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(Research Paper)

Proposing a model for the valuation of technology-based firms for acquisition by the Department of Defense (DOD)

Akbar Rahimi*
Department of Management, Management and Industrial Engineering Faculty, Malekashtar University of Technology, Tehran, Iran, rahimi_akr@yahoo.com
Morteza Abbasi
Department of Industrial Engineering, Management and Industrial Engineering Faculty, Malekashtar University of Technology, Tehran, Iran, morabbasi@gmail.com
Mehdi Bararnia Firouzjaei
Department of Management, Management and Industrial Engineering Faculty, Malekashtar University of Technology, Tehran, Iran, mehdibararnia68@gmail.com

Abstract

Purpose: The growth and development of defence industries are essential to improve deterrence and national security. One way to develop such industries is to acquire technology-based firms that, in addition to improving the ability to manufacture new products, can help them meet their operational and strategic goals. Since the valuation of such firms is considered one of the complexities of acquisition, this paper aims to propose a model for their valuation according to the ecosystem of defence industries.

Design/methodology/approach: To create the model, first the literature in this field has been investigated. Also, the comments and proposals of senior managers, technical designers and experts, economic and financial specialists, and R&D experts in the defence industries have been surveyed and then, the valuation criteria for technology-based firms have been identified using the fuzzy screening technique. Next, by using the fuzzy Analytic Hierarchy Process (AHP), the relative importance coefficients for components, criteria, and subcriteria have been determined, and the valuation model has been developed. Finally, the function of estimating the value of technology-based firms

* Corresponding author, Orcid: 0000-0003-2846-1223

that can be acquired in the Department of Defense (DOD) has been formulated. The study was carried out at the end of 2022 in DOD strategic organizations.

Findings: Since knowledge and intellectual properties are the most significant pillars and competitive advantages of technology-based firms, the results showed that the "intangible assets" criterion is the most significant one for the valuation of firms by a weight of 0.449. Following the criterion are the tangible assets, and the major risks with a weight of 0.351, and 0.20, respectively. In this study, the strategic role and importance of technology-based firms for the defence industries, their synergy with these industries, the protection requirements, as well as the stability and durability of the technology-based firms in the condition of disruption were introduced as specific criteria in the valuation model for the firms. Also, the result of the sensitivity analysis indicated that the ranking of options is the most sensitive subject to changes in the importance and weight of intangible assets and the main risk.

Research limitations/implications: One of the limitations of the research is that this study was not conducted in a specific defence industry such as electronics and radar, energy-rich materials, chemical, air, or marine industries, and was comprehensively planned in all industries. Since tangible, and intangible assets or even risks may be different in each of such industries, this issue leads to the cautious use of the model in each of these specialized areas. Another limitation was the research statistical population, which only included university professors, senior managers and financial managers of defence industries. Although using the opinions of capital market valuation experts venture capitalists and expert valuation experts of the country's innovation and knowledge ecosystem for further validation of the model and criteria statistics and to specify the specific conditions of valuation in the defence environment, seemed useful, there were limitations in their assessment.

Originality/value: Proposing a hybrid model including tangible and intangible assets and considering risks, and also considering the key criteria of the defence sector such as strategic importance, synergy stability and durability of firms, as well as providing functions for estimating the value of technology- base firms that can be acquired in DOD are considered as the two of the most important aspects of contributions and innovations of this research. The current model provides a systematic and scientific plan for defence industry managers and experts who can use it in the valuation of companies that can be acquired in the defence industry and be sure that their interests are taken into account.

Keywords: Acquisition, Valuation, Technology-based firms, Defence industries, Fuzzy screening method, Fuzzy Analytic Hierarchy Process (FAHP)

1. Introduction

A business has two main options for its growth and development, first, is the organic growth based on an increase in its production, sales, and the development of its products and second, is the inorganic growth based on its cooperation. The acquisition of technology-based firms is considered a form of industrial and technological cooperation. Its purpose is to reach new knowledge, capacities, and resources to manufacture various products and improve the supply chain performance to enhance defence deterrence capacities (Rahimi et al., 2021). The acquisition can be done in different ways, but the central issue of this research is the complete acquisition of technology companies in the defence industry. The growth and development of defence industries in an inorganic way can help to improve defence deterrence by using the knowledge capacities of the country that have been formed in the form of technology companies. Therefore, the acquisition of some technology companies that can produce and

have innovation in defence products seems necessary. Successful implementation and application of the process of the acquisition include various challenges and complexities such as cultural, organizational, and technological differences between the parties, the evaluation, and valuation of the target firms, as well as the firms' synergy and their alignment with the defence industries' goals. A successful acquisition is one in which the price that the acquirer pays to the target firm is a real one and is commensurate with its efficiency and tangible and intangible assets. Valuation is one of the most important factors of success and maintaining the success of mergers and acquisitions (Aydin, 2017). Therefore, Overvaluation has been reported as one of the main reasons for the failure of mergers and acquisitions, and determining appropriate valuation criteria is considered a key factor in this process (Moskovich, 2018).

To date, many methods have been proposed for the valuation of technology-based firms. However, they all have constraints that limit their use to some specific cases (Shafia et al., 2012). The balanced scorecard method, risk factor aggregation method, re-establishment cost valuation, venture capital method, discounted cash flow method and First Chicago method are among the common methods of valuing companies in the acquisition process (Payne, 2011; Rahardjo & Sugiarto, 2019). Four popular and common valuation methods for technology start-ups are the discounted cash flow method, income multiple method, net asset method and venture capital method. However, in the context of such companies, each of these methods has shortcomings. First, estimating future cash flows is complex and imprecise, especially given the difficulty of determining an appropriate discount rate. Second, the lack of revenue (actual and reported) for most startups makes it impossible to estimate revenue multiples. The net asset method ignores growth opportunities and focuses on tangible assets, which, as noted above, do not represent the majority of startups. Finally, the difficulty in justifying the venture capital method due to its subjective nature prevents the reliability of this method for companies (Hidayat et al., 2022). According to Aydin (2017), the three main valuation methods in mergers and acquisitions are balance sheet methods, income statement and market coefficients method and cash flow method (DCF). Organizations should use different methods to decide on the valuation of firms according to their conditions, country conditions and market conditions (Aydin, 2017). According to the review of the studies and for the reasons mentioned above, there is no efficient and local method for valuing technology-based firms that is suitable and compatible with the specific conditions of the defence industry, and the existing studies are scattered and do not provide a valuation model. From another point of view, the type of organization and business, culture, market size and opportunity and the importance of each of these factors in the defence industry are different

from the space of commercial and non-defence industries. Thus, it seems necessary to acquire some technology-based firms that have suitable capabilities to produce defence products and provide innovative ones. Therefore, the purpose of this paper is to propose a tailored Model based on the ecosystem of defence industries for the valuation of technology-based firms the Department of Defense can acquire. As well, determining the specific criteria for these industries and the weighted importance of these criteria on the one hand, and focusing on various components for the valuation of the firms, on the other hand, it tries to propose a tailored and applicable model in the form of value estimation functions based on the relative importance coefficient of components, criteria, and subcriteria.

2. Theoretical fundamentals and research background

2.1 Definitions of concepts

Acquisition is defined as owning the property of a firm by another one in which the acquiring firm is larger than the acquired one (Khodamipour et al., 2019). In another definition, the acquisition is defined as one of the methods for industrial and innovative collaboration that is usually realized based on financial, operational, diversification, and strategic restructuring motives through purchasing a per cent of the target firm's assets and securities to gain the control over the acquired firm (DemPamphilis, 2017).

Valuation is the quantitative estimation of the economic value of tangible and intangible assets that is performed based on one of the valid scientific and applicable methods for valuation. In financial fields, valuation is considered the process of determining the present value of an asset or a business (Damodaran, 2009). Figure 1 shows the changes in the value of tangible and intangible assets of the firms over time. As can be seen, the value of firm assets is more determined based on intangible assets compared to tangible ones. Furthermore, intangible assets are considered the main advantage for the survival, profitability, and development of firms. These two caused the valuation process of the firms to become more intricate.

Fig. 1. Changes in the value of tangible and intangible assets of firms over time (Miciula et al., 2020)

Akbarzadeh and Shafizadeh (2017) argue that technology-based firms have many intangible assets, and rely on innovation as their main source of competitive advantage. The law of technology-based firm's support (2013) defines the technology-based firm as one in which knowledge and innovation are inseparable components of its essential assets. These firms are established to make synergy between science and wealth, develop the knowledge-based economy, realize the scientific and economic goals, and commercialize the R&D outcomes in the field of high-tech with abundant added value (Haji Gholam, 2020).

