Journal of Industrial Policy and Technology Management, 7(2), 2024, 33-48

Analysis of International R&D Center Investment Decisions Using AHP Methodology

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Received: May 19, 2024 Accepted: Aug 2, 2024 Published: Dec 30, 2024

Abstract: This paper aims to identify the policies that influence the location decisions of multinational firms' R&D centers in Türkiye and China. It compares the incentive policies for R&D activities in Türkiye and China, analyzes the political factors required for R&D centers, and conducts a comparative analysis of the human resources and legal regulations required for R&D activities. The results of this study reveal important insights into the effectiveness of policies towards R&D activities in Türkiye and China. Additionally, the identification of the factors required for R&D activities in Türkiye and China can inform the location decisions of both domestic and multinational firms' R&D centers in these regions.

Keywords: Multinational Companies, R&D Center Investment, Globalization, Analytic Hierarchy Process (AHP)

JEL Classification: L52

1. Introduction

Long-term investments in human capital, innovation and technological development are key drivers of growth. In addition to such investments, expenditures on education, especially higher education and vocational training, research and development (R&D) expenditures, and investments in facilitating technologies such as information and communication technologies (ICT) are also becoming increasingly important. In recent years, companies have particularly focused on R&D activities and continuous development and growth policies together with the income generated from these activities.

R&D, regional investments in technological development and innovation are strongly correlated with productivity, growth and sustainable international competitiveness. In today's global economy, companies finance their R&D activities in various ways, including from their own funds (e.g., retained earnings) and from local and international

sources. The main international source is payments for R&D from companies abroad, including those with ownership and control links. Research grants and contracts from international organizations are another important source. In many countries, a significant portion of business R&D is supported by funds from abroad. Multinational firms that want to maximize their use of these resources are pursuing a strategy of distributing their R&D investments globally.

It is perceived that regional investment in technological development and innovation, through productivity, growth and continuous international competitiveness, is strongly associated with the creation of regional advantage for firms to sustain their R&D investments with the highest benefit. Firms are increasing their R&D activities day by day and are more willing to use the advantages arising from this. In this direction, multinational firms are increasing their studies to understand the advantages offered by countries when making investment decisions by focusing on the benefit package that will result from not limiting R&D investments to a single country.

There are many factors that are important in the R&D investment decisions of multinational companies in order to gain more competitive advantage.

For this purpose, the options it uses for R&D globalization include mergers and acquisitions, technology licensing and participation in an international R&D consortium. The advantages that countries will have from opening R&D centers with a multinational strategy are primarily; tax reductions provided by the state, incentives provided by calls for projects, the increase of qualified employment opportunities in specific fields, and proximity to relevant markets. R&D globalization, as an important strategic option for expanding capacity between countries, provides multinational companies with opportunities to use firm-specific technological capabilities in new markets and to access new sources of knowledge that can be used to expand these capabilities.

2. Literature and Methodology

2.1. Literature

Holmes Jr., Li, Hitt, and Sutton (2015) examine the factors influencing the decisions of multinational corporations (MNCs) to establish foreign R&D centers in China in their study titled "The Effects of Location and MNC Attributes on MNCs' Establishment of Foreign R&D Centers: Evidence from China." The research evaluates the impact of local advantages such as China's economic growth in encouraging MNCs to establish R&D centers in China. However, it also highlights how local disadvantages like weak

intellectual property protection negatively affect these decisions. The study also delves into how the attributes of MNCs moderate these effects on the establishment of R&D centers.

Methodologically, the research examines R&D centers established by US-based MNCs operating in China over a 15-year period. Data analysis is conducted using regression models and statistical techniques. Findings suggest that understanding the complex effects of local advantages and disadvantages on MNCs' decisions to establish R&D centers in China is crucial.

Fuller, D.B., Akinwande, A.I., and Sodini, C.G. (2017) investigate the effects of globalization through the relocation of semiconductor design to China and India to examine the impact on the technological capabilities of multinational corporations (MNCs) in their home countries.

The study begins with a comprehensive literature review and interviews with industry experts. Data is collected from various sources to understand offshoring trends in the semiconductor industry and MNC activities. Additionally, complex data analysis techniques are employed to assess the impact of offshoring on design capabilities in home countries.

