Improving the impact of innovation and technology centres on the performance of university-based start-ups

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Abstract: The research determined the influence of innovation and technology centres on the effectiveness of university-based start-ups. What affects the productivity of implementing university start-ups' developments have been found. In the empirical part of the study, 140 start-ups were surveyed. The study's results identified the critical functions of innovation and technology centres and their relationship with university-based start-ups. Recommendations have been developed for improving university start-ups' movements, and a mechanism for their work has been proposed. Using cluster analysis procedures, their problems have been analysed, the primary role of marketing as an essential tool in the commercialisation process is identified, and recommendations on the need for marketing by companies at the early stages of development wishing to commercialise results are developed. The practical value of the research results lies in developing a conceptual marketing system as a unique approach for improving the activities of start-ups and the productivity of implementing the developments.

Keywords: innovation and technology centres; ITC; start-ups; universities; commercialisation innovation product; marketing approach.

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1 Introduction

In practice, services for start-ups and innovative companies are distinguished as integral elements of the innovation ecosystem.

A vital element of the innovation infrastructure and ecosystem in various countries are innovation and technology centres (ITC), which, in current practice, are understood as organisations that not only ensure the optimal functioning and development of subjects of innovation activity but also promote the commercialisation of the results of their scientific and technical activities. Within the framework of this study, 'ITC' will be understood as organisations that provide various services that contribute to implementing innovative projects and developing innovative companies. The main goal of creating ITC in all countries is to preserve and develop scientific and technical potential, primarily by providing high-tech enterprises with opportunities to use research and production facilities that have passed the initial stage and are in the development stage. For example, the active processes of integration and globalisation in the global economic space set the pace of development of the entire world community, including Russia and Iran, which today are focused on building a new financial system based on the use of the latest knowledge and technologies (Nasser et al., 2020). The success of the innovative development of countries lies in the activation of innovation and investment activities in their regions. The level of participation of each country in infrastructure development varies from direct and comprehensive (city-country Singapore) to moderate (Amry et al., 2021). 'Technology transfer is the process by which science and technology developed at universities are transferred to companies for technical, scientific and economic development. According to Lopez-Mendoza and Mauricio (2021), the most important

success factors are adaptation to changes, government policy, criteria for selecting a portfolio of projects, the work environment, product satisfaction and how they affect success in three dimensions – scientific, social and financial'.

In European cities, the role of private and international businesses and universities is excellent. Most systematically, cities support the development of ITC, co-working, and urban scientific laboratories (Baran and Zhumabaeva, 2018; Cooper and Vlaskovits, 2010). It is essential for the founders and managers of start-up companies created both based on universities and in general to see how their project or development becomes a reality. The ideal model for developing such a business is displayed in the form of potential investors lined up, the presence of the best and highly qualified personnel capable of creative thinking, and an ever-growing flow of new buyers. However, as the practice has shown, speaking about the very first and essential support provided by ITC in the fundamental commercialisation of scientific results, there needs to be more balance between market requirements and the commercialisation of new products based on technology. As most start-ups are created by young entrepreneurs studying in a university or recently graduated students, universities have become important (Crick et al., 2020).

Moreover, universities are considered potential talent pools in which potential co-founders are identified. Start-up workshops, events and competitions are generally arranged in universities (Gray et al., 2022). Typically, start-up teams include a talent pool of university graduates, and then what these individuals learn in universities becomes more critical. The results of the research conducted by the author Ebrahimi (2023) showed that "as strategies for small and medium enterprises (SMEs), organisations, for example, universities, should create alliances, such as joint ventures or mutual investment corporations, implement effective mechanisms for collecting and using knowledge and experience, as well as provide their clients, huge and profitable, with a variety of services".

This is due to a need for more marketing or strong marketing. If we talk about various start-up support centres, such as ITC and commercialisation promotion centres, then, for the most part, they need to provide such essential and primary services as marketing. Due to the current absence of this service in the list of ITC start-up support, the impact of marketing risks on the start-up development process, and the fact that scientists poorly study this issue, our research topic is relevant.

Due to the lack of marketing and scientific teams, scientists in most start-ups initially do not think about the needs of customers and the search for a market niche. They want to realise their idea and solve the most important scientific problems. The absence of such studies forms the basis for this study: 'to gain a better understanding of the influence of ITC on the effectiveness of university start-ups and improve it'.

2 Literature review

Innovations occupy a vital place in the activities of ITC. It is easy to imagine a modern person's life with the use of innovations. Innovations develop rapidly; there is a constant process of updating them in all spheres of life.

Speaking about the history of innovation centres' the effectiveness of the activities of the ITC has predetermined their demand in the scientific market. Today, more than half of the ITC is being created as an element of the innovation infrastructure of universities. The main field is commercialising technologies, other inventions, and industrial property

objects that can serve as intermediaries between the creators. Scientists and consumers of an innovative product/technology provide a whole range of services, in particular, not only patent-legal but also related to traditional business-services. According to researchers (Lopez-Mendoza and Mauricio, 2021), "Technology transfer is a tool for the development of society, and its success is influenced by such factors as adaptation to changes, public policy, working environment, product satisfaction, ethics). They affect all stages of the technology transfer process from university to industry". Regarding the situation in some countries, for example, to implement the program of State Support for Small Businesses and Innovation in the Russian Federation, the Union of ITC of Russia was created. About 45% of the ITC has been created at universities, often based on already operating technoparks.

There is high activity in studying the problems of the formation and functioning of ITCs worldwide by various scientific researchers. Innovation centres are designed to bring the results of scientific research to the market. Exploring and exploiting potential opportunities for ITC is critical to firm performance (Hamilton and Philbin, 2020; Lyken-Segosebe et al., 2020). ITC contribute to the formal technology transfer mechanism through administrative and infrastructural mechanisms, such as cooperation contracts, licensing, and legal agreements between interested partners (Hamilton and Philbin, 2020). Such centres promote the development of informal technologies and knowledge transfer between partners (Muhamedjanova and Kurpayanidi, 2020), for example, through exhibitions, thematic meetings, and seminars. The results of the research conducted by the author (Ebrahimi, 2023) showed that "as strategies for small and medium enterprises (SMEs), organisations, for example, universities, should create alliances". "It might be joint ventures or mutual investment corporations, implement effective mechanisms for collecting and using knowledge and experience, as well as provide their clients, extensive and profitable, with a variety of services". "The most important reasons (Tajpour et al., 2022) where SMEs management is dealing with the following difficulties in developing countries such as Iran: little creativity and knowledge sharing, the inappropriate hierarchical and governmental structure, the lack of a comprehensive business model, the low level of hardware and software technology, and, finally, the inadequate support from the government". According to the conducted research by authors (Le-Anh et al., 2022), "human resources and networking have a positive impact on innovations and the important role of intra-organisational prerequisites for establishing links between senior management support, network involvement and management innovation".

