https://doi.org/10.53656/str2024-3s-2-eff

AI EFFECTIVENESS AND RISK ASSESSMENT OF INVESTMENTS IN HIGH-RISK START-UPS

Sotir Ivanov, PhD Student,
Dr. Petya Biolcheva, Assoc. Prof.
University of National and World Economy

Abstract. Which business idea or project would be successful? Is it worth investing in it and to what extent? What is the risk level and how can it be mitigated to achieve success? All these questions are relevant to both entrepreneurs and investors, especially when it comes to high-risk start-ups. The purpose of this paper is to present a methodology for intelligent effectiveness and risk assessment (IERA) of investments in high-risk start-ups, with a focus on space industries. Such an assessment is challenging for several reasons, including the lack of unified statistics on space industries, evaluation of benefits other than economic ones, long-term development challenges, etc. The developed IERA methodology integrates a combination of various known methods used in the space industries for both investment appraisal and risk assessment. The application of various AI-based tools for methodology criteria, weights, and scores contributes to obtaining realistic values and ensures the success of the analysis results, thereby benefiting the project itself. Thus, the applied IERA methodology can be implemented in real-time, based on a broad knowledge base, with high accuracy, and requiring significantly fewer financial resources. The main advantage of the developed methodology is the assurance it provides to both entrepreneurs and investors, offering them sufficient certainty and confidence.

Keywords: investment attractiveness; investment appraisal; risk assessment; artificial intelligence; start-up

1. Introduction

The upcoming Industry 5.0 integrates advanced technology and human creativity aimed at creating a flexible production environment (Minchev, Hristova & Stoyanov 2023). It opens up numerous opportunities for starting a business in industries that have been burdened with numerous barriers and the need for significant investments until now. Space industries are a typical example here. According to scientific research, in areas such as space colonisation (Concepcion et al. 2022), entering Industry 5.0 provides an opportunity to uncover a number of challenges for start-ups. Moreover, Industry 5.0 envisions a full-fledged cooperation between man and AI (Nahavandi 2019), which is also linked to uncovering significant opportunities for new forms of development and business models (Biolcheva & Molhova 2023). This provides a prerequisite for the authors to focus their scientific interests on the field of space industries, as an object that requires more extensive academic and empirical study.

According to the European Investment Bank (2019), until recently, the space sector has been synonymous with government spending. The high risks and economic barriers in the space industries made them generally inaccessible to private players. Today, the technological progress and a burgeoning entrepreneurial mind-set are swiftly shaping the new space economy. Space industries have experienced a consistent increase in private capital investment since 2014, reaching a peak in 2021 (Space Capital, n.d.). The value of the sector in 2022 stands at $546 billion (Space Foundation, 2023). However, the recent upswing has primarily been driven by commercial opportunities emerging for entrepreneurs in space exploration and exploitation, thanks to the advancement of high-tech industries and the accumulated knowledge and data derived from these industries (European Investment Bank 2019).

The vast majority of private investments in the space industries come from high-risk capital. Venture capital funds rank first, followed by business angels, corporate investments, and others (Space Capital, n.d.). The sector is high-risk due to the high failure rate of investments driven by the still unexplored opportunities and the lack of sufficient data and knowledge. At the same time, achieving success for investors (often linked to reaching an IPO) in the early stages of a space company can result in substantial profits. However, the main obstacle for the space industries remains their dependence on venture capital and the lack of easily accessible alternative financing options. The requirement for rapid growth and returns in this type of financing hinders the establishment of a sustainable model for companies in this sector.

Specific to the space industries is the time gap between incurring expenditures and generating revenue, which may lead to financial challenges, particularly for small and/or start-up companies (Vollerthun & Fricke 2000). For these and other reasons, it is important for investors to be convinced of the future success of the start-up. This has prompted the authors of this paper to develop a methodology that enables in first place the evaluation of start-ups in the sector. Through it, investors can assess the attractiveness of an idea. Secondly, the risk assessment can evaluate the resilience of the start-up company by analysing both the implementation of the idea and the conversion of potential risk losses into benefits. To achieve this goal, the following research question is posed: How can investments in the space industries be intelligently evaluated (using AI) to ensure that the evaluation results offer an objective perspective on the effectiveness and risk of start-ups? To answer this question, the following chapters are introduced consecutively: literature review, research method, results, and discussion.

