SPACE-RL Innovation Transfer Model "Science – Business"

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Abstract
The article deals with creating the innovation transfer model "science - production – business". It is based on quantitative indicators for assessing the external environment and market analysis, the landscape for implementing the development and introduction of innovation and evaluating the internal environment and the level of readiness for implementation. The authors provide ways of commercializing the scientific research results and describe the role of an entrepreneurial university in achieving the main tasks of innovation and technology transfer. A combined SPACE-RL model for assessing the prospects for new scientific "products" concerning external and internal influencing factors is proposed. The SPACE matrix, from a subjective assessment tool based on qualitative indicators determined by experts, has turned into a SPACE-RL model, in which it is possible to compare the entrepreneurial university's capabilities in terms of the strategy of bringing the invention to the market and the readiness of the invention to become innovation The SPACE-RL model maximally objectifies the innovation transfer process, reducing the influence of qualitative factors on decision-making.

Keywords: Transfer model; innovation; entrepreneurial university; commercializing; SPACE-RL model;

JEL Classification: O31; O32;

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1. Introduction

The transfer of innovation is one of the university's missions, which is implemented in educational and scientific directions. Many works are devoted to this problem, some of which describe the innovative activity of enterprises (including universities) (Dźwigoł, 2021; Ojeda, 2021; Goncharenko, 2020), transfer algorithms (Kaya, 2021; Niftiyev et al.

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2021; Sineviciene et al., 2018; Brimah et al., 2020), socio-economic indicators of the transfer process (Smiianov et al., 2020; Kozmenko and Vasylyeva, 2008; Skrynnyk and Vasilyeva, 2020a; Bilan et al., 2022), models of strategic development of enterprises regarding the use of innovations (Moskovicz, 2021; Brown and Kasztelnik, 2020; Slavinskaite et al., 2022; Ibraghimov, 2022; Koyluoglu and Dogan, 2021), solving the goals of sustainable development through the innovation transfer, etc. (Vorontsova et al., 2020; Skrynnyk and Vasilyeva, 2020b).

The process of technology and knowledge transfer are similar. Therefore, when building a transfer model, one should take into account the main patterns of ensuring the quality of education when describing various aspects of the "environment" (Chen et al., 2013; Benda and Šmejkalová, 2015; Häkkinen, 2013; Badea, 2011; Dragolea et al., 2014; Sedziuviene and Vveinhardt, 2018; Zafiropoulos and Vrana, 2008; Figueira-Cardoso, 2022; Praneviciene et al., 2017; Gad and Yousif, 2021; Gavurova et al., 2019; Krisnaresanti et al., 2020; Jantoń-Drozdowska and Majewska, 2013; Caballero-Morales et al., 2020; Grundey, 2009; Štimac and Šimić, 2012; Hitka et al., 2021; Zaharia et al., 2022; Suciu and Lacatus, 2014; Abdimomynova et al., 2021; Kozma, 2005; Jiang et al., 2021; Sarvašová and Királová, 2018; Hallová et al., 2017; Ivanov et al., 2012; Přívara and Kiner, 2020; Gryshchenko, 2012; Diaconu and Duţu, 2015).

In any case, university educational and scientific products form the object of commercial transfer. The state pays for educational products for higher education students, if it is a state order, and by individuals and legal entities. Educational services for other categories (for example, lifelong learning) are also implemented at the expense of individuals and legal entities. All this takes place in a competitive environment with a specifically formulated technical task (service description) and task performance results (criteria for a successful graduate). As for scientific products, universities have stricter rules of competition in this direction because, in addition to other educational institutions and scientific institutions, there is a business in this market that is immune to anything except indicators of socio-economic efficiency and the risks of not achieving it. A university from a purely educational organization turns into an educational-scientific-production complex, an entrepreneurial university (Rhiannon et al., 2018), where the algorithmization of the scientific product commercialization is a strict necessity.

There are various innovation transfer strategies. The choice of a specific way of promoting a development or service is based on a multifactorial analysis. This analysis can be carried out using different approaches, which in some cases can be fundamentally different.

