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Presenting a model of factors affecting foreign investment risk: multi-criteria decision making and linear regression with a fuzzy approach (Upstream Oil Industries)

M. Eshaghinia*[1], M.R. Shahriari[2], K. Fathi Hafashjani[3]

The main objective of the research is to rank the risk factors of foreign investment and present a model of their impact on the risk of foreign investment in upstream oil industries. It is descriptive in nature and method, and in terms of relationships, inferential and correlational. The statistical population of the research includes managers and experts in the oil industry, and the sample size was estimated at 90 people by random sampling method. The data collected with questionnaires were analyzed using SPSS and Matlab software. The results showed that according to the experts of the statistical population, political risk is in the first rank of mportance in creating foreign investment risk. Also, in the fuzzy regression method, the correlation between foreign investment risk factors and foreign investment risk is completely significant, and political risk has the greatest impact on foreign investment risk, and economic, social and non-commercial risks are in the next ranks. By examining the overall fit of the proposed model, it was determined that the appropriate power of fit of the proposed model has been able to determine the relationship between the independent and dependent variables of the research well.

***Keywords**: investment risk, fuzzy multi-criteria decision making, fuzzy linear regression, Matlab.*

1. Introduction

Economic theories and empirical evidence suggest that a country's economic and production growth is largely influenced by its initial capital and the flow of investments. Jalali et al. [25]. Capital accumulation, as one of the basic prerequisites of the economic growth process, can be provided from domestic or foreign sources. Kiani.[28]. From a theoretical standpoint, the importance of injecting capital into the economy lies in the widely held belief that capital formation acts as the main engine of economic growth and development. Ansari Samani et al. [4]. Unlike a few decades ago, when countries were less focused on attracting external funds, today almost all nations actively compete to attract foreign capital Mohammadzadeh et al. [35]. Beyond its importance in the dynamics of the global economic system, many developing countries suffering from a lack of domestic financial resources see the attraction and utilization of these foreign resources as essential for the continuation of their economic development programs. Kiani.[28].

It is evident that domestic capital financing can be achieved through various means, such as using domestic savings, foreign debt, and attracting foreign investment in many developing countries,

* Correspondence Author
[1] Department of Industrial Management, University of Science and Research, Tehran, Iran, Email: eshaghi. 1970 @yahoo.com
2 Department of Industrial Management, University of Tehran Soth Branch, Tehran, Iran, Email: Shahriari. Mr @gmail.com
[3] Department of Industrial Management, University of Tehran Soth Branch, Tehran, Iran, Email: fathikiamars @yahoo.com

foreign direct investment has become the most stable and significant source of capital inflows. This is mainly because domestic savings are often insufficient to bridge the gap between savings and investment needs Ansari Samani et al. [4]. Attracting FDI in any country depends not only on liberalizing foreign capital and creating profitability conditions for foreign firms by the host country but also on reducing risk and uncertainty. Kiani,[28]. Besides evaluating potential profitability in a host country, foreign investors also take into account factors such as capital security and the protection of unearned profits. Mohammadzadeh et al. [35].

When a host country faces political, economic, and financial instability, it will not be a safe and suitable place for investment, even if the return on investment is favorable. Mohammadzadeh et al. [35]. Root (1987) opined that any foreign investment project must be assessed from the perspectives of its economic, social, political and cultural environments. Adewal Samuel.[1]. Previous studies indicate that several factors influence the attraction of foreign direct investment, including exchange rates, returns on capital, infrastructure quality, inflation (as indicators of economic costs and benefits), the level of domestic investment, economic freedom, quality of inputs, property rights, liquidity, and overall economic growth. Mohammadzadeh et al. [35].

Upstream oil activities are exposed to economic and financial risks on account of significant capital investments, technical risks associated with availability of technology and workforce skills, the amount of proven oil reserves, climate policies for low-carbon economic development, and political risks. Duan et al. [18]. Given that Iran is located in a relatively unstable region of the Middle East and is classified as a developing country, attracting investment is essential for its economic growth and prosperity. Therefore, it is necessary to identify and implement effective strategies to attract foreign capital and gain its associated benefits Jalali et al. [25].

Because of the important role of risk in FDI, here we suppose that the competition occurs on the basis of product price under a stochastic price-depended demand. To focus on the effects of competition, we consider all model parameters as a common knowledge for supply chain members. How will this supply chain compete in the market? What are the optimal wholesale and retail prices? And, how does the risk sensitivity affect the supply chain members' decisions? Our concern here is to answer these questions.

This study aims to identify the most critical risk factors associated with foreign investment and to develop a model that explains these risks in the upstream sectors of Iran's oil industry. Following the introduction, the paper reviews the theoretical foundations of investment and risk, examines the key factors influencing investment attraction, and then applies multi-criteria decision-making and fuzzy linear regression methods to analyze and determine the impact of these risk factors. The findings are subsequently presented and discussed.

The remainder of our research is organized as follows. The Theoretical foundation is reviewed in Section 2 that include foreign investment and its risk and factors, research background and research gap. A fuzzy regression model is presented insection3. We give research methodology, questions and hypothesis are presented in Section 4. Findings of research and sensitivity analyze described in section 5. Finally, in Section 6 we summarize our conclusion, discussion.

2. Theoretical foundations

2.1. Foreign investment and its risk

One of the methods of capital financing is foreign direct investment (FDI), which is generally regarded as a mechanism for transferring technology between countries, leading to the activation of growth engines for employment, technology, and productivity. Based on the benefits of FDI, many

governments—even those concerned about the political and social consequences of dependence on foreign investment—tend to adjust their economic policies and adopt more liberal approaches in order to attract FDI. Attracting direct foreign investments, considered one of the best ways to address capital shortages, access technology, and improve production processes, is a goal for countries Jalali et al. [25]. However, foreign capital can only grow and contribute effectively in a country where suitable political, financial, and economic conditions exist, along with the rule of law, respect for international regulations, and, most importantly, public security. Bayat and Asgari. [9].

