

Identification and Ranking of Barriers to Research and Development Investment in Industrial Centers

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ABSTRACT

Research and Development (R&D), as the primary driver of technological innovation and the enhancement of industrial competitiveness, plays an undeniable role in sustainable economic development. However, empirical evidence and provincial statistics indicate that industrial centers in Mazandaran province face numerous structural, managerial, and operational challenges in attracting investment and establishing R&D units. The primary objective of this study is to identify and rank the barriers to R&D investment in the industrial centers of Mazandaran province. Methodologically, this research is applied in terms of its objective and descriptive-survey in terms of its nature. The statistical population comprised 32 experts and managers affiliated with the industry, academia, science and technology parks, and the Department of Industry, Mining, and Trade of Mazandaran province. Due to the limited population size, a census sampling method was employed. Data collection instruments included open-ended questionnaires (to identify barriers via the Delphi technique) and pairwise comparison questionnaires (AHP). Following data organization in Microsoft Excel, the analysis was conducted using MATLAB software based on the AHP methodology. The Consistency Ratio (CR) for all pairwise comparison matrices was calculated to be less than 0.10, indicating the validity and reliability of the experts' judgments. The findings revealed seven principal factors, ranked by importance, as follows: management (0.195), infrastructure (0.178), financial resources (0.169), policies and procedures (0.153), laws and regulations (0.116), human resources (0.109), and cultural factors (0.077). At the sub-criteria level, the absence of long-term strategic planning, the lack of constructive industry-academia linkages, and the insufficiency of corporate financial resources were identified as the primary bottlenecks. The results of this study emphasize that to accelerate R&D investment, it is imperative to revise managerial structures, strengthen the technology ecosystem, facilitate financial mechanisms, and reform governmental macro-policies.

KEYWORDS: Research and Development (R&D), Industrial Investment, Investment Barriers, Analytic Hierarchy Process (AHP)

1. Introduction

In the contemporary paradigm of the knowledge-based economy, Research and Development (R&D) is no longer regarded merely as an overhead cost or a marginal activity; rather, it is recognized as a strategic investment and a source of sustainable competitive advantage. The accelerating pace of technological change, market globalization, intensifying international competition, and the transition from resource-based to innovation-driven economies have compelled industrial firms to pursue continuous innovation and process optimization to ensure survival, growth, and market share retention. Contemporary technology management literature indicates that nations which have consistently increased their R&D expenditure as a percentage of Gross Domestic Product (GDP) have demonstrated significantly superior performance in global competitiveness indices, total factor productivity, and value-added growth within high-technology industries (Almer et al., 2020; Kim & Park, 2021). However, in many developing countries, a profound gap is observed between macro-level innovation policies and the actual allocation of operational resources to industrial R&D units. This misalignment not only impedes the attraction of both domestic and foreign investments but also disrupts the knowledge transfer cycle to the industrial sector (Chen & Li, 2022).

In Iran, despite the explicit emphasis of national development plans on elevating the R&D expenditure to 3% of GDP, empirical and statistical evidence indicates a lack of logical proportionality between allocated resources and actual innovation outputs. Mazandaran province, recognized as one of the primary industrial hubs in northern Iran, is currently confronting a declining share of the industrial sector in both regional GDP and employment. Statistics indicate that out of approximately 1,500 industrial units in the province, only a marginal fraction holds formal R&D accreditation, with many units either operating informally or lacking any formalized research infrastructure (Pazakinejad & Nowzari, 2010). This situation underscores the critical necessity of identifying investment barriers within this domain. The decline in the contribution of Mazandaran's industry and mining sector to the regional GDP—from 11.14% to 9.83% between 2008 and 2011 (1387–1390 SH)—indicates a systemic neglect of the strategic role of R&D, thereby validating the imperative for a structural investigation of this phenomenon.

Previous studies have demonstrated that barriers to Research and Development (R&D) encompass a wide spectrum of intra-organizational and extra-organizational factors. Studies such as Mehregan et al. (2014) have confirmed the positive impact of R&D expenditures on total factor productivity growth. Heidari and Sanginabadi (2013) examined the role of domestic and foreign R&D on Iran's economic growth, highlighting the necessity of technology absorption through direct investment. Vaezi et al. (2007) demonstrated that R&D expenditures play a pivotal role in increasing the value added of high-technology industries. Conversely, Hosseini Nejad Moghari (2014) analyzed the barriers to industry-university linkages across cultural, structural, and functional dimensions. Salami and Shafieipour (2007) emphasized managerial individual characteristics and top management support as intra-organizational factors affecting R&D effectiveness. Esfanjani (2003) highlighted the financing and intellectual property challenges within research centers. Akbarshahi (2005) documented the

bottlenecks in knowledge processing within industrial units, while Atafar and Analoui (2001) criticized the marginal positioning of R&D units within organizational structures.