2.2 Literature review

Daniel Linders (2023) in a study, introduced a 3-step hedging-based valuation to evaluate hybrid claims, which is a hedging portfolio for traded risks, diversifiable risks, and non-tradable systematic risks. Hidayat et al. (2022) investigated whether the types of recent technologies adopted by startups can act as key factors to be used in the valuation of startups. Using a sample of 4,903 startups in 13 regions during 2008-2018, they found that financial information (revenues) and non-financial information (social media), as well as sector and technology differences, affect startup stock valuations. In this research, the average value of the variables is used for cross-sectional estimates. Dehghani eshrat Abad et al. (2020), taking into account the uncertainties in the first round of financing as well as the flexibility available for venture capitalists in the stages before (abandonment option) and after (development option) the commercialization of the product, the approach presented a new method for determining the value of start-up businesses. Due to the lack of an analytical solution for the developed approach, the numerical method of Monte Carlo least squares simulation (Longstaff-Schwarter) was used to solve it. Comparing the results of the model with the results of the other three scenarios confirms the role and importance of the mentioned flexibilities in making venture investment decisions in start-up businesses.

Silvia Lama (2019) presented an overview of the valuation of startups in Switzerland. The first part focuses on the analysis of financing rounds closed in Switzerland between 2010 and 2019. The existence of patterns and trends is investigated, visualized and expressed. The second part chooses the fair market value valuation method as the best model to estimate the pre-investment valuation range for a target startup. It can be used by investors and founders as a starting point in the investment negotiation process. Ghanbari et al. (2019) designed a valuation model for a start-up oil company considering the goal of developing downstream operations in Iran's oil industry. The research was conducted to investigate the effective factors and identify the drivers of the valuation of oil startups in Iran. Empirical findings showed that respectively, the business team, opportunity size, marketing, sales and partner

channels, competitive environment, product strength and intellectual features, idea implementation time, investment rounds, as well as rules and regulations have the greatest effect in the valuation in Iranian oil startups. Ahangari (2017) in a study on "valuation of technology-based start-up companies in Iran" addressed the literature and research gap between two financial approaches and entrepreneurial management approaches in the valuation of newly established companies. It suggests the use of a strategic management approach as a solution to cover the gap between these two approaches.

Chatsios, et al. (2016) presented a valuation model for Internet of Things start-up companies. The final valuation model was obtained based on multivariable regression, which includes 6 factors, 1 quantitative (employees) and 5 qualitative (development, cooperation, branding, acquisition, suppliers). The philosophy in the presented model is to fill the gap between pre-investment value valuation with qualitative models and post-investment valuation with quantitative models. In their study regarding the valuation of technology-based firms (TBF), Milanesi et al. (2013) explain various challenges including the lack of similar firms for benchmarking, lack of historical data, complexities in the estimation of inconsistencies and uncertainties, and the number of intangible assets considered in a firm's valuation. Generally, they argue that the factors influencing the valuation of technology-based firms are dependent on four parameters including the cash flow of the existing assets, the expected growth in cash flow, periods that the firm can experience high growth rates, and the investment amount. Determining factors for the valuation of a technology-based firm include physical, financial, and human assets, whereas the competitive advantage of a knowledge-based company is its intangible assets. Therefore, a firm's intangible and innovative assets and their valuation are considered necessary for merger and acquisition. The biggest challenge facing the valuation of technology-based firms is identifying the main factors influencing their values that are considered a significant part of the process, especially for new technologies. Thus, the quantitative and qualitative factors have a great influence on the firms' valuation and are employed by the investors.

By examining different valuation models and methods in previous research as well as previous studies regarding the influencing factors and valuation criteria of technology companies, were gathered the valuation criteria of these companies. The results of these investigations were presented in the form of Table 1 as a summary of the background of the research.

Table 1. Criteria for the valuation of technology-based firms based on literature review

No.	Valuation criteria of technology-based firms	Author(s)
1	Human capital	Miciuła et al., 2020; Damodaran, 2011; Hidayat et al., 2022
2	Tangible asset	Taherkhani, 2017; Miciuła et al., 2020
3	Market multiples and revenue multiples	Tabatabaiyan & Gharibi, 2014
4	Opportunity size	Payne, 2011; Ahangari, 2017; Silvia Lama, 2019; Ghanbari et al., 2019; Hidayat et al. 2022
5	Sales and marketing channels	Ghanbari et al., 2019; Hidayat et al. 2022
6	Collaboration and partner channels	Ghanbari et al., 2019; Hidayat et al. 2022
7	Clarity of idea	Akrofi 2016; Ghanbari et al. 2019; Hidayat et al. 2022
8	Competition atmosphere and the degree of competitiveness in the environment	Payne, 2011; Ahangari, 2017; Silvia Lama, 2019; Ghanbari et al. 2019; Hidayat et al. 2022
9	Laws and regulations	Ghanbari et al. 2019; Hidayat et al. 2022
10	The business team and the ability of the management team	Payne, 2011; Ahangari, 2017; Silvia Lama, 2019; Ghanbari et al. 2019; Hidayat et al. 2022
11	Terminal value and investment value	Montani et al. 2020; Tabatabaeian & Gharibi, 2014
12	Current conditions and future changes specific to the industry	Miciuła et al. 2020
13	Income-generating abilities	Miciuła et al. 2020
14	Key performance indicators	Miciuła et al. 2020
15	Market margin	Miciuła et al. 2020; Damodaran, 2011; Hidayat et al. 2022
16	Market growth potential and profitability	Miciuła et al. 2020; Damodaran 2011; Hidayat et al., 2022
17	Future investment needs and investment period	Ghanbari et al. 2019; Miciuła et al. 2020; Damodaran, 2011; Hidayat et al. 2022
18	The opportunity cost of investment	Montani et al. 2020
19	The quality of covering the company's risks (economic, income generation, scalability, synergy)	Wildt, 2019; Damodaran, 2011; Rahardjo & Sugiarto, 2019; Daniël Linders, 2023; Hidayat et al. 2022
20	Financial, human, structural and cultural synergy	Damodaran, 2011; Miloud et al. 2012
21	Costs of reproducing or replacing existing assets	Batista & Perez, 2018
22	Ambitions and motives of entrepreneurs	Wildt, 2019
23	Business model scalability	Linders, 2023; Hidayat et al. 2022
24	The type of innovation and technical complexity	Taherkhani, 2017
25	Adjusted ratios	Bousquet, et al. 2017; Damodaran, 2011; Hidayat et al. 2022
26	Intangible assets (technological superiority, brand)	Damodaran, 2011; Hidayat et al. 2022
27	Intellectual property (patent, copyright, license)	Damodaran, 2011; Hidayat et al. 2022
28	Future cash flow and existing cash flow	Bousquet al. 2017; Damodaran, 2011; Hidayat et al. 2022
29	Type of product and technology	Payne, 2011; Ahangari, 2017; Silvia Lama, 2019; Hidayat et al. 2022
30	The average value of a similar company	Payne, 2011; Ahangari, 2017; Silvia Lama, 2019; Hidayat et al. 2022
31	Customer feedback	Payne, 2011; Ahangari, 2017; Silvia Lama, 2019; Hidayat et al. 2022
32	The probability of each scenario	Milanesi, et al. 2013
33	Discount rate and investor's expected return (ROI)	Milanesi, et al. 2013; Bousquet et al. 2017; Tabatabaeian & Gharibi, 2014
34	Real powers of managers	Akrofi, 2016
35	The speed of product and technology growth	Akrofi, 2016
36	The completeness of the team	Akrofi, 2016
37	Product prototype	Akrofi, 2016
38	Average experience and average education of employees	Chatsios et al. 2016
39	Development and the possibility of training learning and cooperation	Chatsios et al. 2016
40	Coefficients of operating ratios	Bousquet et al. 2017; Damodaran, 2011; Hidayat et al. 2022

3. Research Methodology

This research is descriptive-analytical and applied. Two questionnaires were prepared and analyzed based on fuzzy screening and fuzzy AHP techniques to explore a Model for identifying the factors influencing the valuation of technology-based firms that can be acquired by the Department of Defense. The methodology was chosen to fully investigate the concepts, factors, and components of the valuation methods to identify the main criteria that determine the value of the valuation methods of technology-based firms based on the conditions in defence industries. The goal was to consider the explored factors as a guide to better perform the valuation for technology-based firms that can be acquired by defence industries.

The screening method is the same as the Delphi technique, with the difference that it is done in only one round, and its main purpose is to screen the criteria or indicators of experts in a specialized field.