Results indicate a limited and gradual impact of offshoring on semiconductor design capabilities in home countries. Despite the increasing activities of MNCs in India and China over time, it is concluded that offshoring is unlikely to significantly displace design activities in home countries in the near future.

Urbig et al. (2022) conduct a detailed examination of multinational corporations' (MNCs) R&D internationalization strategies in emerging and developed economies. This research emphasizes the role of various precursors at the firm and country levels in shaping R&D internationalization processes.

At the firm level, it is noted that technological position is crucial in determining R&D strategies and explaining differences between emerging and developed economies. Conversely, at the country level, the host country's institutional environment is closely associated with explorative strategies. In this context, the study demonstrates that R&D internationalization strategies are shaped within a complex network of interactions, with both firm-level and country-level factors playing significant roles. These findings

underscore the importance for MNCs to consider both internal firm-specific factors and external country-level influences when developing R&D strategies.

Long and Cai (2023) explore the strategic potential and welfare outcomes of government incentives aimed at encouraging multinational enterprises (MNEs) to invest in R&D-intensive activities. The study examines the fundamental factors influencing host governments' incentives to promote foreign direct investments (FDI) in R&D and evaluates the potential positive externalities for domestic firms created by these incentives.

The research highlights the importance of comparing these incentives with other policy alternatives and analyzes their impact on industrial policy and technology transfer. Results indicate significant contributions to the literature on industrial policy and technology transfer, suggesting that incentivizing R&D-intensive investments can positively contribute to both domestic and international economic development.

Alexeeva-Alexeev and Mazas-Perez-Oleaga (2023) conducted a study examining the effects of corporate R&D investments in the ICT industry on firms' cash flow and debt status. Analysis was derived from an unbalanced panel dataset comprising financial data from 14,619 companies across 22 countries spanning from 2003 to 2018, using corporate, accounting, and financial data from the S&P Capital IQ database, World Bank World Development Indicators database, OECD Main Science and Technology Indicators, and International Monetary Fund. Researchers followed the latest classification provided by CEPR to classify European countries according to bank- or market-oriented financial systems. Additionally, they noted that ICT companies were represented in sub-sectors corresponding to standard industry classification (SIC) codes within the sample.

This study offers significant findings regarding the management of R&D investments in the ICT industry. Researchers thoroughly examined key factors influencing R&D decisions of ICT companies and valuable insights into innovation, technological uncertainty, and R&D management issues. Furthermore, they contributed valuable insights into understanding the dynamics of R&D investment in the ICT industry across different countries.

Li and Du (2023) investigated the evolution of multinational corporations' investments in the global R&D network from a geographical perspective through network analysis. The research extensively addresses factors influencing the development of global cross-border R&D investments and how these investments' geographical patterns shape the

global network structure. Using negative binomial regression models, the study analyzed data and examined the effects of overdispersion in the distribution of R&D investments. Methods included network analysis and regression models using various variables to determine countries' positions in the R&D network. Findings provide important insights for policymakers seeking to strengthen countries' positions in the global R&D network. Specifically, it emphasizes that technological and market-related capabilities could enhance the likelihood of attracting foreign R&D investments and effectively implementing them. In this context, continuous investment in education, knowledge generation, and innovation capacity is highlighted as essential. The research underscores spatial heterogeneity in the international R&D network by shedding light on relationships between economic geography, international business, and complex networks disciplines.

2.1. Methodology

2.1.1. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a method used to analyze complex decision-making problems (Saaty, 1980). Developed by Thomas L. Saaty in the 1970s, AHP provides a framework for making choices among alternatives (Saaty, 1990).

Key concepts of AHP:

Hierarchy: The decision-making problem is divided into a hierarchy consisting of a set of sub-criteria and alternatives ([Vaidya & Kumar, 2006]). Comparison Matrices: Each criterion and alternative are pairwise compared to other criteria and alternatives ([Saaty, 1980]). Importance Weights: Weights indicating the importance of each criterion and alternative are calculated from comparison matrices ([Saaty, 1990]). Consistency Ratio: Used to check the consistency of comparison matrices ([Saaty, 1980]).

2.1.1.1. Mathematical and Logical Foundations

AHP relies on mathematical and logical tools such as the eigenvector method and Saaty's 9-point scale ([Saaty, 1980]).