Measurable potential loss in an investment is called risk. Ansari Samani et al. [4]. Lowrance defined risk based on measuring the probability and severity of hazardous effects. Gholinezhad-Paji et al. [23]. In investment activities, if the expected rate of return is lower than the interest rate on corporate bonds or bank deposits, the investment is generally considered risky. Mirzakhani and Nouri. [34]. For governments, the primary reason for analysing risk factors is to encourage multinational companies to invest by providing guarantees and, where possible, reducing the cost of foreign investment. At the same time, foreign investors aim to gain benefits with greater certainty compared to investing in other countries. Mohammadzadeh et al. [35]. According to the theory of irreversible investment, future political and economic uncertainty reduces the investment of risk-free firms, this is because multinational investors are aware that sunk costs cannot be recovered if unfavourable market changes occur. Yu and Wang. [51].

The risk of a host country is inversely proportional to its FDI inflow. Zhang et al. [53]. In today's world, as societies continue to modernise, various social, political, and economic risks have increasingly influenced human life. As a result, the risks associated with the process of modernisation are now undeniable. Anbari and Haqqi. [3]. In other words, maintaining a stable macroeconomic and political environment is essential for attracting foreign direct investment and, consequently, supporting economic growth. Yu and Wang. [51]. Foreign capital tends to flow into countries where security is ensured and the overall level of risk is relatively low. Ansari Samani et al. [4]. From a research perspective, risk in any country can be classified into several categories, including political, economic, financial risks, and cultural conflicts. Zhang et al. [53]. In the current situation, many potential foreign investors are reluctant to take on investment risks. This is mainly due to factors such as the high level of risk in the country, economic sanctions, exchange rate instability, and negative perceptions of the political and economic environment. Shokri et al. [46].

2.2. Foreign investment risk factors

Political risk is considered one of the most unpredictable factors affecting foreign companies operating within a country. Internal forces can create significant and rapid changes in a country's conditions, which in turn influence the interests and objectives of foreign firms. Mohammadzadeh et al. [35]. Political risk refers to the risk that a foreign government action will negatively affect the cash flows of a company conducting an international investment. Bekaert et al. [10].

Economic risk refers to unexpected changes in the overall structure of the economy, which may force investors to modify or adjust their projects. Adewal Samuel. [1]. According to some researchers: Economic risk refers to the danger of changes in a country's economic structure or constant fluctuations in its currency exchange rates and economic laws that reduce the return on foreign investments Ansari Samani et al. [4].

Another major barrier to foreign investment is the presence of non-commercial risks. When such risks are reduced, foreign investment flows into developing countries tend to increase. Sabour. [42]. Furthermore, participatory and democratic institutions can lessen the negative effects of external shocks on economic growth. Democracy also supports growth by strengthening property rights, promoting freedom, and encouraging savings among wealthier individuals Ansari Samani et al. [4].

Social risk perception highlights that risk is not only quantitative but also includes subjective elements that are often overlooked in traditional financial and economic analyses. Eelen et al. [19]. The level of risk tolerance is typically assessed by international institutions using socio-economic indicators. Evidence shows that countries with strained international relations often struggle to attract foreign investment. Zhang et al. [53]; Ansari Samani et al. [4].

2.3. Research background

Many studies have examined the relationship between risk factors and foreign direct investment, but their findings are not always consistent. Some research indicates that higher political risk leads to a decrease in foreign direct investment. Gastanga et al. [20]; Ayhan. [6]; Adewal Samuel. [1]; shahriari et al. [44]. In contrast, other studies suggest that political risk has no significant impact on foreign investment. Ayhan. [6]. Interestingly, some research even shows that a considerable number of investors attracted to high-risk countries Mohammadzadeh et al. [35]; Ayhan.[6]; Jalali et al. [25]. Meon and Sekatt (2012) investigated how sensitive the distribution of FDI flows is to political risk by analysing a large sample of both developed and developing countries. Using panel data from 1920 to 2000, their findings showed that political risk has a negative relationship with the level of FDIJalali et al. [25].

Sissani and Belkacem (2014) examined the impact of political and financial risks on foreign direct investment in Algeria from 1990 to 2012. They concluded that political and financial risks were critical for FDI inflows. This conclusion was confirmed by a recent study of the MENA country, namely Egypt, for the period 2005-2015 by Salem and Younis (2021). They identified economic and political risks as determinants of foreign direct investment in the country. Adewal Samuel.[1] And it is also consistent with the research of Shahriari et al (2024) on the impact of political, economical, non-commercial, and social oil outcome risk factors on foreign investment in the Iranian economic industry, which has determined factors on FDI risk. Shahriari et al. [44]. Similarly, Hayakawa et al. (2013) examined the impact of political and financial risks on foreign direct investment inflows to 90 countries from 1985 to 2007 using the generalized method of moments estimator. Their results showed that political risk was associated with foreign direct investment inflows. Zhang et al. [53]. Adewaal Samuel (2022) and Li et al. (2016), identified the following risk factors in a comprehensive qualitative-quantitative risk assessment method to analyze foreign direct investment in oil refining projects for Chinese oil and gas companies: investment environment risk; organization management risk; technical risk; health, safety, environment and social responsibility risk; and economic risk. Adewaal Samuel. [1]; Li et al [33]. In this regard, the impact of political risk in Lebanon for the years 2008-2018 was examined by Bitar et al. (2020). They concluded that political stability is a critical determinant of foreign direct investment. Adewaal Samuel.[1].

Al Boswillem et al. (2011) examined the impact of political risk on the relationship between financial system development and foreign direct investment in the 8-D countries during the period 2001–2007, using a panel data model. Their results indicated that political risk negatively affects both the attraction of foreign investment and the development of financial systems in these countries. Mohammadzadeh et al,[35]. Li et al. (2016) applied the AHP and TOPSIS methods to evaluate foreign direct investment risk in the shale gas sector for Chinese oil companies. Their study identified five main categories of risk: economic, political, geological, technological, and internal management risks. Li et al. [33] Salmani et al. (2014) analysed the impact of terrorism shocks on FDI inflows in MENA countries using a Panel VAR model and the generalized moments method over the period 1970–2012. The results revealed that terrorism shocks have a negative effect on attracting foreign direct investment. Jalali et al. [25]. Desitnikov and Akiba (2016) explored the role of exchange rates and the political environment in the investment decisions of Japanese multinational companies. Their

findings suggest that these firms are generally cautious and tend to avoid exchange rate and political risks in developing countries. Zhang et al. [53].