It is necessary to start with the one who is the "catalyst" for the product's market entry. In the "marketing pull" mode, the creation of products is initiated by the consumer of the development or service, a specific representative of the industry or a branch of industry that needs the product. The "technological push" mode involves the developer's initiative to start a new segment of providing services and creating products for the industry. Both regimes are based on an in-depth analysis of the selected market segment. The research result in the first case is a list of enterprises that need specific investigations, and in the second - a list of objects where development can be embedded. "Marketing pull" involves receiving a technical task from the customer. Within the framework of the implementation of this technical task, it is possible to introduce innovation in the development as a whole and in its parts. "Technology push" is more conducive to innovation but associated with risks at the stage of implementation and determination of performance indicators.

2. Background

For further classification of strategies, it is necessary to place some accents in the conceptual apparatus. The concepts of “innovation” and “invention” should be distinguished. In the first case, it is an already developed solution that has been implemented or is at the implementation stage, the economic efficiency and social significance of which are higher than analogues or have none. An invention is an idea based on increased economic efficiency and social relevance. The idea is the basis of innovation and the invention as an object of intellectual property right is the first stage of innovation implementation. It is the technology of creating or functioning of an innovation. These ideas are born in the vast majority of scientific departments and laboratories of universities; this fact determines the urgency of starting the transfer from the “place of birth”. Thus, the transfer of a certain product on the path “science – production” can develop as a technology or innovation transfer. In any case, this process is the commercialization of the results regarding the scientific and technical activity of the performer of the development or service.

Commercialization of the scientific research results can be implemented in one of the following ways (Caulfield and Ogbogu, 2015):

1. Provision of services and performance of research and development works to order.

2. Transfer of rights to the intellectual activity results with various options for the distribution of property rights.

3. Organization of production based on the protected intellectual property rights.

Each of the methods is implemented with the help of “marketing pull”, “technological push” or a combination of these strategies, as shown by ***Figure 1*** in application to the entrepreneurial university.

However, there are many barriers on the way from an idea to its commercialization:

- lack of a common language between the authors of the invention and the investors because the authors offer a description of the investigation uniqueness, and the investors find out the financial conditions and risks of implementation;
- it is difficult for a scientist to be a scientist and a businessman at the same time, which causes a misunderstanding of the transfer details;
- scientists’ efforts to publish applied research results before they protected the intellectual property right for the invention. It results in the publication of information about the invention, which in the future does not give the author the opportunity to patent his idea;
- low level of scientists’ motivation to be engaged in transforming an invention into an innovation due to insufficient funding, possession of data on the low percentage of commercialization of inventions, etc.;
- the egoism of a scientist who is unable to independently develop a road map for the commercialization of his/her invention, but does not contact specialists because they should receive remuneration for their services;
- the invention has not been brought to the level of commercialization and cannot receive a positive conclusion from the customer due to the lack of technological audit results, a commercialization plan, etc.;

- inventions (with any strategy of their commercialization, “marketing pull” or “technological push”) are created without taking into account market demand;
- universities and scientific institutions are not ready to act in the conditions of competition among themselves and competition from scientific research centres of industrial enterprises;
- universities and scientific institutions are reluctant to create clusters to solve interdisciplinary tasks and develop turnkey projects;
- the future commercialization of the invention and its transformation into an innovation requires additional funding, which is not always available to the university or scientific institution;
- due to the lack of market analysis data, the invention cannot be implemented either as a response to a request ("marketing pull"), or as an offer ("technological push").

The potential of universities to commercialize research results depends significantly on their organizational capabilities, applied approaches to generate new ideas, and used internal processes to transform them into innovation. This implies assessing their dynamic capabilities and “organizational ambidexterity” concerning the entire innovation cycle.

