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Ambiguity in capital market and equity investment

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Abstract

Modeling and predicting fluctuations are important for many financial applications, including asset allocation, risk measurement and option pricing. This paper identifies and ranks the factors affecting market ambiguity and equity investment in companies listed on the Tehran Stock Exchange. This paper reviews the literature to identify the factors affecting market ambiguity and equity investment while conducting semi-structured interviews using the qualitative method of theme analysis. The experts interviewed were eighteen university professors and capital market activists and experts. A literature review, research, and interview results revealed six main themes, categorizing the factors influencing market ambiguity and equity investment in companies. This paper identified and ranked the main factors by the identified key factors and the fuzzy Delphi method. The results showed that the factors of financial performance, market, liquidity, financial analysis, environment, ambiguity and corporate governance are effective in market ambiguity and equity investment of companies, respectively.

Keywords: market ambiguity, equity investment, fuzzy Delphi method
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1 Introduction

Uncertainty is one of the basic characteristics of financial markets and as a result one of the factors affecting capital decisions. Accordingly, rational investors consider various uncertainties and invest in financial assets. In the traditional neoclassical economy, "uncertainty" mainly refers to the results corresponding to those probabilities (the degree of possibility of their occurrence), which is also called "risk". Accordingly, the capital assets pricing model provides a theoretical basis for evaluating the impact of risks on the pricing of capital assets such as stocks. However, with the emergence of market irregularities such as the equity risk premium puzzle and the risk-free rate of return puzzle, researchers should seek to identify and evaluate new factors in asset pricing based on the explanation of market anomalies.

This paper addresses ambiguity as a part of uncertainty overlooked by the traditional pricing models of capital assets. Ambiguity is a part of uncertainty which is referred to as "Knightian uncertainty" in the theory of possibilities, and it is a situation that shows uncertainty about the possibilities or the size of the possibility of investment events.

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According to Knightian uncertainty theory, Ellsberg's paradox was proposed by experiments that prove that people generally avoid uncertain data, i.e., "ambiguity" and dislike facing it. Subsequently, some researchers proposed a set of theoretical models that reflect the belief in "ambiguity" and investors' attitudes towards ambiguity. The literature review based on empirical evidence or theoretical foundations discussed in previous research shows that the most used models in terms of "ambiguity" in decision-making are models, including 1) Maxmin expected utility model (MMEU–model) proved by Gilboa and Schmeidler [14], 2) The expected utility, and 3) The smooth ambiguity model developed in Klibanoff, Marinacci, and Mukerji [15].

Maxmin's expected utility model (MMEU–model) proved by Gilboa and Schmeidler [14] and the expected utility Schmidler's inventive, do not distinguish between ambiguity belief and ambiguity attitude, while the smooth ambiguity model developed in [15] distinguishes these two criteria for the first time. In recent research, Izhakian introduces a new model for decision-making under "ambiguity" conditions. In this research, the aforementioned researcher proposed the expected utility model with uncertain probabilities based on the Bayesian approach and provided a new theoretical basis for measuring "ambiguity".

Some researchers examined the issues of "ambiguity" in financial markets under the above three theoretical models. The research findings show that the capital markets have obvious ambiguous situations, and in addition, investors often avoid ambiguity. The research analysis shows that there is no "ambiguity aversion" in the economic society in general and when faced with profits, investors show "ambiguity aversion" and the degree of "ambiguity aversion" decreases when investors expect losses. Therefore, investors' attitudes to "ambiguity" are different depending on the probability of profit and loss.

The analysis of the content of Sadr al-Zekr's research shows that all the aforementioned researchers are based on a judgmental and subjective approach, through the implementation of theoretical experimental designs to measure "ambiguity" and used performance data in capital markets in conducting research and sometimes they have limited themselves to theoretical random experiments. Accordingly, the investor's decisions in experiments under the influence of many uncontrollable factors may be incompatible with the decisions in real financial markets, and therefore the results obtained from these studies are not completely valid. Therefore, this paper adopts an experimental method to measure the degree of "ambiguity" using real stock return data. Thus, the relationship "depends on the situation" has been investigated based on the idea of Wang et al. [19], to evaluate the relationship between risk, ambiguity and returns in the Iranian capital market to explain the role of ambiguity in explaining stock risk or pricing. Accordingly, this paper first reviewed the research conducted on company risk management to identify the determining factors and, then categorized, prioritized and refined them using Delphi polling of experts and the fuzzy multivariate analysis method. In the end, the paper proposed the future research direction and practical recommendations.

2 Theoretical Foundations

2.1 Ambiguity and ambiguity aversion

Ambiguity in the pricing of capital assets is important because of its potential impact on investment and consumption or purchase decisions. Although generally "risk" and "uncertainty or ambiguity" are used interchangeably and synonymously, these two terms are not necessarily substitute terms for each other, because each refers to a type of variability that reflects different types of information. "Risk" is a criterion that is defined in the real world based on the size of the possibility of occurrence and is defined as a specific probability in terms of the occurrence of results, while "ambiguity or uncertainty" refers to a criterion that must be calculated in a world where existing information is not accurate enough to display results with full probabilities. In the research literature, the terms "uncertainty" and "ambiguity" are used interchangeably and synonymously, and this research used the term "ambiguity". Barberiz et al. have stated that the probabilities only show the relative possibility of the occurrence of events, but they do not provide any indication regarding the reliability of the information used in the extraction of those probabilities. The introduction of "uncertainty" in the probability distribution in decision-making and finance leads to a new discussion in the literature in which risk is redefined in terms of its conventional representation as well as its new known "ambiguity" component.

The historical development of the term "uncertainty" discussion shows that Boldrin was the first to distinguish between risk and uncertainty; that is why literature usually called uncertainty "Knightian uncertainty".

