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DYNAMIC DECISION-MAKING FRAMEWORK FOR EVALUATING THE MARKET POTENTIAL AND SUCCESS OF INNOVATIVE STARTUPS ON THE BASIS OF A MARKETING RESEARCH APPROACH USING R

Currently, the world is highly dependent on technological advancements and innovations (TAI) being the key driver of economic growth, competitiveness, and overall societal progress. And high-tech startups are at the forefront of TAI, developing new products and services that meet the growing needs of consumers. Over the past decades, the quantity and quality of startups have increased significantly, however, they are still known for high risks and low success rates, which often lead to financial losses for investors and startup founders. Therefore, the aim of the study was to develop a dynamic decision-making framework for evaluating the market potential and success rates of innovative startups throughout their lifecycle on the basis of a marketing research approach using R programming language to provide

a unique solution for startup founders, investors, business incubators, startup accelerators, tech hubs, etc. As a result, a new methodology for evaluating the market potential and success rates of innovative startups was proposed based on T. L. Saaty's analytic hierarchy process (AHP) methodology. Taking into account the fact that AHP is based on expert opinions, it was proposed to divide experts into five groups – scientific specialists, investors representatives, manufacturers representatives, practicing startup entrepreneurs, business incubators & startup accelerators representatives. Each group of experts determined the degrees of preference between the proposed criteria and sub-criteria of each of the three components of startup attractiveness – market, marketing and investment attractiveness of the startup project. The decision-making framework was created and tested in the RStudio software environment based on the 'ahp' package and can be used by startup founders, investors, and other stakeholders on a regular basis as new information about their projects becomes available.

Keywords: startup marketing, marketing research, startup management, R programming, analytic hierarchy process, RStudio, innovations marketing

JEL classification: ***C190, M310, O320***

Наразі світ надзвичайно сильно залежить від технологічного прогресу та інновацій, які є ключовими чиниками економічного зростання, конкурентоспроможності, загального суспільного прогресу тощо. Розробляючи нові продукти та послуги, які відповідають постійно зростаючим потребам споживачів, високотехнологічні стартап-проєкти є основою науково-технічного прогресу. За останні десятиліття кількість та якість стартапів значно зросла, проте вони все ще залишаються високоризикованими, мають низькі показники успішності, що часто призводить до фінансових втрат інвесторів і засновників стартапів. Отже, метою дослідження є розробка динамічної системи прийняття рішень для оцінювання ринкового потенціалу і успішності інноваційних стартапів упродовж усього їх життєвого циклу із використанням принципів й інструментів маркетингових досліджень та мови програмування R. Авторські розробки нададуть змогу засновникам стартапів, інвесторам, бізнес-інкубаторам, стартап-акселераторам, технологічнм хабм тощо сформувати виважені й обгрунтовані рішення. Авторами запропоновано нову методологію оцінювання ринкового потенціалу й успішності інноваційних стартапів на основі методу аналізу ієрархій Т. Сааті. З урахуванням того, що цей метод заснований на експертних оцінках, запропоновано розділити експертів на п'ять груп – науковців, представників інвесторів, представників виробників, практикуючих стартап-підприємців, представників бізнес-інкубаторів та стартап-акселераторів. Кожна група експертів має встановити ступінь переваги між запропонованими критеріями та підкритеріями кожної з трьох складових привабливості стартап-проєкту – ринкової, маркетингової та інвестиційної привабливості. Розроблена динамічна система прийняття рішень створена і протестована у програмному середовищі RStudio на базі пакету "ahp" і може застосовуватися на регулярній основі засновниками стартапів, інвесторами та іншими стейкхолдерами по мірі надходження нової інформації про їхні проєкти.

Ключові слова: маркетинг стартапів, маркетингові дослідження, менеджмент стартапів, мова програмування R, метод аналізу ієрархій, RStudio, маркетинг інновацій

JEL classification: ***C190, M310, O320***

Introduction. The modern economy, as well as all areas of human life, is highly dependent on technological advancements and innovations (TAI). In today's rapidly evolving world, TAI have become the key driver of economic growth, competitiveness, and overall societal progress. TAI have revolutionized the way humans work and businesses operate, creating new opportunities for growth and development.

Startups and entrepreneurs are at the forefront of TAI, developing new products and services that meet the changing needs and demands of the growing number of consumers. These new products and services have the potential to supplement or even replace traditional industries and create entirely new ones, leading to the creation of new jobs, increased economic growth of countries, and improved standards of living.

Startups as a unique form of innovative entrepreneurship emerged in 1970-1980 in order to meet all the needs of society in TAI. Since then the quantity and quality of startups

have increased significantly, but at the same time, high-tech startups are still known for their high risk and low success rates, which often lead to financial losses for investors and startup teams.

The evidence of the high failure rate of startups can be found in numerous scientific and professional papers, as well as in interviews with startup founders, which in the case of this study, can also be considered a reliable data source. According to Harvard Business Review 2021 data [1], over two-thirds of startups fail and never generate positive returns for investors.

In 2021, CB Insights identified the 12 most common reasons why startup projects fail [2] They used qualitative analysis methods and studied over 100 explanations for startup failures provided by their teams, founders, and investors since 2018. The list of these explanations is still being updated and can be found on the CB Insights platform [3].

As can be seen from Fig. 1, one of the main reasons for startup failure was 'No market need' observed in 35 % of analyzed projects. Thus, in addition to financial problems (38%), low startup success rates are often associated with poor marketing. Startups can have a great product or service, but if they cannot market it effectively, it may not catch on in the marketplace, resulting in low sales and ultimately failure.

Modern startups often operate in highly competitive markets dominated by established players with large resources and a recognizable brand. In such an environment, it is critical for startups to have a solid marketing mix that differentiates them from their competitors and effectively communicates their value proposition to potential customers. Poor marketing conditions such as inadequate market research, ineffective communication, and lack of brand positioning can ultimately lead to failure.