At the international level, Mata and Woerter (2013) demonstrated that external R&D strategies can enhance the distribution of returns but entail high risks. Nobelius (2004) analyzed the evolution of R&D management from early technology-driven generations to the sixth generation of networked and open innovation. Aghion and Howitt (1992), by proposing the quality-ladder model, showed that R&D-driven innovation leads to creative destruction and long-term productivity growth. Romer (1990) also emphasized the non-rivalrous nature of knowledge and the necessity of government intervention alongside private incentives to stimulate research investment. Furthermore, Baumol (1990) and Jones (2002) highlighted the determinants of resource allocation to R&D, including support for basic research, private incentives, and alternative career opportunities for talented individuals.

Despite the substantial body of research literature, a significant gap remains in localized studies focusing on the structural identification and quantitative prioritization of R&D investment barriers within the industrial centers of specific regions, such as Mazandaran. The majority of existing studies have examined the macro-level relationship between R&D and economic growth, paying scant attention to the operational, managerial, and infrastructural layers that directly influence the decision-making processes of industrial investors. Employing a mixed-methods approach (Delphi technique and Analytic Hierarchy Process [AHP]) and incorporating the direct participation of industry and academic experts in Mazandaran province, this study aims to bridge this gap. The primary research question is: "What are the principal barriers to R&D investment in the industrial centers of Mazandaran, and how should they be prioritized?" Addressing this question can yield actionable insights and practical solutions for provincial policymakers, industrial managers, and technology support institutions. The research objectives encompass identifying the principal barriers, assessing the inhibitory impact of each factor, ranking the influential determinants, and proposing practical strategies to mitigate these barriers. The implicit hypothesis of this study posits that the barriers to R&D investment in Mazandaran's industrial centers are multidimensional and possess varying weights, which can be systematically prioritized utilizing multi-criteria decision-making (MCDM) techniques.

2. Theoretical Foundations and Conceptual Framework

Concept and Evolution of Research and Development

Research and Development (R&D) encompasses systematic, creative, and planned activities aimed at expanding the frontiers of existing knowledge, acquiring novel techniques, resolving practical problems, and fostering innovation in products, processes, and services (Jalalabadi, 2001; Komijani & Asgari, 1992). According to the classifications established by the Organization for Economic Co-operation and Development (OECD) and UNESCO, R&D activities are categorized into three primary domains: basic (fundamental) research, which seeks to expand knowledge without immediate practical application in mind; applied research, which focuses on resolving specific problems and identifying practical applications for fundamental findings; and experimental development, which is concerned with the dissemination, adaptation, and improvement of existing technologies for production purposes.

The evolution of R&D management has been conceptualized across five to six distinct generations. In the first generation, R&D was perceived as an unpredictable and cost-intensive activity. The second generation was characterized by enhanced market orientation and the adoption of matrix organizational structures. The third generation marked the transition toward purposeful and systematic R&D practices. The fourth generation emphasized reciprocal learning with customers and collaborative innovation. The fifth generation positioned knowledge as the core organizational asset, emphasizing systems grounded in collaborative brainstorming and organizational learning. The sixth generation, as articulated by Nobelius (2004), is centered on multi-layered research networks, open intellectual property, and cross-industry collaborations. This evolutionary trajectory demonstrates that to survive within the contemporary technology ecosystem, industrial centers must transition from traditional paradigms to networked and open innovation models.

Barriers to Research and Development in Developing Countries and Iran

In developed countries, R&D activities are predominantly concentrated in the private sector, whereas in developing nations, the public sector plays a dominant role. This inefficient structure leads to challenges such as goal-setting without regard for market technological needs, a lack of connection with the production sector, research duplication, irrational resource allocation, and heavy bureaucracy (Pazakinejad & Nowzari, 2010; Mehdiyan, 1993). In Iran, the weakness in the industrial development process is rooted in the absence of clear development objectives, inadequate information among policymakers, long-term support without competitive pressure, the lack of a competition-preserving institution, deficiencies in attracting targeted foreign investment, and a weak institutional framework for supporting R&D and intellectual property.