According to Knight, "risk" exists when the future results of an investment are unknown, but unique probabilities can be attributed to each of the possible outcomes. On the contrary, ambiguity or "uncertainty" exists when the results of the investment are unknown and furthermore, unique probabilities cannot be attributed to each of the possible outcomes. Although Knight's distinguished definitions of risk versus uncertainty emphasize the absence of

objective probabilities, subsequent studies have focused more on uncertainty over subjective probabilities (Hong et al. [11]). Bolstad and Curran [8] is one of the first empirical studies that evaluated the effect of ambiguity on decision-making in the capital market. The purpose of this research has been to answer this basic question: "What significant effect does Knight's distinction between measurable uncertainty (risk) and immeasurable uncertainty (ambiguity) have on capital decision-making?" The second case means unmeasurable uncertainty (ambiguity) in cases where economic actors are unaware of the probability distribution and tend to behave as if they have preliminary information and are more relevant. However, the defined priorities are only a representation of the beliefs of the decision-makers.

Bolstad and Curran [8] experiments showed that in some cases the agents do not behave as described by Savage's axioms. In the predicted experiments, there were two pots and each one contained 100 identical red and black balls. For each pot, the subjects were asked to play a game with a $100 offer such that the individual would be paid $100 if a ball drawn at random from the bucket was red, and $0 otherwise. In addition, the subjects were informed that the first pot contains 100 red and black balls with an unknown ratio and the second pot contains 50 red and 50 black balls. After that, participants were asked to determine which of the following was more likely:

1. Which one of the events of taking out a red ball or a black ball from the first pot is more likely? In other words, the possibility of a person winning or losing based on the choice of the first pot, which one has more and less risk?
2. Which one of the events of taking out a red ball or a black ball from the second pot is more likely? In other words, the possibility of a person winning or losing based on the choice of the second pot, which one has more and less risk?
3. Which one of the events of getting a red ball out of the first pot or the second pot is more likely? In other words, the possibility of a person winning based on choosing the first or second pot, which one has more and less risk?
4. Which one of the events of taking out a black ball from the first pot or the second pot is more likely? In other words, the possibility of a person losing based on choosing the first or second pot, which one has more and more risk?

The results showed that participants assigned equal probabilities to red and black balls in the first two questions. In response to the third and fourth questions, they chose pot 2 as the choice in which the red or black ball is more likely to be drawn out. This result shows a contradiction. If in question 3, the probability of the red ball drawn out of pot 2 is higher, then it should be concluded that the probability of the black ball drawn out of pot 2 is lower. Nonetheless, in question 4, participants chose the second pot for the ball to be drawn out. While the black ball is more likely to be drawn out. This result is known as the "two-cycle paradox" and contradicts Savage's expected utility model, which describes decision-making based on incremental probabilities. In addition, the choice of the second pot in the third and fourth questions confirms that participants prefer known unknowns to unknown unknowns, which means ambiguity aversion.

Another experiment by Bolstad and Curran provides more evidence in support of ambiguity aversion. In this experiment, the participants were informed that there was a pot containing 30 red balls and 60 black and yellow balls with unknown proportions. In the first game, a ball was drawn from a pot and participants were asked to bet on red or black to win $100 if the correct outcome occurred. In the second game, participants were asked to choose one of two winning balls: 1) red or yellow, and 2) black or yellow. The results show that the participants chose the red ball in the first game and chose black or yellow balls instead in the second game. Ambiguity aversion, in addition to risk aversion, has important consequences in asset pricing. Financial theories assume that asset returns should compensate for higher risk due to risk aversion. Following this logic, since ambiguity aversion is distinct from risk aversion, investors should also demand additional compensation for "ambiguity." In this framework, Bolstad and Curran's findings open a new discussion about asset pricing and suggest that investor behavior in Savage's theory be replaced with another behavior with fewer prerequisites.

2.2 Capital decision making

Literature review shows that modeling the investors' decision-making process is a complex task, and previous studies have developed relatively complex and partially explanatory models. Simply put, "decision-making" can be considered a process of choosing based on beliefs about different choices. In addition; mostly, decision-making factors with access to different information sets constitute decision-making preferences. For example, decision-makers may not be fully informed about the probability distribution of future events, so they are forced to "decide under uncertainty". In fact, this is a realistic scenario considering the complex nature of financial markets.

Therefore, "decision-making under uncertainty" may be considered a more relevant framework for modeling real-world investment processes. It should be noted that previous theoretical studies on decision-making have simplified the

process in such a way that these models assumed that the decision-making agents have access to detailed information about the nature of the future period and as a result, they can assign probabilities to the outcomes. Risk (measurable uncertainty) or known probability distribution is at the center of expected utility theory.

2.3 Decision making under risk conditions (measurable uncertainty)

The basics of decision-making in conditions of uncertainty go back to the famous study of Bernoulli [7]. This study on risk measurement has been a cornerstone of finance and economics due to its contribution to the development of the theory of utility and the theory of decision-making under uncertainty. In his proposed model, Bernoulli assumed that the decision-making agents made a decision by calculating the expected value of "an uncertain event", but the usefulness of the results (moral expectations) is also considered instead of basing their decision on the purely mathematical values of the results (expected value). Hence, preferences based on expected means may differ from preferences based on mathematical expectations.

Bernoulli's other important contribution to utility theory was his definition of "diminishing marginal utility". He argued that the utility of gain is lower than the utility of loss for the same amount of money and at the same level of wealth. These results have provided the basis for the concave utility function of wealth and risk aversion.

2.4 Factors affecting ambiguity

Although there is no official classification in the field of the conducted research, in this section, previous researches are collected and classified in three general headings according to how the literature discusses the relationship between uncertainty and asset pricing. Traditional capital asset pricing models based on efficient market theory are defined based on the assumption of complete information and rational behavior of investors. However, the previous research's empirical evidence analysis shows that during crisis periods such as the global financial crisis, the objective facts indicate that investors' behavior is far from rationality because, in these conditions, the available information becomes more imperfect in the capital market. the quality of information is a key channel for conveying uncertainty about the return of capital assets.

The literature review based on the empirical evidence obtained from previous research shows that the low quality of information or asymmetric information among different decision-makers distorts the formation of expectations about asset returns and distorted expectations and making removing some priorities and formation of a unique background impossible for decision-makers.