The effect of national risk on foreign direct investment in Iran was investigated by Rafat and Farahani (2019) for the years 1985 to 2016 by using a two-stage least squares method. Their results showed that national risk indicators, including religious and ethnic tension, external conflicts, socio-economic status, and military tension, are important factors that affect foreign direct investment in the economy. Adewal Samuel. [1]. Also, Morrissey (2012) in her article examined the relationship between government and foreign direct investment and private investment and concluded that government indicators, which include political stability, lack of violence, regulatory quality, rule of law, and control of corruption, had a direct impact on attracting foreign direct investment and private investment. Kazemi et al. [27]. Rasouli Ghahrudi and Chang (2020) in their article titled Macroeconomic Determinants and the Impact of Sanctions on Foreign Direct Investment in Iran 1991-2014 by using OLS regression. They concluded that macro-determinants such as infrastructure, exchange rate, inflation rate, investment returns, and governance have a long-term impact on foreign direct investment inflows in Iran. Rasouli Ghahrudi and Chang.[41]

Banga (2009) examined the key determinants of foreign direct investment in ten developing countries. The study found that factors such as market size, labour costs, and government external debt significantly influence the attraction of foreign investment. Banga.[8]. Naude and Krugell (2007) identified several factors affecting FDI in African countries, including government expenditure, inflation rate, investment levels, population size, and governance indicators such as political stability, accountability, legal framework, and the rule of law. Their analysis covered the period 1970–1990 using a panel data model Naude and Krugell. [37]. As Bahrami and Pahlavani (2014), in their study titled "The Impact of Globalization on the Attraction of Foreign Direct Investment in Selected MENA Countries," applied the GMM method and found that population growth rate has a negative and statistically significant effect on attracting FDI in these countries. Mohammadzadeh et al. [35].

Research by Rolle and Talbot (2001) analyzed GDP per capita in 162 different countries, covering data from 1995 to 1999. They found that changes in GNI per capita depend on press freedom, political rights, property rights, government spending, and civil liberties. Ayhan. [6]. Busse and Hefeker (2007) examined the relationship between political risk and FDI flows in 83 developing countries. Their analysis collected data from 1984 to 2003. According to their findings, government stability, internal and external conflicts, corruption and ethnic tensions, law and order, democratic accountability of government, and quality of bureaucracy are all statistically significant variables for foreign direct investment. Adewal Samuel. [1]. Wisniewski and Pathan (2014) examined the role of political factors in the decision-making of investors of multinational corporations. Their findings, using data from 33 OECD member countries during 1975-2009, indicated that foreign investors are reluctant to invest in countries where government spending is mostly spent on military spending and their own expenses. Mohammadzadeh et al. [35]. This is consistent with the results of Taylor et al. (2013) for the factors attracting foreign direct investment to oil-producing economies from 1996 to 2010 using panel ordinary least squares to estimate the determinants of FDI for an unbalanced panel of 47 developing countries. Sookram et al. [47].

Table 1 shows the most important risk factors for foreign investment, including political, economic, non-commercial and social risks, along with the sub-criteria that create them. Research conducted on foreign investment risks also reveals the most important factors that cause them.

Table 1. Factors affecting foreign investment risk

Row	Risk	Factor	Source
1	Political	Exchange rate	Ansari Samani et al, [4]; Jalali et al. [25]; Adewal Samuel. [1]; Zhang et al. [51]
		Internal conflicts	Ansari Samani et al.,[4]; Shahriari et al.,[44]; Jalali et al,[25]
		corruption	Ayhan,[6]; Adewal Samuel. [1]; Jalali et al,[25]; Shahriari et al.,[44]; Ansari Samani et al. [4]
		Change in policy	Jalali et al,[25]; Ansari Samani et al. [4]; Zhang et al,[53]
		Sanction	Ialfani et al.,[24]; Galini & Amasia,[21]; Shokri et al.,[46]; Shahabadi et al.,[43]
2	Economic	Customs tariff	Jalali et al. [25]; Mirzakhani & Nouri,[34]; Nathan, [36], Asadnejad et al.,[5]; Sookram,[47]
		Invest return rate	Ansari Samani et al.,[4]; Kianpour & Piri,[29]; Jalali et al. [25]; Shahriari et al.,[44]
		Foreign debt	Ansari Samani et al. [4]; Adewal Samuel [1]; Jalali et al [25]; Raei and Fazelian. [40]
		Budget balance to GDP ratio	Kiani, [28]; Jalali et al, [25]; Kianpour & Piri,[29]; Adewal Samuel,[1]
3	Non-commercial	Expropriation	Ansari Samani et al.,[4]; Bayat & Asgari, [9]; Ayhan, [6]; Shihata, [45]; Mohammadzadeh et al., [35]
		Entry of competitors	Mohammadzadeh et al, [35]; Bobenic Hintosova et al.,[12]; Yu & Wang,[51]; Click Reid,[14]
4	Social	Militarism	Kiani, [28]; Kazemi et al.,[27]; Ayhan,[6]; Adewal Samuel, [1]; Zhang et al,[53]
		Population	Ostadi et al.,[39]; Mohammadzadeh et al,[35]; Bromandfar, [13]; Naude & Krugell,[37]; wijweerra et al.,[50]

Source: Research findings

2.4. Research gap

The research gap in the study done is the lack of integrated studies combining advanced techniques such as fuzzy multi-criteria decision-making (such as FAHP, FTOPSIS) and fuzzy regression methods. specifically for considering multiple investment risk factors simultaneously. Although numerous
studies have examined various foreign investment risk factors gaps remain in the existing research:

- Failure to combine multiple-criteria decision-making models with causal approaches using a fuzzy logic framework to assess the uncertain nature of risk factors, particularly in the oil industry.
- Inadequate comprehensive application of these methods for simultaneously evaluating foreign investment risk factors characterized by multiple types of uncertainty.
- Lack of focus on determining the intensity of impact of various foreign investment risk factors.

The innovation of this study lies in the simultaneous use of decision-making methods and fuzzy regression, as well as measuring the intensity of impact of various factors affecting foreign investment risk in the oil industry.