Today, there are many conflicting opinions in the professional literature about whether serious market research should be done before creating a minimum viable product (MVP) for a high-tech startup. According to the approaches of S. Blank, B. Dorf [4] and E. Rees [5] to the development of lean startups, teams should focus on creating a lean MVP and getting constant feedback from potential customers to improve the product. But while this approach is good at

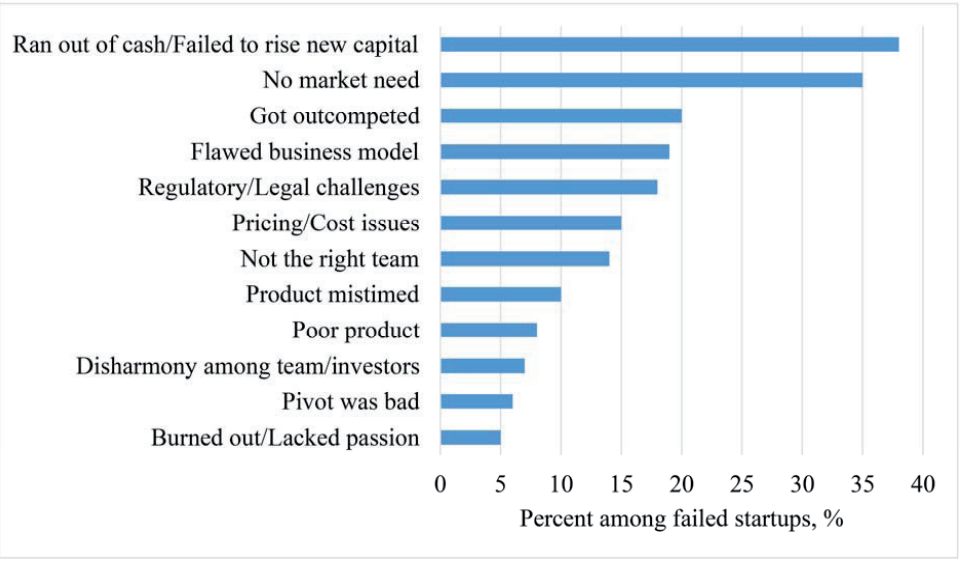


Fig. 1. The most common reasons for startups' low success rates
Source: Created by authors based on [2]

the beginning of a startup's life cycle, in the later stages, market research can be much more important, even if it can be costly and time-consuming. Therefore, for founders to succeed, it is important to find a balance between reliable market research tools and a lean approach. In other words, it is important to develop a solution that can combine the best of the two approaches.

And such a solution can be valuable not only for the founders of startups. Venture capitalists and other investors are constantly on the lookout for promising projects that can disrupt markets and provide significant returns on investment, becoming "unicorns" with wide market scale and huge returns. As such, they must be able to pinpoint the market potential and success rate of a particular startup.

Therefore, it is crucial to develop a new solution for assessing the market potential and the expected success of innovative startup projects throughout their lifecycle in order to help founders, investors, business incubators, accelerators, tech hubs, etc. make a decision regarding startup development and financing.

Statement of the problem and analysis of literary sources. The topics of marketing and startup management, marketing research and evaluation of the success of startups in recent years have attracted a significant increase in interest from the scientific community. This demonstrates the growing recognition of the relevance and importance of start-ups as engines of innovation, economic growth and job creation, as well as the importance of developing new solutions in this area.

The research presented in this article is part of a more complex study that has been conducted since 2015 and focuses on the development of startups, marketing and startup management, as well as the development of tools to quantify the success of such projects in the market. In particular, in [6], we identified the main success factors of a startup and developed a tool for assessing the success of a startup based on a mathematical model in the form of a Bayesian network. The tool presented in [6] can be used to assess the success of startups in the whole country or a specific market, while the approach proposed in this article is intended to assess the market potential and success of a particular startup or to compare several projects with each other.

An analysis of literary sources has shown that at present, many domestic and foreign scientists are conducting research on evaluating and predicting the success of startups, as well as on developing new tools for marketing and managing startups.

In particular, the work of T. Bielialov [7] considers the features of risk management in startups developing innovative products. The study suggests that startups that focus on innovation face higher risks and uncertainties, which can lead to failure if not managed properly. The paper identifies various risk factors that startups should consider, including technological, market, financial, and operational risks. The study proposes a framework for risk management that includes identifying risks, assessing their probability and impact, and also risk mitigation strategies. The paper highlights the importance of communication and collaboration among stakeholders, including founders, investors, and employees.

In turn, M. Chhibber [8] presents a machine-learning approach for predicting the profitability of startups. He argues that predicting the success of startups is critical for investors and entrepreneurs. The paper proposes a framework that utilizes various machine learning techniques such as decision trees and random forests to predict the profitability of startups.

J. Jiao [9] focuses on the analysis of the factors influencing internet precision marketing for small and medium-sized enterprises (SME) in China. The study highlights that SME face greater challenges compared to large enterprises due to limitations in scale, capital, and technology. The author proposes a model for SME internet precision marketing based on the analytic hierarchy process to identify the key factors that influence internet precision marketing for SME.

T. Štofa and R. Dráb [10] examined the success factors of crowdfunding campaigns for innovative projects compared to regular projects. The authors analyzed a dataset of over 250,000 registered projects on the Kickstarter platform and found that regular projects had a higher success rate compared to innovative projects.

Another important investigation was conducted in [11] by M. Berre and B. Le Pendeven. The study provides a systematic literature review of peer-reviewed studies on startup-valuation drivers. The authors examined 87 studies published between 1985 and 2020 and identified more than 30 drivers of startup valuation, which they cluster into five macro-themes: entrepreneur characteristics, firm characteristics, investor characteristics, market conditions and deal conditions. Then the authors construct an integrative meta-model based on the macro-themes. The study identifies key research gaps and promising directions for exploring the startup-valuation field.

The most interesting study from the point of view of our research [12] was conducted by Y. Chen, C. Tsai and H. Liu, who substantiated and validated the AHP methodology relevance for high-tech startup success evaluation. They identified five major dimensions and fifteen criteria of startup success and used them for prediction by AHP. One of the main differences between our approach to assessing the success of a startup and theirs is that we primarily focus on the marketing aspects of the development of a startup project.