Considering that the screening method is a method for making decisions and reaching consensus on issues that specifically specify its goals and axes, and since expert evaluations are based on the competence of people and are subjective, it is better to use definite numbers instead of definite numbers (Izadikhah, M., et al., 2020). In this research, according to the necessity of identifying appropriate criteria for the valuation of technology-based firms, the opinions of defence industry experts were collected and analyzed using the fuzzy screening method.

The fuzzy hierarchy analysis process is one of the multi-criteria decision-making methods based on pairwise comparisons. Fuzzy theory is used to deal with most real phenomena in which there is uncertainty, and many sets, numbers and events in the real world can be justified by fuzzy logic. The uncertainty in the preference judgments increases the uncertainty of prioritizing alternatives and, in the same proportion, makes it difficult to determine the agreement of priorities. Fuzzy AHP was developed to avoid these bugs for solving fuzzy hierarchical problems (Rahimi, & Brarania. 2021).

In this research, the Fuzzy Analytical Hierarchy Process method (FAHP), was chosen due to its advantages such as determining the priority of elements, comparing each criterion based on its upstream unmediated criterion, and considering the uncertainties in individual judgments.

Figure 2 shows the phases of research implementation. The study was carried out at the end of 2022 in DOD strategic organizations. Since the fuzzy AHP technique was employed to build and analyze the questionnaire, the inconsistency rate method was used to determine the questionnaire's reliability. According to the results of the analysis that was performed in

Excel ®, the inconsistency rate based on the two indexes of CRg and CRM were both less than 0.1 in all tables regarding the analysis and determination of the components and criteria that indicate that the fuzzy matrix has an appropriate consistency. To determine the validity, we employed the comments of 3 university professionals.

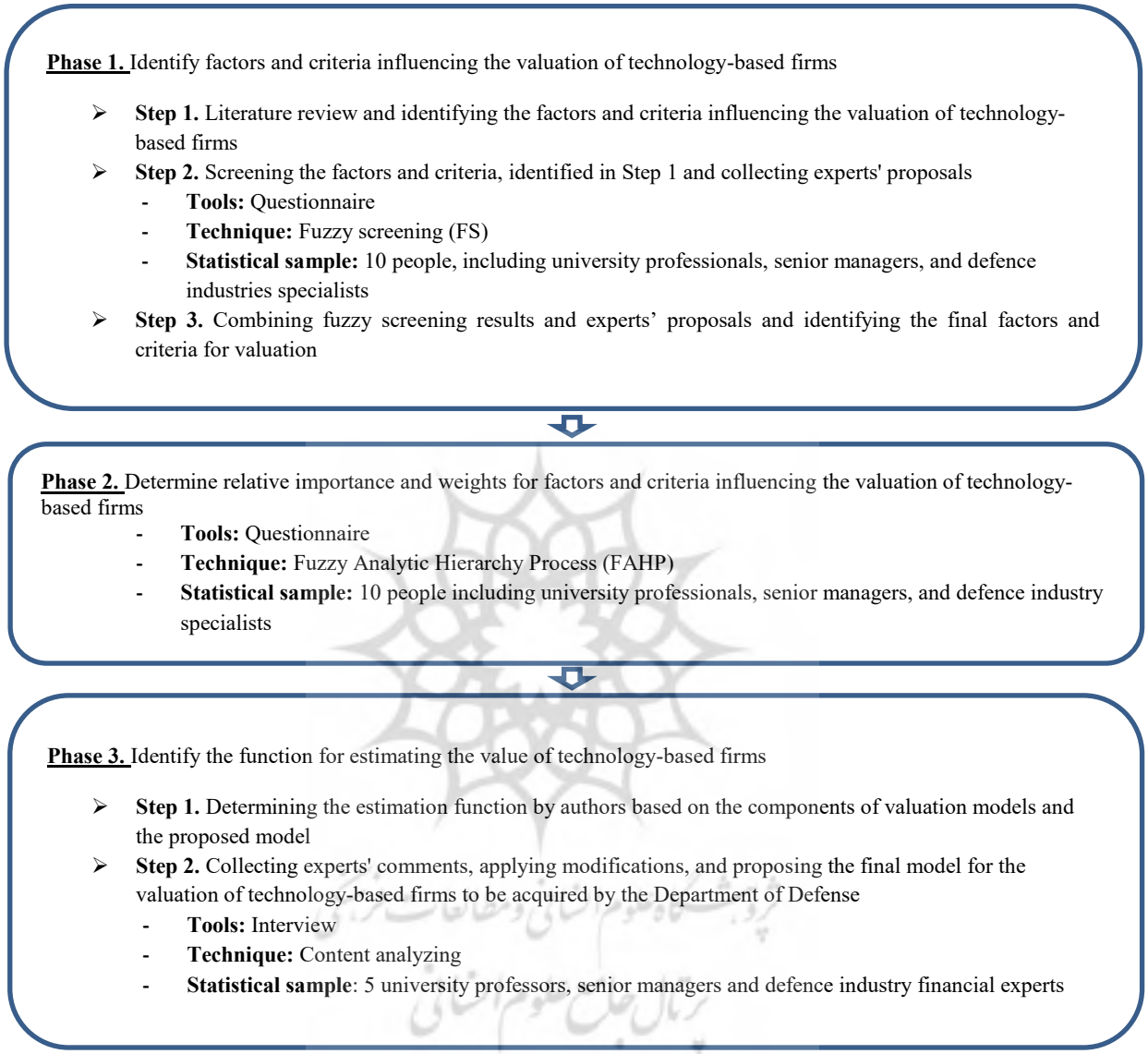

Fig. 2. Phases of research, data collection tools and data analysis method

4. Findings

4.1 Demographic characteristics

The demographic characteristics of the respondents in the three stages of data collection through the fuzzy screening questionnaire, the pairwise comparison questionnaire, and the determination of the value estimation function are summarized in Table 2.

Table 2. Statistical demographics characteristics

Demographic characteristic		Number of individuals in each phase of the research	
		Fuzzy screening phase and FAHP process phase	Determination of the value estimation function
Age	Between 30 to 40 years old	4	2
	Older than 40	6	3
Education	Master	5	1
	PhD	5	4
Work experience	15-20 years	3	1
	20-25 years	6	3
	25 years and more	1	1
Job type	University professionals and industrial researchers	3	2
	Senior managers	2	-
	Financial managers and specialists	3	3
	Industry defence R&D managers and specialists	2	-

4.2 Screening criteria for the valuation of technology-based firms and collecting experts' proposals

As the purpose of the first phase was to screen the factors and criteria based on the environment and ecosystem dominating defence industries, the fuzzy screening technique was used. To perform the fuzzy screening calculations, Excel was used. In this regard, all the factors, criteria, and components influencing the valuation of technology-based firms were identified. They were stated in the questionnaire and inquired from interested respondents. As well, new factors and criteria proposed by experts based on specific characteristics of defence industries were also received. After distributing the fuzzy screening questionnaire among respondents and collecting their responses, the collected data were entered into Excel ®. Once the fuzzy value of each criterion was obtained, the final defuzzified one of each was calculated based on the fuzzy screening algorithm. According to the deffuzified value of each criterion in Appendix 1, and the threshold considered in this research (0.7), those valuation criteria for technology-based firms with a deffuzified value less than 0.7 are known as ones that have no high significance for the valuation of technology-based firms in defence industries. These criteria were removed from the whole.

The excluded criteria include Ambitions and motives of entrepreneurs, Business plan scalability, Market profit margin, Sales and marketing channels, Competition atmosphere, Product prototype, Dominating Laws and regulations, Cost of investment opportunity, Adjusting factors, Key performance indicator, Operational coefficients and ratios, Ultimate (terminal) value & Enterprise Value (EV), Coefficients of operating ratios, Discount rate and investor's expected return (ROI), Existing assets cash flow, Real manager's authorities, Customer feedback, the probability of each scenario. According to the criteria extracted from the research background (Table 1) as well as the criteria extracted from fuzzy screening

(Appendix 1) and the suggestions of experts in the phase of fuzzy screening (Table 3), the following items can be proposed, and the knowledge-based value criteria were formed based on their summation.

In the fuzzy screening questionnaire, the experts were asked to propose new criteria that haven't been stated in previous studies. They were also asked to state their criteria based on the prevailing literature in defence industries. Table 3 summarizes the criteria that should be added to the initial ones identified in the fuzzy screening phase, according to the experts' comments.