Eigenvector method: Eigenvectors are calculated to indicate the importance of each criterion and alternative from comparison matrices ([Saaty, 1990]). Saaty's 9-point scale: A scale used to create comparison matrices ([Saaty, 1980]). The scale is as follows:

Table 1. Table of Saaty

Value	Definition	Comments
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Judgment slightly favors one element over another
5	Strong importance	Judgment strongly favors one element over another
7	Very strong importance	Judgment strongly favors one element over another, its dominance is demonstrated by experience
9	Extreme importance	The dominance of one element over another is demonstrated and absolute
2, 4, 6, 8	Middle values	can be used to express intermediate values

2.1.1.2. Structural and Content Components

Structural components of AHP:

- Goal: Specifies the objective of the decision-making problem.
- Criteria: Criteria used to achieve the goal.
- Sub-Criteria: Subsets of criteria.
- Alternatives: Options evaluated in the decision-making problem.

Content components of AHP:

- Comparison Matrices: Matrices where each criterion and alternative are pairwise compared to other criteria and alternatives (Saaty, 1987).
- Importance Weights: Weights indicating the importance of each criterion and alternative are calculated from comparison matrices (Saaty, 1987).
- Consistency Ratio: Used to check the consistency of comparison matrices (Saaty, 1987). Various methods are available for its calculation (Vargas, 1990).

The stages and steps of decision analysis using AHP are as follows (Saaty, 1990):

- **Problem identification:** The main objective and scope of the decision-making problem are determined.
- **Determination of criteria:** Criteria that are important for solving the problem are identified and organized hierarchically.
- **Identification of alternatives:** Alternatives to be evaluated are determined and added to the hierarchical structure.
- **Creation of comparison matrices:** Matrices are created where each criterion and alternative are pairwise compared to other criteria and alternatives.
- **Calculation of importance weights:** Weights indicating the importance of each criterion and alternative are calculated from the comparison matrices.

- **Calculation of consistency ratio:** Calculated to check the consistency of the comparison matrices.
- **Interpretation of results:** Based on the calculated importance weights and consistency ratio, the most suitable alternative is determined.

2.1.1.3. Rationales for the Main Criteria Used in AHP Analysis:

In this section, the rationales for the main criteria used in my doctoral thesis, namely Economic Factors, Talent Pool, Infrastructure, and Political and Legal Factors, will be presented. The justification for selecting sub-criteria for each criterion will also be provided, along with an explanation of their relevance and importance to the research problem.

Economic Factors:

Economic factors play a significant role in site selection for investment. Elements such as market size, labor costs, tax rates, and R&D incentives directly influence the attractiveness and potential returns of investments. According to Holmes Jr., Li, Hitt, and Sutton (2016), local advantages such as China's economic growth encourage multinational companies to establish their R&D centers in China. Therefore, it has been determined that economic factors are decisive main factors in directing R&D investments.

Sub-Criteria:

- **Market Size:** A large market translates to more potential customers and revenue for investments.
- **Labor Costs:** Low labor costs can enhance investment profitability and create an attractive environment for investors.
- **Tax Rates:** Low tax rates can incentivize investments by increasing net income for investors.
- **R&D Incentives:** Incentives provided for R&D activities can enhance long-term investment success by promoting innovation and new product development. The study by Hewitt-Dundas and Roper (2011) clearly articulates the impact of publicly funded R&D centers on economic development, productivity, and competitiveness.

Talent Pool:

A talented workforce is key to success in any sector. Elements such as the number and quality of engineers in a region, scientific research capacity, and collaboration opportunities with universities indicate the availability and quality of the human

resources necessary for investments. Cheng and Kwan (2000) conducted a comprehensive study covering the period from 1985 to 1995 to investigate the determinants of foreign direct investment in China. The research analyzes how factors such as regional infrastructure, labor quality, wage levels, market size, and education affect foreign direct investment flows in China.

Sub-Criteria:

- **Number and Quality of Engineers:** an adequate number of qualified engineers facilitate keeping pace with technological advancements and facilitating the development of innovative products.
- **Scientific Research Capacity:** A strong scientific research infrastructure enables the generation of new knowledge and technologies, contributing to the accumulation of knowledge for investments.
- **Collaboration Opportunities with Universities:** Close collaboration with universities can contribute to firms' research and development activities and assist in nurturing new talents. The study by Young, Hewitt-Dundas, and Roper (2008) compares university-based and company-based research centers, highlighting differences in intellectual property strategies and the importance of potential knowledge processing processes.