So, according to the above rationale, **the aim of the study** is to develop a dynamic decision-making framework for evaluating the market potential and success rates of innovative startups throughout their lifecycle based on a marketing research approach using R programming language to provide a unique solution for startup founders, investors, business incubators, startup accelerators, tech hubs, etc.

Methods. The developed dynamic decision-making framework for evaluating the market potential and success rates of innovative startups is based both on traditional marketing research approaches and the ideas highlighted in the works of S. Blank, B. Dorf, and E. Ries, which are fundamental for the contemporary startup industry [4, 5]. These professionals are well-known proponents of the lean startup methodology and the customer development approach. The developed dynamic decision-making system for assessing the market potential and success of innovative startups is based both on traditional marketing research approaches and on the ideas outlined in the works of S. Blank, B. Dorf and E. Rees, which are fundamental for the modern startup industry [4 , 5]. These professionals are well-known proponents of the Lean Startup methodology and customer development approach. At present, these approaches are often covered in the works of other specialists and scientists, in particular, in [13–15].

In [4] S. Blank and B. Dorf argue that startups should focus on customer development before product development. They propose a quick step-by-step guide to help startup founders understand the needs of their customers, create and test products, and develop scalable businesses. They advocate for a continuous feedback loop that involves customer discovery, validation, creation and building.

E. Ries in [5] expands the approach to customer development and advocates the approach of lean entrepreneurship (methodology of lean start-up). He emphasizes the importance of creating an MVP to test the feasibility of a business idea with real customers who are the target audience. He proposed a unique methodology for testing and verifying assumptions and adjusting the product based on customer feedback.

So, the key ideas of S. Blank, B. Dorf, and E. Ries stress the importance of customer development, continuous feedback, and innovation in creating a successful startup. The lean startup methodology and customer development approach provide startup founders with a framework to quickly test and validate their business ideas, reduce the risk of failure, and build a successful, scalable business.

But at the same time, the methodologies mentioned above lack some of the deep quantitative approaches to assessing the viability of startups that traditional marketing research methods have. Thus, in this study, to evaluate start-up projects, including those developed within the framework of the lean start-up methodology and the approach to customer development, it is proposed to use a more traditional method of marketing research - the process of analytical hierarchy by T. L. Saaty [16]. The AHP method was used in a way described in detail in the next section. The 'ahp' package designed by C. Glur [17] was used in RStudio software to implement the AHP method and develop the dynamic framework for startup evaluation.

Criteria and sub-criteria for the decision-making framework for assessing the market potential and success of innovative startups were selected based on the analysis of numerous sources of scientific and professional literature, interviews with startup founders and investors, as well as their explanations of the reasons for failure on resources such as the CB Insights platform [3].

Results and discussion. The new dynamic decision-making framework for evaluating the market potential and success of innovative startups throughout their lifecycle was developed on the basis of T. L. Saaty's analytic hierarchy process using the 'ahp' package in R in order to give stakeholders data-driven advice regarding continuing startup project development and financing.

The developed framework takes into account the market, marketing and investment attractiveness of startups. The corresponding hierarchy was created on the basis of the set of criteria identified for each of the components of startups attractiveness mentioned above (Fig. 2). As can be seen from Fig. 2, at the end of the analysis one of the two alternatives is chosen based on expert opinions – to continue or stop the startup project development (SPD) taking into account all three groups of criteria. In Fig. 2 below $R_1...R_n$ stand for market attractiveness criteria; $M_1...M_n$ and $M_{1.1}...M_{n.m}$ – criteria and sub-criteria of marketing attractiveness; $I_1...I_n$ and $I_{1.1}...I_{n.m}$ – criteria and sub-criteria of investment attractiveness of a startup project.

An important aspect of the developed framework is that it is dynamic. Dynamic decision-making refers to the process of making decisions in an environment that is constantly changing or uncertain. This includes considering not only the current state of the system, but also how it might evolve in the future, and making decisions that can adapt to changing circumstances. By taking into account the changing nature of the system and adapting strategies accordingly, dynamic decision-making can help startups navigate uncertainty and achieve their goals.

The introduction and scaling of startups is a delayed process. Therefore, at various stages of the SAP, representing the life cycle of a startup, investors need to evaluate the feasibility of continuing to finance the project. At the same time, startup founders also need a tool to decide whether to spend more time and resources on a project.

The startup lifecycle can be considered in different ways depending on the scientific approach used, however, in our opinion, in order to evaluate a startup project and determine the feasibility of continuing its development and financing among these stages, it is better to highlight three key stages of the startup projects market implementation, which we also consider as stages of their lifecycle, namely:

– approbation stage – in general, it is characterized by the fact that funds are collected for the development of prototypes at the MVP level;

– capitalization stage – is characterized by increased competition between newly created startups for the fastest capitalization. At the same time, the startup that managed to capitalize first gets the opportunity to bring its own technological solution to the industrial implementation level and eventually to mass production;

– business scaling stage – is characterized by directing efforts and resources to consolidation, expansion to the whole market along with achieving the effects of experience and scale, which