2. Literature review

Determining investment attractiveness requires clear assessment mechanisms and a systematic approach to identifying the determinants for continuation and improvement (Moskalenko et al. 2021). Not surprisingly, it is identified as a key component of competitiveness (Moskalenko et al. 2022). A literature review conducted in scientific databases revealed the existence of various methodologies for evaluating investments in space industries. For the purpose of the present study, six methodologies have been selected. Three of them are similar and largely interdependent, so they will be considered as a whole. These are the methodologies of Sonter (1997), Ross (2001), and Vergaaij et al. (2021), which focus on the investment appraisal of mineral extraction projects from near-Earth orbit asteroids. All three are based on the method of evaluating and comparing alternative projects by calculating the Net Present Value (NPV).

Another methodology is that of Vollerthun and Fricke (2000), who have developed a three-phase approach for creating investment projects in the space industries. In the section on investment appraisal, the authors have primarily used Return on Investment (ROI) as the main investment appraisal method and break-even point as secondary.

The fifth methodology aims to analyse and evaluate R&D investments with a long-term horizon in space commercialisation. The author of the study is Sheahen (1984), who utilised the Internal Rate of Return (IRR) as the primary method for assessing the impacts of R&D investments.

The last one was created by Hof et al. (2012) and was specifically developed for use by ESA. It differs from the others for two main reasons. Firstly, it considers and evaluates the effects of public investment in the space sector. Secondly, it is a combination of two methods: Social Cost Benefit Analysis (SCBA) when it comes to monetary benefits and Multi-Criteria Analysis (MCA) for non-monetary effects. It is the only methodology that considers multiple types of benefits (technological, social and environmental).

A comparative analysis is used to identify the advantages and disadvantages of the methodologies. The main criterion is the suitability of evaluation methods for high-risk space industries, where projects have a longer time horizon. IRR is an important and widely used tool, but it is difficult to calculate, and it can drastically reduce the discounted cash flows in the long term. This makes space projects less attractive due to the requirement for a high rate of return (over 30% and more). Furthermore, it fails to take into account the additional benefits of such an investment. NPV, on the other hand, is more difficult for investors to understand, although it is easier to calculate and reflects actual capital growth. ROI is the easiest to calculate and the most preferred by investors, but it does not consider the time value of money. The SCBA is also laborious to calculate, and it is mainly focused on the public sector, where non-financial benefits hold greater significance.

Major drawback of the compared methodologies is that none of them include risk analysis. As mentioned, the risk in the space industries is much higher. An exception is the sensitivity analysis, which in some methodologies is based on a subjective determination of the deviation. Another drawback is the absence of visual representation in some of the methodologies, making them less appealing and harder to comprehend.

3. Method

The development of the IERA methodology is based on the following three steps:

I. Identifying the benefits and overcoming the drawbacks and limitations of the already reviewed methodologies.

II. Synthesising improved methods for investment appraisal and risk assessment that could provide sufficient information for evaluating start-ups and projects.

III. Applying AI tools at different stages of the methodology in order to obtain more accurate results with less efforts and costs.

It should be noted here that the description of IERA only mentions the individual AI tools without defining how they actually function. This is subject of another scientific work.

4. Results

The results of the conducted research led to the creation of the Intelligent Effectiveness and Risk Assessment (IERA) methodology, which is illustrated in Figure 1.

The purpose of the IERA is to provide a sequence of steps for assessing the performance and risk of investing in high-risk start-ups. Obtaining higher accuracy within each step is attributed to the application of various artificial intelligence tools. These tools are based on the utilisation of diverse databases pertinent to environmental analysis, strategic planning, sector positioning, statistics, data, sector development forecasts, investment climate, investors, and funding sources. The combination of powerful algorithms and computational capabilities of Machine Learning (ML), Deep Learning (DL) and semantic analysis produces an objective assessment of the future positioning of start-ups. This guarantees accuracy, impartiality, faster analysis combined with relatively lower costs of its conduct and real-time updates in response to environmental changes.