Infrastructure:

Advanced infrastructure reduces the costs of investments, increases efficiency, and creates business opportunities. Factors such as ease of transportation, technology infrastructure, and communication infrastructure reduce the logistical costs of investments, strengthen supply chains, and facilitate access to the global market. Urbig et al. (2022) emphasize the critical importance of technological location in determining R&D strategies and show that R&D internationalization strategies are shaped within a complex network of interactions, with both firm-level and country-level factors playing significant roles in shaping these strategies.

Sub-Criteria:

- **Ease of Transportation:** A fast and reliable transportation network is critical for raw material supply, product distribution, and export activities.
- **Technology Infrastructure:** Adequate and advanced technology infrastructure (high-speed internet, cloud computing services) enables the digitalization of investments and provides an advantage in global competition.
- **Communication Infrastructure:** A robust communication infrastructure (telephone, internet) facilitates seamless communication between investments

and their business partners, customers, and suppliers, speeding up business processes. Alexeeva-Alexeev and Mazas-Perez-Oleaga (2023) conducted a study examining corporate R&D investments in the ICT industry. This study provides significant findings on factors influencing ICT companies' R&D decisions and valuable insights into innovation, technological uncertainty, and R&D management. It also explains the importance of understanding the dynamics of ICT industry R&D investment in different countries.

Political and Legal Factors:
Political stability, investor-friendly policies, and protection of intellectual property rights create a secure environment for investors and support the long-term success of investments.

Sub-Criteria:

- **Political Stability:** A politically stable environment is essential for investors to make long-term plans and conduct investments securely.
- **Investor-Friendly Policies:** Government policies that promote investments (tax exemptions, bureaucratic facilitations) create an attractive environment for investors. The study by Long and Cai (2023) describes the strategic potential and welfare significance of incentives offered by governments to multinational enterprises (MNEs) to encourage R&D-intensive investments.
- **Protection of Intellectual Property Rights:** Effective protection of intellectual property rights encourages the development of innovative products and enhances the competitiveness of investments. Awokuse and Yin (2010) emphasize the significant impacts of intellectual property rights reforms in developing countries on technology transfer and trade.

4. Conclusion

Economic factors, talent pool, infrastructure, and political and legal factors are fundamental criteria to consider in site selection for investments. Each of these criteria represents important factors directly influencing the success and sustainability of investments.

In the tables below, the steps of the Analytic Hierarchy Process (AHP) analysis are shared based on the responses provided by a randomly selected individual participating in the process. Comparison tables for each of the main criteria and sub-criteria, from Table 1 to Table 5, are provided regarding their relationships with each other.

Example: AHP Results for Evaluator 2

Table 2. Comparative Analysis of All Criteria for Evaluator 2

Criteria	Economic Factors	Talent Pool	Infrastructure	Political and Legal Factors
Economic Factors	1	1/2	3	1
Talent Pool	2	1	5	2
Infrastructure	1/3	1/5	1	1/3
Political and Legal Factors	1	1/2	3	1

Table 3. Comparative Analysis of "Economic Factors" for Evaluator 2

Subcriteria	Market Size	Labor Cost	Tax Rates	R&D Incentives
Market Size	1	1/5	1/2	1/3
Labor Cost	5	1	3	2
Tax Rates	2	1/3	1	1/2
R&D Incentives	3	1/2	2	1

Table 4. Comparative Analysis of "Talent Pool" for Evaluator 2

Subcriteria	Number and Quality of Engineers	Scientific Research Capacity	Cooperation Opportunities with Universities
Number and Quality of Engineers	1	1	3
Scientific Research Capacity	1	1	3
Cooperation Opportunities with Universities	1/3	1/3	1

Table 5. Comparative Analysis of "Infrastructure" for Evaluator 2

Subcriteria	Easy Access	Technology Infrastructure	Communication Infrastructure
Easy Access	1	1/5	1/3
Technology Infrastructure	5	1	3
Communication Infrastructure	3	1/3	1

Table 6. Comparative Analysis of "Political and Legal Factors" for Evaluator 2

Subcriteria	Political Stability	Investor-Friendly Policies	IPR Protection
Political Stability	1	7	3
Investor-Friendly Policies	1/7	1	5
IPR Protection	1/3	1/5	1