3. Fuzzy Multiple Regression Model

Fuzzy regression is generally divided into three types:

1. Fuzzy regression in the case that the relationships between the variables (regression model

coefficients) are assumed to be fuzzy.

2. Fuzzy regression in cases where the observations in the dependent variable and independent

variables are imprecise and fuzzy.

3. Fuzzy regression, in which both relationships between variables and fuzzy observations are

considered. Behdani and Darehmiraki. [11].

Given the descriptive-correlational nature of this research, appropriate statistical methods such as correlation tests and fuzzy regression are employed to examine the relationships between independent and dependent variables. The model used is a fuzzy multiple regression equation of a probabilistic type with fuzzy coefficients. In this model, the input variables are non-fuzzy, while the output is a fuzzy response, representing the dependent variable as a function of the independent variables. Equation (1) presents the main fuzzy model used in this study.

$$\tilde{Y}_j = \tilde{\alpha}_0 + \tilde{\alpha}_1 X_{1j} + \tilde{\alpha}_2 X_{2j} + \tilde{\alpha}_3 X_{3j} + \tilde{\alpha}_4 X4j \quad (1)$$

So that:

$\tilde{Y}j$: Fuzzy value of the dependent variable (output) in the jth observation

$\tilde{\alpha}_0$:Fuzzy constant value of the regression equation

$\tilde{\alpha}_1$ ، $\tilde{\alpha}_2$ ، $\tilde{\alpha}_3$ ، $\tilde{\alpha}_4$:The fuzzy coefficient values are the variables X1, X2, X3, and X4.

X1, X2, X3 and X4: represent independent variables including political, economic, non-commercial and social risk factors, respectively.

Based on the relations used for the fuzzy multiple regression problem, 2m inequalities are formed. One way to solve fuzzy multiple regression is to transform the problem into a linear programming problem. Koureh Pazan Dezfuli. [31].

To estimate the parameters of the fuzzy regression model, i.e. the fuzzy coefficients, based on a set of observations, the following criteria and metrics have been considered:

1. The membership value of each yi in $\tilde{Y}j$ (the model output for xij) is a large number. In other words, the fuzzy output $\tilde{Y}$ for all values of $\tilde{Y}j$ (j=1, 2, …, m) has a membership degree of at least as large as h, where 0<h<1.

2. Second, the uncertainty (which is equal to the sum of the individual expansions related to each of the fuzzy parameters of the model) in the prediction based on the model is minimal. That is, the fuzzy coefficients $\tilde{\alpha}$i are such that the uncertainty of the fuzzy output is minimized. The wider the width of a fuzzy number, the greater its uncertainty.

3. To perform the fuzzy multiple regression test, triangular fuzzy numbers $\tilde{\alpha}_i$ =(a_l, a_m, a_r) with a 5-option spectrum were used. Karbasi et al. [26]. Due to the use of the research population, the final numbers were obtained from the geometric mean of the opinions of the research population and therefore are asymmetric. Therefore, the right and left widths of the fuzzy numbers will not necessarily be equal, and all parameters such as$\tilde{\alpha}_0$, $\tilde{\alpha}_1$, $\tilde{\alpha}_2$, $\tilde{\alpha}_{13}$and $\tilde{\alpha}_{14}$will include triangular fuzzy numbers with different left and right widths. The relationship between the left and right widths of the fuzzy coefficients of the equation will be as described in equation (2)

$$S_{ir} = K_i * S_{il} \quad (2)$$

Where S_{ir} is the right width of the i-th variable and S_{il} is the left width and K_i is the coefficient of skewness. According to equation (2), the research model will have coefficients S_1, S_2, S_3, S_4, a_1, a_2, a_3, a_4, K_1, K_2, K_3, K_4. Considering the use of cut h in the membership function of fuzzy numbers, the cut value from 0 to 1 will be divided into ten equal parts.

To achieve the above goal, we minimize the objective function by the sum of the widths of the fuzzy outputs Ỹj related to all data sets. Considering the above, the problem should be solved as a linear programming in the form of equation (3). Therefore, the objective function of the problem with the constraints of equations (4) and (5) will be:

$$min : z=(Sl0+Sr0)+\sum_{i=1}^{n}\left[(S_i^l + S_i^r)\sum_{j=1}^{m} x_{ij}\right] \quad (3)$$

s.t.:

$$(1-h)k0S0l+(1-h)\sum_{i=1}^{n} k_i S_i{}^l x_{ji} + \sum_{i=1}^{n} a_i^c x_{ij} + a_0^c \geq yi\ , \forall_j; j = 1,2,\dots,m \quad (4)$$

$$(1-h)\ k0s0 +(1-h)\sum_{i=1}^{n} k_i\ s_i^l\ x_{ij} - \sum_{i=1}^{n} \alpha_i^c\ x_{ij}\ - \alpha_0^c\ \geq -yj\ ,\ ,\ \forall_j,\ j=1,\ 2,\ \dots,\ m \quad (5)$$

These inequalities are the algorithm for the linear programming problem of fuzzy regression with asymmetric elongation coefficient, which is adapted from the method of Tanaka et al. [49]. where i is the number of variables (i=1,2, …, n) and j is the number of observations (j=1,2, …, m), xij is the ith variable in the jth observation, Si is the left width of the fuzzy number of the ith variable, ki is the ratio of the right width to the left width of Si. Karbasi et al., [26].

To determine the role of risk factors and their sub-criteria in creating foreign investment risk, a 17-item questionnaire was used for a sample size of 90 people based on Green's theory. This theory is based on the minimum acceptable sample size for the overall fit test of the regression model (R^2 test). Green has proposed equation (6) for the sample size in regression. Green [22]

$$N \geq 8k + 50 \quad (6)$$

Where k is the number of predictor variables. Therefore, given the 4 predictor (independent) variables in this study, the minimum sample size is 82. Therefore, depending on the sample size and the number of independent variables of the research problem, Equation 3 will be transformed into equation (7).

$$Z=(s0l+ s0r\ )+(s1l+ s1r)\sum_{j=1}^{90} x_{j1}+ (s2l+ s2r)\sum_{j=1}^{90} x_{j2}+ (s3l+ s3r)\sum_{j=1}^{90} x_{j3}+ (s4l+ s4r)\sum_{j=1}^{90} x_{j4} \quad (7)$$

Where xj_1 is the political risk index, xj_2 is the economic risk index, xj_3 is the non-commercial risk index, and xj_4 is the social risk index. The presented functions of the problem can be observed with m and solved with MATLAB software, considering the 2m generated constraints (in this study, 180 constraints).