Table 3. Factors and criteria proposed by experts in the fuzzy screening phase for the valuation of technology-based firms

component	criterion
tangible assets	initial inventory, current costs (wages and other costs)
technology	Technology Readiness Level (TRL), capability to develop technology, novelty and authenticity of the idea, technical feasibility
human capital	commitment and adoption by employees, cultural and legal requirements, information protection and security requirements
market	firm size of the market in the defence sector, strategic importance, business sustainability, strategic relationships
synergy	operational
main risk	implementation and operational risk, technology risk

4.3 Aggregating results and determining final criteria for valuation of firms

The criteria explored from previous studies (Table 1) and the ones obtained from fuzzy screening (Appendix 1), as well as those proposed by experts (Table 3), were combined based on common literature in defence industries and summarized as holistic categories in Table 4. The criteria in Table 4 are basic ones for pairwise comparisons and fuzzy analytical hierarchy processes. Some implications were considered in combining the criteria obtained from fuzzy screening and those proposed by experts based on which the criteria for the valuation of technology-based firms were summarized.

Some factors and criteria explored from the literature review focus on the market and meeting its needs. For defence industries whose main purpose is providing defence deterrence, those criteria aren't so applicable. Some of these criteria include logos, brand, and goodwill, motives and ambitions of entrepreneurs, market's profit margin, competition atmosphere, rules and regulations, cost of investment opportunity, real managers' authorities, and expected return on investment (ROI), business plan scalability, and value of similar firms. Some factors and criteria like the main team's capabilities, the average levels of employees' education and experiences, and technical complexities with TRL have some overlaps. Therefore, the main team's capabilities and the technical complexities were eliminated.

Some other criteria proposed by experts are only considered based on their necessities and importance in the ecosystem of defence industries. Some such criteria are the strategic importance of firms for the Department of Defense, legal and cultural requirements, information protection and security requirements, financial, operational, and structural synergy, and the employees' commitment and acceptance. In the process of firms' acquisitions by the Department of Defense, those are considered the first candidates that develop components, subsystems, or systems employed in strategic defence products with high priorities. Thus, the criterion "strategic importance and role of firms in developing products that have priorities from the Department of Defense point of view" has been well considered by research experts. Cultural similarities between the firm acquired and the Department of Defense (e.g., surveying cultural beliefs) is another criterion considered. Experts proposed another criterion. It is the firms' legal documents including certificates of incorporation, board members, insurance records, taxes, etc. that all must be unambiguous. The criterion focuses on the legal and cultural adaptability of the Department of Defense.

Sticking to information protection and security requirements is so important in the Department of Defense that all firms must be granted the certificate of the Department of Defense Supplier Management Organization (SAMTA) before they can collaborate with the defence sector. The certificate is issued in cases where the firms meet all information protection and security instructions and directives, and after investigating the lack of criminal records. It is worth mentioning that if an acquirable firm had fundamental problems regarding information protection and security requirements, it would be removed from the list of candidates before the firms are considered as candidates to be acquired by the Department of Defense. These firms aren't listed as ones that can be evaluated based on the proposed model. However, since the firms passed into the valuation phase and are listed as qualified ones have no equal levels of security in meeting information protection requirements, the security assessment is considered another criterion for the valuation of candidates. Those firms will receive more value in the acquisition process that can meet the information protection requirements more. Therefore, the criterion is appropriately considered by the experts and entered into the final model. The criterion of "operational and structural synergy" is also among the most important ones. If there isn't enough synergy between the acquirable firms and the Department of Defense, the acquisition process faces dramatic difficulties. Since some employees working in the private sector do not tend to work in the defense one and prefer the convenience of working in the private sector to the limitations of the defense one, another criterion proposed by the experts: "commitment and acceptance by acquirable technology-based firms' employees".

Table 4. The final consolidated criteria for the valuation of technology-based firms

Main component	Factor/Criterion	Subcriteria
Intangible assets	Product, technology, and intellectual property	Technology Readiness Level (TRL) of the firm, potential for technology growth and development, innovation (in processes, design, products), intellectual property (rights, permissions, patents, copyrights, licenses)
	Idea and business plan	Idea and business plan novelty and authenticity, technical feasibility, need for investment periods, idea clarity
	Management and main team	Feasibility for training and learning of employees, commitment and adoption by employees, average level of employee education, average level of employee experiences, degree of team perfectness
	Size of market and opportunity	Size of market, potential for market growth and profitability
	Organization capital	Partnership and strategic relationships, business sustainability, legal and cultural requirements, information protection and security requirements, strategic importance
	Synergy	Operational, financial, and human-structural (culture) synergy
Tangible assets		Buildings, land, administrative and workshop equipment, current costs (wages and other costs), initial inventory
Firm major risks		Team and implementation risks, income generation risks, synergy risks, scalability risks, basic risk

4.4 Calculating relative importance coefficients and weights of criteria for valuation of the firms

Once the comments of experts were summarized by the fuzzy screening technique and the criteria were combined with proposals received from experts, the fuzzy analytical hierarchy process (FAHP) was employed to calculate the relative importance of factors, main criteria, and subcriteria for the valuation of technology-based firms. Then, distributing the second questionnaire among experts, summarizing results, and performing analysis using Excel 2016, the relative importance of factors, main criteria, and subcriteria for the valuation of technology-based firms were calculated which are summarized in Tables 5, and 6. As can be seen from the tables, since there isn't a third criterion to be compared by the two first components in a pairwise comparison of factors and criteria, there exists no inconsistency rate. For instance, the criterion "size of market and opportunity" includes only two subcriteria and thus, the inconsistency rate has no meaning for the criterion in Table 6.

According to the results of fuzzy hierarchical analysis in Table 5 and Figure 3, in the acquisition process Valuation of Technology-based Firms in the defense industry, the relative importance coefficient of intangible assets is 0.449, tangible assets is 0.351, and main risks is 0.20.

Table 5. Relative importance coefficients of the main components and factors for valuation of firms

Main component	tangible assets	intangible assets	main risks
Relative importance coefficient	0.35	0.449	0.20
Inconsistency rate	CRg = 0.094, CRm = 0.055		

Table 6. Criteria and subcriteria weights for influencing factors in the model for valuation of technology-based firms

Component/criterion	Rank	Criteria/subcriteria	Relative weight	Inconsistency rate CRg	CRM
Intangible assets	1	Management and the main team	0.251	0.77	0.038
	2	Product, technology, and intellectual properties	0.202		
	3	Organizational capitals	0.188		
	4	Idea and business plan	0.162		
	5	Synergy	0.126		
	6	Size of the market and opportunity	0.071		
Management and main team	1	The average level of employees' experiences	0.329	0.072	0.04
	2	Degree of team perfectness	0.273		
	3	Average level of employees' education	0.213		
	4	Commitment and acceptance by employees	0.136		
	5	Feasibility for training and learning	0.05		
Product, technology, and intellectual properties	1	Technology readiness level	0.374	0.065	0.029
	2	Capability of development and technology growth rate	0.325		
	3	Intellectual properties	0.170		
	4	Innovation (in processes and products)	0.130		
Idea and business plan	1	Technical feasibility	0.382	0.003	0.001
	2	Need for investment periods	0.364		
	3	Idea clarity	0.151		
	4	Novelty and authenticity	0.103		
Size of market and opportunity	1	Size of business market	0.620	-	-
	2	Potential for market growth and profitability	0.380		
Organizational capital	1	Strategic importance	0.277	0.032	0.019
	2	Firm sustainability and endurance	0.235		
	3	Partnership and strategic relationships	0.167		
	4	Size of the firm	0.152		
	5	Information protection and security requirements	0.118		
	6	Legal and cultural requirements	0.043		
Synergy	1	Operational synergy	0.480	0.014	0.003
	2	Human-structural synergy	0.406		
	3	Financial synergy	0.114		
Tangible assets	1	Land	0.272	0.024	0.011
	2	Buildings	0.205		
	3	Administrative and workshop equipment	0.186		
	4	Initial inventory	0.171		
	5	Current costs	0.168		
Major risks	1	Team and implementation risk	0.223	0.039	0.019
	2	Technology risk	0.199		
	3	Income generation risk	0.186		
	4	Synergy risk	0.179		
	5	Scalability risk	0.129		
	6	Basic risk	0.083		

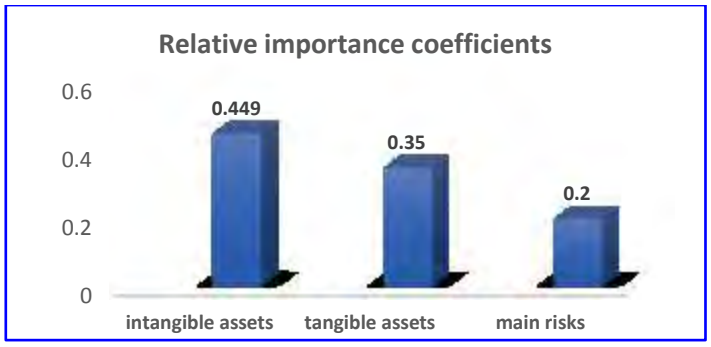

Fig. 3. Relative importance coefficients of the main components of valuation

As can be seen in Tables 5 and 6, inconsistency rates (CRg, and CRm) are both less than 0.1 which means that the components, criteria, and subcriteria have acceptable inconsistency rates. Figure 4 shows the final hierarchical Model for the valuation of firms. Relative importance coefficients for all the components, criteria and subcriteria are shown in the model. In the final hierarchy Model, the "intangible assets" component has the highest importance, whereas the lowest importance coefficient is assigned to the "major risks" one.