Results obtained from the ratings of Evaluator 2:

Table 7. Priorities by criterion

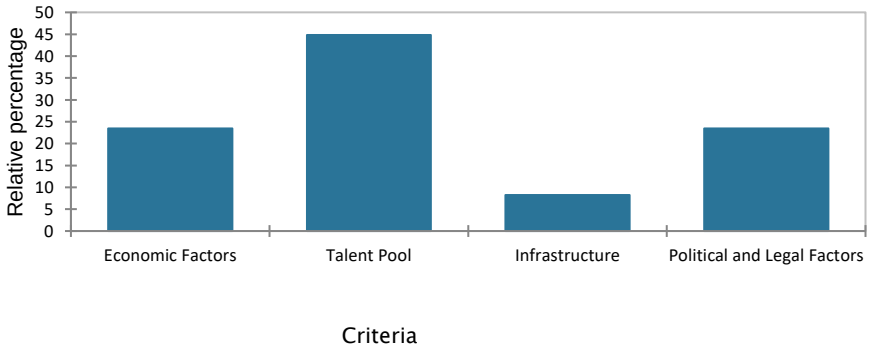
Criteria	%
Economic Factors	23,47
Talent Pool	44,86
Infrastructure	8,20
Political and Legal Factors	23,47

IC = 0,001; RC = 0,15%

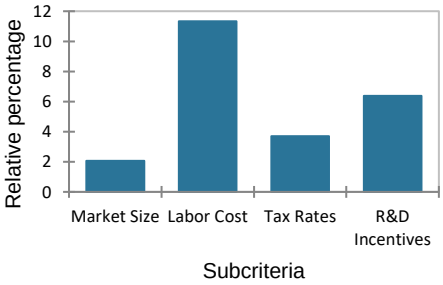
In Table 6, priority percentages of the main criteria are provided based on this sample. According to this individual, when making decisions to establish R&D centers, Economic Factors are considered 23.47% important, followed by Talent Pool with 44.86% importance. Infrastructure adequacy is deemed 8.20% important, while Political and Political Factors are considered 23.47% important. This evaluation has been calculated separately for each participant. When calculated according to the consistency ratio formula, these results are consistent.

In Graph 1, the results mentioned above are presented comparatively.

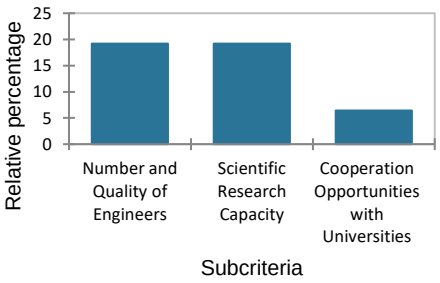
Graph 1. Priorities by criterion



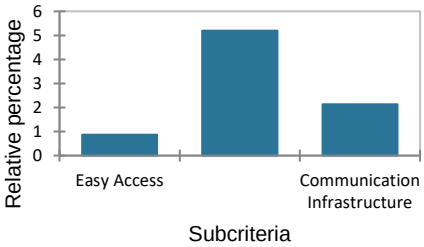
Graph 2. Priorities by subcriterion of criterion (Economic Factors)



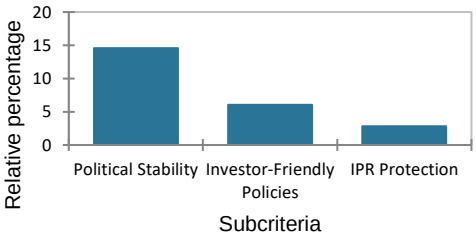
Graph 3. Priorities by subcriterion of criterion (Talent Pool)



Graph 4. Priorities by subcriterion of criterion (Infrastructure)



Graph 5. Priorities by subcriterion of criterion (Political and Legal Factors)



From Graph 2 to Graph 5, only the values of the evaluation results related to the sub-criteria for this participant are shown.

