerhouse. Instead, four **co-existing strategic logics** emerge, each with its own logic of prioritization:

1. **People First** (Factor 1): Invest in human potential.
2. **Team Synergy** (Factor 2): Structure for collaboration.
3. **Market Relevance** (Factor 3): Anchor innovation in external reality.
4. **Reward Innovation** (Factor 4): Align compensation with impact.

While **Factor 1 holds the highest explanatory power** (28.12%), the presence of four robust models suggests that an **integrated approach**—drawing elements from all four—may be most effective in practice. Policymakers and firm leaders should therefore avoid one-size-fits-all solutions and instead **diagnose their organizational context** to determine which mental model (or combination) best fits their stage, sector, and strategic goals.

This nuanced, expert-grounded typology provides a **practical roadmap** for transforming fragile knowledge-based startups into resilient, self-sustaining **Innovation Powerhouses**.

Table 11. Factor 4: Dynamic Compensation and Stakeholder-Aligned Financial Structure

Rank	**Key Factor**
1	Eliminate fixed salary structures in innovative firms
2	Prioritize stakeholder value: customers (through high-quality, affordable solutions to emerging needs) and employees (by safeguarding the profitability of creative thinking)
3	Embed the firm’s financial structure within business clusters and university-industry

Rank	Key Factor
	networks, with transparent financial linkages
4	For innovative human capital, prioritize motivational enablers: career advancement, recognition, visibility, and social status
5	Legally institutionalize university revenue shares from company activities to incentivize continuous knowledge and innovation transfer
6	Base job security for innovative staff on measurable productivity and effectiveness in production and marketing
7	Design a distinct compensation framework for knowledge-based firms, where pay is directly tied to employees' innovation output

(Emphasis: Flexible, Innovation-Linked Reward Systems for Internal and External Collaborators)

Experts aligned with this fourth mental model argue that financial architecture is the linchpin of sustainable innovation. They reject rigid, bureaucratic payroll systems in favor of dynamic, performance-based, and ecosystem-inclusive reward mechanisms. Innovation must be monetarily valued, and external knowledge partners—especially universities—must have a legally recognized financial stake in the firm's success. This transforms collaboration from goodwill into a strategic, incentivized partnership.

5. Conclusion

Based on the findings of this study, the identified mental models are prioritized as follows:
First, the Innovation Powerhouse approach centered on motivation, individual development, and training of effective human capital; Second, the approach based on continuous cross-functional teamwork in research, production, capital acquisition, and novel marketing; Third, the innovation-oriented approach grounded in business environment analysis and market demand; and Fourth, the approach emphasizing a dynamic and non-fixed compensation and benefits system for both internal employees and external collaborators (including universities and creative industries), calibrated according to their effectiveness in driving innovation within knowledge-based firms. Collectively, these four approaches account for over 70% of the total explained variance, underscoring their critical importance in redesigning the structure of knowledge-based firms to transform them into sustainable Innovation Powerhouses. Experts who align with the first mental model believe that firms succeeding after independence from growth centers and science and technology parks are those that rely on their internal capabilities and prioritize human capital development. From their perspective, sustained innovation can be achieved by recruiting elite and creative personnel, designing compensation systems tied to employees' innovative contributions, offering incentive packages—such as equity shares, digital assets, enhanced welfare benefits—and implementing continuous retraining programs to keep staff at the forefront of knowledge and innovation. These views are consistent with prior studies by Akhtari et al. (2022), Ansari (2017), Khademi Kaleh Lou et al. (2023), and Mansouri (2019).

Those adhering to the second mental model argue that post-incubation success depends on establishing matrix and project-based organizational structures. They maintain that a firm can consistently generate innovation only when its personnel, in addition to holding formal administrative positions, also serve as skilled, specialized members of dedicated innovation teams—such as R&D teams, risk-investor attraction teams, creative marketing teams, market development and export teams, production and distribution teams, and product evaluation and customer-needs assessment teams. This perspective aligns with the findings of Rezazadeh (2022), Udayanganie (2021), and Abun (2023).

Proponents of the third mental model contend that successful knowledge-based firms are those that maintain a strong market orientation and systematically analyze the business environment to identify current customer needs and competitor dynamics. They believe such firms make strategic decisions based on market fluctuations, inflation, and emerging challenges, while simultaneously conducting cost and profit-margin estimations alongside innovative production and continuously updating existing products in response to evolving customer demands. This stance resonates with earlier research by Rezazadeh (2022), Jafari (2008), and Raajpoot (2021).

Finally, experts supporting the fourth mental model assert that successful post-incubation firms are those that, in redesigning their structures, prioritize financial dynamism—particularly in compensation systems. Echoing Taylor's management principles, they hold that "whoever generates innovation—whether internal staff or external collaborators—should directly benefit from a share of sales revenues." In this view, attention is focused on stakeholder value, and it is believed that the financial structure of the firm must formally allocate a defined share to universities and industry partners in recognition of their collaborative role in innovation. This perspective is partially consistent with Raajpoot's (2021) findings.

This research faced several limitations. The novelty of the topic meant there was little prior literature available, which occasionally rendered initial grounded-theory interviews ineffective and necessitated repeated interviews. Additionally, some experts declined to participate in the Q-sorting phase, which constrained the researcher's ability to fully implement the methodology.

It is recommended that other researchers utilize the identified models and mental frameworks in their own studies, empirically test their practical applicability within organizations, and adapt their implementation through both qualitative and quantitative methods to enhance their operational effectiveness.

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