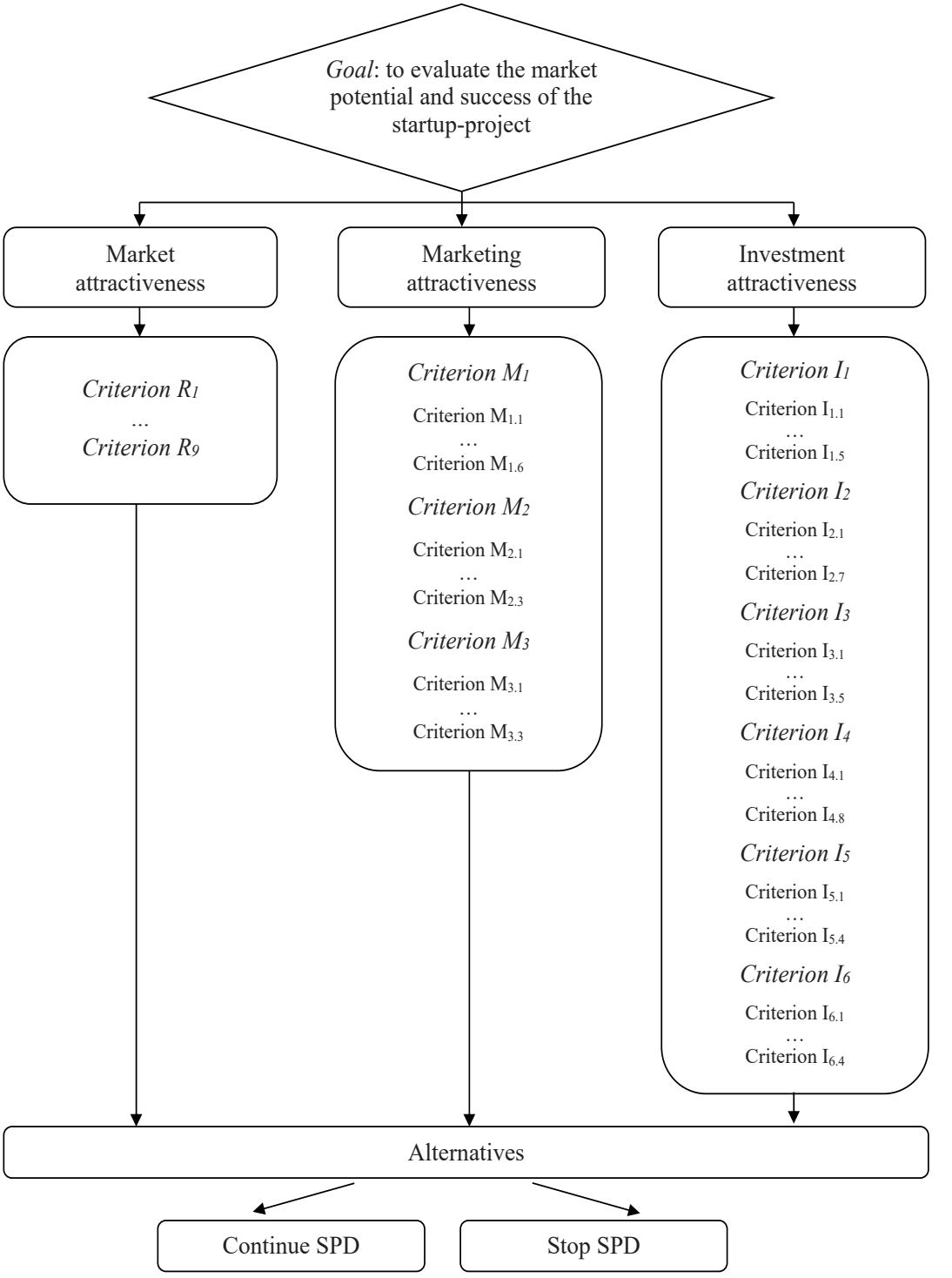


Fig. 2. Hierarchical system of the framework criteria for evaluating the market potential and success of innovative startups throughout their entire lifecycle
Source: Developed by authors

provides an opportunity to reduce the cost of the final product and to expand market share.

The 'ahp' package implemented through the RStudio software complex, allows the creation of new software products based on T. L. Saaty's analytic hierarchy process for solving specific tasks. The created software products can be reused later an unlimited number of times.

The developed framework can be applied to the analysis of any startup project by assigning the appropriate degrees of preference by different groups of experts. Degrees of preference refer to the relative importance or priority of different criteria or alternatives in a decision-making process. These degrees of preference are expressed through pairwise comparisons, where the decision-maker expert assesses the relative importance of each pair of criteria or alternatives on a numerical scale.

In the study, the degree of preference was determined according to the classical fundamental scale of absolute numbers ranging from 1 to 9 points, which is used to assess the strength of expert judgments. According to this scale, if the degree of preference is 1 point, then the two alternatives are equally preferable. If the degree of preference is 9 points, then there is an absolute predominance of the alternative or criterion 'A' over 'B'. Intermediate values are used to indicate the degree of relative importance between the two elements being compared [16].

Once pairwise comparisons have been made for all relevant criteria or alternatives, the 'ahp' uses mathematical calculations to derive a set of weights or priorities for each criterion or alternative. These weights reflect the degrees of preference expressed in the pairwise comparisons and are used to guide the final decision – continue or stop SPD, which means that the particular startup project has high success rates and market potential.

The proposed methodology is based on the opinions of five experts groups:

– Scientific Specialists (Group #1) – specialists in the field of innovative entrepreneurship, innovative marketing, innovation management having significant scientific experience and practical skills in the context of the implementation of any innovative projects, including startup development;

– Investors Representatives (Group #2) – business angels; investment funds specialists; venture investors; experts in the banking sector; persons engaged in investing on crowdfunding platforms, etc.;

– Manufacturers Representatives (Group #3) – specialists in the sphere of production of scientific and technical products, including those in various scientific organizations, science parks, private entrepreneurs, etc.;

– Practicing Startup Entrepreneurs (Group #4) – persons who are engaged in or were engaged in the implementation of startups, especially high-tech projects in the scientific-technical area;

– Business Incubators & Startup Accelerators Representatives (Group #5) – qualified persons, including mentors with experience in startup incubators and accelerators or cooperate with them.

So, according to Fig. 2, the representatives of each group of experts first determine the degrees of preference between the criteria and sub-criteria of each of the three components of startup attractiveness – first according to the criteria of market attractiveness $R_1...R_n$, then according to the criteria and sub-criteria of marketing attractiveness $M_1...M_n$ and $M_{1.1}...M_{n.m}$, and after that – according to the criteria and sub-criteria of investment attractiveness $I_1...I_n$ and $I_{1.1}...I_{n.m}$.