Table 8. Priorities by Alternative

Criteria	Türkiye	China
Economic Factors	3,49	8,64
Market Size	0,46	2,32
Labor Cost	0,58	1,74
Tax Rates	1,41	4,23
R&D Incentives	1,04	0,35
Talent Pool	1,02	5,68
Number and Quality of Engineers	0,60	4,18
Scientific Research Capacity	0,31	0,94
Cooperation Opportunities with Universities	0,11	0,56
Infrastructure	6,86	16,40
Easy Access	1,49	0,30
Technology Infrastructure	4,29	12,86

Criteria	Türkiye	China
Communication Infrastructure	1,08	3,25
Political and Legal Factors	15,43	42,48
Political Stability	4,51	31,56
Investor-Friendly Policies	9,01	9,01
IPR Protection	1,91	1,91

In Table 7, the degrees of importance according to this participant's results for all criteria and sub-criteria are shown, comparatively for China and Türkiye. In Graph 6, it is also explained visually, comparatively.

Graph 6. Priorities by alternative

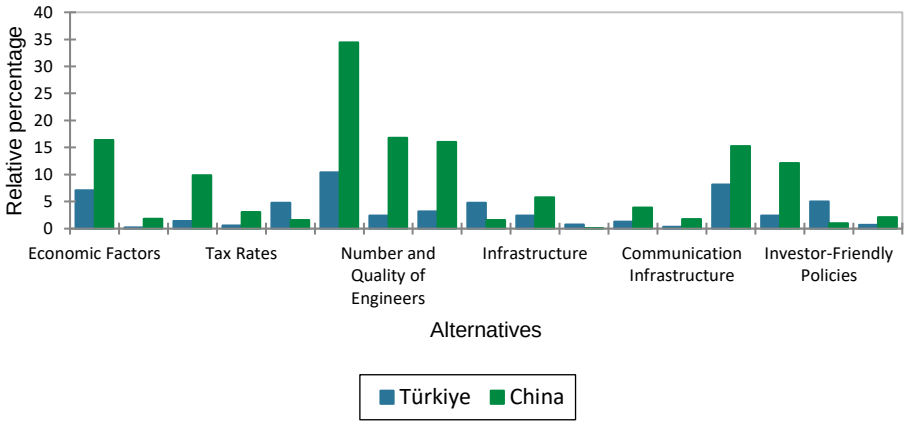
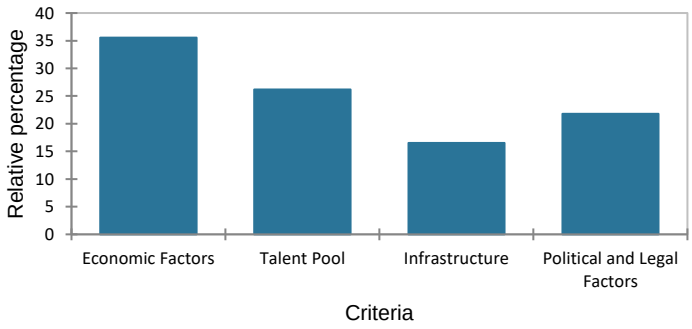


Table 9. Mean Priorities by Criterion

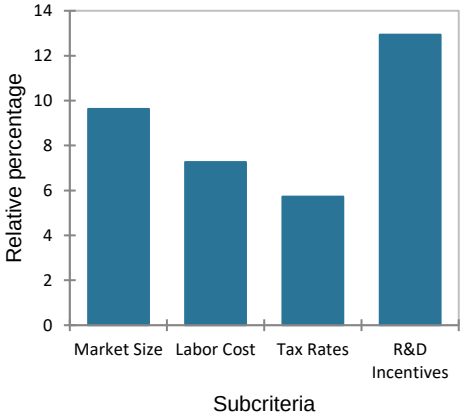
Criteria	%
Economic Factors	35,56
Talent Pool	26,16
Infrastructure	16,50
Political and Legal Factors	21,78

In Table 8, when considering evaluations from all participants in this study, the priority percentages of the main criteria are provided. According to the analysis, while Economic Factors are deemed to be 35.56% important in making decisions to establish R&D centers internationally, Talent Pool follows with 26.16% importance. Infrastructure adequacy is considered 16.50% important, whereas Political and Political Factors are deemed 21.78% important in the country. In Graph 7. Priorities by criterion all these values have been visually compared.