By the above and based on experts' opinions, this research is about the importance and necessity of the ITC's existence as a primary element in ensuring the country's economic growth and innovative development. This is due to the activation of innovation activities that significantly contribute to the involvement in the financial turnover of the results of research, technical and innovative activities of companies and universities, and, as a result, strengthening regional and international positions in the market of high-tech products and services. Integrating the creative activity of higher education into the innovative potential of any country, as well as market and public institutions, will ensure progress in creating the results of innovative activity and the efficiency of use by universities and regions and the country as a whole.

One of the elements of regional innovation systems in all countries is universities. They are considered a critical link in the triple helix of innovation as a source and

constant generator of creation. The innovation infrastructure of universities is, in turn, part of the innovation infrastructure of regional innovation systems.

An innovative economy based on the flow of knowledge, continuous technological improvement, production, and export of high-tech products with very high added value is recognised as a promising development concept. In this case, profit mainly creates the intelligence of innovators and scientists, not material production and concentration of capital. Salamzadeh (2018) concluded that "as most start-ups are created by young entrepreneurs studying in a university or recently graduated students, universities become so important. Moreover, universities are considered potential talent pools in which potential co-founders are identified. Normally, start-up teams include a talent pool of university graduates, then what these individuals learn in universities becomes more important".

The experience of developed countries (USA, Germany, Japan, China, etc.) shows that the strategic economic growth model is intensive research and development of high-tech products based on them with different outputs to international markets (Lyken-Segosebe et al., 2020). The exploration of potential opportunities by Wolfe and Hepburn (2014) about the Fraunhofer-Gesellschaft as ITC. It is a critical partner in Germany's innovation ecosystem. "The core function of it is to conduct application and results-oriented research activities that will generate technological innovations and new systems solutions for the benefit of private and public sector contractual partners. Based on the five services rendered, the primary objective of the Fraunhofer is to promote economic development, international competitiveness, and social welfare while ensuring that the innovations produced are ethically sound and environmentally compatible. Over the past 65 years, the Fraunhofer-Gesellschaft ITC has significantly advanced the global innovation frontier and brought to market a range of technology-based products, processes and services that have benefitted communities worldwide". Goddard et al. (2012) has found that "German and UK counterparts, the American ITC model currently have a low global profile. The USA's experiences are all of the small innovation companies located in the USA and led by institutions in the USA. However, as the ITC develops, it is expected to link and leverage all available resources to have a national and global impact. Indeed, one of the core missions of the ITC is to enhance American industrial competitiveness on a regional, national and global level". He stated that "the German, UK and American models all have a similar decentralised organisational structure that provides their centres with the autonomy necessary to develop innovations in highly-specialised areas of focus. More start-up companies than large, peaceful, and stable nations like Japan, China, India, Korea, Canada, and the UK. It has the highest density of tech start-ups in the world". Hideyuki (2019) in the research found that Japan' ITC is focused on 'consolidating innovation infrastructure by doubling the number of new start-ups and creating university spin-offs, reform of universities and technology transfer from academia to industry'. By the Ranga et al. (2017) "there are increasing investment and ITC in strategic areas such as the environment, biotechnology, data transmission, nanotechnology and materials; implementing a support programme for venture businesses; promoting the formation of industrial clusters; and building local human networks". For China (Wenzhong, 2022), the science and technology innovation centre is vital in transforming economic development and enhancing industrial competitiveness. The formation and development of a science and technology innovation centre depend on gathering innovative talents, the support of first-rate universities and

research institutions, and cooperation and mutual promotion between innovation organisations and enterprises.

The specifics of innovative products explain the need to include marketing structures in the innovation infrastructure: innovative products, as a rule, are new and unknown to a wide range of consumers, require massive advertising, protection of intellectual property rights; organisations responsible for training and retraining personnel for innovation in a market economy and providing at all stages of the creation of a scientific and technical product (Nwakanma et al., 2007). Thus, a study that Ebrahimi et al. (2022) conducted showed that commercialisation centres in scientific organisations and innovative start-up companies still need more market and marketing research, especially during the crisis period, more than ever before. An ITC is a structural and functional element of a university, which, as a rule, has the status of a legal entity, created to provide the necessary services to small and medium-sized businesses, with a strategic goal of facilitating the integration of education, science and the real sector of the economy. This definition reflects the affiliation of the ITC to the innovation infrastructure of the university, which, in our opinion, is an essential aspect since it is the university and its structural and functional elements of innovation that produce not only qualified personnel, new knowledge, but also new technologies, innovative developments, which will later acquire a material form and become an innovative product.

The tasks of ITC are also defined in different ways. In addition to providing a standard set of services, as well as a set of services to ensure innovation and economic activity, they may be required to represent and protect the interests of innovation entities located on their territory in public authorities, carry out joint research with firms, train students, organise and finance new commercial companies at the formation stage. There needs to be a clear opinion on the standard set of services that ITC should provide to create the most favourable conditions for participants in innovation processes within their competencies.

In this study, we contribute to the scholarly conversation on learning from failure and the implications of the mistakes of services that provide ITC by exploring the contextual factors that help explain the link between commercialisation and the importance of marketing services, for example.