According to the given criteria and sub-criteria, degrees of preference between two alternatives are determined – to continue the SPD or to stop the SPD. After that, the degrees of preference determined by experts should be entered into the developed software product based on the 'ahp' package, and further calculations are carried out using RStudio. An example of the application of the framework is shown in Fig. 3.

Fig. 4 shows the hierarchical system of criteria for evaluating the market attractiveness of the startup project, which is a component of the complex hierarchy presented in Fig. 2.

Fig. 5 shows the hierarchical system of criteria proposed for evaluating the marketing attractiveness of innovative startup projects. In turn, Fig. 6 and Fig. 7 show the hierarchical system of criteria proposed for evaluating the investment attractiveness of innovative startups. Infrastructural support mentioned in Fig. 7 refers to startup and business incubators, accelerators, science parks, tech hubs, etc.

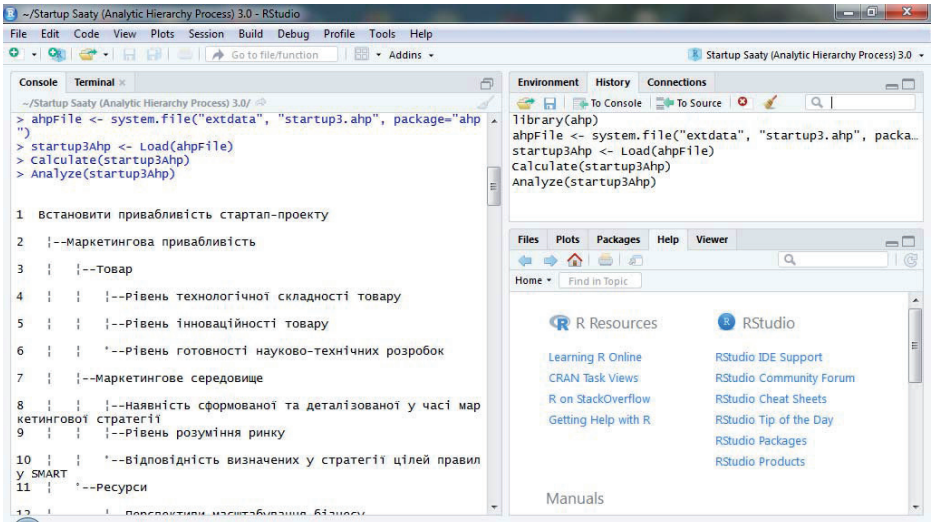


Fig. 3. Example of the application of the dynamic decision-making framework for evaluating the market potential and success rates of startups using AHP & R

Source: Programmed by authors

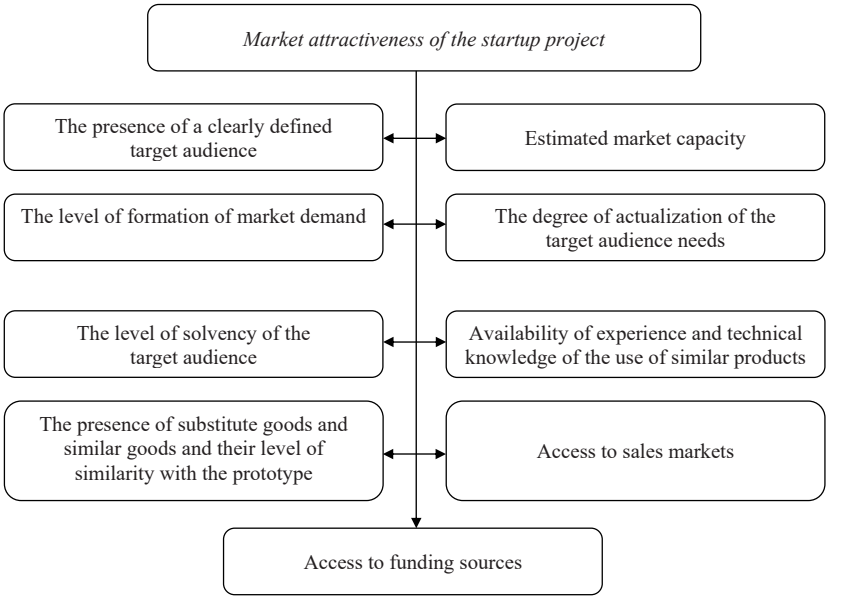


Fig. 4. Hierarchical system of criteria for evaluating the market attractiveness of the innovative startup project

Source: Developed by authors

An example of the output of calculation results in RStudio in the tabular form is shown in Fig. 8. As can be seen from Fig. 8, the result is represented as a percentage for each of the alternatives and for each criterion and sub-criterion. At the same time, the results are automatically structured from a bigger value to a smaller one, depending on the weight parameter, which is displayed in the second column. The analysis process and results shown in Fig. 3 and Fig. 8 are presented in Ukrainian because they have been conducted for the Ukrainian startup, but depending on the situation, the criteria names can be presented in another language, including English.