Halim et al. in [10] evaluated uncertainty in investment returns and factors affecting it. their empirical evidence results show that they have identified 1) low-quality information and 2) fundamental fluctuations of the company as two main sources of uncertainty. Their results showed that behavioral biases such as: showing less or more reactions are revealed based on the low quality of information, and in other words, the quality of information is closely related to the anomalies of efficiency. Zhang [22] used six distinctive indices as metrics to measure uncertainty, which includes: 1) company size, 2) company age, 3) analyst coverage, 4) dispersion in analyst forecasts, 5) returns vitality and 6) operating cash flow vitality. The research results analysis showed that the stock price and return show less reaction to new information if there is more ambiguity. Accordingly, they concluded that the market's reaction to new information is complete for stocks with low uncertainty, but incomplete for stocks with high uncertainty.

Anand and Venkataraman in [2] have focused on evaluating the effect of effective factors on ambiguity and classified the information into tangible and intangible components. According to this research, tangible information is specific information such as dividend announcements, while intangible information refers to uncertain information such as profit forecasts. The signal quality of intangible information can be low and noisy if you have incomplete knowledge. Investors evaluate these noisy signals as ambiguous and do not update their beliefs according to Bayesian law. Instead, in such conditions, decision-makers behave according to the theory of maximum expected utility and make decisions based on the results of the worst scenario. Their research findings claim that this behavioral motivation requires an asymmetric response to the release of information and that decision-makers have relatively reacted to bad news because they evaluate bad news as more reliable than good news. Greater sensitivity to bad news coincides with lower expected excess returns in periods of low information quality. Since the entry of low-quality information implies uncertainty and lower expected returns, uncertainty-averse decision-makers demand additional returns to hold assets that are likely to release low-quality information. They also evaluate the effect of information certainty on capital decision-making. The research empirical evidence analysis showed that if the information is limited to a probability measurement, investors make their decisions based on multiple probability distributions. Thus, the low-quality information, to a large extent, leads the decision-makers to move away from the average possible return as much as possible and confuses the results.

Bali and Zhou in [4] emphasized the role of the investor's ability to interpret new information instead of the quality of received information. Their research findings analysis showed that if the decision-makers do not have the required data and experience in processing new information, they do not have complete information about the distribution of asset returns and have several decision priorities. In addition, the research findings showed that the entry of new information into the market encourages investors to protect against uncertainty about the return distribution and leads to slow portfolio response and excess return volatility.

2.5 Ambiguity and anomalies

Bali et al. [3] evaluated the impact of returns anomalies on uncertainty in investment. The research empirical evidence analysis showed a direct relationship between the anomalies of excess returns observed in the market and the excess returns caused by uncertainty. By definition, non-normative in asset return refers to cases where the asset return cannot be explained by a simple version of the capital asset pricing model. Literature shows that Driouchi and Trigeorgis [13] relate stock risk with ambiguity aversion, according to equity risk premium puzzle. They showed that the annual return difference between the stock market return and the risk-free rate is about 6% for the period between 1889 and 1978 in the United States. According to the general equilibrium models, the historical averages of equity risk have not been consistent with investors' expectations. It means that equity risk premium is very high and the risk aversion among investors must be very high to consider such a high level of equity risk premium. At this point, the additional returns to uncertainty in addition to the conventional risk aversion may provide a plausible explanation for the well-known equity risk premium puzzle. Literature review shows that another anomaly closely related to equity risk premium is home bias. accordingly, Barberis and Thaler in [6] showed that home bias leads to low-diversity portfolios with unnecessary risk. Therefore, investors demand more risk premium to bear a higher level of risk. In addition, ambiguity and ambiguity aversion may be the reason for the distorted relationship between risk and return, which leads to home bias and low portfolio diversification . The findings analysis shows that the effect of company size is another anomaly of efficiency that has been widely discussed in the uncertainty literature. The size of the company may affect the quality of information and the research results show that in general, the quality of information is lower in small companies. As a result, investors demand more risk premium and additional returns to hold shares of small and low-quality companies.

For example, Bali and Zhou [4] investigated the relationship between company size and the level of ambiguity in investment returns. They obtained evidence of the inverse relationship between company size and ambiguity and showed that market sentiments through ambiguity have a positive effect on the equity risk premium of small companies' stock returns. Therefore, when market sentiment is worse and there is uncertainty, small companies have higher equity risk premium.

In addition, Barberis in [5] also studied the effect of company size on the relationship between the level of fear and the expected risk appetite of investors. Their research showed that the size of the company weakens the negative relationship between the level of uncertainty and the expected additional return. The findings also showed that a part of the abnormal excess return of stocks which is explained based on the size of the companies under investigation can be a mere indication of ambiguity risk.

Momentum is another anomaly of stock returns mentioned by Chen et al. [9] and Halim et al. [10]. investigated the factors affecting ambiguity aversion during a research. They related anomalies of momentum with ambiguity aversion and concluded that if there is ambiguity, the investor becomes pessimistic about the stock returns and underestimates the new signals in the market. Therefore, decision makers in the capital market under such conditions can strengthen their information and react better to new information such as profit announcements. They also evaluate the effect of ambiguity aversion on the incorrect pricing of capital assets. the proposed model in this research states that investors consider the ambiguity of mass information and do not fully integrate publicly available information. Inadequate inclusion of public information in the prices leads to a delay in the continuous adjustment of the prices of capital assets towards the correct price level. This adjustment mechanism in turn leads to the momentum effect.

3 Literature review

Wang et al. [20] discussed the Markov regime in asset pricing and uncertainty measurement in the stock market. Based on the theoretical framework of the expected utility with uncertain probability, in this paper, the actual prices of CSI300 and Hang Seng Index are used to empirically measure the degree of uncertainty in the capital markets of China and Hong Kong to determine the difference in the degree of uncertainty in the mainland and the United States. Then, an ambiguity factor and a risk factor are presented to analyze the variable relationship between risk,

ambiguity and return under different conditions. In addition to mean and variance, higher order moments were used to measure skewness and kurtosis, and investigated the effect of ambiguity on the relationship between variables. The results showed that the degree of uncertainty in the Chinese stock market is significantly higher than that in the Hong Kong stock market and there are significant differences between the two markets. In addition, the regression results examined the relationship between risk, uncertainty and return.