While IERA presents the overall process of evaluating an investment idea in high-risk space start-ups, the focus of this paper is on investment appraisal and risk assessment. Recognising the need to incorporate an environmental aspect into the overall investment appraisal, especially in the space sector where the challenge of space debris is continuously escalating and leading to higher costs, IERA introduces *Discounted Sustainable Return on Investment or DS-ROI* as the primary evaluation method. DS-ROI is calculated using the following formula:

Formula 1 – Discounted Sustainable Return on Investment (DS-ROI)

$$\text{DS-ROI} = \frac{-C_0 + \frac{R_1 - C_1}{(1+d)} + \frac{R_2 - C_2}{(1+d)^2} + \dots + \frac{R_n - C_n}{(1+d)^n}}{I} \text{ x } 100$$

$C_{0,1,2,\dots,n}$ – amount of costs in the current moment, first, second and n-year

$C_{0,1,2,\dots,n}$ = development costs (C_{RD}) + production costs (C_P) + operating costs (C_O) + finance costs (C_F)

$R_{1,2,\dots,n}$ – sum of revenues/benefits at the first, second and n-year

$R_{1,2,\dots,n}$ = economic (R_E) + technological (R_T) + strategic (R_{ST}) + scientific (R_{SC}) + environmental (R_{ECO}) + social (R_{SO})

d – discount rate

d = weighted average cost of capital (WACC)