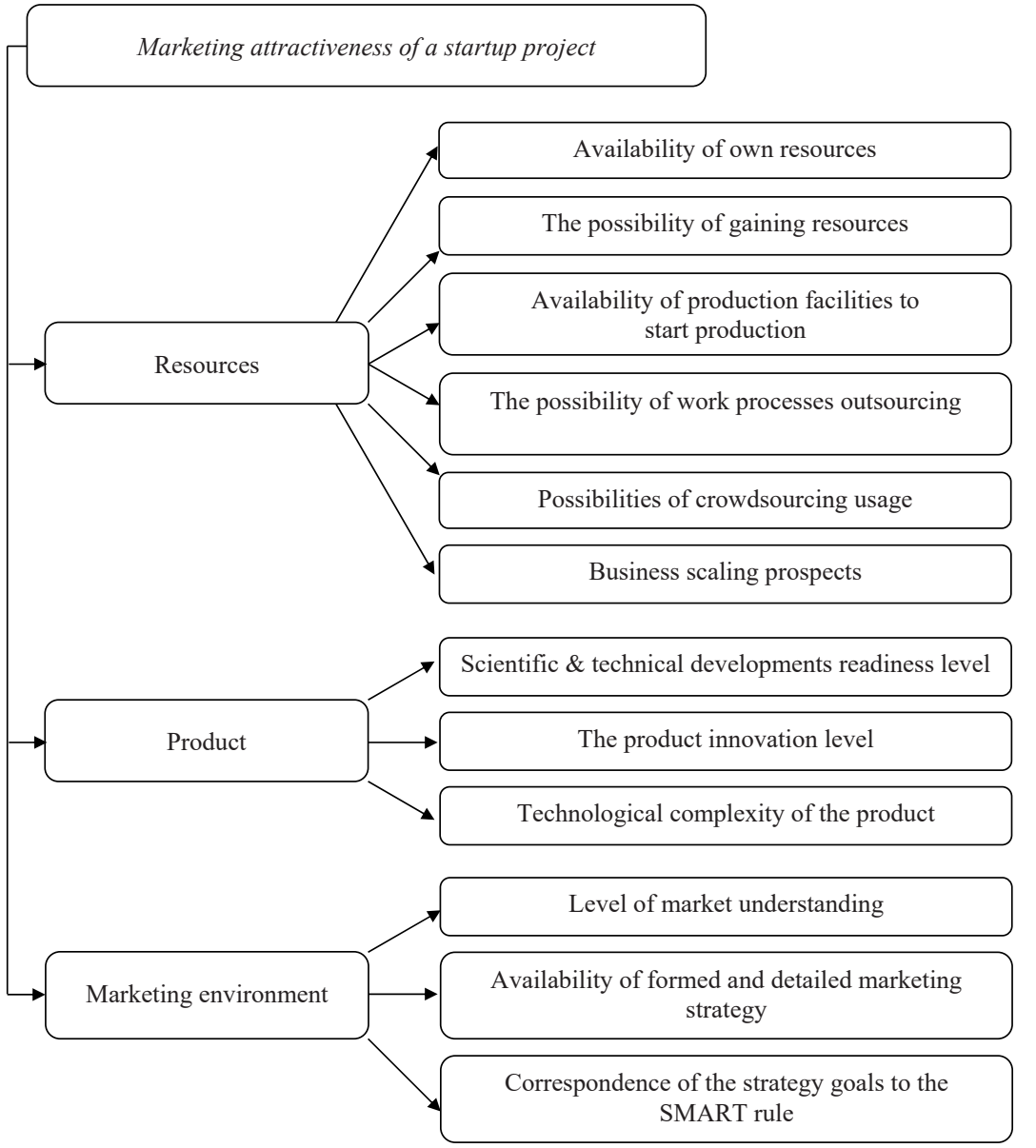


Fig. 5. Hierarchical system of criteria for evaluating the marketing attractiveness of a startup project
Source: Developed by authors

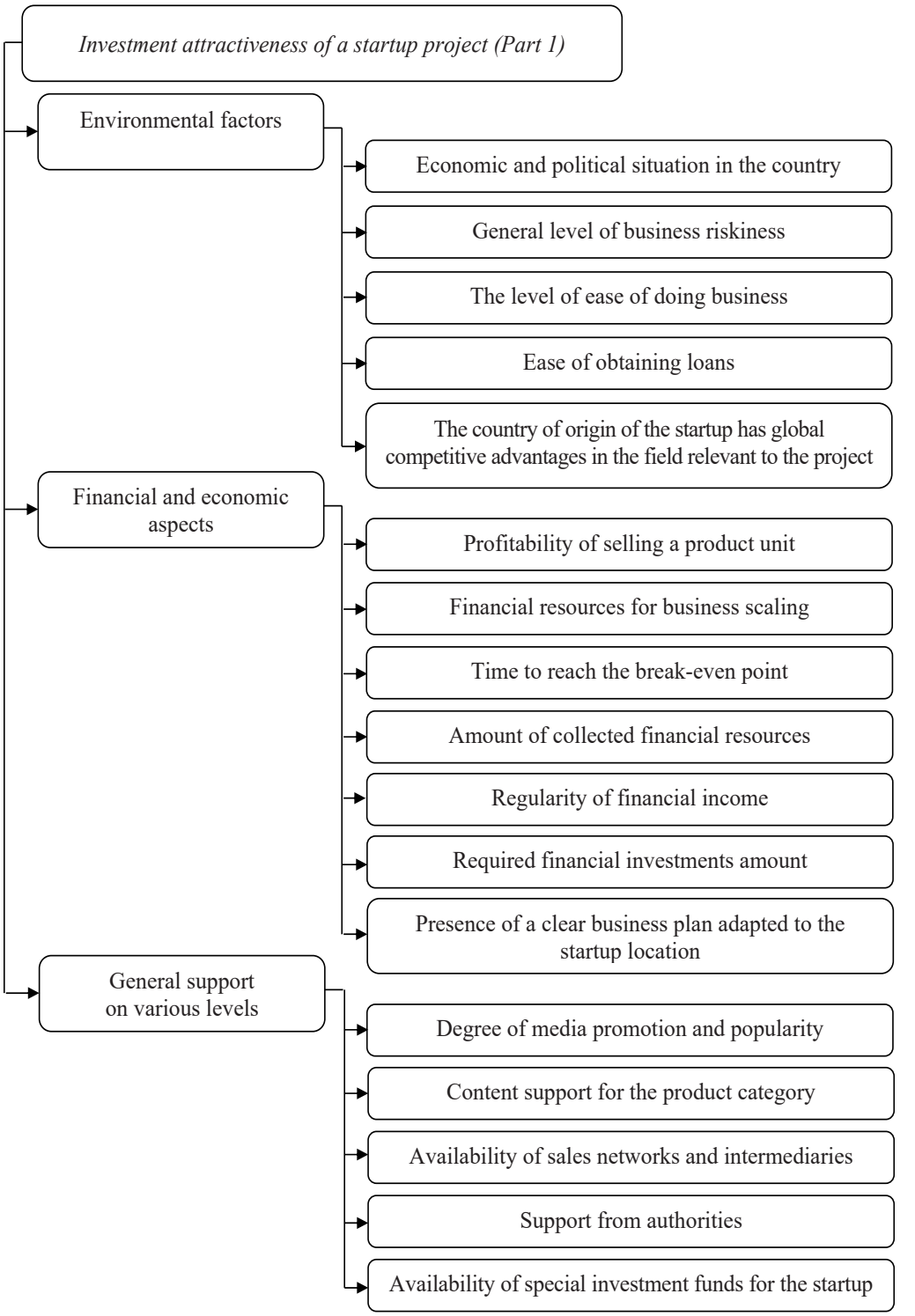


Fig. 6. Hierarchical system of criteria for evaluating the investment attractiveness of a startup project (Part 1)
Source: Developed by authors