Jin et al. [12] investigated uncertainty, long-term risks and asset prices in a continuous time. In this research, long-term risk models (LRR) were developed based on the formulation of returns and the use of LRR models. In this research, a multi-objective model was formulated with criteria of return and uncertainty of the investor in the field of uncertainty. The research empirical evidence analysis showed that considering the ambiguity in uncertainty, especially the high uncertainty about long-term risks, LRR models can significantly improve the performance of equity risk and risk-free rate when using the deviation coefficient of the low risk ratio. Li investigated the volatility index behavior of cryptocurrencies and stock markets during the Covid-19 pandemic through the wavelet coherence approach and the self-regulating Markov switching model. The results indicate a financial instability during this pandemic; as during the Covid-19 pandemic, cryptocurrencies and stock prices fell sharply. However, cryptocurrencies immediately showed rebounds, while stock markets were caught in a declining phase. In general, this research showed that the price dynamics during the epidemic depends on the type of market.

Shi [18] investigated the joint effects of economic policy uncertainty and company characteristics on the capital structure of companies. The results showed that economic policy uncertainty and company characteristics are jointly effective in the formation of financing and debt or capital structure of companies. In addition, they showed that the marginal effects of economic policy uncertainty cannot be constant in financing and debt, and many indicators of corporate characteristics have different positive and negative relationships with financing and financial leverage, and ultimately economic policy uncertainty has had an inverse relationship with the capital structure and debt financing in the companies under investigation.

Maqsood et al. [16] investigated stock returns in Tehran Stock Exchange using dynamic averaging models and monthly data in the time period from April 2009 to April 2017. Thus, macro variables and parallel market indices have been used to predict stock returns. Estimates of regression models, time-varying parameter models (TVP), dynamic model selection (DMS) and dynamic model averaging (DMA) were estimated. The research analysis findings showed that the DMS model has a higher prediction accuracy compared to other methods based on the prediction performance measurement criteria. Also, the estimation results showed gold price variable (48 periods), exchange rate (36 periods) and inflation variable (30 periods) inflict higher effect on stock returns, respectively with global oil price and GDP variables having the lowest impact with 28 and 2 repetitions, respectively. Finally, the results showed that the use of dynamic models, taking into account the time changes of parameters and changes in the model, increases the efficiency of predicting stock returns.

Sabouri and Karimpour [17] attempted to determine the joint effects of economic policy uncertainty and company characteristics on the capital structure of companies listed on Tehran Stock Exchange. Their findings of the regression model analysis showed that the uncertainty of the economic policy and the characteristics of the company have a common and significant effect on the capital structure of the companies listed on Tehran Stock Exchange. Results showed that economic policy uncertainty has a direct and positive effect on financial leverage and capital structure, but corporate characteristics have an inverse and negative effect on financial leverage and capital structure. In other words, the uncertainty of economic policy by 10.79 increases the capital structure and corporate characteristics by 5.20 leads to its decrease, which is consistent with that of Xiao and Qiu [21]. Ashairi [1] investigated the effect of economic policy uncertainty on the risk of falling stock prices in companies listed on Tehran Stock Exchange based on performance data from 2011 to 2018. The paper was an applied, descriptive and correlational research. The empirical evidence analysis showed that the risk of falling in the price of a certain stock increases with the increase of uncertainty in the economic policy. The effect of uncertainty in economic policy on the risk of falling stock prices increases with the increase in the beta of economic policy uncertainty returns. Finally, the findings analysis showed that there is a positive and significant relationship between the uncertainty of the economic policy and the risk of falling stock prices in the market.

4 Methodology

This is an applied paper. Scientific papers can be classified into descriptive (non-experimental) and experimental categories in terms of data collection methods. This is a descriptive paper in terms of the data collection method with the objective of describing the conditions under investigation to be implemented in the decision-making process. The fuzzy Delphi method was used to identify and screen the key factors. The Delphi method is based on the views of

the respondents. In this technique, verbal expressions are used to measure the point of view. Verbal expressions have limitations in fully reflecting the respondent's mental states. For example, the expression "high" for person A, who is strict, is different from the expression "high" for person B. If a definite number is used to quantify the views of both individuals, the results will be biased; therefore, this problem can be overcome by developing a suitable phase spectrum. The traditional Delphi method has always suffered from low convergence of experts' opinions, high implementation cost, and the possibility of omitting some people's opinions. To improve the traditional Delphi method, Moori et al. presented the concept of integrating the traditional Delphi method with fuzzy theory in 1985. In the fuzzy Delphi method, the experts' opinions are used to reach a consensus. The participants in this Delphi are specialists and experts who have the characteristic of knowledge and experience in the subject of the internal control system of the company, in such a way that they feel that the information obtained from a group agreement will be valuable for them as well as the desire to have enough time for the company and skills with effective communication .

Therefore, a researcher-made questionnaire was prepared including 34 effective factors with a Likert scale and free questions in each main factor to express their opinions, if there is another item, they are interested in. The face validity of the questionnaires is confirmed by industry and university experts including managers and professors in terms of appearance and ease of answering. Moreover, data was analyzed using Excel and MATLAB. The time domain of this field research paper is the three months of winter 2020-2021. The subjects of the study included companies listed on Tehran Stock Exchange.

