WEP Warwick Evans Publishing

International Journal of Global Economics and Management

ISSN: 3005-9690 (Print), ISSN: 3005-8090 (Online) | Volume 4, Number 3, Year 2024
DOI: https://doi.org/10.62051/ijgem.v4n3.03
Journal homepage: https://wepub.org/index.php/IJGEM/index

Research on the Development, Measurement, and Role of Universities in New Productive Forces

Chenmin Ni

School of International Business, Zhejiang Yuexiu University, Shaoxing, 312000, China

ABSTRACT

As the global economy undergoes rapid transformation, traditional productivity models based on material inputs, such as labor and capital, are increasingly replaced by new qualitative productivity, driven by knowledge, technology, and innovation. This study explores the development and measurement of new qualitative productivity, focusing on the role of universities. Key components of new qualitative productivity, including innovation, technological progress, human capital, and information resources, are examined. The Entropy Weight Method (EWM) is introduced as a tool for measuring new qualitative productivity, dynamically adjusting the weights of multiple indicators based on their variability. While current applications of EWM provide objective static measurements, the need for dynamic frameworks to capture temporal changes and the long-term impacts of innovation is emphasized. The study also evaluates the Total Factor Productivity (TFP) model as a macro-level measurement tool. Furthermore, the role of universities in advancing new qualitative productivity is highlighted through their contributions to scientific research, technology transfer, and talent development. The paper concludes by proposing the adoption of advanced dynamic measurement frameworks to better assess the sustained effects of innovation on productivity growth.

KEYWORDS

New Qualitative Productivity; Entropy Weight Method (EWM); Total Factor Productivity (TFP); Productivity Measurement; Knowledge Economy

1. INTRODUCTION

Amidst the continuous transformation of the global economy, the concept of productivity has undergone fundamental changes. Traditional productivity has typically relied on the input of material resources such as capital and labor. However, since the beginning of the 21st century, new qualitative productivity, driven by knowledge, technology, and innovation, has gradually replaced traditional productivity as the primary driver of economic growth. New qualitative productivity emphasizes improving production efficiency through innovation and technological advancements. Its essence goes beyond material resources, encompassing the optimization of human capital, information, and data [1].

In the context of globalization and digitalization, innovation-driven development has become a common strategic goal among nations. How to measure and evaluate new qualitative productivity, and thus formulate effective development strategies, has become a key focus for both scholars and policymakers [2]. Simultaneously, universities, as critical hubs of knowledge and technological innovation, are playing an increasingly prominent role in advancing new qualitative productivity. This paper aims to explore how new qualitative productivity can be accurately measured and further examine the specific role universities play in promoting its development. Through an analysis of university-led scientific research, talent cultivation, and social collaboration, this paper will provide a detailed discussion on how universities contribute to the enhancement of new qualitative productivity [3].

2. THEORETICAL FOUNDATIONS OF NEW QUALITATIVE PRODUCTIVITY

2.1. Definition and Connotations of New Qualitative Productivity

The concept of new qualitative productivity has evolved with the changing economic landscape, particularly with the rise of the knowledge economy. It emphasizes the pivotal role of knowledge, technology, and innovation in production, distinguishing itself from traditional productivity that mainly relies on labor and capital inputs. Essentially, new qualitative productivity is a new recognition of efficiency enhancement, largely driven by intellectual capacity, innovation, and technological progress. It is the key force behind the development of an "intellectual-intensive" economy. In addition to considering material resource input-output relationships, new qualitative productivity also involves the effective utilization of non-material resources, such as information, data, and creativity.

Table 1 provides a comparison between traditional productivity and new qualitative productivity, highlighting their respective drivers, resource types, and core characteristic

Table 1. Differences Between Traditional and New Qualitative Productivity

Type	Main Drivers	Resource Types	Core Characteristics
Traditional Productivity	Labor, Capital	Material Resources	Relies on material resource input, emphasizes labor productivity
New Qualitative Productivity	Knowledge, Innovation	Non-material Resources	Relies on knowledge, innovation, and technological progress, emphasizes intellectual productivity

As shown in Table 1, new-quality productivity differs from traditional productivity in that it relies more on knowledge and technology. The competitiveness of enterprises and countries no longer depends solely on the accumulation of capital and labor, but also on innovation capabilities, technological progress, and rapid responses to market changes. In the context of globalization, industrial upgrading and technological innovation have become important driving forces for economic development, and new-quality productivity is the core element in achieving this transformation. Especially in high-tech industries, the competitiveness of enterprises is not only reflected in capital accumulation and labor quantity, but also in their technological reserves, innovation capabilities, and rapid responses to changes in market demand. Therefore, the connotation of new productive forces is not only the relationship between the input of production factors and output, but also the emphasis on improving overall production efficiency through knowledge innovation and technology application.