Domestic barriers to industrial growth in Iran include the lack of logical linkage among the components of the industry, agriculture, and mining sectors, severe technological and foreign exchange dependency, disproportionate tax policies, a consumption-oriented rather than capital-oriented industrial structure, and a weak culture of teamwork and innovation (Siami Doudaran, 2002; Azimi, 1992). Furthermore, university-industry linkages face obstacles such as weak legislation, bureaucracy, excessive academic orientation, mutual distrust, a lack of demand-driven thesis research, and a scarcity of joint projects (Hosseini Nejad Moghari, 2014).

R&D-Based Growth Models

Endogenous growth literature posits Research and Development (R&D) as the primary engine of long-term economic growth. The quality-ladder model (Aghion & Howitt, 1992) demonstrates that qualitative innovations lead to the obsolescence of older technologies and the enhancement of total factor productivity (TFP). The expanding variety model (Romer, 1990) is predicated on the principle that increasing the diversity of intermediate inputs through R&D enhances specialization and accelerates TFP growth. Both models emphasize that without sustained investment in R&D and robust intellectual property protection, knowledge accumulation stagnates, thereby decelerating economic growth.

Determinants of Resource Allocation to R&D Units

The optimal allocation of resources to R&D is a function of three critical factors: support for basic research (due to the non-rivalrous nature of knowledge and positive externalities), private

incentives for innovation (which necessitates the excludability of knowledge through patent systems), and alternative career opportunities for talented individuals (which ensures the channeling of elite human capital toward wealth creation rather than rent-seeking) (Baumol, 1990; Jones, 2002). In small and medium-sized enterprises (SMEs), innovation is a prerequisite for survival, and the establishment of dedicated R&D units enables them to respond to the complex demands of the global market with high agility (Luetkenhorst, 2004).

Based on the theoretical foundations and literature review, the conceptual framework of this study is predicated on the premise that investment in the Research and Development (R&D) of industrial centers is influenced by a set of intra-organizational and extra-organizational inhibiting factors. These factors are categorized into seven primary dimensions: management, infrastructure, financial resources, policies and procedures, laws and regulations, human resources, and cultural factors. Each factor encompasses specific operational sub-criteria, and assessing their inhibitory impact on the decision-making of industrial investors in Mazandaran province necessitates their identification and quantitative prioritization. This framework served as the foundation for the design of the research instruments and the subsequent data analysis.

3. Research Methodology

In terms of its objective, this research is applied, and regarding its nature, it is descriptive-survey. The statistical population of the study comprised 32 experts and experienced managers in domains related to industrial R&D in Mazandaran province. This population included university professors, managers from the Department of Industry, Mining, and Trade, officials from the Science and Technology Park, as well as senior managers and R&D directors of industrial firms (with more than 50 employees). Given the limited size of the population and the highly specialized nature of the research topic, sampling was dispensed with, and a census method was employed to encompass the entire population. The distribution of respondents by gender (81.5% male), educational attainment (68.8% holding a Master's degree and 21.9% holding a Ph.D.), and professional tenure (over 50% possessing more than 15 years of experience) demonstrated that the population possessed the requisite specialized expertise and practical experience.

The data collection process was executed in two distinct phases. In the first phase, a comprehensive literature review and the Delphi technique were employed to identify the preliminary barriers. An open-ended questionnaire was designed and administered to a panel of experts. The collected responses were categorized, cross-referenced with the existing research literature, and rigorously screened to extract the final list of barriers and their corresponding sub-criteria. In the second phase, the Analytic Hierarchy Process (AHP) was utilized to prioritize the identified factors. A pairwise comparison questionnaire was designed utilizing Saaty's 1-to-9 fundamental scale, wherein experts assessed the relative preference of each row element over each column element.

The collected data were initially organized within a Microsoft Excel environment. Subsequently, the geometric mean method was applied to aggregate the experts' judgments, thereby constructing the pairwise comparison matrices. To ensure the consistency of the judgments, the Inconsistency Ratio (IR) was calculated. For all matrices, the IR value was calculated to be less than 0.10, indicating a high degree of validity and precision in the

responses. In the final step, the data were processed and converged using MATLAB software and the limit algorithm to determine the final weights of each factor and sub-criterion. The validity of the research instrument was confirmed through expert and academic judgment (content validity), while its reliability was assessed by calculating the consistency ratio.