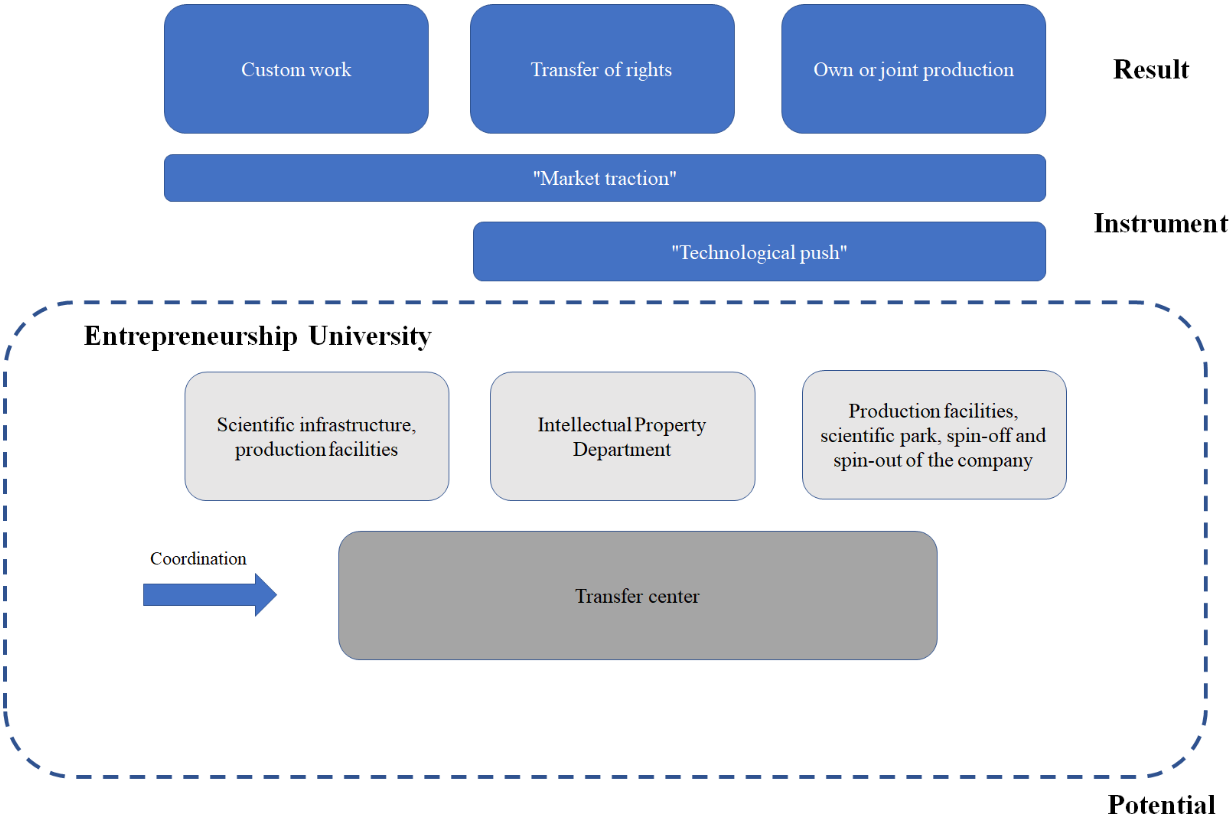
Emphasizing the entrepreneurial aspect, universities' dynamic capabilities relate to their ability to integrate, build, and reconfigure internal and external competencies to respond to a rapidly changing environment (Teece et al., 1997). In some cases, external factors can essentially shift the universities’ potential as well as the whole country’s intellectual potential patterns (Mishchuk et al., 2019; Oliinyk et al., 2022). The impetus to innovative activity and development of the university-business cooperation can be achieved in the case of increasing attention to entrepreneurial education development (Barrientos-Báez et al., 2022; Carvalho et al., 2021) resulted in increasing the entrepreneurial intention of the students (Rodríguez Loor and Muñoz-Fernández, 2022). These reasons enforce the universities for seeking and maintaining partnerships with businesses (Czako et al., 2021). At the same time, dynamic capabilities imply the presence of appropriate internal processes and procedures to ensure the implementation of the innovation process (Eisenhardt and Martin, 2000). Dynamic capabilities in themselves do not create end results but help to organize and use university resources in such a way as to lead to the desired end results. This idea reflects the possibility for universities to apply different models for managing their resources and adapting their organizational processes to the dynamics of the external environment. Thus, universities' dynamic capabilities in creating innovations for moderately dynamic markets rely on routines and practices based on pre-existing knowledge, consistent application, and relatively more easily predictable outcomes. In high-velocity markets, however, the dynamic capabilities of universities imply experimental, unstable processes that rely on rapidly acquired knowledge, trial-and-error method, and hard-to-predict results (Eisenhardt and Martin, 2000).