5 Data analysis and findings

Demographic findings: Knowing the demographic characteristics of the statistical sample can be useful in generalizing the results to other statistical societies by considering the similarities in general characteristics. Therefore, out of the 17 sample of the research, 13 subjects, equivalent to 76%, were male with only 4 female subjects, i.e. 24% of the total members of the statistical sample. 10 subjects aged 30 to 40, which make up 59% of the whole sample, the frequency of subjects aged 40 to 50 were 5 subjects in the sample, which make up 29% of the total sample. Also, 1 subject aged less than 30 and 1 subject aged more than 50, with the frequency of 6%. Out of the 17 subjects, 6 subjects held PhDs, which was 35% of the total members of the statistical sample of the research. The number of subjects with doctoral and master's students are 6 and 5, respectively, which is equivalent to 35 and 29% of the total members of the statistical sample of the research, with 7 in the field of accounting and finance and the rest in the field of auditing (equivalent to 41%). 6 subjects from the sample of 17 subjects had 10 to 15 years of experience, which make up 35% of the whole sample, the number of people who had between 15 to 20 years of experience were 3 subjects in the sample, which make up 17% of the whole sample. 2 subjects had more than 20 years of experience, which is 12%. Also, the number of people who had less than 10 years of experience is equal to 34% of the total sample. Factors affecting the market ambiguity and equity investment: The propositions are classified into seven main themes and thirty-four sub-themes by comparing the literature and the interviews conducted, as well as the confirmation of the professors. The main themes include ambiguity, corporate governance, financial analysis, financial performance, environment, liquidity and market. Table 1 shows factors affecting market ambiguity and equity investment

Definition of linguistic variables: the components were designed in the form of a questionnaire with the aim of obtaining experts' opinions about their agreement with the components following conducting an interview with the members of the statistical sample and identifying the factors affecting market uncertainty and equity investment. The experts expressed their level of agreement through the verbal variables of very low, low, medium, high and very high. Since the different characteristics of people affect their subjective interpretations of qualitative variables, by defining the scope of qualitative variables, experts answer questions with the same mentality. According to diagram 1 and table 4, these variables are defined in the form of triangular fuzzy numbers.

The crisp numbers in Table 2 are calculated using the Minkowski equation as follows.

$$m + \frac{\beta - \alpha}{4} \tag{5.1}$$

where, m, α and β are the first, second and third numbers from left to right, respectively.

First stage survey: At this stage, the experts were provided with a questionnaire on influential factors of market uncertainty and equity investment, which have been identified using semi-structured interviews. The questionnaire results were analyzed to obtain the fuzzy average of factors affecting market uncertainty and equity investment according to the proposed option and the defined linguistic variables from the examination of the answers given. The

Table 1: Factors affecting market ambiguity and equity investment

Main-theme	Sub-theme	Support
Ambiguity	Stock turnover, trading volume, turnover volatility, trading volatility, market return volatility, excess return volatility, stock price volatility, forecast volatility	Wang et al. [20]
Corporate governance	Institutional ownership, independence of the board of directors, decentralization of ownership, size of the board of directors	Agency theory
Financial analysis	Information quality, information accuracy, profit volatility	Information advantage and signaling theory
Financial performance	Sales margin, return on assets, return on capital, asset turnover, company value	Organizational theory
Environment	Competition, company age, company size, technology	Strategic theory
Liquidity	Current ratio, Quick ratio, cash flows, asset liquidity	Free cash flow and liquidity theory
Market	Market risk premium, size, growth opportunities, profitability, investment, human capital	Portfolio theory

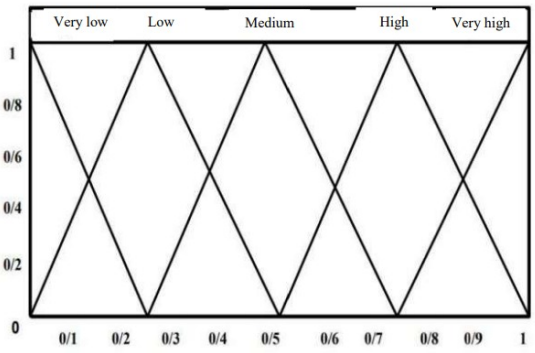

Figure 1: Definition of linguistic variables

following equations were used to calculate the fuzzy average (Mousavi et al.):

$$A_i = (a_1^{(i)}, a_2^{(i)}, a_3^{(i)}), \quad i = 1, 2, 3, \ldots, n \tag{5.2}$$

$$A_{ave} = (m_1, m_2, m_3) = (\frac{1}{n}\sum_{i=1}^{n} a_1^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_2^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_3^{(i)}) \tag{5.3}$$

where in equation (5.2), A_i represents the opinions of experts and A_{ave} represents the average opinions of experts. After collecting the questionnaires, the number of answers given to each factor was counted and checked. In the first stage survey, the results of counting the answers given are shown in Table 3.

The Minkowski formula and determined fuzzy numbers are used to calculate each factor following the number of answers given to the factors affecting the uncertainty of the market and equity investment is determined after calculating the triangular fuzzy average for the factors. The results of the average Fuzziness and de-fuzzification of the components are shown in Table 4.

To reach a conclusion, it is necessary to conduct the second stage after the end of the survey in the first stage so that the results obtained from both stages can be compared.

Second stage survey: In the second stage survey, the results of counting the answers given to the factors affecting market uncertainty and equity investment are shown in Table 5.

Each component was calculated using the Minkowski formula and the fuzzy numbers were determined per component, following determining the number of answers given to the factors affecting the uncertainty of the market and equity investment in the second stage and after calculating the triangular fuzzy average for the factors. The results

Table 2: Table of triangular fuzzy numbers

Verbal variables	Triangular fuzzy number	Crisp numbers
1	(0.75,1,1)	0.75
2	(0.5,0.75,1)	0.5625
3	(0.25,0.5,0.75)	0.3125
4	(0,0.25,0.75)	0.0625
5	(0,0,0.25)	0.0625

obtained from the fuzzy average and the de-fuzzification of the factors in the second stage are shown in Table 6.

The difference between the de-fuzzified average of the factors affecting market uncertainty and equity investment should be analyzed following completing both stages of the survey. Examining the difference of the de-fuzzified average of factors affecting market uncertainty and equity investment in the first and second stages is as described in Table 7. The views presented in the first stage and its comparison with the results of the second stage show that the survey process will be stopped if the difference between the de-fuzzified average in both stages is less than 0.1. Considering that the de-fuzzified average difference of the experts' opinions in both stages is less than 0.1, the experts have reached a consensus on the factors affecting the uncertainty of the market and equity investment, and the survey is stopped at this stage. This means that the experts had almost the same view on the components and dimensions identified in the research. Accordingly, the ranking of the effective and creating uncertainty factors of the market and equity investment is shown in Table 10. In ranking the components, the fuzzified average of the second stage is used; that is, any component whose de-fuzzified average is higher is given first priority.