4. Research Methodology

This research has attempted to select the most important factors affecting foreign investment risk and present its linear regression model using the multi-criteria decision-making method and linear regression with a fuzzy approach to determine the relationships between the independent and dependent variables of the research. For this purpose, multiple-choice questionnaires have been used.

4.1. Research questions and hypothesis

The research question is: What is the ranking of risk factors affecting foreign direct investment risk? And the research hypothesis is based on the impact of political, economic, non-commercial and financial risks on foreign investment risk.

4.2. Research methodology

This research is applied in terms of its purpose, descriptive survey in terms of its data collection method, and cross-sectional in terms of its time period. On the other hand, this research is descriptive-correlational in terms of its nature and approach. The data and method used for analysis are quantitative and inferential statistics have been used. The reliability of the questionnaires was determined by the inconsistency index and Cronbach's alpha coefficient in the multi-criteria decision-making method and fuzzy linear regression. Cronbach's alpha in the second questionnaire was 0.898. The research used two hierarchical models and fuzzy linear regression based on the research of Mirzakhani and Nouri. [34] and Kazemi et al. [27].

5. Research findings

5.1. Risk factor ranking

In the first part, risk factors were ranked using the fuzzy multi-criteria decision-making method. The results of pairwise comparisons, eigenvectors, and risk factor inconsistency rates, final fuzzy weights, fuzzy weight rankings, are as shown in Tables 2 and 3.

Table 2. Eigenvector values and inconsistency rate of the fuzzy hierarchical method

Risk	Eigenvector	inconsistency
Political	5.38,5.28	0.09,0.065
Economic	4.086,4.096	0.079,0.088
Non-commercial	0	0
Social	0	0

Source: Research findings

Table 3. Final fuzzy weights of the hierarchical model sub-criteria

Risk	Weight	Rank	Subcriteria	Fuzzy weight	Rank
Political	0.14,0.45,1.42	1	Change in policy	0.008,0.214,3.235	1
			Exchange rate	0.006,0.097,2.011	4
			Internal conflicts	0.005,0.074,1.66	6
			corruption	0.004,0.047,0.962	9
			Sanction	0.002,0.022,0.437	10
Economic	0.09,0.35,0.94	2	Invest return rate	0.016,0.153,1.215	3
			Foreign debt	0.008,0.145,1.57	2
			Customs tariff	0.004,0.041,0.608	7
			Budget balance to GDP	0.002,0.015,0.125	12
Non-commercial	0.04,0.35,0.71	3	Expropriation	0.015,0.117,1.394	5
			Entry of competitors	0.004,0.017,0.186	11

Social	0.02,0.05,0.15	4	Militarism	0.004,0.042,0.483	8
			Population	0.002,0.010,0.097	13

Source: Research findings

5.2. Ranking of risks affecting foreign investment risk using the fuzzy TOPSIS method

After determining the fuzzy weights of risk factors and their sub-criteria, the final ranking of risks using the fuzzy TOPSIS method is determined based on the criterion of proximity to the ideal index. Table 4 shows the values of the distances of proximity and distance from the ideal index.

As Table 4 shows, the most influential factor on foreign investment risk in the studied area is political risk, followed by economic, non-commercial, and social risks.

5.3. Model Performance Evaluation and Optimal Model Selection

In order to compare the performance of the designed fuzzy regression approaches and evaluate the model, the following statistical measurement parameters were used. These parameters are:

- Mean Square Error (MSE)
- Root Mean Square Error (RMSE)

Mean Absolute Percentage Error (MAPE)

Table 4. Ranking of risks affecting foreign investment risk

Row	Risk	d-			d+			CC+	Rank
1	Political	0.0002	0.04	1.21	0.117	1.214	1.260	0.328	1
2	Economic	0.0001	0.07	1.19	0.241	1.195	1.259	0.320	2
3	Non-commercial	0.0002	0.02	1.01	0.256	1.16	1.32	0.276	3
4	Social	0.0001	0.01	0.953	0.262	1.13	1.29	0.264	4

Source: Research findings

To select the most appropriate model, one can choose the most appropriate model based on the values of the parameters listed below:

- Coefficient of determination: The criterion for selecting a model is its maximum value according to the value of the coefficient of explanation.
- Mean Square Error: The selection of the appropriate model is made according to the value of the mean square error, considering its minimum value.
- Root Mean Square Error: To select a model based on the values of the root mean square error, its minimum value should be used as the criterion for action.

Mean Absolute Error Percentage: If the appropriate model is selected from the values of the average absolute error percentage, its minimum value will be the selection criterion.

The optimal model is the model that has the lowest MSE value or the highest R^2 value. Karbasi et al. [26]. To obtain the optimal solution, we can calculate the solution to the problem for different slices h ($0<h<1$) and select the optimal value for MSE and R^2 in these solutions. In this research, the effect of risk factors including political, economic, non-commercial and social factors in the state of uncertainty on foreign investment risk for different slices h has been investigated.

5.4. Correlation coefficients and fuzzy regression

Investigating the structure of correlation and the relationship between variables is one of the issues of interest in statistics. The correlation coefficient is an index that shows the degree of relationship between variables. In situations where fuzzy data is used, by applying the definition of Pearson's

correlation coefficient for quantitative data and the expansion principle, it is possible to calculate the upper and lower bounds of the fuzzy correlation coefficient. Zarei and Kianpour. [52]. The values of the correlation coefficients between the factors and risks affecting the risk of foreign investment in the research model after defuzzification are as shown in Table 5.