The in-depth research of Sukhanova has identified the cognition underlying studying the impact of ITC on university-based start-ups and how to improve their performance. According to research conducted by Sukhanova (2013) on the example of three national research universities of the Russian Federation: Perm National Research University (PSNIU), Perm National Research Polytechnic University (PNRPU), Tomsk State National Research University (TGNU). The various configurations of the innovation infrastructure were compared, such as the activities of the ITC. Analysis of existing innovative infrastructures, particularly ITC, showed standard features, many differences in their functions, and the need for infrastructure elements responsible for developing entrepreneurial abilities and stimulating entrepreneurial activity. So, in particular, considering the four elements of infrastructure and their functions in the main areas of the university's innovation infrastructure, it was noticed that one of the first and most important is the stimulation of research. The functions of this infrastructure element called the 'R&D Marketing Department' should be marketing research to study the market niche and identify market segments, analyse potential sales markets and buyers and their preferences, and stimulate research on business orders (Sukhanova, 2013).

This finding is likely relevant in our analysis, where conclusions and theorising offer an initial step in this direction. In doing so, we contribute to learning from failure and project termination literature.

Finally, we contribute to appraisal theory by considering the role of prior failure contributing ideas by considering the main motives for joining ITC for small enterprises: the opportunities to get premises for production, office services, and information services. The lowest rating (or lack thereof) has such ITC, where such assistance as marketing, protecting intellectual property rights, and certification of products is carried out. Thus, what should be the main thing in the work of the ITC still needs to be such, and the main attractive factor for entering the ITC is only favourable rental conditions. The lack of marketing services subsequently negatively affects the creation of a product that will not be in demand on the market and will lead to the failure of the start-up.

3 Methodology of research

3.1 Research questions and research scope

As practice has shown, there are immediate adverse problems associated with the very first and vital type of support and service of ITC based on universities, provided by them in the actual process of commercialisation of the results of scientific activity. This may impact the imbalance between market requirements and the commercialisation of new products based on developments or technologies created by universities by start-ups. Also, the services provided by ITC and their services directly impact the effectiveness of university start-ups.

The critical initiators of the ITC founding are universities and scientific organisations.

The target audience of users of ITC services is research teams, scientists, and start-ups.

Start-ups are the primary users of the services of ITC and their services. So, for example, due to the need for some services (for example, marketing), many ITC, scientific teams, and scientists in most start-ups at the start need to think about the needs of customers and the search for a market niche. They want to realise their idea and solve the most important scientific problems. This shows the significance of this study. The absence of such studies forms the basis for this study: ‘to gain a better understanding of the process of influence of ITC on the effectiveness of university start-ups and improve it’.

The scope of this study is limited to a set of 140 start-ups – residents of business incubators and technology parks in Russia and Iran, who will be contacted using their university e-mail accounts. This recruitment period will last a maximum of two quarters or six months and end when either 140 volunteer respondents have been recruited or six months have ended. Each respondent representative of a research start-up will be asked to fill out a short questionnaire to assess the main reasons for the failure of commercialisation of development/technology specifically in their company through the opinions of representatives of start-ups who made decisions based on their subjective, individual assessment. This will allow us to understand how it is possible to change the service provided by ITC by start-ups and assess the process of their influence to improve it and increase the efficiency of university start-ups.

As for the limitations on the scope of the study, the main ones are:

1 The sample size and/or the timing of recruiting volunteer respondents.

2 Restrictions on the category of respondents, opening the recruitment only to people with a university e-mail, i.e., anyone who does not attend university will be excluded from this study.

3 The respondent must necessarily be an employee of a start-up organised based on a university; any start-up not created based on a university and a technopark will be excluded from this study.

4 The respondent must necessarily be an employee of an innovative product or technology; that is, any participant in the survey who does not have an innovative product or technology will be excluded from this study.

This can be an essential factor in interpreting the results of this study; therefore, a comparison between those who conduct research and create developments and technologies based on the university and those who work with innovative products outside it is beyond the scope of this study. We are also told that the methodology used to evaluate any changes is carried out using a questionnaire. This is a clear definition of how the measure of the result will be investigated, and any other methods are not within the scope of the study. Their exclusion may be a limitation of the study.

3.2 Data collection

This study was conducted to identify the problems and obstacles faced by start-ups in the implementation process at all stages of the life cycle of an innovative product, to improve the activities of ITC, and to increase the efficiency of university start-ups. One of the most effective methods and ways to identify and assess problems is using questionnaire-based surveys.

The essence of the survey methodology lies in that the researcher (interviewer) asks the respondents (interviewees) various questions directly or indirectly, to which the latter should give answers. As a rule, a specific group of citizens acts as respondents who represent the market's target audience. This study's interviews focused on a predetermined set of discussion questions.

The clarity and professional readiness of the questions determine the reliability of the information obtained during the survey of respondents. The questionnaires were used for conducting surveys or interviewing.

Surveying by the questionnaire method assumes that respondents answer the questions of the questionnaire proposed to them. At the same time, filling out questionnaires is possible both in the absence of the interviewer and in his presence, in a group or alone with the researcher. In recent years, unique survey methods have been increasingly being used with the development of Internet technologies. These include interactive and Internet surveys. In our study, we used an online survey.

The interview guide was prepared based on the following:

- To assess the reasons for the failure of commercialisation of the development/ technology, according to respondents as the most 'important'.

The following reasons were proposed, based on previous studies and surveys, where it was possible to identify the most popular reasons for the failure of commercialisation of development/technology.

Figure 1 The survey respondents, as the main ones in the work of small innovative enterprises, identified problems (see online version for colours)

№1	№2	№3	№4
Introduction of products to the market at wrong time	Strong competition	Lack of an optimal business model	Incorrect pricing policy
№5	**№6**	**№7**	**№8**
Unprofessional team, lack of specialists	Lack of a market where they can sell their product	Lack of demand for the product or technology	No market testing and no customer feedback
№9	**№10**	**№11**	**№12**
Lack of funding or investment	Poor marketing, the application of an ineffective marketing concept	Regulatory gaps	Problems with the management and resources of the company
№13	**№ 14**	**№15**	
Product sales did not meet expectations	Disagreements with investors/ founders	Technical or production problems	

Source: Own source

The data collected using questionnaires allowed for an initial statistical check of the differences in values.