2.2. Components of New Qualitative Productivity

The key components of new qualitative productivity include:

Knowledge and Innovation Capacity: In the knowledge economy, technological research and product innovation are crucial for productivity improvement. Innovation not only drives the rise of high-tech industries but also facilitates the upgrading of traditional sectors.

Human Capital: The quality of human capital determines a country's or enterprise's innovation capabilities. High-quality talent, cultivated through higher education and research, provides intellectual support for enhancing new qualitative productivity.

Technological Progress and Digitalization: Advances in technology make production processes more efficient, while the widespread application of information technologies (such as the Internet of Things and artificial intelligence) further improves production and management efficiency.

Data and Information Resources: Data management and utilization have become new competitive factors. Data-driven decision-making can significantly enhance operational efficiency.

Figure 1 shows the composition of China's new productive forces, indicating the approximate proportion of different elements (knowledge and innovation, human capital, technological progress, data and information) in new productive forces.

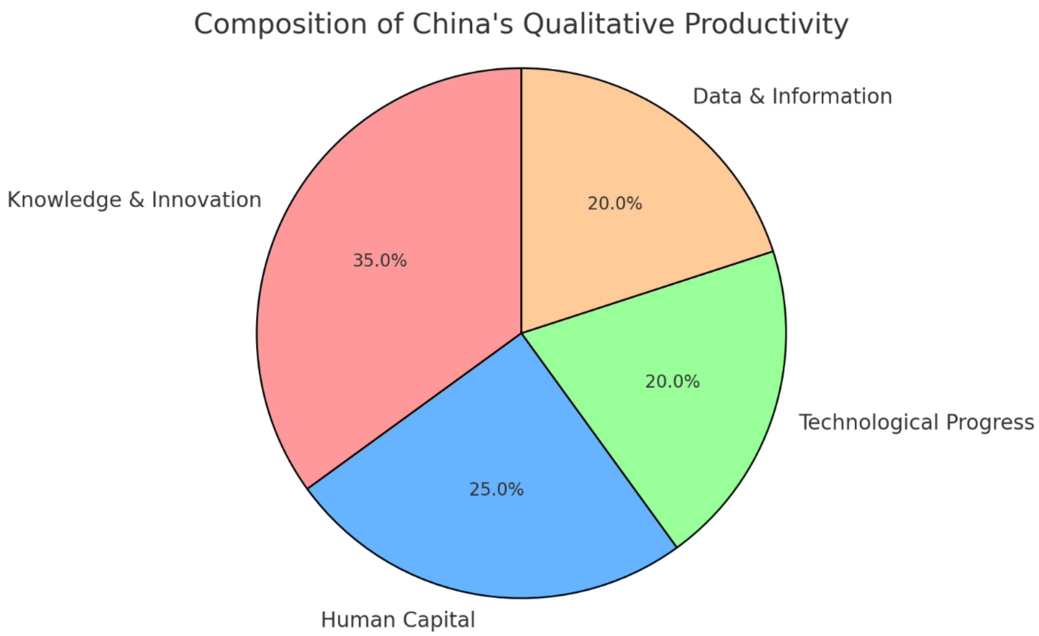

Figure 1. Components of New Qualitative Productivity

From Figure 1, it is evident that knowledge and innovation account for the largest proportion, underscoring the importance of innovation-driven growth in China's economy. Human capital, technological progress, and data also play key roles in driving economic development.

3. METHODS FOR MEASURING NEW QUALITATIVE PRODUCTIVITY

3.1. Theoretical Framework for Measuring New Qualitative Productivity

Measuring productivity has long been an important topic in economics. In the industrial economy, productivity was typically measured using traditional methods, such as labor productivity and capital-output ratios. However, with the rise of the knowledge economy and the digital economy, these methods that rely solely on material resource input can only partially capture the complexity of modern economic productivity. New qualitative productivity involves non-material factors such as knowledge, technology, and innovation, making its measurement more challenging. A practical measurement framework must integrate quantitative and qualitative analyses, particularly those that reflect the contributions of technological progress and innovation inputs. Various methods have been developed to measure new qualitative productivity in recent years. The Entropy Weight Method (EWM) has emerged as a more advanced quantitative method. EWM dynamically adjusts the weight of different indicators based on their information entropy, providing a more objective and scientifically sound measurement approach. However, current applications of EWM are mainly static, emphasizing the need to incorporate time-series analysis tools for dynamic measurement, which will be a key research focus in the future [4].