The organizational ambidexterity of universities reflects their ability to reconcile and simultaneously use two seemingly opposite approaches in the innovation transfer process – reactive and proactive. In a broader context, they are associated with the combined application of both – alignment (exploitation) and adaptability (exploration). Exploitation is associated with refining work, execution and implementation, whereas exploration is search, experimentation, innovation and risk-taking (March, 1991). Alignment means that universities exploit the benefits of their established processes, good past practices and assets. In contrast, adaptability reflects the ability to move quickly toward new opportunities and adjust to volatile markets (Birkinshaw and Gibson, 2004).

Thus, the organizational ambidexterity of universities expresses their ability to pursue incremental and revolutionary innovation simultaneously, which requires them to use different, sometimes opposing, structures and processes to support individual phases of the innovation cycle. Moreover, exploitation activities are linked to incremental innovation, which is suitable for the idea implementation phase, while exploration activities are linked to radical innovation, associated with the idea generation phase (Bledow et al., 2011). The initiation phase of the innovation implies a high degree of complexity, a low degree of formalization, and a weak centralization of decision-making. In contrast, the implementation phase of the innovation requires a low degree of complexity, a high degree of formalization, and a strong centralization.

Organizational ambidexterity can be seen as a driver to increase the innovation activity of universities because it contributes to resolving internal contradictions arising from the peace of mind of relying on established and verified past good practices against the uncertainty of the future.

Figure 1. Commercialization of the scientific research results in an entrepreneurial university



Source: Authors' development

According to the described situation, the optimal solution is to use a tool for assessing the level of invention and the prospect of its transformation into an innovation. This tool should become a "common language" between the authors of the invention and prospective customers of the product. At the same time, attention should be paid to both internal and external factors that accompany the process of creating an innovation from an invention and its subsequent commercialization. For the successful implementation of the innovation transfer process, a tool is also needed that can evaluate the innovation and the prospects of its introduction to the market according to several specific indicators. These indicators should be determined either according to the rating scale or according to specific signs of compliance of the indicator with one or another level. The tool should describe the innovation transfer strategy and at the same time determine the level of the product:

1. Technological level of readiness.

2. Innovative level of readiness.

3. A Review of Approaches to the Analysis of Influence Factors as Applied to the Transfer of Innovations

Among many approaches to analyzing internal and external factors influencing the decision-making process, only certain tools were selected for analysis in application to the transfer of innovations. The main criterion for choosing the following list of tools is the possibility of their application to assess the prospects of turning an invention into innovation with subsequent market entry.

Approaches to the analysis of influencing factors in decision-making can be classified as follows.

1. Qualitative analysis approaches:
   - SWOT (Satria and Shahbana, 2020; Ali et al., 2019);
   - PEST, PESTEL, PESTELI, STEEP, LONGPESTEL (Graham, 2007; Graham 2018);
   - SMART (Bjerke and Renger, 2017);

2. Approaches to finding cause-and-effect relationships and quality control:
   - the Ishikawa method (Milosavljevic et al., 2018; Reilly et al., 2014);
   - The Deming-Shewhart cycle (Aggarwal, 2020).

3. Approaches involving strategic analysis with obtaining qualitative indicators of strategy elements:
   - Ansoff matrix (Ecobici, 2017);
   - Abell matrix (Abell, 2014);
   - Balanced scorecard matrix (Farooq and Hussain, 2011);
   - GE McKinsey matrix (Tsakalerou, 2015);
   - SPACE matrix (Pyo, 2022);

The first group of approaches enables the assessment of the internal and external landscape of the prospects / futility of decision-making but does not operate with parameters that directly relate to the features of the invention and the stage of its possible transformation into an innovation.

The second group of approaches allows for a more in-depth assessment of the risks on the way to the emergence of innovation and to determine what criteria an invention must meet to become an innovation. However, this approach is subjective because only the author of the invention conducts the analysis.

The third group of approaches is the most suitable for implementing innovation transfer processes. These approaches can take into account two (Ansoff matrix), three (Abel matrix and four (Balanced scorecard measures)) groups of factors and determine the interval value of a group of factors for expanding strategic positions (GE McKinsey matrix). At the same time, the proposed methods are characterized mainly by qualitative indicators assessment and taking into account the opinion of experts, which also gives subjectivity to the results of the analysis. These methods also do not consider the importance of factors in each group.