I – sum of investments from all used funding sources

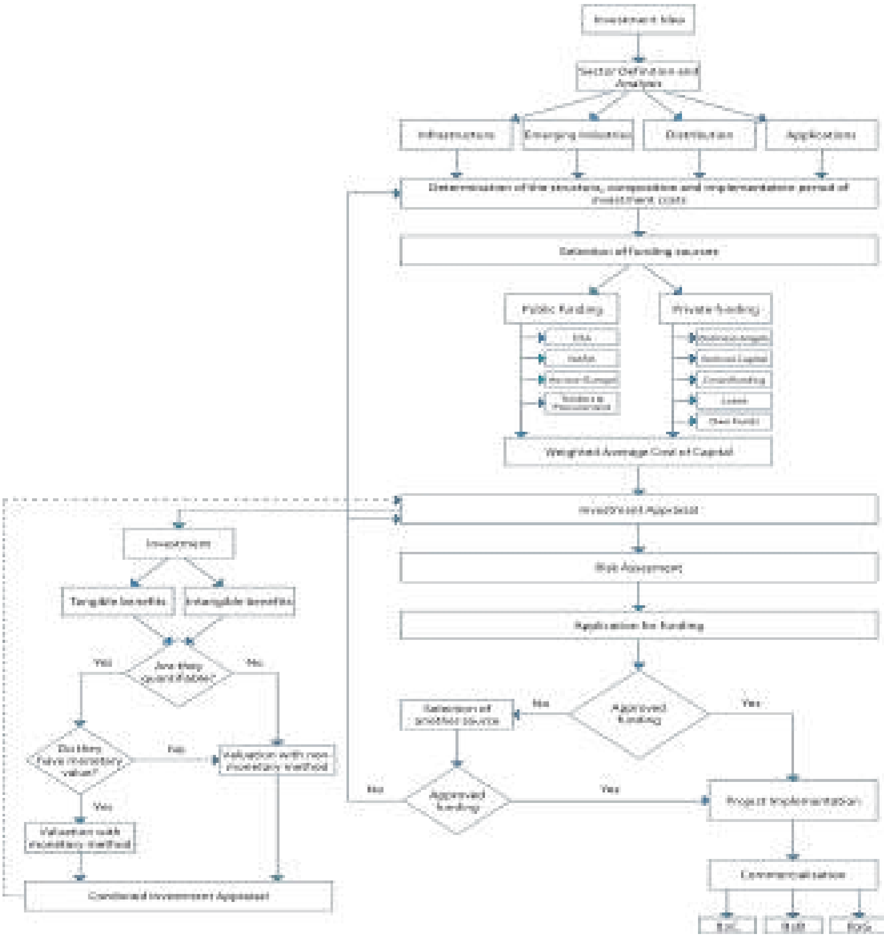

Figure 1. Intelligent Effectiveness and Risk Assessment (IERA) Methodology

In addition, the *Discounted Payback Period (DPB)* is used. The reason for this choice is that ROI as a method does not take into account the investment period and the economic lifetime of the project. A non-monetary method, the *Multicriteria Analysis (MCA)*, is also used to assess non-quantifiable benefits or those to which no monetary value can be assigned. Its assessment is based on a comparison with parameters, benefits, and costs from similar completed projects. For this purpose, ML conducts an analysis of historical databases. In this way, the DS-ROI assessment is complemented, delivering a more comprehensive overview to potential investors through semantic web analysis. This set of methods offers an intelligent assessment: the greater the number of projects/companies considered (the database), the more comprehensive and unbiased the assessment becomes. The use of ML and Neural Networks (NN) algorithms makes evaluation possible even in the absence of quantifiable monetary benefits, by comparing them with similarities in historical databases of already implemented projects.

The next step is to determine the maximum value and the score for each quantifiable benefit, which will be mapped on a scale from 1 to 10 with rounding to one decimal place. The value is calculated using the following formula:

Formula 2 – Mapping quantifiable benefits

$$\text{Mapped value of quantifiable benefit} = \frac{9 \text{ x } (\text{result} - \text{minimum value})}{\text{maximum value} - \text{minimum value}} + 1$$

The appraisal through MCA is conducted using ML, which considers both current and potential benefits. This enables the methodology to assign a monetary value or at least provide a measurable metric for each benefit. However, if the project generates benefits that cannot be quantified, ML assesses the qualitative indicators (such as reputation, scientific discoveries, etc.) and compares them with those of existing companies operating in the same industry.

An important aspect of intelligent multi-criteria analysis is determining the relative weights. ML considers historical and surveyed opinions of subject matter experts and supplements them with relevant databases on key factors (technological, strategic, scientific, environmental, and social) to determine the potential weights of individual benefits. Thus, the investment appraisal provides better accuracy, enabling investors to make an informed and unbiased decision on whether to invest in the project or not.

One of the main shortcomings of the reviewed methodologies is the absence of a comprehensive risk assessment, which is crucial for high-risk space industries. The first step of the risk assessment in the IERA methodology is to identify the risks that may directly or indirectly affect the project's feasibility. The risks are divided into eight groups as described by Gerstein et al. (2016): supply chain, cost and schedule, human capital, organisational and managerial, external dependency, political, and technical, with added environmental risks.

The next step is to identify the specific risks for the project based on the eight risk groups, along with the indicators and methods of measurement. Another key element in this step is to distinguish the effects that can influence the risks toward mitigation or neutralisation. There may be more than one way of influencing the risks, with varying degrees of mitigation. The process for risk assessment is similar to MCA where AI tools can significantly enhance the process in terms of speed, ease, and accuracy.

IERA continues with the determination of the likelihood of risks and their potential impact on the project. Thresholds are set for each value on the scale from 0 to 5 against which they will be evaluated. This is achieved by using expert opinions, statistical and historical data from other comparable projects/companies, gathered and synthesised through ML. After that, the likelihood and consequences for each risk in every risk group are defined. Consequences and likelihood are multiplied to obtain the score for each risk, which is then divided by the sum of the likelihood scores to obtain the normalised score. Finally, all the normalised scores are added together to calculate the overall score for the risk group. An essential element here is the effects that mitigate the individual risks, written down with a negative sign. Their score is calculated by multiplying the likelihood of the risk they mitigate by the value by which they reduce the consequences.

After this step, the methodology calculates the overall risk score for the entire project. It is an arithmetic mean and is equal to the sum of the normalised scores of the risk groups divided by their total number. A radar chart is also used to graphically present project risks. Once the overall risk score is determined, it is used in conjunction with the investment appraisal. For this purpose, it is first necessary to convert it into a percentage value, called the Risk Index (RI).