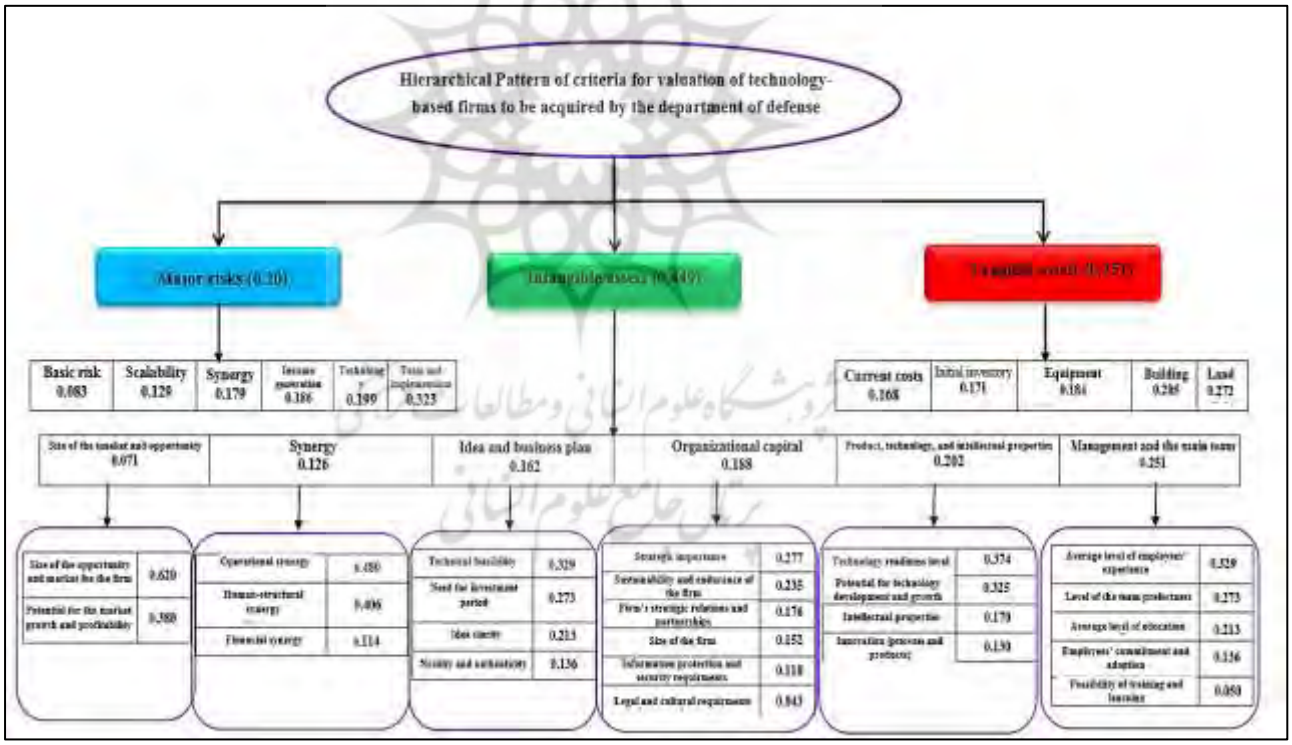

Fig. 4. Hierarchical Model for the valuation of technology-based firms acquired by the department of defence

4.5 etermining the function for estimating the value of technology-based firms

To obtain a function to estimate the value of technology-based firms, the hierarchical valuation Model shown in Figure 4 was designed based on criteria according to the kind of activities and ecosystem of defence industries. In cases where there are similar evaluated

firms in the market with those that can be acquired by the defence sector, all determined criteria and subcriteria in Figure 4 are compared to those of similar ones. Furthermore, their separate weights are calculated by the balanced scorecard technique and firms that can be acquired by the defence sector are priced. In the following, we explain how to calculate the value estimation function of a firm using the method proposed by the authors. The method was developed by interviewing five experts and modified, verified, and finalized in a joint meeting.

1. One can use two methods to calculate the value of a firm's tangible assets. First, the tangible assets of the target firm are assigned a value based on their objective, which will be considered a part of the firm's final value. In this case, the weight of intangible assets in the hierarchical Model of Figure 4 (0.351) has no share in its final price calculation. Therefore, the weights of the two components of intangible assets, and major risks in the model become 0.692 and 0.308, respectively. Then, intangible assets and risks are calculated based on these weights.

In the second method, tangible assets are compared with similar firms based on the criteria shown in Figure 4, just as intangible ones and the risk do. As it seems that no exactly similar firm exists to be compared by those that can be acquired by the defence sector, the experts decided to use the values of those that have up to a 60% difference with the target one, in cases where no previously evaluated one exists. In other words, the similar firms are considered those with at least a 40% similarity with the target firm based on our assumed criteria. Thereby, the target firm is compared with its similar one based on the criteria provided in Figure 4 and is rated based on a maximum difference of plus and minus 60%.

In the second method, a point between -60% and +60% is assigned to the candidate firm, based on the fact that its assets have a very high or very low difference with its similar firm, according to Table 7. Great situation (+++) means that the acquirable firm condition in terms of the considered asset has a significant positive difference with its similar firm and is assigned a +60 point. On the other hand, a very very weak situation (---) shows that the acquirable firm condition in terms of the considered asset has a significant negative difference with its similar firm and is assigned a -60 point. Once the rate of each tangible asset is calculated based on the point obtained from Appendix 1 multiplied by its weighted importance (Pi), the rates of all the assets are summed ($\sum Pi$), and the result is used in calculating the final value function of tangible assets. Equation 6 is the ultimate value function of tangible assets in which the sum of all tangible assets equals 1. So, the value of a candidate firm's assets can be higher or lower than its similar one, depending on the fact that the total rate of its assets ($\sum Pi$) is positive or negative. VTS is the value of similar firm

tangible assets, whereas VTA indicates the value of tangible assets of the firm that can be acquired by the defence sector.

$$V_{TA} = (1 + \sum P_i) * V_{TS} \quad (1)$$

Table 7. Rating criteria about similar firms to obtain their ultimate value

No.	Acquirable firm situation compared to a similar one	Rate
1	Great (+++)	+60%
2	Very good (++)	+40%
3	Good (+)	+20%
4	Neutral	0
5	Weak (-)	-20%
6	Very weak (--)	-40%
7	Very very weak (---)	-60%

2. To calculate the value of intangible assets all the rates assigned to each intangible asset are summed. To obtain the rate of each criterion (Si), one must calculate the summation of all the rates received by each of its subcriteria (Sj) and multiply the result by its coefficient of importance (WI) (Equation 2).

$$S_i = (\sum (S_j)) * W \quad (2)$$

3. The ultimate value function of intangible assets (VIA) is obtained by equation 8. In this relation, the rates of all the intangible assets criteria are summed (∑Si). After adding a 1 to the result, it is multiplied by the value of intangible assets of a similar firm. Adding 1 to the summation of all rates of intangible assets means that the value of the candidate firm's assets can be estimated higher or lower than the similar firm, depending on the fact that the total rate of its assets (∑Si) is positive or negative. VIS is the value of a similar firm's intangible assets, whereas VIA indicates the value of intangible assets of the firm that can be acquired by the defence sector.

$$V_{IA} = (1 + \sum Si) * V_{IS} \quad (3)$$

4. To calculate the value of hedging the firms' major risks, a point between -60% and +60% is assigned, depending on the negative or positive impacts of the risk on the future firm's performance, according to Appendix 1. Once the rate of each risk criterion is calculated based on the point obtained from Appendix 1 multiplied by its weighted importance (R_i), the rates of all the risks are summed ($\sum R_i$), and the result is used in calculating the ultimate value function of risk hedging. Equation 4 is the ultimate value function of risk hedging. The sum of all risks equals 1. So, the value of a candidate firm's risk hedging can be higher or lower than its similar one, depending on the fact that the total rate of

its assets ($\sum S_i$) is positive or negative. V_{RS} is the value of a similar firm's risk hedging, whereas V_R indicates the value of risk hedging of the firm that can be acquired by the defence sector.