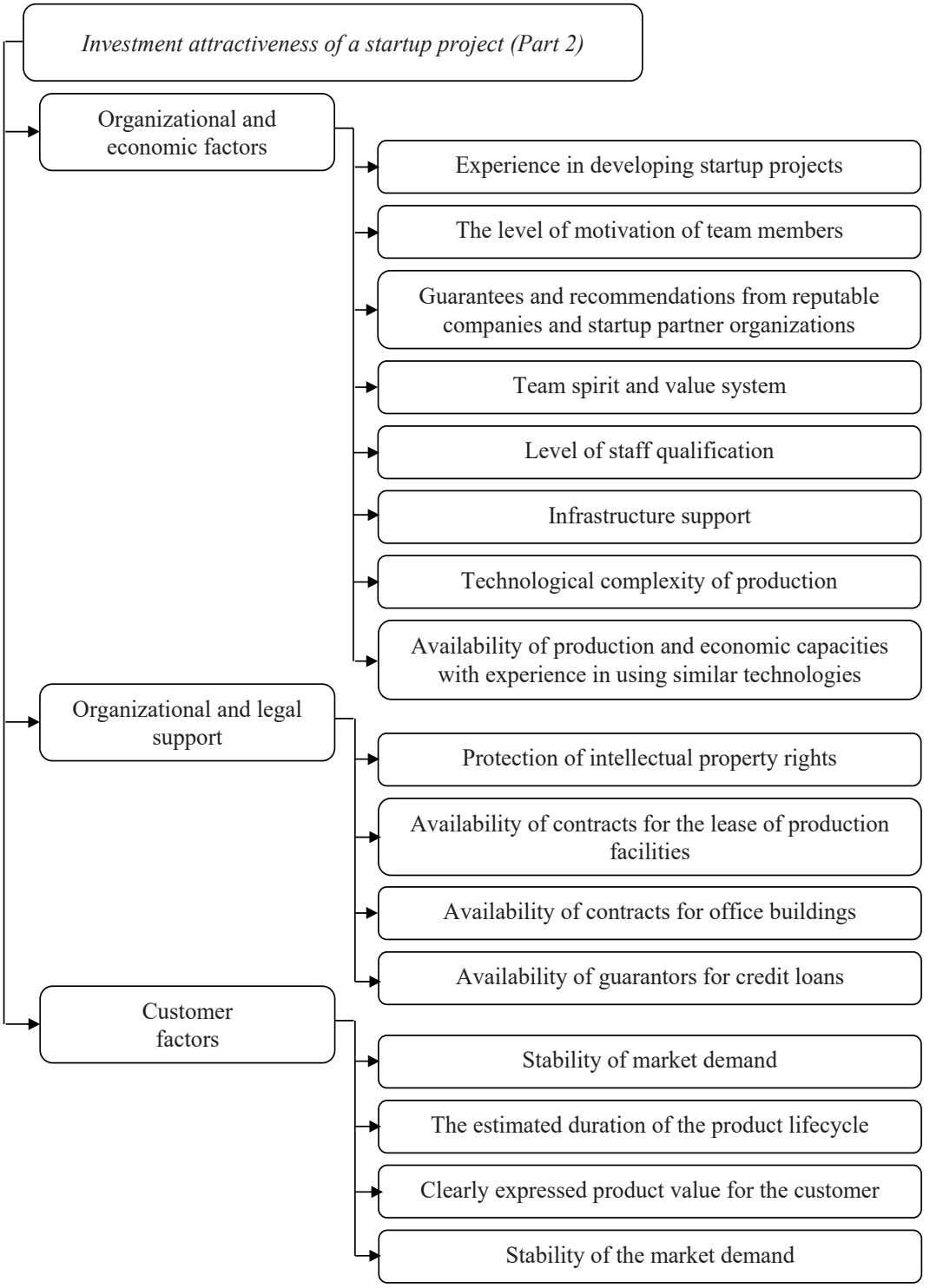
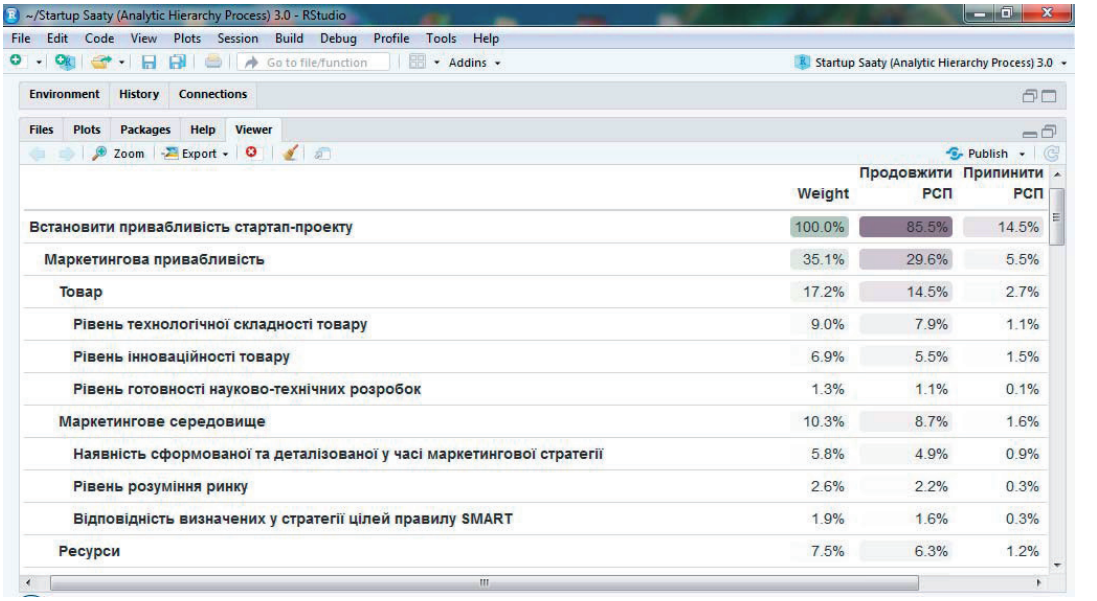