6 Discussion and conclusion

Financial predictions have been the subject of valuable studies in recent decades as challenging issues. The occurrence of recent financial crises in large companies around the world has intensified the need to modify the existing financial architecture. In general, it is believed that warning signs and alarms may be observed before businesses face an economic problem or crisis. The general goal of identifying the factors affecting risk management in companies or a business is to present models that can extract knowledge related to risk assessment from past observations and assess the risk of a business crisis with much wider ranges in companies. This assessment identifies new international financial architecture policies such as crisis prevention, crisis forecasting and crisis management methods. This paper attempts to conduct a systematic and comprehensive study to identify metrics effective on market uncertainty and equity investment, with a complete database of these metrics. Therefore, all the accounting variables and components affecting the uncertainty of the market and equity investment will be examined by summarizing the research literature and in other words by examining the field of knowledge. In this paper, the author's effort is to identify the factors affecting the uncertainty of the market and the equity investment of companies listed on the Tehran Stock Exchange by studying the existing literature and interviewing experts. The factors were initially identified following conducting interviews and reviewing existing studies, using theme analysis. Then, the factors identified were classified into main themes after several stages. By taking from the studies and examining the different classifications of the six factors, including ambiguity, corporate governance, financial analysis, financial performance, and indicators related to the factors were also classified. Finally, the fuzzy Delphi method was used to prioritize the relevant factors and indicators.

This paper has raised two general questions: first, what factors affect the market ambiguity and equity investment of companies? And secondly, how was the prioritization of effective factors and how important is each factor? The results show that the following factors play a role in the market ambiguity and equity investment of companies in the order of priority: 1. Financial performance, 2. Market, 3. Liquidity, 4. Financial analysis, 5. Ambiguity and 6. Governance Corporate.

The ambiguity sub-dimensions, in order of priority, are 1. Additional returns volatility, 2. Stock price volatility, 3. Trading volatility, 4. Financial turnover volatility, 5. Forecast volatility, 6. The volume of transactions and 7. Stock financial turnover.

The sub-dimensions of corporate governance, in order of priority, are 1. Institutional ownership, 2. Lack of

Table 3: The results of counting the responses of the first stage survey

Variable	Very high	High	Medium	Very low	low	Variable	Very high	High	Medium	Very low	low
Stock turnover	2	1	0	8	6	Return on capital	11	4	2	0	0
Turnover	2	1	1	5	8	Asset turnover	8	6	2	1	0
Financial turnover volatility	3	0	1	4	9	Value of the company	3	4	4	1	5
Trading volatility	4	1	2	1	9	Competition	4	2	2	2	7
Market returns volatility	5	5	4	1	2	Company age	5	2	3	1	6
Additional returns volatility	6	6	4	1	0	Company size	10	2	2	1	2
Stock price volatility	6	5	2	3	1	Technology	5	1	2	3	6
Forecast volatility	2	1	2	3	10	Current ratio	4	3	6	0	4
Institutional ownership	3	2	3	5	4	Quick ratio	6	2	2	3	4
Independence of the board of directors	2	1	2	3	9	Cash flows	10	5	1	1	0
Lack of concentration of ownership	2	1	3	6	5	Asset liquidity	9	5	2	1	0
Board size	1	2	1	2	11	Equity risk premium	11	4	2	0	0
Information quality	0	4	2	7	4	size	13	2	1	1	0
Accuracy of information	2	3	2	2	8	Growth opportunities	9	4	2	1	1
Profit volatility	11	4	2	0	0	Profitability	8	7	1	1	0
Sales margin	2	3	2	2	8	Profitability	3	2	7	2	3
Return on assets	12	4	1	0	0	Human Capital	4	2	5	2	4

concentration of ownership, 3. Size of the board of directors and 4. The independence of the board of directors, plays a role in the effectiveness of the corporate governance factor.

The sub-dimensions of financial analysis, in order of priority, are 1. Profit volatility, 2. Accuracy of information and 3. Quality of information plays a role in the effectiveness of the factor of financial analysis. The sub-dimensions of financial performance, in the order of priority, are 1. Return on assets, 2. Return on capital, 3. Asset turnover, 4. Company value and 5. Sales margin has a role in influencing the financial performance factor.

The sub-dimensions of the environment, in the order of priority, are 1. Company size, 2. Company age, 3. Technology and 4. Competition plays a role in the effect of environmental factors. The sub-dimensions of liquidity, in order of priority, are 1. Cash flows, 2. Assets liquidity, 3. The current ratio and 4. Quick ratio plays a role in the effectiveness of the liquidity factor. And finally, the sub-dimensions of the market factor, in order of priority, are 1. The equity risk premium, 2. Size, 3. Growth opportunities, 4. Profitability, 5. Investor and 6. Human capital plays a role in the effectiveness of the market factor. The results showed that it is possible to identify the factors affecting the market ambiguity and the equity investment of companies based on the analysis of the field of knowledge and the content analysis model. Moreover, a combination of persuasive polling and the fuzzy Delphi approach enables us to refine the more effective factors. Accordingly, capital market and investment companies analysts are advised to