Table 5. Correlation coefficient of risk factors affecting foreign investment risk

Political	r	Economic	r
Change in policy	0.829	Invest return rate	0.763
Exchange rate	0.740	Foreign debt	0.724
Internal conflicts	0.798	Customs tariff	0.369
Corruption	0.471	Budget balance to GDP	0.541
Sanction	0.363		
Non-commercial	r	Social	r
Expropriation	0.782	Militarism	0.843
Entry of competitors	0.562	Population	0.531

Source: Research findings

The values of the correlation coefficient in Table 5 show that the correlation between the factors of corruption and sanctions with political risk, customs tariff and budget-to-GDP ratio with economic risk, the entry of competitors with non-commercial risk, and population with social risk is weak, and therefore it can be said that their impact on political risk and consequently on foreign investment risk is weak. Also, the values of the correlation coefficients in the fuzzy regression model of the research between risks and foreign investment risk for different values of the cut h are as follows in Table 6.

According to the values of Table 6, it is observed that the highest value of the correlation coefficient for political risk factors is recorded in the cut h=0.4, for economic risk in the cut h=0.1, non-commercial
risk and social risk in the cut h=1.

Table 6. Values of the correlation coefficient of different cuts h

h	Political Risk	Economic	Non-commercial	Social
0.1	0.6785	0.8181	0.6740	0.4164
0.2	0.6991	0.7943	0.6993	0.4627
0.3	0.7194	0.7603	0.7324	0.5190
0.4	0.7773	0.7392	0.7700	0.5802
0.5	0.7505	0.7268	0.8071	0.6395
0.6	0.7572	0.7001	0.8387	0.6907
0.7	0.7570	0.6631	0.8620	0.7303
0.8	0.7508	0.5964	0.8766	0.7577
0.9	0.7404	0.5882	0.8839	0.7744
1	0.7276	0.5860	0.8860	0.7828

Source: Research findings

Table 7 shows the values of h, α_0, α_1, α_2, α_3, α_4. According to the values of the coefficients for the independent variables of the linear regression model, the values of MSE, RMSE, MAPE and R^2 of the fuzzy regression model of the research based on different values of the cut h are given in Table 8.

Table 7. Values of coefficients of linear regression equation for different cuts h

h	α_0			α_1			α_2		
0.1	-0.2560	-0.1690	-0.1040	0.1967	0.2085	0.2172	0.2052	0.2675	0.3289
0.2	-0.2180	-0.1690	-0.1040	0.1967	0.2085	0.3027	0.2052	0.2675	0.3027
0.3	-0.1991	-0.1690	-0.1040	0.1967	0.2085	0.2167	0.2052	0.2675	0.2810
0.4	-0.1831	-0.1690	-0.1040	0.1967	0.2085	0.2154	0.2052	0.2626	0.2675
0.5	-0.1690	-0.1657	-0.1040	0.1967	0.2085	0.2135	0.2052	0.2472	0.2675
0.6	-0.1690	-0.1473	-0.1040	0.1967	0.2085	0.2114	0.2052	0.2348	0.2675
0.7	-0.1690	-0.1165	-0.1040	0.1967	0.2096	0.2248	0.2052	0.2248	0.2675
0.8	-0.1690	-0.1165	-0.1040	0.1967	0.2085	0.2086	0.2052	0.2169	0.2675
0.9	-0.1690	-0.1078	-0.1040	0.1967	0.2083	0.2085	0.2052	0.2105	0.2675
1	-0.1690	-0.1048	-0.1040	0.1967	0.2081	0.2085	0.2052	0.2058	0.2675

Source: Research findings

Table 7 continues. Values of coefficients of linear regression equation for different cuts h

h	α_3			α_4		
0.1	0.2731	0.2961	0.2995	0.2204	0.2653	0.3096
0.2	0.2759	0.2961	0.2995	0.2375	0.2653	0.3096
0.3	0.2801	0.2961	0.2995	0.2526	0.2653	0.3096
0.4	0.2848	0.2961	0.2995	0.2653	0.2658	0.3096
0.5	0.2891	0.2961	0.2995	0.2653	0.2768	0.3096
0.6	0.2925	0.2961	0.2995	0.2653	0.2858	0.3096
0.7	0.2948	0.2961	0.2995	0.2653	0.2932	0.3096
0.8	0.2960	0.2961	0.2995	0.2653	0.2994	0.3096
0.9	0.2960	0.2961	0.2995	0.2653	0.3047	0.3096
1	0.2960	0.2961	0.2995	0.2653	0.3096	0.3096

Source: Research findings

As the values in Table 8 show, the lowest MSE value is related to the cut h=0.6 and the highest R^2 value is related to the cut h=0.7. The value of the objective function also increases approximately with the increase in h. Therefore, by considering the optimal MSE value to select the most appropriate regression

model for the research, the best fit of the research regression model can be considered according to the

Table 8. MSE, RMSE, MAPE and R^2 values for different cuts h

h	z	MSE	RMSE	MAPE	R^2
0.1	0.7532	0.0137	0.1173	3.4114	0.9833
0.2	0.7076	0.0076	0.0876	2.1858	0.9896
0.3	0.7121	0.0046	0.0168	1.5128	0.9933
0.4	0.7700	0.0030	0.0551	1.1266	0.9956
0.5	0.7970	0.0022	0.0470	0.9175	0.9962
0.6	0.8459	0.0018	0.0431	0.7616	0.9976
0.7	0.8992	0.0018	0.0434	0.7028	0.9979
0.8	0.9208	0.0022	0.0474	0.6956	0.9978
0.9	0.9378	0.0029	0.0541	0.7273	0.9975
1	0.9423	0.0039	0.0628	0.7909	0.9971

Source: Research findings

coefficient values obtained for h=0.6 as equation (8).

$$Y=(-0.169,-0.1473,-0.104)+(0.1967,0.2085,0.214)X_1+(0.2052,0.2348,0.2675)X_2+(-0.292,-0.296,0.299)X_3+(0.265,0.285,0.309)X_4 \quad (8)$$

According to the rule of magnitude of fuzzy numbers, the magnitude and ranking of fuzzy coefficients of risk factor variables will be as shown in Table 9.

Table 9. Ranking of fuzzy coefficients of fuzzy regression equation

Risk	fuzzy coefficient at cut 0.6			Normal Defuzzification coefficient
Political	0.1967	0.2085	0.2114	0.618
Economic	0.2052	0.2348	0.2675	0.268
Non-commercial	0.2925	0.2961	0.2995	0.033
Social	0.2653	0.2858	0.3096	0.079

Source: Research findings

According to the values in Table 9, it is clear that, based on the results of the research, the coefficient of influence of political risk in creating foreign investment risk ranks first, economic risk ranks second, social risk ranks third, and non-commercial risk ranks fourth.