Nevertheless, for example, if the approach to its application is improved (determining the degree of importance of this or that factor according to the opinions of experts, quantitative assessment of factors, parametric identification of the innovation transfer model), the SPACE matrix can become a reliable tool for use in the construction of road maps of innovation output, created in a university or scientific institution, to the market.

It is proposed to choose a strategy for innovation transfer based on the SPACE matrix, in which the university will be described as entrepreneurial. The approach to using this matrix will be improved to provide a quantitative assessment of strategy selection indicators and to compensate for the shortcomings noted above. At the same time, it is proposed to determine the technological and innovative level of readiness of the invention for implementation. In this way, a multifactor model of the algorithm for deciding on the strategy of entering the invention into the market is created, the description of which will be presented below.

4. The SPACE-RL Model of Decision-Making about the Strategy of Bringing an Invention to the Market as an Innovation

The proposed SPACE-RL model is shown by ***Figure 2***. The model has three planes. The SPACE matrix was used as a strategy selection tool in the conditionally lower plane (according to the formal location in space in the figure). In the conditionally upper plane, the technological and innovative level of development is defined. The middle plane is used to compare the analysis results of the invention readiness and determine whether it is a technology (without innovative solutions) or an innovation.

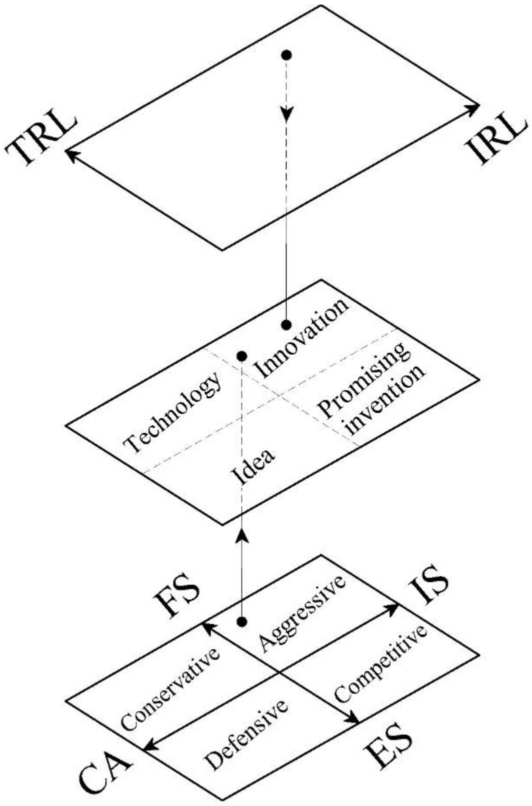
The model works as follows. In the first stage, the SPACE matrix is used to determine the type of strategy for bringing a scientific product to the market. The originality of the approaches in using the SPACE matrix is as follows:

1. The matrix is used to describe business processes in the entrepreneurial university.

2. The subjectivity degree to select factors for each of the groups specified in the matrix is reduced due to the selection of those factors whose impact on the innovation creation process is statistically confirmed. For example, such confirmation can be data from the Global Innovation Index (***Figure 3***) or data from rating agencies, in the methodology of which key factors are defined for each group of the SPACE matrix.

3. The market experts and representatives of potential or real customers define the importance of the factors selected for strategy development. At the same time, the degree of experts' opinion consistency must be determined using the Kendall concordance coefficient (Field, 2014), obtained on the basis of the experts' assessment matrix (***Table 1***). At the same time, the expert has the right to recognize several factors as equivalent, assigning them the same rank number.

Figure 2. SPACE-RL model: CA – competitive advantage; FS – financial strength; ES – environmental stability; IS – industry strength; TRL – technology readiness level; IRL – innovation readiness level



Source: Authors' development

4. Factors for each group have a numerical value and a rating scale in the range "minimum – maximum". An example of such a factor can be one of the indicators of the formula for the distribution of state budget expenditures for higher education among higher education institutions (Ukrainian Government, 2020): "The indicator of the scientific activity of the higher education institution is determined depending on the amount of income to the special fund based on the results of scientific and scientific-technical works under international cooperation projects, on the results of scientific and scientific-technical works under economic contracts and on the results of the scientific service provision per scientific and pedagogical employee at the main place of work (PE_i) on average for the previous three calendar years and is accepted in the following amounts:

1 - if the PE_i does not exceed 500 UAH (12,5 EUR) per person;
1.1 - if PE_i is equal to 501-2000 UAH (12,51-50 EUR) per person;
1.2 - if PE_i is equal to 2001-5000 UAH (50,01-125 EUR) per person;
1.3 - if PE_i is 5,001-10,000 UAH (125,01-250 EUR) per person;
1.4 - if PE_i is equal to 10,001-20,000 UAH (250,01-500 EUR) per person;
1.5 - if PE_i exceeds 20,001 UAH (500,01 EUR) per person".