3.3 Data analysis and measurement

This study was carried out to deal with several concepts related to the attitudes, perceptions, beliefs, and opinions of entrepreneurs regarding the problems associated with the process of launching an innovative product on the market, such as 'reasons for the failure of commercialisation of development/technology'.

In this section, the research aims to describe the samples using the characteristics of start-ups created based on universities and scientists-innovators using the specification of start-ups created based on universities and scientists-innovators. In this regard, their responses to the questionnaire are taken into account. The general information provided in the questionnaire covers 15 questions (Figure 1). These 15 questions were used when compiling the survey. Why did we choose these questions? Similar studies were carried out in various analytical and marketing agencies that conducted such surveys:

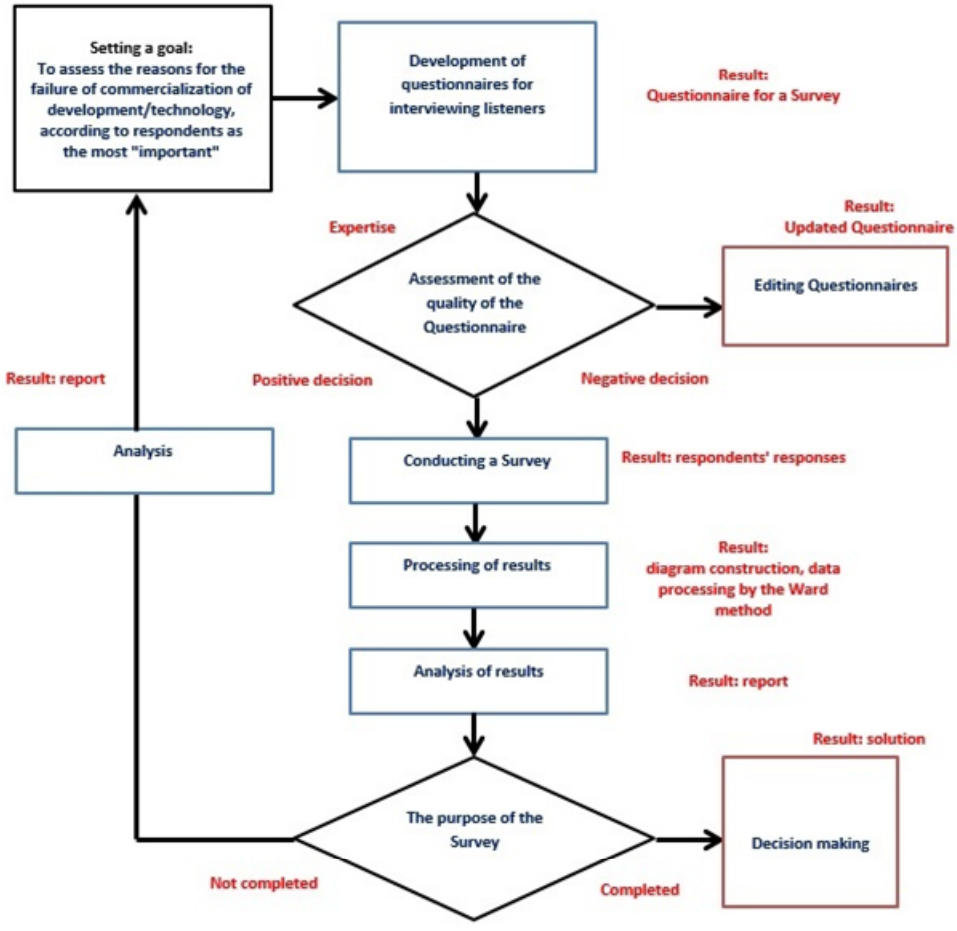
The selection and ensuring of the validity of the questionnaire questions take place by testing the listeners and after the listeners' answers. Figure 2 shows the algorithm of the process of conducting a survey of respondents participating in start-ups, which includes the following stages:

- setting the purpose of the questionnaire
- development of questionnaires for interviewing listeners
- checking the validity of the developed questionnaires
- reviewing of questionnaires
- conducting a survey

- processing of survey results; listeners
- analysis of the results of the audience survey
- analysis of verifying the fulfilment of the set goal
- adoption and approval of a management decision.

The purpose of the survey depends on the task: to assess the reasons for the failure of commercialisation of the development/technology, according to respondents as the most 'important'.

Figure 2 The algorithm of the process of conducting a survey of respondents (see online version for colours)



The development of questionnaires for the survey was carried out based on officially published data from well-known analytical and marketing agencies. A group of experts checking the validity of the questionnaire are successful innovators and doctors of

sciences who clearly understand the survey's goals. Evaluation and argumentation of the meaningful validity of questionnaires are mainly descriptive.

Why did we choose these questions in Figure 1? Similar studies were carried out in various analytical and marketing agencies that conducted such famous surveys:

- The study was commissioned by CB insights specialists (Lorenzo, 2020); based on the results of such a post-mortem analysis, 101 start-ups compiled their list of the 15 most common reasons that caused their commercial failure (in this ranking, higher places are occupied by the reasons that the authors of post mortems themselves most often called).

- The study was commissioned by researchers of the agency 'HighTechSrategies' (Rani, 2021), which surveyed 200 start-ups in which they were focused on finding the main reasons for the failures of young high-tech companies. The rating reflected the 15 most significant reasons for the loss of start-ups (Rani, 2021).

- The study was commissioned by the 'synoptic' academic analysis of the critical causes of failures of innovative projects presented in a theoretical review by Swiss researcher Jean-Philippe Deschamps, who wrote a particular chapter on 'classic root causes of innovation failures' in the significant monograph strategy and communication for innovation has been published in 2017 by Springer publishing house (Cantamessa et al., 2018).

The next step is to develop our research project based on the findings of defining the research paradigm, approach, and strategy. 'Research design is the logic that links the data to be collected (and the conclusion to be drawn) to the original research questions'. 'Research projects always address certain key issues, such as who will be studied, how these people will be selected, and what information will be collected from or about them'. Research design is the plan by which a strategy should be executed.

It defines methods and procedures for data collection, measurement, and analysis.