$$V_R = (1 + \sum Ri) * V_{RS} \quad (4)$$

To calculate the ultimate value of a technology-based firm, once the values of tangible and intangible assets, and the major risks are obtained:

a. If one uses the objective updated value of tangible assets to determine their value, equation 5 will be the function to obtain the ultimate value of the firm acquired by the defence sector. In this equation, one should notice that the weights for intangible assets (W_{IA}) and the risks (W_R) are 0.692 and 0.308, respectively. The weights have been obtained without considering the weights of tangible assets in Figure 4. In other words, the importance coefficient of 1 is only shared between the two criteria of intangible assets and the risks. These two importance coefficients are summed to 1.

$$V = V_{TA} + (V_{IA} * W_{IA}) + (V_R * W_R) \quad (5)$$

Where,

V: ultimate value of the technology-based firm

V_{TA}: objective value of the target firm's tangible assets

V_{IA}: the ultimate value of intangible assets

W'_{IA}: weight of intangible assets

V_R: the ultimate value of the major risk hedging

W'_R: weight of major risks

b. If one doesn't use the objective updated value of tangible assets to determine their value, and the values are obtained based on their comparisons with the ones of its similar firm -like the intangible assets and the risks- their weighted sum will be calculated and considered as the ultimate value of the technology-based firm. In this approach, the ultimate function to estimate the value of a technology-based firm acquired by the defence sector is as equation 6.

$$V = (V_{TA} * W_{TA}) + (V_{IA} * W_{IA}) + (V_R * W_R) \quad (6)$$

Where,

V: ultimate value of the technology-based firm

V_{TA}: the ultimate value of tangible assets

W'_{TA}: weight of tangible assets based on the hierarchical model for valuation

V_R: the ultimate value of the major risk hedging

W'_R: weight of major risks based on the hierarchical model for valuation

If only the firm's ultimate value is known and is not available as its three components of tangible assets, intangible assets, and the risks, one can use equation 7 to obtain the value of

the firm that can be acquired by the defence sector, where VS is the firm's total value. The tangible assets, intangible assets, and major risks are factors influencing the value of a technology-based firm (Figure 4), whose weights are 0.351, 0.449, and 0.20, respectively.

$$V = \{1 + (\sum P_i) * W_{TA} + \left(\sum S_i\right) + W_{IA} + (\sum R_i) * W_R\} * VS \quad (7)$$

4.6 Sensitivity analysis

Sensitivity analysis is a procedure that is generally implemented after obtaining the optimal answer, and its purpose is to examine the possible changes of parameters on the optimal answer. Therefore, the purpose of sensitivity analysis is to identify completely sensitive parameters so that their estimation can be done more accurately and the new optimal solution can be calculated based on this (Ahmadi, et al, 2007). The set of sensitivity analysis is performed in hierarchical analysis to investigate the effect of changes in weights (preference) on the ranking of options (Abbasian & Vahidkiani, 2022). In fact, by using sensitivity analysis, it is possible to quickly determine how a change in the importance of a criterion will affect the selected options. The final priorities of the options strongly depend on the weights attached to the main criteria. Therefore, small changes in relative weights can cause major changes in the final ranking. Since these weights are usually based on highly subjective judgments, the stability of the rankings under different criteria weights should be tested. For this purpose, sensitivity analysis can be performed based on scenarios that reflect alternative future developments or different views on the relative importance of the criteria. By increasing or decreasing the weight of individual criteria, changes due to priorities and ranking of alternatives can be seen. Therefore, sensitivity analysis provides information about the stability of the ratings. If the ranking is very sensitive to small changes in the weights of the criteria, careful consideration of the weights is recommended (Chang, Che-Wei, et al. 2007). Therefore, to evaluate how realistic the final results obtained in this section are, a sensitivity analysis was performed using the Express Choice software. The performance chart (Figures 5 to 8) shows how the alternatives work after changing the importance and weight of the main criteria.

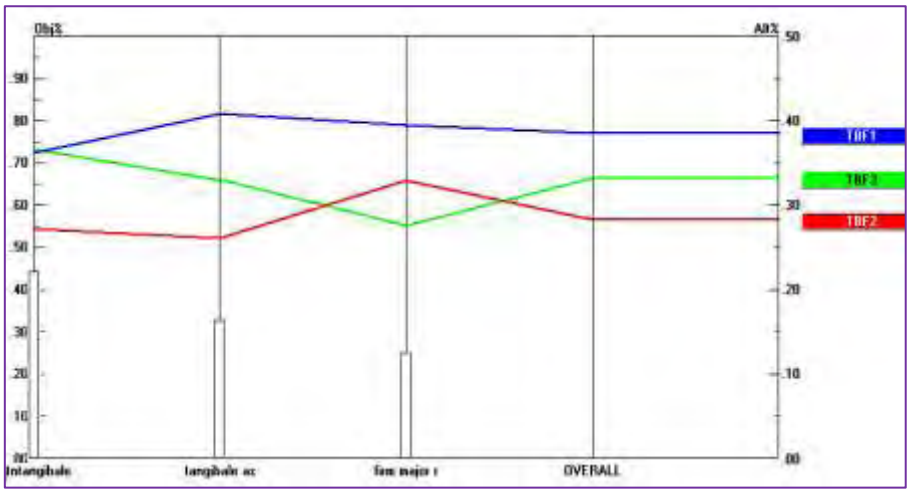

Fig. 5. Performance sensitivity of alternatives in the initial state

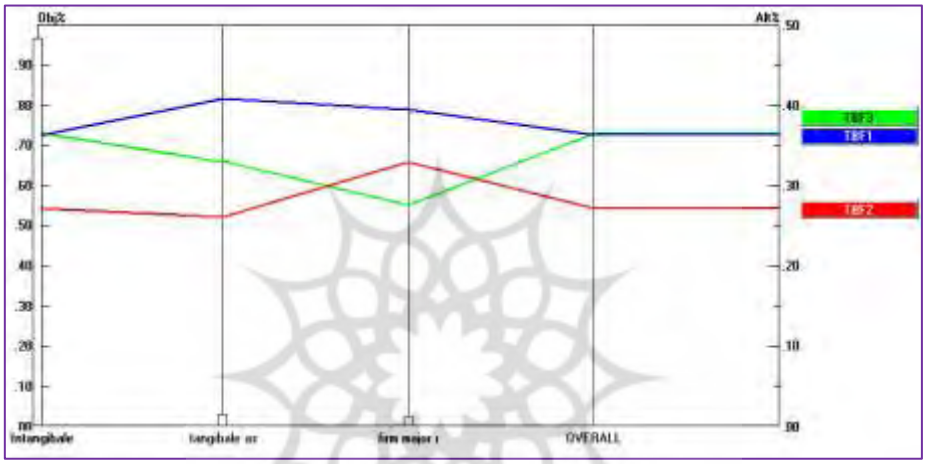

Fig. 6. Performance sensitivity of alternatives in the case of increasing the weight of intangible assets

To analyze the valuation model and the main component in this research, three companies were selected as the alternatives of TBF1, TBF2, and TBF3. In the above forms, according to Figure 5, in the initial state of an intangible asset, tangible asset and main risk, respectively, 45%; 35% and 20% are important, and according to the results, among the three assumed options, TBF1 ranks first, TBF2 ranks third, and TBF3 ranks second. According to Figure 6, in the first scenario, by increasing the weight of intangible assets from 45% to 97%, the ranking of alternatives changes, and in this case, TBF3 replaces TBF1 in the first place.

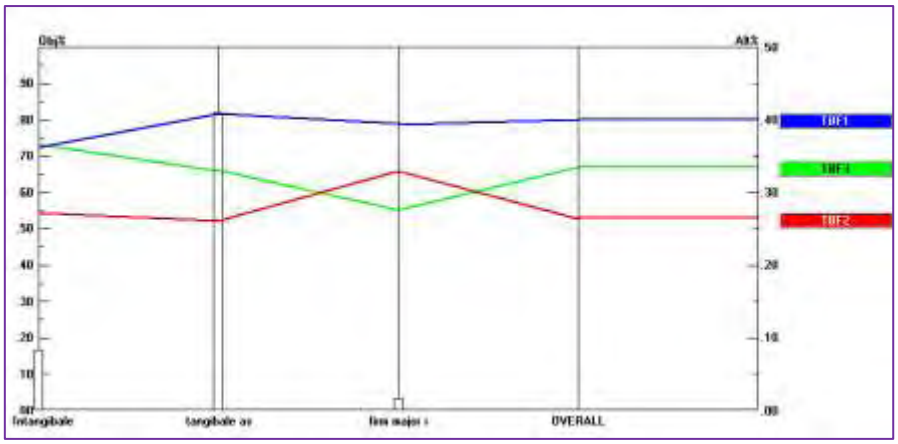

Fig. 7. Performance sensitivity of alternatives in the case of increasing the weight of tangible assets

In the second considered scenario, the ranking of alternatives does not change by increasing the weight of tangible assets from 35% to 80% and even higher. Therefore, in this case, changes in the importance of tangible assets do not affect the ranking of the alternatives and do not cause sensitivity.