4. Results and Findings

Following data processing and the execution of hierarchical analyses, the weights and ranks of the inhibiting factors for Research and Development (R&D) investment in the industrial centers of Mazandaran province were calculated. Table 1 presents a summary of the ranking of the seven primary factors:

Table 1. Ranking of the Primary Inhibiting Factors for R&D Investment in Industrial Centers

Rank	Primary Factor	Final Weight	Inconsistency Ratio (I.R.)
1	Management	0.195	0.020
2	Infrastructure	0.178	0.019
3	Financial Resources	0.169	0.021
4	Policies and Procedures	0.153	0.023
5	Laws and Regulations	0.116	0.007
6	Human Resources	0.109	0.021
7	Cultural Factors	0.077	0.029

As observed in Table 1, the management factor, with a weight of 0.195, was identified as the most critical barrier to R&D investment. The consistency parameters of the main factors matrix were calculated with a maximum eigenvalue (λ_{max}) of 7.157, an Inconsistency Index (I.I.) of 0.026, and a Consistency Ratio (I.R.) of 0.020, which is well below the permissible threshold of 0.10. This indicates that the experts' judgments possess a high degree of logical consistency, confirming that the results derived from the AHP analysis hold the requisite scientific validity.

At the sub-criteria level, the AHP analyses revealed which specific indicators exert the greatest inhibitory effect within each respective factor. For the sake of conciseness and to maintain a focus on the key findings, the tables corresponding to the top three factors (management, infrastructure, and financial resources) are presented.

Table 2. Ranking of the Sub-criteria of the Management Factor (as the Primary Barrier)

Rank	Sub-criterion	Weight	Matrix I.R.
1	Absence of long-term (strategic) planning and strategic roadmaps in R&D	0.104	0.023
2	Failure to utilize specialized consultants in project design	0.093	0.023
3	Insufficient managerial awareness regarding the position of R&D in industrial investment	0.078	0.023
4	Inaccurate perception of technology, market, competition, and available resources	0.070	0.023
5	Imposition of managers' personal views in project execution	0.069	0.023

Table 3. Ranking of the Sub-criteria of the Infrastructure Factor

Rank	Sub-criterion	Weight	Matrix I.R.
1	Absence of appropriate and constructive interaction and collaboration among industries, universities, and research centers	0.089	0.019
2	Lack of private sector participation in providing R&D services to other companies	0.078	0.019
3	Outdated technology and equipment in industrial centers (presence of worn-out machinery)	0.077	0.019
4	The predominantly educational nature of universities rather than their research orientation	0.076	0.019
5	Low level of knowledge and skills among university graduates	0.076	0.019

Table 4. Ranking of the Sub-criteria of the Financial Resources Factor

Rank	Sub-criterion	Weight	Matrix I.R.
1	Shortage of financial resources in industrial companies	0.168	0.021
2	High costs of research projects and prototype development	0.131	0.021
3	Lack of return on investment in the event of project failure	0.128	0.021
4	Lack of banking facilities for establishing R&D units	0.128	0.021
5	High costs associated with research activities	0.108	0.021

The analysis of the sub-criteria for the remaining factors also revealed that within the "Policies and Procedures" category, the government's excessive reliance on oil revenues (0.127) and the weakness of executive policies regarding public-private partnerships (0.109) constitute the primary bottlenecks. In the "Laws and Regulations" section, the lack of investment incentives (0.138) and the absence of investment guarantees for R&D units (0.136) exert the greatest inhibitory impact. Within the "Human Resources" domain, a low propensity for teamwork (0.086) and the lack of continuous training for researchers (0.079) ranked at the top. Finally, in the "Cultural" dimension, a weak research culture within industrial centers (0.160) and a low level of trust among industrialists toward academics (0.140) were identified as major barrier. Testing the research hypotheses based on the AHP outputs demonstrated that the weights of all primary and secondary factors are significantly distinct from zero, and all matrices exhibit a consistency ratio of less than 0.10. These findings confirm that the barriers to R&D investment in Mazandaran's industrial centers are multidimensional, hierarchical, and possess significant priorities. The management factor, positioned at the apex of the barrier hierarchy, indicates that even in the presence of adequate infrastructure and sufficient financial resources, the absence of strategic leadership and long-term planning will inevitably lead to the failure of R&D investments.

5. Discussion and Conclusion

This study was conducted with the aim of identifying and ranking the barriers to Research and Development (R&D) investment in the industrial centers of Mazandaran province. The findings revealed that seven categories of primary factors influence investors' decision-making with varying weights, at the apex of which are management (0.195), infrastructure (0.178), and financial resources (0.169). These findings are consistent with the results of previous studies.