The reliability of the questionnaire is determined by measuring the distribution of listeners' responses to the questions asked. The criteria for the survey of listeners are given. The level of personal dissatisfaction with the problems with the commercialisation of development or technology is determined by combining the answers to the points to get a summary score for the respondent. The assessment then measures the respondents' 'intensity' regarding the concept. We used an interval scale (numbers: 1, 2, 3, 4 and 5), where respondents were asked to assess the severity of the corresponding trait or preference on a 15-point scale (to rank the answers according to the degree of importance), where 1 is the minimum significance, 15 is the maximum significance.

The Ward method was used to assess the reliability of the questionnaire indicators and data processing.

These questions relate to the problems arising in the company's activities and its external and internal environment and personnel. We are interested in innovative start-ups as an object of scientific research. Methods of descriptive statistics and correlation analysis were used to analyse the data. For a visual representation of correlations between the studied variables and their grouping, the SPSS Statistics program was used for cluster analysis.

Cluster analysis is a common name for a set of computational procedures used to create a classification. Cluster analysis is designed to divide the source data into

interpretable groups so that the elements in the same group are as 'similar' as possible while the components from different groups are as 'different' as possible. Cluster analysis is designed to divide the source data into interpretable groups so that the elements included in the same group are maximally 'similar' and the parts from different groups are maximally 'different'. K-means clustering method and hierarchical clustering are the most popular methods. When clustering by the K-means method, we are looking to divide a set of observations into a predefined number of clusters.

On the other hand, in hierarchical clustering, we are still determining how many clusters we want to get. The tree-like algorithm ends with a visual representation of observations called a dendrogram, which allows us to see the partitions obtained for each possible number of clusters, from 1 to n. Each of the approaches has its advantages and disadvantages.

Choosing an approach in hierarchical clustering is a way to calculate the distances between clusters. One of the main clustering methods is the Ward method. Methods of variance analysis are used here to estimate the distances between clusters. Its essence and advantage, among other things, is that two clusters are grouped during the integration process to ensure a minimal increase in the intra-group sum of squares of deviation.

As the distance between clusters, the increment of the sum of the squares of the distances of objects to the cluster centre obtained as a result of their union is taken:

$$\Delta = \sum_{i} (x_i - \overline{x})^2 - \sum_{x_i \in A} (x_i - \overline{a})^2 - \sum_{x_i \in B} (x_i - \overline{b})^2$$

where *A*, *B* clusters, a, b are cluster centres, x is the cluster object.

Two clusters are combined at each algorithm step, increasing the minimal variance. This method is used for tasks with closely spaced clusters.

The purpose of the algorithm in the K-means method is to minimise the sum of the squares of the intracluster distances to the cluster centre by the following formula:

$$V = \sum_{i=1}^{k} \sum_{x_i \in A} (x - \mu_i)^2$$

where k is the number of clusters, *Si* is the resulting clusters, $i = 1, 2, \ldots, k$, and μ_i are the centres of mass of all vectors x from the *Si* cluster.

The problems of the k-means algorithm include knowing the number of clusters and sensitivity to outliers in advance. Furthermore, the main advantages include the possibility of visual interpretation of clusters using a graph of 'average values in clusters'.

When analysing the results of sociological research (surveys), it is recommended to study the methods of the hierarchical agglomerative family. We have grouped the problematic factors that prevent start-ups from bringing a new product to market using hierarchical clustering. Visual inspection of the dendrogram helps understand the data structure, especially in the case of small sample sizes. Furthermore, to analyse the problems assessed by respondents, we use the k-means method with an assessment of cluster centres. Analysing the clusters' centres will allow us to evaluate the differences between the formed groups of problems.

One such method is Ward's method. Its essence and advantage, among other ways, are that the two clusters are grouped in the integration process to provide a minimal increase in the intra-group sum of squares of deviation.

Objects can be grouped by a hierarchical method using various distance functions. In the present paper, the function 'Euclidean distance' was used as the most commonly used measure for calculating the distance on the plane between points. The main result of hierarchical cluster analysis is a dendrogram – a graphical representation of the sequential clustering process carried out in the distance matrix.

Thus, it can be concluded that the resolution of the problem of the validity of measuring the reasons for the failure of commercialisation of development/technology, according to respondents, largely depends on the lack of the necessary type of service provided by the ITC, for example, consumer market analysis, marketing, etc. in natural conditions.

In different case studies, data collection may be based on other sources of evidence. In our case, a questionnaire is a survey that is an essential source of factual data since informed respondents can not only give important information about the situation but it makes it possible to collect a wide range of information on a more significant number of questions (Figure 1).

Since this study and survey were carried out by e-mailing an online questionnaire form developed by Google Forms, this service provides a tool for conducting surveys that any researcher can use at his discretion, for example, to complete a survey.

In the empirical part of the study, a survey is a form for receiving feedback. The invitation to fill out the questionnaire was sent to the respondent by e-mail. The survey was carried out by e-mailing an online questionnaire form developed by Google form, then transported to Google Docs, which was conducted from the 4th quarter of 2021 – to the 1st quarter of 2022. One hundred forty companies from the register of small innovative enterprises were selected by random sampling, where 100 are residents of the universities of BSTU named after V.G. Shukhov and Belgorod State University (BelSU), Russia, and 40 are residents of business incubators and Pardis Technology Park, Iran.

The data for this survey were collected in the main block of analysis. The survey focused on the opinions of entrepreneurs on various issues. The survey was conducted with a brief explanation of the purpose of the study and a brief description of it.

These questions are directly related to problems arising in the company's activities and its external and internal environment and staff. Of greater interest to this analysis as an object of scientific research is start-up innovative companies created based on universities.

Working with the concept requires a precise definition of the stages, followed by a working definition. This working definition provides the basis for the instrument (or scale) to measure the concept. Developing a scale is usually called 'operationalisation of the concept'. The measurement of concepts is achieved through multi-position rating scales, which, in turn, are combined to provide a composite scale for the concept.

This research shows the characteristics of concepts investigated in a survey – testing these properties in a questionnaire.

Developing a scale (or measure) for a concept involves defining several variables corresponding to a purpose that can be used as a proxy for the idea.

These variables are displayed as questions or statements in the questionnaire.

Then, the idea is to measure attitude, perception, opinion, or values concepts.