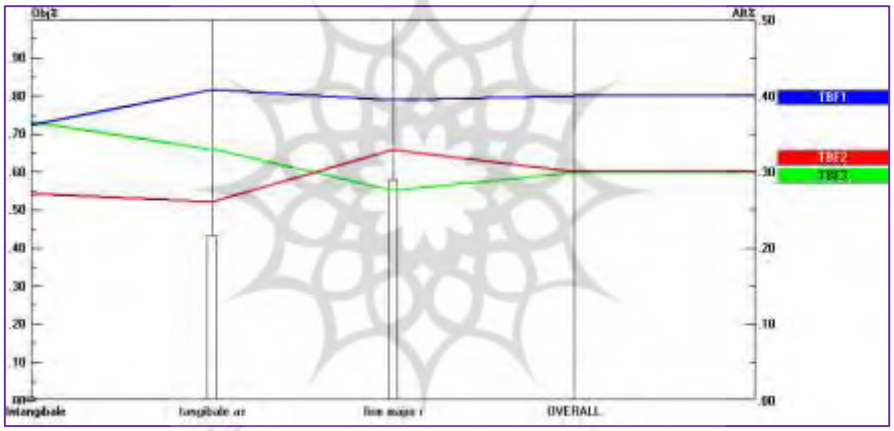

Fig. 8. Performance sensitivity of alternatives in the case of increasing the main risk weight

According to Figure 8, in the third considered scenario, by increasing the weight of the main risk from 20% to 60%, the ranking of the alternatives changes, and in this case TBF2 replaces TBF3 in the second place. Therefore, the result of the sensitivity analysis shows that the ranking of options is most sensitive to changes in the importance and weight of intangible assets and the main risk.

In the presented model, each of the main components and their criteria have a specific weight. However, the model and calculations are designed so that this weighting is flexible in different conditions and dynamic environments, and if there are changes in the main criteria and sub-criteria at the level of the country or defence industries, the weighting can be changed. For example, to calculate the value of the company's tangible assets, if the target company's tangible assets are high and can be valued, in the current valuation model, the tangible assets of the target company can be valued based on their objective value and daily

price, and this value, as A part of the final value of the target company should be considered. In this case, in the hierarchical model of Figure 4, the weight of tangible assets (0.35) no longer plays a role in calculating the final price, and therefore the weight of the two components of intangible assets and main risks in this model changes to 0.69 and 0.31, respectively. Calculations of intangible assets and risks based on these weights should be done. Also, due to changes and economic impulses in the country, the risk of the company becomes more important. In this case, the basic risk, which is included as the macroeconomic risk in this model, can be more important. In the field of technology, the embargo of technology and the intensity of emerging technology lead to an increase in technology risk. In this model, it is possible that by changing the conditions based on the opinion of valuation experts and the desired industrial field, the importance coefficient of each of the main components and criteria and sub-criteria changed.

5. Discussion

Based on the information mentioned in the research method section and Figure 2, To present a valid model in this research, the following has been done. In the first step, to identify and prioritize the local components of the valuation of technology-oriented companies, the opinions of 10 experts in this field, including; University professors, senior managers experts and financial specialists of defense industries were used. In addition, the basis of the analyzed data in the methods of fuzzy screening and fuzzy hierarchy analysis that are used in this research is the opinion of experts and since these methods are part of the accepted and logical methods in determining the weighting criteria and importance are, the validity of the model is also confirmed. After extracting the final model, to confirm it, the opinions of 5 university professors and defence industry financial experts were used and the components, criteria, weights and value estimation function presented in this research were approved by them. Also, based on the results of the sensitivity analysis, the information of three technology companies that can be acquired by the defence industry was included in the model as a sample, and the results were validated by the managers and decision-makers of the defence sector, and the results were reasonable.

Using appropriate techniques, the results of the analysis were discussed in previous sections. The results can be investigated in four main aspects.

First, why aren't some valuation criteria from previous literature considered in the valuation of firms acquired by the Department of Defense? In this regard, one can say that some criteria that were eliminated in this study are those that aren't considered appropriate for the valuation of technology-based firms acquired by the defence sector. The eliminated

criteria can be grouped into two general categories. One is the market-centred criteria category, and the other is based on the results of investments. For example, Ghanbari et al. considered criteria including the commercial team, size of the opportunity, sales and market channels, partners' collaboration and channels, competition atmosphere, power of the product and intellectual properties, clarity of idea, and investment periods as those that have the most impact on the valuation of emergent firms in the Iranian oil sector. However, as the comments of defence experts surveyed in this study imply, the main goal of acquiring firms in the defence sector is improving the power to develop modern and technology-based products, as well as to meet its operational and strategic ones that are performed based on the market and investment implications. Thereby, those criteria considered in previous studies for other firms' acquisition have little importance in the defence sector and have been eliminated in the process of fuzzy screening.

Second, why did the defence experts propose criteria in Table 4 for the valuation of firms acquired by the Department of Defense? As shown in Figure 4, comments from the experts are provided in six groups, including tangible assets, technology, human capital, market, synergy, and risks. In other words, the items are those the experts are interested in. For example, concerning tangible assets, the experts argue that most candidates to be acquired by the Department of Defense are firms that have considerable amounts of raw materials, parts, and subsystems in their field of activity, the value of which must be considered. One must also pay attention to their current costs because these costs are imposed on the acquiring firm in the process of acquisition. Based on Tables 1 and 6, the components and criteria introduced in this research, with the studies of Linder (2023), Hedayat et al. (2022), Miciuła et al. Batista and Perez (2018), Damodaran (2011), Bousquet (2017) and Taherkhani (2017), Ahangari (2017), Payne (2011) are congruent and harmonious.

Third, why are the weighted importance of criteria and subcriteria as those indicated in Figure 4? In this regard, one can say that the main criteria include tangible assets, intangible assets, and major risks whose coefficients of importance are considered logically. Since most technology-based firms were formed based on their technical value creation, their intangible assets are so important that were assigned a value of 0.429. In addition to intangible assets, these firms have also tangible ones, including land, buildings, initial inventory, etc., that have been also considered. Risks of the team, technology, scalability, and synergy are among the most important ones that were considered in our final model. Intangible assets were more significant than tangible assets in studies including Linder (2023), Rahardjo and Sugiarto (2019), Taherkhani (2017), Payne (2011) and Damodaran (2011) who also considered in this study.

Fourth, the criterion size of the opportunity and the market was considered one of the most important criteria in most studies and valuation methods. For instance, the criterion was one of the most important ones in the balanced scorecard technique and Ghanbari et al. (2019) study. Although the size of the opportunity and market is the foundation of calculations in the cash flow method, we considered it a low-important factor. One can argue that in civil and commercial sectors, profitability and investments are the main motives of firms, whereas the main goals of acquisition in the defence sector are the completion of the defence chain, operational synergy, and the development of defence products based on diversification. Here, the motives aren't financial and profitability ones. In this study, items like strategic importance, synergy, and firm's sustainability and endurance are the most important criteria for the valuation of knowledge-based firms in the acquisition process that isn't seen in previous literature.

5.1 Practical and managerial implications

The successful implementation of the acquisition project faces challenges and complications such as the identification of companies that can be acquired, the cultural, organizational and technological differences, the correct evaluation and valuation of the target company, their synergy with the defence industry, and the continuation of operations after the acquisition. In the present study, in addition to presenting the valuation model of companies that can be acquired in the defence sector, the value estimation functions of technology companies based on the criteria and weights determined for them in the model of Figure 4 were presented. The use of this valuation model is especially recommended for start-up and knowledge-based companies. This valuation model and method can be very useful as a complementary and combined method along with the cash flow method and other accurate valuation methods.

According to the results of the research, intangible assets, especially human capital and management teams, have value in the evaluation of knowledge-based companies in the defence industry. Also, managers and experts in the field of defence are familiar with the special features of the defence industry, including; The strategic importance of companies for defence, legal and cultural requirements, protection and security requirements, financial, operational and structural synergy, as well as acceptance and acceptance for special attention. Using this function in determining the value of companies that can be acquired can give an estimate of the value of these companies so that the defence department has a comparable basis for evaluating their proposed value and by paying costs close to reality, it avoids wasting national funds. prevent them from acquiring and purchasing them unrealistically.