Fig. 7. Hierarchical system of criteria for evaluating the investment attractiveness of a startup project (Part 2)
Source: Developed by authors



	Weight	Продовжити РСП	Припинити РСП
Встановити привабливість стартап-проекту	100.0%	85.5%	14.5%
Маркетингова привабливість	35.1%	29.6%	5.5%
Товар	17.2%	14.5%	2.7%
Рівень технологічної складності товару	9.0%	7.9%	1.1%
Рівень інноваційності товару	6.9%	5.5%	1.5%
Рівень готовності науково-технічних розробок	1.3%	1.1%	0.1%
Маркетингове середовище	10.3%	8.7%	1.6%
Наявність сформованої та деталізованої у часі маркетингової стратегії	5.8%	4.9%	0.9%
Рівень розуміння ринку	2.6%	2.2%	0.3%
Відповідність визначених у стратегії цілей правилу SMART	1.9%	1.6%	0.3%
Ресурси	7.5%	6.3%	1.2%

Fig. 8. Example of the AHP calculation results for evaluating the market potential and success of the startup project in RStudio
Source: Calculated by authors

According to the example in Fig. 8, first of all, the alternative with the highest weight is determined, which is placed in the first column among all alternatives. After that, the component of the attractiveness of the startup with the highest weight is placed on the top level, and then a similar ranging takes place according to each criterion and sub-criterion of this component. The following two components of the attractiveness of a startup are similarly placed. This makes it possible to establish which criteria and sub-criteria experts consider most influential in the context of a particular startup.

So, in our opinion, today especially interesting and socially important are startups prioritizing sustainable development, environmental protection, decarbonization, circular economy, natural resources conservation, energy efficiency and energy supply diversification, urban resilience. Therefore, one of the ways we propose to implement this framework is to promote the development and scaling of such startups to achieve positive social and economic transformation.

Our previous studies, in particular [6], show that the start-up development industry and the associated academic innovation infrastructure have become a significant source of solving various social and environmental problems. Scientific research leads to the emergence of a large number of start-up projects, which, in turn, contribute to the further development of scientific research, creating a cycle of positive changes. Thus, both science and start-ups are extremely important tools for solving environmental and social problems, achieving sustainable development goals, for example, by modeling and mitigating the effects of air pollution [18], developing green and eco-mining technologies [19, 20] , smart city benefits [21], etc.

Conclusions. It was determined that innovative startups and entrepreneurs play a vital role in driving economic growth, creating jobs, and improving overall humanity's well-being. Therfore, it is important to create tools for fostering startup development. Over the last decades, the quantity and quality of startups have grown significantly, but the risks of their development are still very high.

As a result, a dynamic decision-making framework was proposed to assess the market potential and success of innovative

start-ups throughout their entire life cycle. A framework based on the marketing research approach, T. L. Saaty's analytical hierarchy process, was developed as a software component in RStudio using R. In accordance with the objectives of the study, it was proposed to divide the startup life cycle into three main stages - approbation, capitalization, and business scaling.

To implement the AHP approach pre-selected experts were devided into five groups – scientific specialists, investors representatives, manufacturers representatives, practicing startup entrepreneurs, business incubators & startup accelerators representatives. Expert groups determine the degrees of preference between the criteria substantiated in the study and subcriteria of each of the three components of startup attractiveness. These three components are the market, marketing, and investment attractiveness of the startup.

The developed framework can be used by startup founders, investors and other stakeholders in order to reduce the losses of financial and other types of resources and choose the most viable ideas and projects.

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DYNAMIC DECISION-MAKING FRAMEWORK FOR EVALUATING THE MARKET POTENTIAL AND SUCCESS OF INNOVATIVE STARTUPS ON THE BASIS OF A MARKETING RESEARCH APPROACH USING R

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Currently, the world is highly dependent on technological advancements and innovations (TAI) being the key driver of economic growth, competitiveness, and overall societal progress. And high-tech

startups are at the forefront of TAI, developing new products and services that meet the growing needs of consumers. Over the past decades, the quantity and quality of startups have increased significantly, however, they are still known for high risks and low success rates, which often lead to financial losses for investors and startup founders.

Therefore, the aim of the study was to develop a dynamic decision-making framework for evaluating the market potential and success rates of innovative startups throughout their lifecycle on the basis of a marketing research approach using R programming language to provide a unique solution for startup founders, investors, business incubators, startup accelerators, tech hubs, etc.

As a result, a new methodology for evaluating the market potential and success rates of innovative startups was proposed based on T. L. Saaty's analytic hierarchy process (AHP) methodology. Taking into account the fact that AHP is based on expert opinions, it was proposed to divide experts into five groups – scientific specialists, investors representatives, manufacturers representatives, practicing startup entrepreneurs, business incubators & startup accelerators representatives. Each group of experts determined the degrees of preference between the proposed criteria and sub-criteria of each of the three components of startup attractiveness – market, marketing and investment attractiveness of the startup project. The decision-making framework was created and tested in the RStudio software environment based on the 'ahp' package and can be used by startup founders, investors, and other stakeholders on a regular basis as new information about their projects becomes available.

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