Figure 3. Statistical coherence in the Global Innovation Index: Correlations between sub-pillars and pillars

	Sub-pillar	Institutions	and research	Infrastructure	sophistication	sophistication	outputs	outputs
INNOVATION INPUT SUB-INDEX	1.1. Political environment	0.95	0.79	0.86	0.71	0.79	0.70	0.79
	1.2. Regulatory environment	0.92	0.71	0.72	0.62	0.74	0.66	0.72
	1.3. Business environment	0.85	0.67	0.70	0.62	0.66	0.64	0.63
	2.1. Education	0.57	0.77	0.55	0.38	0.52	0.50	0.52
	2.2. Tertiary education	0.63	0.81	0.67	0.50	0.51	0.53	0.56
	2.3. Research and development (R&D)	0.75	0.88	0.77	0.73	0.87	0.86	0.74
	3.1. Information and communication technologies (ICTs)	0.80	0.82	0.93	0.72	0.74	0.72	0.79
	3.2. General infrastructure	0.57	0.55	0.68	0.50	0.53	0.52	0.51
	3.3. Ecological sustainability	0.63	0.53	0.75	0.44	0.58	0.55	0.66
	4.1. Credit	0.63	0.53	0.55	0.86	0.57	0.50	0.58
	4.2. Investment	0.46	0.38	0.36	0.68	0.43	0.36	0.34
	4.3. Trade, competition, and market scale	0.52	0.65	0.72	0.70	0.62	0.63	0.61
	5.1. Knowledge workers	0.77	0.81	0.77	0.68	0.88	0.77	0.73
	5.2. Innovation linkages	0.58	0.50	0.53	0.52	0.77	0.60	0.64
	5.3. Knowledge absorption	0.64	0.64	0.63	0.56	0.84	0.79	0.64
INNOVATION OUTPUT SUB-INDEX	6.1. Knowledge creation	0.68	0.78	0.66	0.63	0.81	0.90	0.79
	6.2. Knowledge impact	0.54	0.61	0.62	0.47	0.62	0.79	0.62
	6.3. Knowledge diffusion	0.62	0.61	0.62	0.54	0.73	0.81	0.59
	7.1. Intangible assets	0.60	0.60	0.69	0.55	0.64	0.65	0.89
	7.2. Creative goods and services	0.70	0.65	0.72	0.63	0.68	0.70	0.83
	7.3. Online creativity	0.82	0.74	0.76	0.62	0.81	0.77	0.85