One of the most important applications of the current model is to provide a basic, systematic and scientific framework for managers and experts in the valuation process of companies and organizations in the unique environment of defence industries. Another application of this research is to introduce defence managers and experts to the financial issues of technological cooperation methods such as acquisitions, alliances, and consortiums. This research was focused on weighting the criteria and presenting the valuation function. Due to the quantitative and qualitative features of the current valuation model, the evaluator can play a key role in the application and implementation of the current valuation model. The model presented in this research is a static model and its criteria can be updated over time with a future-oriented approach. Therefore, since pricing is an up-to-date phenomenon and is based on daily prices and environmental changes can add new criteria to it, it is necessary to pay attention to this issue when using this model.

6. Conclusions

Defence deterrence and national security are considered the main missions of defence industries, part of which is performed by manufacturing equipment and products. Products with appropriate operational capabilities and qualities comparable with those of leading countries can play a significant role in improving defence deterrence. Therefore, improving quality and operational capabilities, and developing defence products are the main concerns of senior managers in these industries, and they try to employ all existing national capacities in this regard. Technology-based firms are considered precious capacities for value creation and developing defense-related products. Employing a knowledgeable, young, and motivated workforce, the firms start their activities. Acquisition of such firms can be effective in the strategic development of defence products. As one of the strategies for developing defence industries, acquisition enabled the development of products with improved operational capabilities using operational synergy between these industries and the technology-based firms. It can also ensure diversification in some defence products with an enhanced level of defence deterrence.

This research was conducted to provide a model for the valuation of technology companies that can be acquired in the defence sector, and it was tried based on local criteria and by determining the weighted importance of these criteria on the one hand and focusing on the different components of companies' valuation. On the other hand, provides a native and practical model in the form of value estimation functions based on the relative importance coefficient of components, criteria and sub-criteria.

Providing a hybrid model including tangible and intangible assets and considering risks, also, pays attention to the key criteria of the defence sector such as strategic importance,

synergy stability and durability of firms, as well as providing functions for estimating the value of technology- base firms that can be acquired in DOD is considered to be two of the most important aspects of contributions and innovations in this research. The current model provides a systematic and scientific plan for defence industry managers and experts who can use it in the valuation of companies that can be acquired in the defence industry and be sure that their interests are taken into account. To achieve this goal, in the first stage, by reviewing previous research and studies as well as reviewing different valuation models, the valuation criteria of Technology-based Firms were identified (Table 1). Then, the fuzzy screening technique was employed, and the experts were surveyed (Appendix 1). New criteria proposed by the experts were also collected (Table 3). Next, the explored criteria were summarized, and the ultimate components and criteria were identified for the valuation of technology-based firms acquired by the Department of Defense. The criteria were grouped into three categories including tangible assets, intangible assets, and major risks (Table 4). Criteria identified as influencing the valuation of technology-based firms based on their priorities include the development of strategic products, sustainability and endurance of a firm in the cases of crisis and disruptions, the firm's relationships and its strategic partnerships, adoption of information protection and security requirements, and legal and cultural ones, as well as the firm's synergy with the defence sector in terms of its operational, human and financial aspects. The analytical hierarchical process (AHP) was employed to obtain the importance and weights of the identified criteria and factors regarding the valuation of technology-based firms acquired by the Department of Defense. Figure 4 (hierarchical model for the valuation of technology-based firms acquired by the Department of Defense) indicates the results. As can be seen, the components of tangible assets, intangible assets, and major risks have respectively the highest weights and importance in the firms' valuation process. As was expected, the intangible assets criterion is considerably more significant than others in the valuation process.

Other criteria having respectively the highest to the lowest weighted importance, categorized as tangible assets include the land, buildings, administrative and workshop equipment, initial inventory, and the firm’s current costs. Team and implementation risks, income generation, synergy, scalability, and basic risk are among the most important risks in the acquisition process and have respectively the highest to the lowest weighted importance. Criteria including management and the main team, product, technology, and intellectual properties, organizational capital, idea and business plan, synergy, size of the market, and opportunities for growth and profitability were identified as intangible assets. The criteria have their specific subcriteria that were shown in figure 4 and sorted based on their weighted

importance Also, the result of the sensitivity analysis showed that the ranking of alternatives is most sensitive to changes in the importance and weight of the main risk and intangible assets. Changes in the importance of tangible assets do not affect the rating of the option and do not create sensitivity.

6.1 Research limitations and future study agenda

One of the limitations of the research is that this study was not conducted in a specific defence industry such as electronics and radar, energy-rich materials, chemical, air, marine industries, and the like, and was comprehensively planned in all industries. Since tangible, and intangible assets or even risks may be different in each of these industries, this issue leads to the cautious use of the model in each of these specialized areas. Another limitation was the research statistical population, which only included university professors, senior managers and financial managers of defence industries. Although using the opinions of capital market valuation experts venture capitalists and expert valuation experts of the country's innovation and knowledge ecosystem for further validation of the model and criteria statistics and to specify the specific conditions of valuation in the defence environment, seems to be useful, but there was limitations in accessing them.

Although the model presented in this research can be used for all technology companies at any stage of their life cycle, the importance of the criteria in different periods of the life cycle can be different. Mature technology-based firms have more tangible assets that can play a greater role in their bottom line. Therefore, determining the importance of the components of the model presented in this research for technology-based firms at different stages of their life cycle is suggested as a suggestion for future research. In this research, assuming the existence of a similarly valued company, the function of estimating the value of the target company was determined, so how and the criteria for choosing a similar company and the relationship and impact of the valuation criteria on each other can be considered as another future research.

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Appendix 1. The results of fuzzy screening for criteria regarding the valuation of technology-based firms

No.	Criterion	Fuzzy value of each criterion			Criterion deffuzified value of each criterion
		U	M	L	
1	Capability of the main team	1.00	0.93	0.68	0.90
2	Ambitions and motives of entrepreneurs	0.70	0.63	0.38	0.60
3	feasibility for training and learning of employees	0.90	0.83	0.58	0.80
4	Average level of education	1.00	0.95	0.70	0.92
5	Average level of employees experiences	1.00	0.98	0.73	0.94
6	The business team and the ability of the management team	0.88	0..80	0055	0.77
7	Size of market and opportunity	0.80	0.75	0.50	0.72
8	Business plan scalability	0.75	0.70	0.45	0.67
9	Market profit margin	0.70	0.58	0.33	0.55
10	Potential for market growth and profitability	0.83	0.75	0.50	0.72
11	Sales and marketing channels	0.48	0.40	0.20	0.38
12	Partners collaboration and channels	0.90	0.88	0.63	0.84
13	Competition atmosphere	0.60	0.53	0.30	0.50
14	Product prototype	0.58	0.48	0.25	0.45
15	Technical complexities	0.90	0.83	0.58	0.80
16	Kind of innovation	0.83	0.73	0.48	0.70
17	Growth rate of the product and service	0.83	0.78	0.53	0.74
18	Intellectual properties (patent, copyright, licenses, and commercial secrets)	0.83	0.78	0.53	0.74
19	Buildings	0.85	0.88	0.63	0.85
20	Land	0.83	0.73	0.48	0.70
21	Administrative and workshop equipment	1.00	0.93	0.68	0.90
22	Intangible assets (technological superiority, brand)	0.85	0.85	0.63	0.81
23	Future investment needs and investment period	0.83	0.75	0.50	0.72
24	Idea clarity	0.80	0.75	0.50	0.72
25	Dominating Laws and regulations	0.58	0.50	0.28	0.48
26	The quality of covering the company's risks (economic, income generation, scalability, synergy)	0.83	0.63	0.8	0.70
27	Income generation abilities	0.80	0.73	0.48	0.70
28	The average value of the similar company	0.83	0.75	0.48	0.72
29	Financial, human, structural and cultural synergy	0.80	0.73	0.48	0.70
30	Cost of investment opportunity	0.65	0.58	0.33	0.55
31	Adjusting factors	0.68	0.60	0.35	0.57
32	Key performance indicator	0.55	0.53	0.28	0.49
33	Operational coefficients and ratios	0.60	0.53	0.28	0.50
34	Ultimate (terminal) value and enterprise Value (EV)	0.73	0.65	0.40	0.62
35	Coefficients of operating ratios	0.38	0.35	0.18	0.33
36	Discount rate and investor's expected return (ROI)	0.60	0.53	0.30	0.50
37	Existing asset's cash flow	0.75	0.70	0.45	0.67
38	Real managers authorities	0.55	0.8	0.25	0.45
39	Customer feedback	0.75	0.70	0.45	0.67
40	The probability of each scenario	0.63	0.58	0.33	0.55