3.2. Specific Indicators for Measuring New Qualitative Productivity

Measuring new-quality productivity requires establishing a reasonable index system that reflects multiple aspects such as knowledge, technology, and innovation. The following are some commonly used indicators for measuring new-quality productivity:

As the core driver of new qualitative productivity, innovation input can be measured by indicators such as the proportion of R&D expenditures to GDP, the number of R&D personnel, and the number of patent applications. The Innovation Investment Factor (IIC) measures the intensity of innovation investment in a country or region regarding new productive capacity. The Technology Research Rate (TR) reflects indicators of the practical application of scientific and technological innovation in production, such as sales of high-tech products and the success rate of patent applications. The Talent Quality Index (TQI) is a crucial indicator of human capital quality measured by the rate of higher education and the proportion of technical personnel in the total workforce. Table 2 gives the indicators for measuring new qualitative productivity [3].

Table 2. Indicators for Measuring New Qualitative Productivity

Dimension	Specific Indicators	Measurement Method
Innovation Input	R&D Expenditures, Patent Applications	IIC = R&D Expenditures / GDP
Technological Output	High-tech Product Sales, Success Rate	TR = High-tech Product Sales / R&D Expenditures
Human Capital	Higher Education Rate, Technical Personnel Ratio	TQI = Technical Personnel / Total Labor Force

3.2.1. Application of the Entropy Weight Method (EWM)

To evaluate the relative importance of each indicator in measuring new qualitative productivity, the Entropy Weight Method (EWM)- TOPSIS can be employed [2, 4, 5]. This method assigns weights to the indicators based on their variability (entropy) across different regions or countries, ensuring an objective and scientifically sound evaluation.

The basic idea of the EWM is to calculate the entropy value for each indicator, which reflects the level of variability or uncertainty. The greater the variability in an indicator, the more important it is considered, and thus it is assigned a higher weight. In contrast, indicators with less variability across regions or samples are assigned lower weights.

Step 1: Normalize the Data

Since the units of measurement for various indicators differ, the first step in EWM is to normalize the data, bringing them to a comparable scale. The normalized value Z_{ij} is calculated using the following formula:

$$Z_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)} \tag{1}$$

Where Z_{ij} is the normalized value for the i-th sample on the j-th indicator, X_{ij} is the original value for the i-th sample on the j-th indicator, $\min(X_j)$ and $\max(X_j)$ represent the minimum and maximum values of the j-th indicator across all samples.

Step 2: Calculate the Proportion of Each Indicator

The proportion of each indicator is calculated as follows:

$$p_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{m} Z_{ij}} \quad (2)$$

Where p_{ij} is the proportion of the j-th indicator for the i-th sample, m is the number of samples (e.g., countries or regions).

Step 3: Calculate the Entropy Value

The entropy value E_j for each indicator is calculated using the following formula:

$$E_j = -\frac{1}{\ln(m)} \sum_{i=1}^{m} p_{ij} \ln(p_{ij}) \quad (3)$$

Where E_j is the entropy value for the j-th indicator, m is the number of samples, p_{ij} is the proportion calculated in the previous step.

A lower entropy value indicates greater variability, meaning that the indicator plays a more significant role in differentiating between samples.

Step 4: Determine the Weight of Each Indicator

After calculating the entropy values for each indicator, the weight W_j for each indicator is determined as follows:

$$W_j = \frac{1-E_j}{\sum_{j=1}^{n} (1-E_j)} \quad (4)$$

Where W_j is the weight of the j-th indicator, E_j is the entropy value of the j-th indicator, n is the total number of indicators.

Indicators with lower entropy values (greater variability) are assigned higher weights, indicating that they have a stronger impact on the overall measurement of new qualitative productivity.