Formula 3 – Risk Index (RI)

$$\text{Risk Index (RI)} = \frac{\text{overall risk score} - \text{minimum value}}{\text{maximum value} - \text{minimum value}} \text{ x } 100$$

The combination of investment appraisal and risk assessment is conducted using sensitivity analysis and Monte Carlo simulation. The calculation is performed by modifying the main parameters of the project while maintaining the base value of the others. This variation can be either negative or positive by multiplying or dividing the parameter by the risk index.

5. Discussion

The IERA methodology aims to be an instrument for a more comprehensive and realistic investment appraisal. For example, it includes the process of identifying the available funding sources, which, in the developed methodology, occurs before conducting the investment appraisal. The reason for this is related to the calculation of the cost of capital and its use as a discount rate. The specifics of each source can also impact the development and planning of the company. As the literature study revealed, venture capital funds seek high and short-term returns, while public sources aim to increase the general welfare in terms of science, ecology, society, and economy.

The comparative analysis identified the need for a sufficiently thorough risk assessment and highlighted the unjustified use of an arbitrarily chosen risk level, respectively standard deviation in the sensitivity analysis. Relying on pre-defined percentages such as 10%, 20%, or even 30% in high-risk aerospace industries is likely to lead to unrealistic revenue forecasts. The combined approach to investment appraisal contributes not only to providing greater certainty for investors but also to an appraisal that will stimulate and inspire more entrepreneurs to pursue their ideas in the space industries, leading to more of them being funded and successfully implemented.

The results of the conducted applied research on a selected company (EnduroSat) have also shown that the developed methodology provides a lower valuation compared to the methodology of Vollerthun and Fricke (2000). This is because their methodology does not discount the cash flows. In this case, DS-ROI returns values that would be below the rate of return expected by the investors, which could rule out potentially good ideas. That’s why, according to the case study on EnduroSat, the acceptance criterion for a project evaluated by the DS-ROI method is for the value of the indicator to be positive (DS-ROI > 0). DS-ROI also does not take into account the achievement of a return on the sale of shares in an IPO, which is the primary goal of venture capital funds.

The IERA methodology is flexible enough to be applied by a wide range of companies in the space industries. It is equally suitable for private and public capital financing. A key role in the initial phase is played by the environmental and sub-industry analysis, which serves to identify possible funding sources and competitors. It provides a basis for benchmarking and participating in the determination of some of the costs, revenues, and barriers. Through this analysis, the IERA methodology can be adapted to the specifics of the sub-industry. The wide range of assessed benefits attracts a spectrum of investors with motivations that can vary from generating profits to stimulating fundamental research.

6. Conclusion

The need for the development of improved evaluation methodologies for investment projects is undeniable, especially as the world is entering the so-called “era of artificial intelligence”. This paper demonstrates the characteristics of a contemporary intelligent performance and risk assessment when investing in high-risk start-ups, particularly in the space industries. Due to the significance of investment appraisal and risk assessment, this work focuses on integrating various established methods to enhance accuracy through the impartiality and objectivity of AI-based tools. The authors of this paper will continue their research on this topic by fully developing all stages and testing the IERA methodology in real-world conditions.

Acknowledgements
This work is financially supported by the UNWE Research Programme (Research Grand No 5/2023A).

REFERENCES

CONCEPCION, R.; RAMIREZ, T.; ALEJANDRINO, J.; JANAIRO, A.; BAUN, J.; FRANCISCO, K.; RELANO, R.; ENRIQUEZ, M.; BAUTISTA, M.; VICERRA, R.; BANDALA, A. & IZZO, L., 2022. A Look at the Near Future: Industry 5.0 Boosts the Potential of Sustainable Space Agriculture. *2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, pp. 1 – 6. DOI:10.1109/HNICEM57413.2022.10109559.

EUROPEAN INVESTMENT BANK, 2019. *The future of the European space sector*. Available at: https://doi.org/10.2867/497151.