The data for this was collected using rating scales that include questions (statements) and precoded categories, one of which is chosen by the respondent.

The answers to the items that reflect the concept are combined. It is usually done by combining the solutions to the items to get a summary score for the respondent. The assessment then measures the respondents' 'intensity' regarding the concept. However, we used an interval scale (numbers: 1, 2, 3, 4, and 5), where respondents were asked to assess the severity of the corresponding trait or preference on a 15-point scale (to rank responses by importance), where 1 is the minimum significance, 15 is the maximum significance.

This part used descriptive statistics and correlation analysis methods to analyse the data. For a visual representation of correlations between the studied variables and grouping, cluster analysis was used in the SPSS Statistics program.

Objects can be grouped by a hierarchical method using various distance functions. In the present paper, the function 'Euclidean distance' was used as the most commonly used measure for calculating the distance on the plane between points. The main result of hierarchical cluster analysis is a dendrogram – a graphical result representation of the sequential clustering process, which is carried out in terms of the distance matrix. As a result, we found that the majority of respondents noted their main reasons for the failure of start-ups as «poor marketing», «application of an ineffective marketing concept», «launching a product at the wrong time», and «lack of market testing and customer feedback». These are different from the reasons described by various researchers. It gives the basis to conduct our in-depth research and analysis, adding new versions of the main current problems of start-up companies to the initial list of factors.

When analysing the responses about ranking the problems of start-up companies, we used cluster analysis, particularly the hierarchical method, to obtain the final data. Figure 3 shows a vertical dendrogram of the problematic factors that prevent start-ups from launching a new product on the market. The results of the cluster analysis indicate that the following problems noted by respondents as the main ones in the work of small innovative enterprises are very close:

- 'The presence of strong competition', 'incorrect pricing policy', 'gaps in normative regulation', 'sales of products did not meet expectations', and 'disagreements with investors/with the founders'.

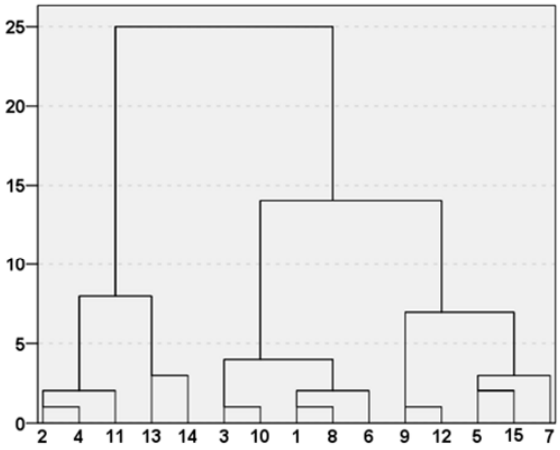
  This cluster characterises the problems of intense market competition and incorrect pricing policy. The most significant correlation is observed between the variables 'The presence of fierce competition' and 'incorrect pricing policy' ($r = 0.60$). This cluster's average value (centroid) is 5.34, the smallest among the formed groups.

- 'Lack of an optimal business model', 'poor marketing, application of an ineffective marketing concept', 'launching a product at the wrong time', 'lack of market testing and customer feedback', and 'lack of a market where they can sell their product'. This cluster characterises the problems of SIEs in promoting products and services and the vision of the company's status in a competitive environment. These problems have a close positive correlation with each other. The most significant correlation is observed between the variables 'lack of an optimal business model' and 'poor marketing and the ineffective marketing concept' ($r = 0.67$). The average value of this cluster is 9.74 and is the largest. Marketing and other problems that correlate with it are noted as very important for SIEs.

- ‘Lack of funding or investment’, ‘problems with the management and resources of the company’, ‘unprofessional team, lack of specialists’, ‘technical or production problems’, and ‘lack of demand for a product or technology’. This cluster characterises the problems of SIEs related to resource management: financial and human resources and production problems. The most significant correlation is observed between the variables ‘lack of funding or investment’ and ‘problems of management and company resources’ ($r = 0.45$). The average value of this cluster is 8.92. The second most important is management and production problems against a lack of professional personnel and difficulties accessing financial resources for SIEs.

Thus, according to the survey results and clustering of variables, the most critical problems of SIEs are the market choice, understanding of customers and promotion of products and services in the market. Dendrogram using the Ward method and combining a cluster of recalibrated states.

Figure 3 Dendrogram using the Ward method



Note: The main reasons noted by the respondents for refusing to work in scientific institutions (see Figure 1 for the name of the characteristics.

Source: Own source

In the second step, the K-means method in SPSS software is performed clustering. Figure 3 shows the average values of indicators of the problem intensity associated with SIE activities. The k-means process creates K-groups from a set of objects to make the group members most homogeneous. This is a popular cluster analysis technique for examining a data set. The number of clusters was chosen by conducting a hierarchical analysis and was determined by the number 4. To estimate the cluster centroids from observations, 140 iterations were performed. Figure 1 shows the average values of the characteristics for the four clusters sorted in descending order. The second and fourth clusters comprise 75% of respondents. The numbering of the traits is shown in Table 1.