Table 4: The average of the experts' opinions of the second stage survey

Variable	Triangular fuzzy average (m, α, β)	De-fuzzified average	Variable	Triangular fuzzy average (m, α, β)	De-fuzzified average
Stock turnover	(0.100,0.238,0.425)	0.100	Return on capital	(0.538,0.750,0.825)	0.538
Turnover	(0.113,0.225,0.413)	0.113	Asset turnover	(0.475,0.688,0.800)	0.475
Financial turnover volatility	(0.125,0.225,0.400)	0.125	Value of the company	(0.263,0.413,0.588)	0.263
Trading volatility	(0.200,0.300,0.463)	0.200	Competition	(0.225,0.350,0.513)	0.225
Market returns volatility	(0.363,0.550,0.700)	0.363	Company age	(0.275,0.413,0.563)	0.275
Additional returns volatility	(0.425,0.638,0.775)	0.425	Company size	(0.450,0.638,0.725)	0.450
Stock price volatility	(0.375,0.575,0.713)	0.375	Technology	(0.250,0.388,0.538)	0.250
Forecast volatility	(0.088,0.175,0.375)	0.088	Current ratio	(0.300,0.463,0.625)	0.300
Institutional ownership	(0.200,0.636,0.538)	0.200	Quick ratio	(0.300,0.463,0.600)	0.300
Independence of the board of directors	(0.125,0.225,0.413)	0.125	Cash flows	(0.513,0.725,0.813)	0.513
Lack of concentration of ownership	(0.138,0.288,0.475)	0.138	Asset liquidity	(0.478,0.700,0.800)	0.478
Board size	(0.100,0.175,0.375)	0.100	Equity risk premium	(0.538,0.750,0.825)	0.538
Information quality	(0.125,0.288,0.500)	0.125	size	(0.550,0.763,0.813)	0.550
Accuracy of information	(0.175,0.288,0.475)	0.175	Growth opportunities	(0.463,0.763,0.663)	0.463
Profit volatility	(0.538,0.750,0.825)	0.538	Profitability	(0.488,0.700,0.813)	0.488
Sales margin	(0.175,0.288,0.475)	0.175	Profitability	(0.250,0.425,0.600)	0.250
Return on assets	(0.563,0.775,0.838)	0.563	Human Capital	(0.263,0.425,0.588)	0.263

take a broader perspective and make decisions based on the financial risk of companies instead of paying attention to companies' profitability and stock price changes. In this case, they can make multi-dimensional assessments and measure the risk management of the companies under review based on identified and refined factors in the dimensions of ambiguity, corporate governance, financial analysis, financial performance, environment, liquidity and market. In this case, more comprehensive decisions will be made based on the opinion of experts and scientific foundations. The results of this research are consistent with that of Wang et al. [20].

This paper has adopted the model of knowledge analysis and content analysis to identify the factors affecting market uncertainty and companies' equity investment using experts' opinion polling and the fuzzy Delphi method. Other researchers are suggested to use methods such as fuzzy TOPSIS or fuzzy network analysis. In addition, the information theory believes that each of the financial and accounting variables or ratios can convey specific operational information to the decision maker, and accordingly, companies may be ranked differently with different risk management. Also, the research results can be used by rating agencies that have started to operate. Future researchers are recommended to use composite criteria such as entropy to combine different and sometimes contradictory criteria to judge market uncertainty and equity investment.

Table 5: The results of counting the responses of the second stage survey.

Variable	Very high	High	Medium	Very low	low	Variable	Very high	High	Medium	Very low	low
Stock turnover	2	1	0	7	7	Return on capital	12	2	2	0	1
Turnover	2	1	1	4	9	Asset turnover	7	7	1	1	1
Financial turnover volatility	3	1	2	4	7	Value of the company	4	5	5	1	2
Trading volatility	4	1	2	3	7	Competition	3	2	4	2	6
Market returns volatility	5	4	5	2	1	Company age	4	2	4	1	6
Additional returns volatility	7	5	4	1	0	Company size	9	3	3	1	1
Stock price volatility	5	6	2	3	1	Technology	4	2	2	3	6
Forecast volatility	1	1	4	3	8	Current ratio	3	4	5	2	3
Institutional ownership	3	4	3	5	2	Quick ratio	5	2	3	4	3
Independence of the board of directors	2	1	2	5	7	Cash flows	9	7	0	1	0
Lack of concentration of ownership	2	1	4	5	5	Asset liquidity	9	4	2	1	1
Board size	1	2	3	2	9	Equity risk premium	12	3	2	0	0
Information quality	0	4	3	6	4	size	11	3	1	1	1
Accuracy of information	2	3	4	3	5	Growth opportunities	8	5	2	1	1
Profit volatility	9	6	2	0	0	Profitability	7	6	1	1	2
Sales margin	2	3	3	3	6	Profitability	4	1	7	2	3
Return on assets	10	6	1	0	0	Human Capital	3	2	5	2	5

Table 6: The mean of the experts' opinions of the survey's second stage

Variable	Triangular fuzzy average (m, α, β)	De-fuzzified average	Variable	Triangular fuzzy average (m, α, β)	De-fuzzified average
Stock turnover	(0.100,0.225,0.413)	0.100	Return on capital	(0.525,0.725,0.788)	0.525
Turnover	(0.113,0.213,0.400)	0.113	Asset turnover	(0.450,0.650,0.775)	0.450
Financial turnover volatility	(0.163,0.288,0.463)	0.163	Value of the company	(0.338,0.525,0.688)	0.388
Trading volatility	(0.200,0.325,0.488)	0.200	Competition	(0.213,0.350,0.525)	0.213
Market returns volatility	(0.350,0.550,0.700)	0.350	Company age	(0.250,0.388,0.550)	0.250
Additional returns volatility	(0.438,0.650,0.775)	0.438	Company size	(0.450,0.650,0.750)	0.450
Stock price volatility	(0.363,0.563,0.713)	0.363	Technology	(0.225,0.363,0.525)	0.255
Forecast volatility	(0.113,0.225,0.425)	0.113	Current ratio	(0.275,0.450,0.625)	0.275
Institutional ownership	(0.250,0.438,0.613)	0.250	Quick ratio	(0.275,0.450,0.600)	0.275
Independence of the board of directors	(0.125,0.250,0.438)	0.125	Cash flows	(0.513,0.725,0.825)	0.513
Lack of concentration of ownership	(0.150,0.300,0.488)	0.150	Asset liquidity	(0.463,0.663,0.763)	0.463
Board size	(0.125,0.255,0.425)	0.125	Equity risk premium	(0.550,0.763,0.825)	0.550
Information quality	(0.138,0.300,0.513)	0.138	size	(0.500,0.700,0.775)	0.500
Accuracy of information	(0.200,0.350,0.538)	0.200	Growth opportunities	(0.450,0.650,0.763)	0.450
Profit volatility	(0.513,0.725,0.825)	0.513	Profitability	(0.425,0.613,0.738)	0.425
Sales margin	(0.188,0.325,0.513)	0.188	Investment	(0.263,0.438,0.600)	0.263
Return on assets	(0.538,0.750,0.838)	0.538	Human Capital	(0.225,0.375,0.550)	0.225