GERSTEIN, D.; KALLIMANI, J.; MAYER, L.; MESHKAT, L.; OSBURG, J.; DAVIS, P.; CIGNARELLA, B. & GRAMMICH, C., 2016. *Developing a Risk Assessment Methodology for the National Aeronautics and Space Administration*. Santa Monica, CA: RAND Corporation. Available at: https://www.rand.org/pubs/research_reports/RR1537.html.

HOF, B.; KOOPMANS, C.; LIESHOUT, R. & WOKKE, F., 2012. Design of a methodology to evaluate the direct and indirect economic and social benefits of public investments in space: technical note 3. (SEO-rapport; No. 2012-42). *SEO Economisch Onderzoek*. Available at: http://www.seo.nl/uploads/media/2012-42_Public_Investment_in_Space.pdf.

MINCHEV, N.; HRISTOVA, V. & STOYANOV, I., 2023. Structural Changes in Educating Managers for Industry 5.0. *Strategies for Policy in Science & Education-Strategii na Obrazovatelnata i Nauchnata Politika*, vol.31, no. 6s, pp. 112 – 125. DOI: 10.53656/str2023-6s-10-stu.

MOLHOVA, M. & BIOLCHEVA, P., 2023. Strategies and Policies to Support the Development of AI Technologies in Europe. *Strategies for Policy in Science & Education-Strategii na Obrazovatelnata i Nauchnata Politika*, vol.31, no. 3s, pp. 69 – 79. DOI:10.53656/str2023-3s.

MOSKALENKO, B.; LYULYOV, O. & PIMONENKO, T., 2022. The investment attractiveness of countries: Coupling between core dimensions. *Forum Scientiae Oeconomia,* vol. 10, no. 2, pp. 153 – 172. DOI:10.23762/FSO_VOL10_NO2_8.

MOSKALENKO, B.; LYULYOV, O.; PIMONENKO, T.; KWILINSKI, A. & DZWIGOL, H., 2021. Investment attractiveness of the country: Social, ecological, economic dimension. *International Journal of Envi-*

ronment and Pollution, vol. 69, no. 1 – 2, pp. 80 – 98. DOI:10.1504/IJEP.2021.125192.

NAHAVANDI, S., 2019. Industry 5.0 – A human-centric solution. *Sustainability*, vol. 11, no. 16, p. 4371. DOI:10.3390/su11164371.

ROSS, S., 2001. Near-Earth Asteroid Mining. *Space Industry Report*.

SHEAHEN, T., 1984. *Space Commercialization: Analysis of R&D Investments with Long Time Horizons*.

SONTER, M., 1997. The Technical and Economic Feasibility of Mining the Near-Earth Asteroids. *Acta Astronautica*, pp. 637 – 647. Available at: https://doi.org/10.1016/S0094-5765(98)00087-3.

SPACE CAPITAL. (n.d.). *Space Investment Quarterly Dashboard*. Available at: https://www.spacecapital.com/quarterly

SPACE FOUNDATION. 2023. *The Space Report 2023 Q2*. Available at: https://www.spacefoundation.org/2023/07/25/the-space-report-2023-q2/.

VERGAAIJ, M.; MCINNES, C. & CERIOTTI, M., 2021. Economic assessment of high-thrust and solar-sail propulsion for near-earth asteroid mining. *Advances in Space Research*, vol. 67, no. 9, pp. 3045 – 3058. Available at: https://doi.org/10.1016/j.asr.2020.06.012.

VOLLERTHUN, A. & FRICKE, E., 2000. The Future of the Space Age or How to Evaluate Innovative Ideas. *Acta Astronautica*, vol. 50., no. 9, pp. 579 – 586. Available at: https://doi.org/10.1016/S0094-5765(01)00207-7.

✉ **Sotir Ivanov, PhD Student**
ORCID iD: 0009-0009-4586-4420
✉ **Dr. Petya Biolcheva, Assoc. Prof.**
ORCID iD: 0000-0001-9430-773X
Industrial Business Department
Business Faculty
University of National and World Economy
19, December 8th St.
1700 Sofia, Bulgaria
E-mail: sotir.ivanov@unwe.bg
E-mail: p.biolcheva@unwe.bg