Esfanjani (2003) and Akbarshahi (2005) also emphasized the importance of strategic management and the challenges of knowledge processing within industrial units. The present results indicate that the absence of long-term planning and strategic roadmaps in R&D constitutes the most critical managerial gap in the industrial centers of Mazandaran. This aligns perfectly with the findings of Salami and Shafieipour (2007), who emphasized managerial individual characteristics and awareness of contemporary scientific achievements as determinants of R&D effectiveness.

The infrastructure factor ranked second, reflecting the weakness of the technology ecosystem in the province. The lack of constructive industry-university linkages and the obsolescence of equipment are key structural barriers. This finding overlaps with the study by Hosseini Nejad Moghari (2014), which emphasized the structural and functional barriers to industry-university linkages. Furthermore, the results of Anoosheh (2011), which demonstrated the positive impact of government and academic R&D expenditures on economic growth, corroborate the importance of strengthening research infrastructure.

The financial factor ranked third. The scarcity of internal corporate resources, the exorbitant costs of prototyping, and the risk of non-recovery of investment in the event of project failure significantly amplify the risks associated with R&D investment. This finding aligns with international studies such as Ozcelik and Taymaz (2008), which demonstrated that public support for R&D exerts an accelerating effect on private sector investment. Furthermore, the findings of Al-Rasoul (2009) indicate that the disproportionately low share of R&D expenditures in the GDP of developing nations, including Iran, has constrained its efficacy in driving economic growth.

Within the dimension of policies and regulations, the excessive reliance on oil revenues coupled with inadequate investment incentives signifies a deviation of policymaking from an innovation-driven trajectory. This observation corroborates the findings of Atafar and Analoui (2001), who emphasized the marginalization of R&D units relative to core production structures. In the realm of human resources and culture, the deficient propensity for teamwork and the weak research culture are deeply rooted in traditional educational and managerial paradigms, which perceive innovation as a luxury or a high-risk endeavor rather than a fundamental organizational value.

Synthesizing these insights, it can be concluded that fostering R&D investment in the industrial centers of Mazandaran necessitates a paradigm shift from reactive approaches to strategic planning, alongside the cultivation of a supportive ecosystem. The barriers identified in this study underscore that merely injecting financial capital or physically establishing R&D units—without reforming managerial structures, fortifying university-industry linkages, and instituting sustainable policy incentives—will fail to yield the desired outcomes. The prioritization derived from the AHP analysis unequivocally demonstrates that strategic management and leadership, technological infrastructure, and financial sustainability constitute the three foundational pillars that must be addressed simultaneously and in a coordinated manner.

Based on the findings, the following strategies are proposed to accelerate investment and the development of research and development centers:

1. **Management and Strategy:** Formulating national and provincial strategic roadmaps for R&D with the active participation of the industrial sector. Establishing R&D units directly under the supervision of the company's Chief Executive Officer (CEO) to elevate their organizational standing and mitigate internal bureaucracy.
2. **Infrastructure and Linkages:** Establishing joint industry-university research consortia. Developing specialized databases and facilitating access to reference laboratories. Transitioning the core mission of universities toward a research-oriented paradigm and mandating student internships within industrial R&D units.
3. **Financing and Regulations:** Providing low-interest, long-term financial facilities through commercial banks to R&D units. Implementing tax exemptions and production subsidies for companies manufacturing innovative, export-oriented products. Issuing government guarantees to mitigate the risk of failure in research projects.
4. **Human Resources and Culture:** Designing advanced in-service training programs for industrial researchers. Implementing reward systems predicated on innovation and patent registration. Promoting a culture of utilizing domestic products and recognizing outstanding R&D units.

The limitations of this study include its geographical confinement to Mazandaran province, its reliance on questionnaires as the sole data collection instrument, and a scarcity of comparable studies for more precise benchmarking. It is recommended that future research conduct comparative analyses between Mazandaran and other successful industrial provinces. Furthermore, investigating the value added by R&D activities within the province and examining the structural barriers affecting the effectiveness of R&D units could serve as complementary studies. Ultimately, this study demonstrates that sustainable industrial development in Mazandaran is unattainable without targeted investment and strategic management in research and development.