3.2.2. Traditional Total Factor Productivity (TFP) model

In addition to the entropy weight method, the traditional Total Factor Productivity (TFP) model is still an important tool for measuring new qualitative productivity. The TFP model calculates the impact of technological progress on output, providing a comprehensive evaluation of productivity improvements.

$$TFP = \frac{Y}{K^{\alpha} L^{\beta}} \quad (5)$$

Where:

Y represents total output.

K and L represent capital and labor inputs, respectively.

α and β are elasticity coefficients for capital and labor.

While the TFP model focuses on macro-level productivity measurement, EWM is better suited for detailed multidimensional data analysis.

3.3. Challenges in Measuring New-Quality Productivity

Although the entropy-weighting method and other quantitative measurement methods have significantly improved the accuracy of new-quality productivity measurement, there are still many challenges in practical application:

(1) Data acquisition and standardization issues: There are significant differences between countries and regions in data acquisition and the definition of technological innovation standards, which makes cross-country comparisons difficult [22].

(2) Cross-country comparison issues: The different levels of science and technology, economic structures, and cultural backgrounds in different countries have resulted in productivity measurement results with strong country-specific characteristics, making it difficult to unify standards.

(3) Dynamism and long-term issues: The evolution of new-quality productivity is a long-term process that demands our immediate attention. Most current measurement methods are static, which poses a challenge in reflecting the dynamic evolution of productivity over time. The long-term benefits of technological innovation and the time lag between innovation inputs and technology diffusion are particularly elusive through static measurements. It is imperative to focus on dynamic measurement methods, which capture the immediate state of new-quality productivity and track it is changing trends over time, thereby enabling decision-makers to identify potential growth or risks in advance.

In conclusion, as the significance of new-quality productivity in the global economy continues to grow, the adoption of advanced methods such as the entropy weight method for scientific measurement will become the norm. However, it is crucial to emphasize that constructing a dynamic measurement framework is not just a solution to the problems of data standardization and international comparability. It is a necessity for more accurately assessing the long-term benefits of technological innovation and its dynamic impact on productivity growth. A comprehensive, long-term assessment is the key to understanding the true potential of new-quality productivity.

4. THE IMPACT OF UNIVERSITIES ON THE DEVELOPMENT OF NEW PRODUCTIVE FORCES

4.1. Universities as Essential Incubators of New Productive Forces

Universities play an irreplaceable and pivotal role in promoting the development of new productive forces, mainly in knowledge innovation, technology transfer, and talent cultivation. As the core base for knowledge and technological innovation, universities promote breakthroughs in cutting-edge technologies through scientific research projects and cultivate many high-quality, innovative talents through education, providing intellectual support for the social economy [6-8].

First, universities' research capabilities enable them to produce forward-looking and groundbreaking scientific and technological achievements continuously. Many universities, especially top research universities, have vital resources and world-leading research teams. These projects often focus on basic research and exploring cutting-edge technologies. Although research in these fields may not directly generate economic benefits in the short term, it lays a solid theoretical foundation for technological innovation. For example, basic research in artificial intelligence, nanotechnology, and biotechnology has gradually developed through universities' long-term research accumulation [2].

Second, technology transfer and the transformation of scientific and technological achievements are some of the important contributions of universities to new productive forces. Many universities have established close cooperative relationships with enterprises, governments, and scientific research institutions, forming an innovative ecosystem of industry-university-research cooperation. Universities are not only providers of scientific research results, but also apply theoretical research results to actual production through technology transfer and the transformation of scientific and technological achievements. For example, science and technology parks and innovation incubators within universities help quickly transform scientific research into marketable products by providing funding, equipment, and technical support, promoting emerging industries' formation and development [9]. Many founders and core technical members of technology companies and high-tech enterprises often come from universities or have grown up relying on universities' technological and innovative capabilities.

Talent cultivation is another meaningful way for universities to promote the development of new productive forces. As the cradle of innovative talent, universities have produced many high-end talents with innovative capabilities and technical literacy for society through a systematic education system. Highly qualified talent plays a role in enterprises and provides strategic support for developing new productive forces in fields such as scientific research and government. Especially in engineering, science, and information science, talent with a solid theoretical foundation and innovative, practical ability has become the core driving force for promoting industrial transformation and upgrading [7]. For example, in high-tech industries, university graduates' research and development, design, and problem-solving capabilities provide essential support for the innovative development of enterprises.