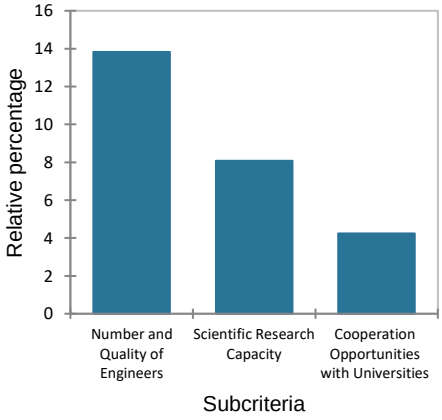
Graph 7. Mean priorities by criterion



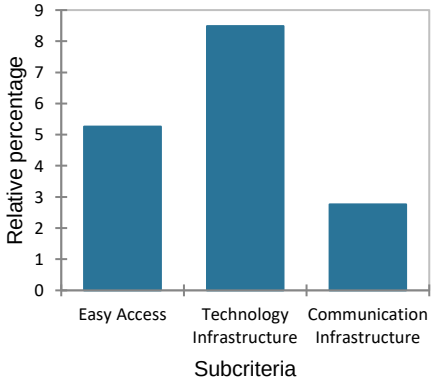
Graph 8. Economic Factors



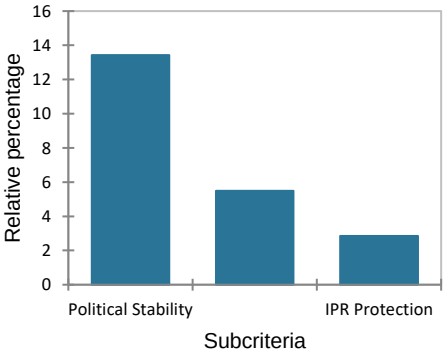
Graph 9. Talent Pool



Graph 10. Infrastructure



Graph 11. Political and Legal Factors



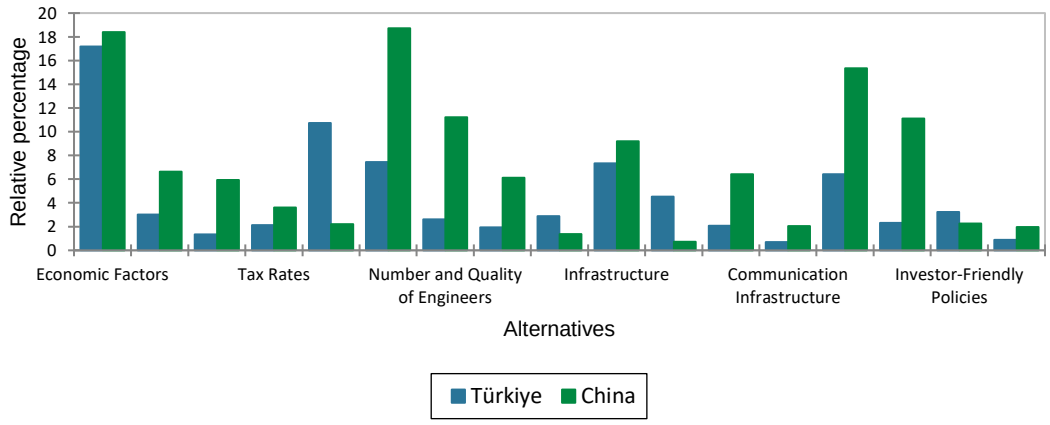
The values related to the evaluation results of the sub-criteria are shown from Graph 8 to Graph 11.

Table 10. Mean Priorities by Alternative

Criteria	Türkiye	China
Economic Factors	17,18	18,38
Market Size	3,00	6,63
Labor Cost	1,34	5,93
Tax Rates	2,11	3,62
R&D Incentives	10,72	2,21
Talent Pool	7,44	18,72
Number and Quality of Engineers	2,61	11,22
Scientific Research Capacity	1,95	6,13
Cooperation Opportunities with Universities	2,88	1,37
Infrastructure	7,32	9,18
Easy Access	4,54	0,72
Technology Infrastructure	2,08	6,41
Communication Infrastructure	0,71	2,05
Political and Legal Factors	6,43	15,35
Political Stability	2,32	11,12
Investor-Friendly Policies	3,22	2,27
IPR Protection	0,88	1,97

When considering evaluations from all participants, the importance values for each criterion and sub-criterion for China and Türkiye are shown in Table 9.

Graph 12. Mean priorities by alternative



Graph 12 further demonstrates that when China and Türkiye are compared according to different main and sub-criteria, they emerge differently in terms of certain criteria, while similar values are found for certain main or sub-criteria as a result.

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