5.5. Testing research hypothesis

At this stage, the values and table of fuzzy coefficients of the fuzzy regression model in Table 7, the table of correlation coefficients (6) and equation (7) can be used to examine the research hypotheses. To prove the research hypotheses, the existence of an appropriate and meaningful relationship between the independent and dependent variables must be confirmed. For this, the values of the correlation coefficients between the independent and dependent variables, the values of the coefficients of the independent variables in the regression equation and the amount of regression error can be used.

- The value of the correlation coefficient of the political risk variable is 0.7572, the value of R^2 is 0.997 and the MSE is 0.00186 at the optimal cutoff value of h=0.6, indicating that there is a significant relationship between this variable and foreign investment risk, and the positive value of the correlation coefficient indicates that this relationship is direct. Therefore, it can be said that the variable affects foreign investment risk.
- For the economic risk variable, considering the values of the correlation coefficient equal to 0.7001, the R2 value equal to 0.997, and the MSE equal to 0.00186 at the optimal cutoff value of h=0.6, it can be said that there is a significant relationship between this economic risk and foreign investment risk, and the positive value of the correlation coefficient indicates that the relationship is direct but weaker than that of political risk. Therefore, it should be said that the economic risk variable affects foreign investment risk.
- Regarding the non-commercial risk variable, the values of the correlation coefficient are 0.8620, the R^2 value is 0.997, and the MSE is 0.00186 at the cutoff h=0.6, which shows that there is a significant relationship between this variable and foreign investment risk, and the positive value of the correlation coefficient indicates that this relationship is direct and that the non-commercial risk variable affects foreign investment risk.
- For the social risk variable with a correlation coefficient of 0.6907, an R^2 value of 0.997, and an MSE of 0.00186 at a cutoff of h=0.6, it can be shown that there is a significant relationship

between the aforementioned variable and foreign investment risk, but this relationship is weaker than other variables. The positive value of the correlation coefficient indicates that this relationship is direct and that the social risk variable has an effect on foreign investment risk. Also, considering the coefficient values of the independent variables in the fuzzy regression equation (Table 9), the above results can be confirmed and it can be said that all variables have a positive and direct effect on foreign investment risk. However, the greatest impact comes from political risk, then economic risk, and non-commercial and social risks have a much smaller impact.

5.6. Sensitivity Analysis

Here, a sensitivity analysis is performed in order to validate the model. To do this, by keeping all parameters and changing only one of them, we should check the model's behavior. The desired parameters for checking their effects on the behavior of the model on an objective function include political risk, economic risk, non-comercial risk and social risk. The analysis results are shown in tables 10 and Figure 1.

Table 10. sensitivity analysis

h	α_0	α_1	α_2	α_3	α_4
0.1	0.089	0.056	0.062	0.021	0.152
0.2	0.072	0.024	0.062	0.106	0.114
0.3	0.057	0.016	0.062	0.02	0.095
0.4	0.044	0.011	0.005	0.019	0.079
0.5	0.044	0.007	0.020	0.017	0.065
0.6	0.044	0.004	0.033	0.015	0.065
0.7	0.044	0.004	0.043	0.015	0.065
0.8	0.044	0.004	0.051	0.012	0.065
0.9	0.044	0.004	0.057	0.000	0.065
1	0.044	0.004	0.062	0.000	0.065

Source: Research findings

The sensitivity analysis of the fuzzy regression coefficients across varying h-levels (from 0.1 to 1.0) provides critical insights into the robustness of the risk factors studied. The intercept (α_0) exhibited the highest degree of spread variation, reflecting the model's flexibility in accommodating overall system fluctuations. Among the explanatory variables, Political Risk (α_1) and Social Risk (α_4) displayed significant sensitivity to changes in the possibility level; this indicates that as the confidence threshold increases, the epistemic uncertainty associated with these risks diminishes rapidly. Conversely, Non-commercial Risk (α_3) demonstrated the highest stability across all h-levels, suggesting a more deterministic impact on the dependent variable. The convergence of all risk coefficients at h=1 validates the model’s reliability, confirming that the fuzzy estimates transition systematically into a crisp decision-making framework without losing structural integrity.

6. Conclusion and Discussion

Foreign direct investment is widely regarded as one of the most effective ways to address capital shortages, gain access to advanced technology, and improve production processes—key objectives for any country. In addition to various established factors, risk is also a critical element influencing foreign direct investment, particularly in economic, political, non-commercial, and social dimensions. This factor is especially important because governments can enhance investment security with

relatively low physical costs by improving economic, political, commercial, and social structures. Strengthening the

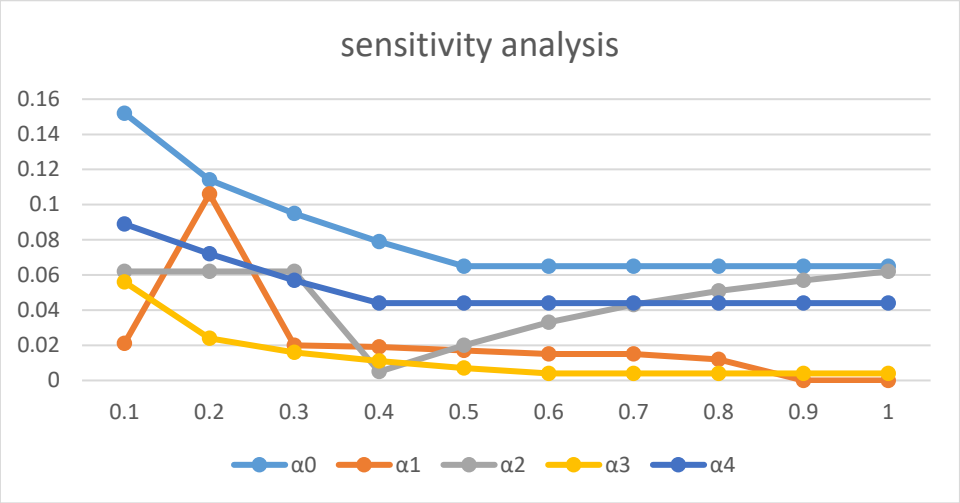

Figure1. sensitivity analysis
Source: Research findings

performance of institutions that influence risk can, in turn, improve investment conditions and contribute to achieving broader development goals.