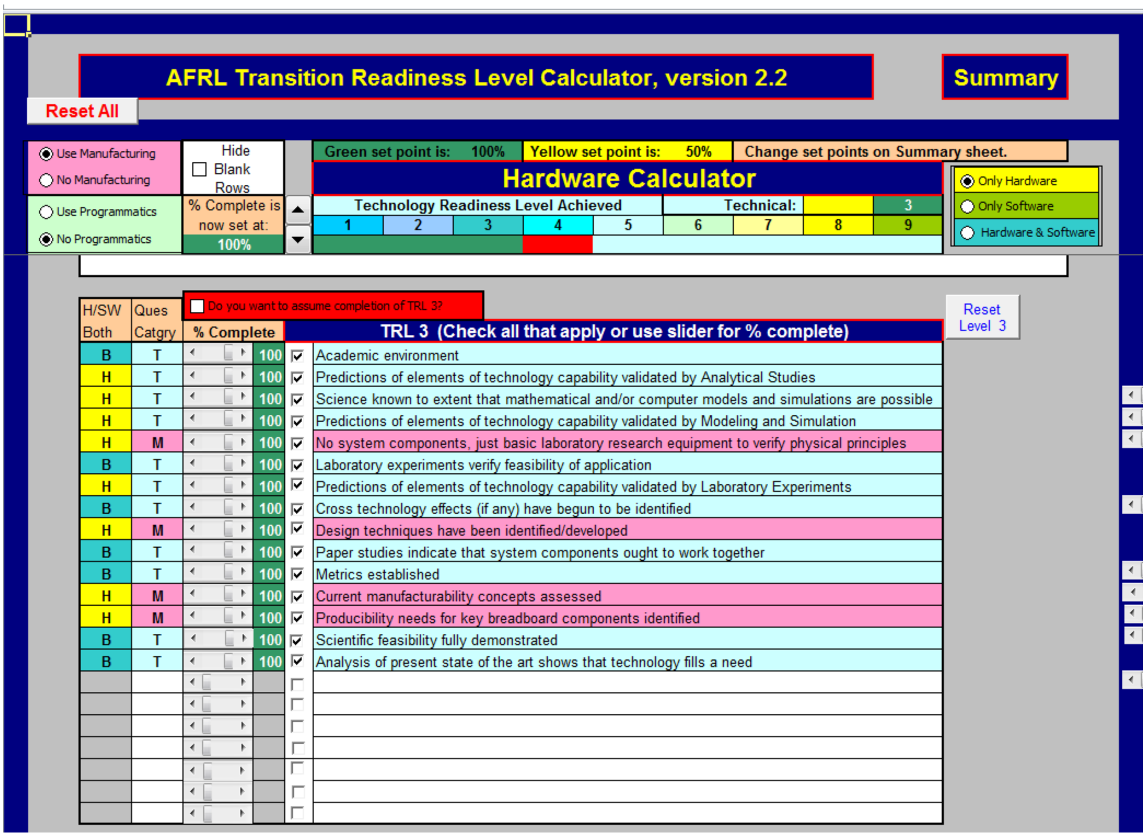
Source: Global Innovation Index

Table 1. A matrix for calculating the degree of experts' opinions consistency of using the Kendall's concordance coefficient: xi - factor number; Ni – place number according to the expert's opinion

Expert / Factor	1	2	3	4
x_1	N_1	N_3	N_2	N_4
x_2	N_2	N_1	N_3	N_3
x_3	N_3	N_4	N_1	N_2
x_4	N_4	N_2	N_4	N_1

At the second stage, the technological and innovative level of the invention readiness for implementation is determined according to specifically defined compliance indicators of each level for TRL and IRL (Lavoie and Daim, 2017), for example, using specialized calculators (Technology Readiness Level (TRL) Calculator, 2021). An example of indicators of compliance with a specific TRL level is shown in ***Figure 4***.

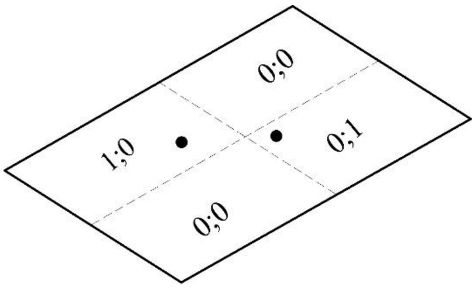
Figure 4. Calculation of the invention TRL using an online calculator



Source: Authors' development on the base of Technology Readiness Level (TRL) Calculator

The comparison stage allows us to determine the relationship between the possibilities for introducing innovation and the actual state of its development. The comparison can look like in ***Figure 5***. The comparison results determine further actions (including achieving specific numerical indicators in the SPACE matrix) regarding the desired strategy based on the assessment of the invention readiness level. Another option is to define specific measures to change the level of invention readiness to achieve the desired implementation strategy. In addition, the commercialization path (or a combination of paths) and the corresponding mode of the product's entry into the market ("market thrust" or "technological push") are chosen. If both resulting points coincide, the commercialization path is determined immediately (with the possibility of changing it due to a road map of measures for transition to another category in case of dissatisfaction with the modeling results).