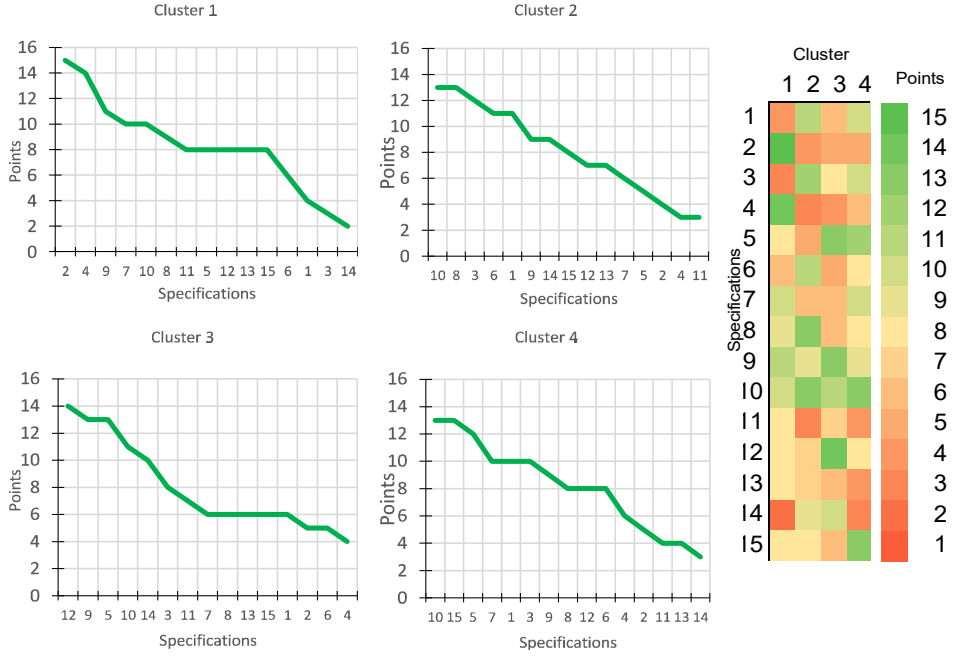
Based on the data obtained, we can characterise the clusters as follows:

- Cluster 1. The number of respondents is about 10%. This cluster is characterised by the fact that the most critical problems for the participants are intense competition and incorrect pricing policy against the background of a lack of financial resources.

A possible problem for this group of respondents is the need for particular relevance of their products and an inflated price relative to analogues. The solution may be to deepen and expand cooperation with the university by introducing innovative solutions to the production process and improving the quality of product characteristics.

- Cluster 2. The number of respondents is about 35% of the total number. The most critical problem for this cluster is the marketing strategy and positioning of the product on the market. Since most inventors and representatives of SIEs initially make the big mistake of underestimating the importance of marketing, developing and producing a finished product or technology without elementary segmentation, targeting and positioning the market.

Figure 4 Average values of observations for four clusters in descending order (see Figure 1 for the name of the characteristics) (see online version for colours)



Source: Own source

Inherently, there is no market demand for a ready-made innovation, there is no clear understanding of the type of B2B, B2C or B2G market for segment allocation and commercialisation, and as a result, sales fail after the product is put on the market due to the lack of a customer. The second most important factor, if there is a customer, is the need for a proper marketing strategy and the concept of market survival in current or potential competition conditions. The solution may be to invite a marketer to the team, order and use these services on the terms of outsourcing or with the help of a university, for example, when receiving comprehensive

information and consulting support based on established innovation centres where a marketer can be on the staff.

- Cluster 3. The number of respondents is about 15% of the total number. For this cluster, the most critical problems are related to management and financial resources against a lack of professional personnel. The solution can also be using these services in terms of outsourcing or assistance from the university, for example, when obtaining comprehensive information and consulting support based on established innovation centres and the benefits of effective scientific management. This management type will help identify more valuable and practical scientific cooperation conditions.

  Scientific analysis is also used to determine the best ways to achieve goals and solve problems: the importance of selecting competent researchers, their training, and providing these employees with the resources necessary to perform their creative tasks effectively. Assistance in managing various types of accounting and protection of intellectual property rights, preparation of draft agreements and contracts on the transfer of exclusive rights to intellectual property objects and additional financial support in the form of grants and subsidies.

- Cluster 4. The number of respondents is about 40% of the total number. For this cluster, the most critical problems are related to the production process and the market promotion of products and services. Promoting products also depends on proper marketing, analysis and understanding of the market, its needs and competitors. In addition, a close relationship with laboratories and technical and production sites of scientific organisations will eliminate emerging problems and improve the quality characteristics of products or technologies.

4 Results and discussion

The analysis and identification of the most significant problems showed the lack of a market and potential buyers where small innovative companies can sell their innovative products, weak marketing of the company and the lack of a specific marketing strategy, and misunderstanding of the strategy of competitors, gave us reason to establish the urgent need for companies in competent marketing. We will propose a solution to overcome current and potential problems through a Conceptual marketing system for ITC. Its implementation will support the sustainability of the activities of innovative start-up companies and develop an optimal and individual conceptual approach for them, allowing them to successfully accompany an innovative product at different life cycle stages from the idea stage to market introduction.

The last part of the study clarified and revised the research questions on complex circumstances that have not been investigated in the literature' and identified the main factors influencing the successful commercialisation of innovative products by scientists and start-ups about participation in the market of knowledge-intensive services. After taking results, this scientific research may solve the primary purpose, which is to improve the influence of ITC by offering those necessary functions – tools that will directly affect the effectiveness of university start-ups and the success of commercialising university start-up developments. Let us compare all the current problems related to our research

topic to today. In that case, the most significant ITC and start-ups still need to solve the problems of commercialisation of an innovative product in the first place. This is especially true for start-up small, innovative start-up companies (the main generators of new ideas), which systematically need help in bringing the final product to market. In this regard, it is necessary to emphasise the relevance of this topic due to the close interest of scientists and researchers worldwide trying to find the best way out of this situation. Building on the cognition and learning of scientists, we develop a theory that at any stage of the ITC's work, problems may arise in helping to bring an innovative product unknown to the consumer to the market, which may lead to rejection.

In contrast, products known to consumers, including modified ones, are much less likely to be rejected by the market. The market companies analysed before the crisis have undergone significant changes, and their current strategies for introducing developments to the market may no longer work. Thus, they had to revise the applied market and marketing plans to new facts in the market (Karpov, 2020; Romanovich et al., 2018). They needed to consider further segmentation, target market research, and positioning in a new market (Teixeira et al., 2021).

The experts (Tokarev, 2018; Amry et al., 2021) noted the importance of marketing research and revision of old strategies of innovative companies, as this will allow commercialising developments but also attract investment in projects from the idea stage to commercialisation for all participants in the innovation environment: start-ups, entrepreneurship, investors, business angels, and venture capital. This coordinated investment in R&D, talent, wealth, location, and exclusivity is necessary to strengthen regional innovation ecosystems (Amry et al., 2021; Korpysa, 2021). The use of marketing tools as one of the fundamental functions in ITC significantly increases the efficiency of innovation activities of universities (Shonia et al., 2021). Universities have historically been one of the critical centres of innovation generation within the framework of scientific activity. However, in current conditions, only creating a good technology or product does not guarantee commercial success. Innovation may not occur because the breakthrough development of the university needs to be adapted to the market and integrated into sales channels. Information about it must be tritely brought to the decision-makers about the purchase.