The present study was conducted with consideration of the effectiveness of fuzzy decision-making models in handling uncertainty, particularly when qualitative variables are converted into quantitative forms in the context of foreign investment risk. The main objective of this research is to support decision-making related to foreign investment risk in the upstream oil sector. To achieve this, a fuzzy multi-attribute decision-making model was developed to suit uncertain conditions. By using linguistic variables and transforming precise numerical values, the model reduces the limitations associated with converting qualitative data into quantitative measures through tools such as the Likert scale, thereby improving the interaction between variables.

The findings from the fuzzy TOPSIS ranking indicate that political risk has the greatest impact on foreign investment risk in the upstream oil industry, followed by economic, non-commercial, and social risks. These results suggest that establishing clear and stable political frameworks in this sector plays a crucial role in reducing investment risk. Subsequently, the design and implementation of effective economic policies also significantly influence risk levels. Overall, the study confirms that political, economic, non-commercial, and social risks have a direct and significant relationship with foreign direct investment risk. These findings are consistent with previous studies, including those of Al-Boswillem et al(2022), Gross and Trevino (2005), Hakayawa Kimura and Lee(2013), Meon and Sekatt(2008), Illoi (2015), Topal and Gol (2016), Salehnia et al. (2019). Ansari Samani et al. [4]; Jalali et al.[25];Adewal Samuel. [1]. Shahriari et al. [44].

The ranking of risks affecting foreign investment, based on multi-criteria decision-making methods using fuzzy AHP and TOPSIS techniques, indicates that political risk has the greatest impact on foreign direct investment risk. This finding is consistent with previous studies, including Jalali et al. [25], which examined political risk and foreign investment in Iran, as well as Kiani [28], who analyzed foreign investment risk levels in the country. Similar results have also been reported by Click Reid [14] in the context of the United States of America, and by Ansari Samani et al. [4] in their study on economic, financial, and political risks in selected developing countries. Furthermore, this outcome aligns with the findings of Mirzakhani and Nouri [34], Li et al. [33], Duane et al. [18],

Tafour et al. [48], and Edwal Samuel [1], all of whom applied AHP and TOPSIS methods and reached similar conclusions

In the fuzzy regression analysis, the relationship between different types of risk—including political, economic, non-commercial, and social risks and foreign direct investment risk was examined. The results show that all these risk factors have a significant and direct impact on foreign investment risk. Moreover, based on the coefficients of the variables in the fuzzy regression equation, political risk was found to have the strongest influence. These findings are consistent with studies by Mohammadzadeh et al. [35], Al-Mahmoud (2014), Salehnia et al. (2019) and Adewale Samuel (2022), which highlight the importance of these risk categories. In addition, the dominant role of political risk is in line with the results of Gross and Trevino (2005). After political risk, economic risk was identified as the second most influential factor, which supports the findings of Salehnia et al. (2019). Adewal Samuel. [1]; Ayhan. [6].

Furthermore, the fuzzy regression equations indicate that the most significant contributor to political risk is policy change, which is consistent with the findings of Gugerdchian et al. (2016). This is followed by factors such as internal violence and exchange rate fluctuations, which also have a strong influence and align with studies by Salmani et al. (2014), Durnev et al. (2015), Gerlach and Yook. (2016), Phillips and Ahmadi Esfahani (2008), and Lee and Nakonnoi. (2014). Ansari Samani et al. [4], Jalali et al. [25], Adewal Samuel. [1]. However, the study found no significant relationship between corruption and sanctions and political risk. This result is consistent with the findings of Kianpour and Piri. [29] and Lestari et al. [32], but contradicts the conclusions of Al-Saddiq [2] and Cruz et al. [15].

In terms of economic risk, the results show that the rate of return on capital has the greatest impact, followed by external debt, which is consistent with the findings of Komijani and Abbasi [30], and Dey and Mohammad. [17]. Additionally, the study found that the budget balance-to-GDP ratio and customs tariffs do not have a significant effect on economic risk. This result supports the findings of Shahabadi and Mahmoudi (2006), although it contradicts those of Nanen Kemp (2002). Furthermore, the findings indicate that GDP-related factors are associated with elements such as expropriation and the entry of competitors in non-commercial risk, as well as the quality of bureaucracy in social risk With regard to non-commercial risk, the findings confirm that expropriation is a significant and influential factor, which is consistent with the results of Smarrinska (2002) and Niaman and Tice (2012). However, no significant relationship was found between the entry of competitors and non-commercial risk. Jalali et al. [25], Nunnen kamp.[38], Mohammadzadeh et al.[35],

In terms of social risk, only the factor of militarism was found to have a significant relationship with social risk. This finding is consistent with the studies of Bass and Heffker (2007), Wisniewski and Patan (2014), and Kiani (2019). In contrast, no significant relationship was identified between population and social risk in the context of foreign investment risk. This result aligns with Bailey (2017) but contradicts the findings of Nannenkamp (2002). Adewal Samuel.[1], Kiani. [28], Bailey. [7], Nunnen kamp [38].

Overall, the results of this study based on multi-criteria decision-making methods and fuzzy regression analysis indicate that different types of risk play a significant role in shaping foreign direct investment risk. In particular, political risk (including factors such as policy changes, internal violence, and exchange rates), economic risk (including return on investment and foreign debt), non-commercial risk (especially expropriation), and social risk (notably militarism) all have a direct impact on foreign direct investment. These findings are consistent with previous studies, including Dargahi (2006), Raei and Fazelian (2012), Abdolrahman (2002), and Marsobraga (2004). Based on these results, it is recommended that policymakers and stakeholders adopt more effective decision-making strategies in political, economic, and social domains. By improving institutional structures

and reducing risk factors, it is possible to enhance the security of foreign investment, particularly in upstream industries. Dargahi.[16], Raei and Fazelian.[40] and Ansari Samani et al. [4].

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