Table 7: The de-fuzzified mean of survey's first and second stages

Variable	First stage de-fuzzified mean	Second stage de-fuzzified mean	First and second stages de-fuzzified mean difference	Variable	First stage de-fuzzified mean	Second stage de-fuzzified mean	First and second stages de-fuzzified mean difference
Stock turnover	0.100	0.100	0.000	Return on capital	0.538	0.525	0.016
Turnover	0.113	0.113	0.000	Asset turnover	0.457	0.450	0.022
Financial turnover volatility	0.125	0.163	0.038	Value of the company	0.263	0.388	0.072
Trading volatility	0.200	0.200	0.000	Competition	0.225	0.213	0.009
Market returns volatility	0.363	0.350	0.013	Company age	0.275	0.250	0.022
Additional returns volatility	0.425	0.438	0.009	Company size	0.450	0.450	0.003
Stock price volatility	0.375	0.363	0.009	Technology	0.250	0.255	0.022
Forecast volatility	0.088	0.113	0.025	Current ratio	0.300	0.275	0.022
Institutional ownership	0.200	0.250	0.050	Quick ratio	0.300	0.275	0.022
Independence of the board of directors	0.125	0.125	0.000	Cash flows	0.513	0.513	0.003
Lack of concentration of ownership	0.138	0.150	0.013	Asset liquidity	0.488	0.463	0.025
Board size	0.100	0.125	0.025	Equity risk premium	0.538	0.550	0.009
Information quality	0.125	0.138	0.013	size	0.550	0.500	0.044
Accuracy of information	0.175	0.200	0.025	Growth opportunities	0.463	0.450	0.009
Profit volatility	0.538	0.513	0.019	Profitability	0.488	0.425	0.059
Sales margin	0.175	0.188	0.013	Investment	0.250	0.263	0.009
Return on assets	0.563	0.538	0.019	Human Capital	0.263	0.225	0.034

References

[1] A. Amin Ashairi, *Investigate the relationship between economic policy uncertainty and the risk of falling stock prices*, New Res. Approach. Manag. Account. **4** (2021), no. 77. [In Persian]

[2] A. Anand and K. Venkataraman, *Market conditions, fragility, and the economics of market making*, J. Financ. Econ. **121** (2016), 327–349.

[3] T.G. Bali, S. Brown, and Y. Tang, *Disagreement in economic forecasts and expected stock returns*, Georgetown McDonough School of Business Research Paper **2407279** (2016).

[4] T.G. Bali, H. Zhou, *Risk, uncertainty, and expected returns*. J. Financ. Quant. Anal. **51** (2015), 707–735.

[5] N. Barberis, *X-CAPM: An extrapolative capital asset pricing model*, J. Financ. Econ. **115** (2015), no. 1, 1-24.

[6] N. Barberis and R. Thaler, *A survey of behavioral finance*, Handbook of the Economics of Finance 1, Elsevier, 2003, pp. 1053–1128.

[7] D. Bernoulli, *Hydrodynamica sive de viribus et motibus fluidorum commentarii*, Johannis Reinholdi Dulseckeri, 1738.

[8] W.M. Bolstad and J.M. Curran, *Introduction to Bayesian Statistics*, John Wiley & Sons, 2016.

[9] B. Chen, X. Liu, H. Zhao, and J.C. Príncipe, *Maximum correntropy Kalman filter*, Automatica **76** (2017), 70–77.

[10] E. Halim, Y.E. Riyanto, and N. Roy, *Costly information acquisition, social networks, and asset prices: Experimental evidence*, J. Finance **74** (2019), no. 4, 1975–2010.

[11] K. Hong, J. Miao, and N. Wang, *Risk, uncertainty, and option exercise*, J. Econ. Dyn. Control **35** (2021), 442—461.

[12] G. Jin, H. Liu, and Z. Yang, *Optimal consumption and investment strategies with liquidity risk and lifetime uncertainty for Markov regime-switching jump diffusion models*, Eur. J. Oper. Res. **280** (2020), no. 3, 1130–1143.

[13] R.H.Y. Driouchi and T.L. Trigeorgis, *Investor ambiguity, systemic banking risk and economic activity: the case of too-big-to-fail*, J. Corp. Financ. **62** (2020), 101549.

[14] D. Gilboa and I. Schmeidler, *Maxmin expected utility with non-unique prior*, J. Math. Econ. **18** (1989), no. 2, 141–153.

[15] M. Klibanoff, S. Marinacci, and P. Mukerji, *A smooth model of decision making under ambiguity*, Econometrica **73** (2005), no. 6, 1849–1892.

[16] H. Maqsood, H. Vakilifard, and T. Torabi, *Testing the variability of effective factors in forecasting stock returns using dynamic averaging models*, Financ. Engin. Secur. Manag. **11** (2020), no 45, 639–660.

[17] N. Sabouri and E. Karimpour, *Investigate the joint effects of economic policy uncertainty and company characteristics on capital structure (Case study: Companies admitted to the Tehran Stock Exchange)*, New Res. Meth. Manag. Account. **5** (2021), no. 66.

[18] Z. Shi, *Time-varying ambiguity, credit spreads, and the levered equity premium*, J. Financ. Econ. **134** (2019), no. 3, 617–646.

[19] X. Wang, H. Rong, and S. Zhao, *Optimal investment and benefit payment strategy under loss aversion for target benefit pension plans*, Appl. Math. Comput. **346** (2019), 205–218.

[20] J. Wang, M. Zhou, X. Guo, L. Qi, and X. Wang, *A Markov regime switching model for asset pricing and ambiguity measurement of stock market*, Neurocomputing **435** (2021), 283-294.

[21] R. Xiao, and S. Qiu, *Risks for the long run: A potential resolution of asset pricing puzzles*, J. Finance **59** (2021), 1481–1509.

[22] R. Zhang, *Uncertainty aversion with second-order utilities and probabilities*, Manag. Sci. **52** (2006), 136–145.