Thus, this research confirms that the practical, innovative activity of the university is only possible with competent marketing support. All of the above is confirmed by the experience of innovative and successful enterprises and organisations, according to which it is marketing technologies and tools integrated into their activities that make it possible to increase its effectiveness and adaptability in the context of the development of global markets and more formidable competition for consumers.

However, despite the obvious relevance, the issues of marketing integration with the activities of higher education organisations, particularly ITC, still need to be systematically considered. The application of the marketing approach in the university's educational activities and the ITC related to innovation activities remains mainly open. Since marketing is a tool for increasing the efficiency of the business, it is crucial to separate scientific/scientific and technical activities aimed at obtaining and applying new knowledge from innovative ones aimed at generating income through selling high-tech products in a competitive market.

The analysis carried out in this scientific research found that marketing is necessary for innovative companies at each stage of a start-up, and its ITC or commercialisation centres need to apply marketing:

1 Firstly, speaking about the ordinal significance of the set of ITC services, marketing should be fundamental and the first service every ITC in a university should provide. This is because risks are minimised when an innovative company created based on a university has generated some new idea about a future high-tech product or technology due to the implementation of the primary function of analysing market demand and searching for a potential product. Here, risks are understood as the possibility of identifying the absence of likely demand and market needs for this product or technology, which will reduce the risk of losing significant material resources. Both are owned, invested by start-up participants, and attracted by various subsidies, grants, and investments.

2 Secondly, if the market analysis conducted by ITC marketing staff has shown the viability and commercial feasibility of a start-up's development or technology, then marketing will need to be adapted to different stages of the functioning of the start-up's innovative product lifecycle since there is no single approach, model or concept of marketing an 'intelligent' product. Based on the analysis and the data obtained, the following principle of building a marketing concept for implementing ITC in their work with start-ups from the beginning of building a concept or idea to its introduction to the market of high-tech services at universities. Its implementation will support the sustainability of the activities of innovative start-up companies and develop an optimal and individual conceptual approach for them, allowing them to successfully accompany an innovative product at different life cycle stages, from the idea stage to market introduction.

According to the data in Figure 1, different consumers need different marketing since marketing is about consumers. Since consumers' behaviour differs at each stage, innovative technology centres based on universities must select appropriate responses to various aspects of their attitudes, motivations, reactions, and consumer actions.

Figure 5 The conceptual marketing system for ITC on start-up innovations at different stages of work with an innovative product (see online version for colours)

Source: Own source

The study's results suggest the following 'conceptual marketing system' includes the following stages and five interrelated levels.

The first stage of pre-seed marketing is the basic level of marketing at the analysis stage of the innovation idea (pre-seed), which provides information and analytical functions for monitoring the market. This is where the project is developed and finalised, and the basis for market opportunities for an innovative product is evaluated and laid.

The second stage (seed marketing) is the cultivation of ideas, setting and finding solutions to problems for the study of the future consumer by using, in our opinion, a more optimal model of marketing 4C Lauterborn.

The third stage of early-growth marketing is marketing an innovative product to bring the idea to the finished product, its packaging and launching to the market, testing on the first customers, and establishing feedback.

The fourth stage of expansion marketing is to work with new specific customers and lap with already loyal buyers. Thus, a new product for the market is gradually forming a market niche, and it will be necessary to transform the 4P complex.

The fifth and final stage (exit-development marketing), taking into account the successful completion of the previous ones, is crucial in product development and expansion. The classic 4P marketing model is combined with the full use of strategic principles of planning, program development, implementation control, market segmentation, positioning, and other mandatory tools for such cases.

Thus, there is a logical interconnected chain based on the proposed concept of start-up marketing.

5 Conclusions

This study was conducted to assess the impact of ITC on the effectiveness of university start-ups and to develop recommendations for improving their activities. The survey of 140 start-ups helped to identify and rank by importance the factors that influence the productivity of the implementation of university start-up developments. The variance analysis and the Ward method were used as a methodology.

As a result of this scientific research and analysis:

1 IT has been defined as an element of innovation infrastructure in the world.

2 The role of the university as the initiator of the founding of the ITC and its role in the innovation economy was considered.

3 The influence of ITC on the activities of start-ups, and their role in the commercialisation of technologies was revealed.

4 It analysed and evaluated the main reasons for the failure to commercialise the developments/technologies of start-ups created based on universities.

5 The mechanism of influence of ITC on the effectiveness of university start-ups has been improved and proposed to improve the efficiency of entering the market and consumer choice and solving research tasks.

In the literature, there is a high activity in the study of the problems of the formation and functioning of the ITC by various scientific researchers worldwide. ITC play an essential role in promoting the technologies and products of start-ups, which are crucial for the

company's effectiveness (Lopez-Mendoza and Mauricio, 2021; Le-Anh et al., 2022; Salamzadeh, 2018).

According to the literature analysis, SMEs identify the following difficulties (Tajpour et al., 2022) that limit their activities: insufficient creativity and knowledge sharing, inappropriate hierarchical and governmental structure, lack of a comprehensive business model, low level of hardware and software technologies, and, finally, insufficient support from the government'.

Having conducted a cluster analysis of the problems faced by start-ups in Russia and Iran, and based on the data obtained from the survey, we can conclude that it is necessary to pay increased attention to marketing as a fundamental service that the university's ITC is obliged to provide. It was found that groups of start-up problems with high scores and widespread distribution among respondents are associated with promoting products on the market.

This research proposed a solution to overcome current and potential problems through a conceptual marketing system for ITC. Its implementation will support the sustainability of innovative start-up companies and develop an optimal and individual conceptual approach, allowing them to successfully accompany an innovative product at different life cycle stages – from the idea stage to market launch.

After receiving the results, this scientific research can solve the main task of increasing the influence of ITC, offering those necessary functions – tools that will directly affect the effectiveness of university start-ups and the success of commercialising university start-up developments.

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