References

- Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica*, 60(2), 323–351.
- Akbarshahi, A. (2005). Bottlenecks, problems and barriers facing R&D activities in industrial units. *Proceedings of the National Conference on R&D Centers in Industries*. (In Persian)
- Ali Ahmadi, A. R. (1998). *Management of research and technology development*. Islamic Azad University Press. (In Persian)
- Almer, J., Wilson, K., & Chang, A. (2020). Investment barriers in corporate R&D: Evidence from emerging markets. *Journal of Technology Management*, 15(2), 112–128.
- Al-Rasoul, S. M. (2009). *The effect of R&D on economic growth in developing countries with emphasis on Iran* (Master's thesis, University of Tehran). (In Persian)
- Anoosheh, S. (2011). The effect of R&D expenditures on economic growth by investment sectors. *Journal of Applied Economics*, 7, 1–22. (In Persian)
- Atafar, A., & Analoui, A. (2001). Investigation of causes and factors of growth and barriers to progress of R&D units in organizations. *Industrial Management Quarterly*, 12, 34–56. (In Persian)
- Azimi, H. (1992). *Development traps in Iran's economy*. Nashr-e Ney. (In Persian)
- Baumol, W. J. (1990). Entrepreneurship: Productive, unproductive, and destructive. *Journal of Political Economy*, 98(1), 893–921.
- Chen, W., & Li, Y. (2022). Bridging the innovation gap: Policy frameworks for R&D investment in developing economies. *Research Policy*, 51(4), 104–119.
- Esfanjani, A. A. (2003). Strategic management of R&D. *Industrial Management Quarterly*, 15, 45–62. (In Persian)
- Heidari, H., & Sanginabadi, B. (2013). The impact of R&D on economic growth in Iran. *Journal of Economic Research*, 2, 1–23. (In Persian)
- Hosseini Nejad Moghari, M. (2014). Barriers and solutions for developing mutual industry-university relations. *Journal of Technology Management Studies*, 5(2), 45–68. (In Persian)
- Jalalabadi, E. (2001). *The role and effect of R&D expenditures on economic growth in Iran* (Master's thesis, Allameh Tabataba'i University). (In Persian)
- Jones, C. I. (2002). *Introduction to economic growth*. W.W. Norton & Company.
- Kim, H., & Park, S. (2021). Global competitiveness and the role of R&D intensity: A cross-country analysis. *Journal of Industrial Economics*, 29(2), 201–218.

Komijani, A., & Asgari, M. M. (1992). Theoretical investigation of R&D using growth models and comparative analysis of R&D expenditures in selected countries. *Journal of Economic Research*, 4–5, 19–45. (In Persian)

Luetkenhorst, W. (2004). *SMEs and sustainable development*. OECD Publishing.

Mata, J., & Woerter, M. (2013). Risky innovation: The impact of internal and external R&D strategies upon the distribution of returns. *Research Policy*, 42(2), 495–501.

Mehdiyan, A. (1993). *Selection and technology strategies for developing countries*. Iranian Research Organization for Science and Technology. (In Persian)

Mehregan, N., & Soltani Sehat, L. (2014). R&D expenditures and total factor productivity growth in the industrial sector. *Journal of Applied Economic Studies in Iran*, 5, 1–24. (In Persian)

Nobelius, D. (2004). Towards the sixth generation of R&D management. *International Journal of Project Management*, 22(5), 369–375.

Ozcelik, E., & Taymat, E. (2008). Does government support for R&D crowd out private R&D investment? Evidence from Turkish manufacturing firms. *ERC Working Papers*.

Pazakinejad, E., & Nowzari, M. (2010). *Investigation of the position of R&D in Mazandaran province during the first, second and third development plans*. Governor's Office of Mazandaran. (In Persian)

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5), S71–S102.

Salami, S. R., & Shafieipour, D. (2007). Intra-organizational factors affecting the effectiveness of R&D activities. *Proceedings of the 6th International Conference on Industrial R&D Centers*. (In Persian)

Shahabadi, A. (2007). The effect of foreign direct investment, international trade and human capital on total factor productivity of Iran's economy. *Economic Essays*, 4(7), 134–199. (In Persian)

Shibli, K. (1996). *Research and development management*. Industrial Management Institute. (In Persian)

Siami Doudaran, Z. (2002). *Why didn't we industrialize? Historical investigation of barriers to industrial development in Iran*. Amir Kabir Publications. (In Persian)

Vaezi, M., Tayebi, K., & Ghanbari, A. (2007). The role of R&D expenditures in value added of high-technology industries. *Economic Review*, 4, 53–72. (In Persian)

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ETHICAL CONSIDERATION

Authenticity of the texts, honesty and fidelity has been observed.

CONFLICT OF INTEREST

Author/s confirmed no conflict of interest.