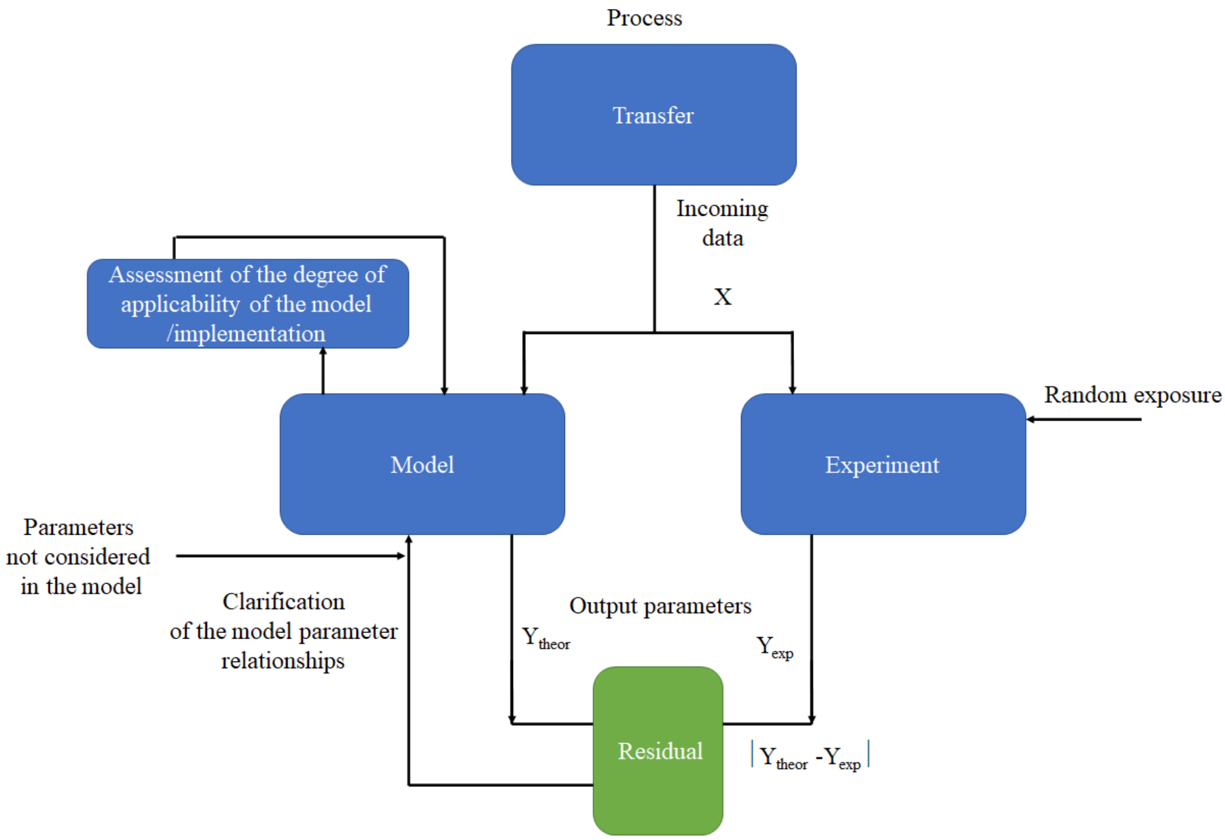
Figure 5. Comparison of the results of determining the strategy and the invention readiness: the first number - TRL-IRL, the second number - SPACE; 0 - non-compliance, 1 - compliance



Source: Authors' development

It is possible to use the parametric identification of the product release model according to the strategy based on the SPACE matrix (if accepted as the final one) as an adjusting tool for the strategy of invention promotion to the market. Parametric identification is carried out based on a model for calculating the economic indicators of the invention implementation, as well as experimental data - actual economic features for implementing investigation analogues or in a specific market. Parametric identification allows you to determine the discrepancy between the model and the experiment with the determination of measures to eliminate this discrepancy by adjusting the mathematical model. The technology transfer process is presented for analysis in the form of a “black”, “grey”, or “white” box, depending on the completeness of the mathematical description. The process of parametric identification can be represented as shown in ***Figure 6***.

Figure 6. Parametric identification of the technology transfer model



Source: Authors’ development

5. Conclusion

Thus, the SPACE matrix from a subjective assessment tool based on qualitative indicators determined by experts has turned into a SPACE-RL model. It enables to compare capabilities of an entrepreneurial university in terms of the strategy of bringing the invention to the market and the real level of the invention readiness to become an innovation. The SPACE-RL model maximally objectifies the innovation transfer process, reducing the influence of qualitative factors on decision-making.

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