In addition, international cooperation between universities also brings a global perspective and technical resources to the development of new productive forces. Through international research collaborations and academic exchanges, universities can introduce the world's most cutting-edge research results and innovative ideas and apply them locally. International cooperation not only accelerates technological progress, but also promotes the improvement of domestic research capabilities. For example, Tsinghua University's cooperation with top universities worldwide in artificial intelligence and quantum computing has promoted China's rapid progress in these technological fields. This kind of international cooperation has created conditions for universities to cultivate interdisciplinary and intercultural innovative talents, and has injected global resources into the country's innovation and development [10].

4.2. Close Collaboration Between Universities and Enterprises and Integration of Industry, Academia and Research

Universities are a source of knowledge innovation and promote the rapid growth of new productive forces through collaboration with enterprises, governments, and other social organizations. This close industry-university-research collaboration model shortens the time for scientific and technological achievements to be transformed from the laboratory to the market. It also verifies the feasibility of scientific research results in practice, further promoting technological optimization and innovation.

Many universities have established innovative incubators and science and technology parks to provide an incubation environment for innovative enterprises. Cooperation between universities and enterprises enables new technologies to be quickly applied in practical production through joint research and development, technology sharing, data analysis, and other methods. For example, the close relationship between Stanford University's incubator and Silicon Valley has contributed to the birth of many high-tech companies. These companies have quickly captured the market and promoted the widespread use of technology by leveraging cutting-edge technologies and research and development results from universities [5]. This model has provided a strong driving force for developing the global innovative economy. It is also an important reference for Chinese universities as they gradually develop and strengthen the industry-university-research cooperation model.

In China, the model of industry-university-research collaboration is also gradually being promoted. The government encourages universities and enterprises to tackle major scientific and technological projects jointly through policy incentives and financial support. For example, national special funds for scientific and technological innovation projects and local government industrial funds have promoted in-depth cooperation between universities and enterprises. Through this mechanism, many cutting-edge research and development projects can not only complete basic research in universities, but also achieve market application through cooperation with enterprises, providing a sustainable driving force for promoting the upgrading of new productive forces [11].

4.3. University Research Platforms and the Construction of an Innovation Ecosystem

With the intensifying global competition in science and technology, the construction of innovative research platforms and innovation ecosystems has become one of the essential measures for universities to promote the development of new productive forces. Many universities have established interdisciplinary research centers and laboratories, bringing together experts and scholars from multiple fields to overcome complex technological challenges through interdisciplinary collaboration. This integrated research platform improves research efficiency and promotes technological breakthroughs and innovation [8, 12].

For example, Peking University's Interdisciplinary Research Center integrates resources from the fields of physics, chemistry, biology, and information science to solve core technical problems in nanotechnology and biomaterials through collaborative innovation. These research platforms have not only achieved technical breakthroughs but have also promoted the interdisciplinary development of new productive forces through the sharing and transfer of research results.

The construction of an innovation ecosystem is also an important part of universities' promotion of new productive forces. The innovation ecosystem includes the synergy of multiple forces, such as scientific research institutions, enterprises, governments, and venture capital, which work together to create innovative resources, share results, and cooperate to create a healthy and sustainable innovation environment. Universities are not only providers of scientific research resources in this system, but also promote technological innovation and the development of emerging industries through collaborative cooperation with external forces.

5. OUTLOOK AND CONCLUSION

5.1. Future Trends in the Development of New Productive Forces

As emerging technologies such as artificial intelligence, big data, and blockchain further mature, new productive forces will continue to be an important driving force for economic and social development. Especially on a global scale, technological innovation will become an important part of national competitiveness. Therefore, how to continuously improve the level of new productive forces will become the focus of attention of all countries. As the core base of technological innovation, universities will play an increasingly important role in this process [13].

5.2. The Role of Universities in Future New Productive Forces

As an essential incubator of new productive forces, universities play a multidimensional role in promoting innovation and technological progress. Through scientific research and innovation, technology transfer, talent cultivation, and international cooperation, universities provide a solid foundation for promoting industrial transformation and economic development. In the future, with the intensification of global scientific and technological competition and the continuous emergence of new technologies, universities will play an even more critical role in enhancing new productive forces, and through collaborative cooperation with enterprises and governments, they will further promote the formation and development of an innovation ecosystem that integrates industry, academia and research [14].

5.3. Policy Recommendations

To better promote the development of new-quality productivity, the government and policymakers should strengthen their support for universities, especially by providing more policy incentives in terms of scientific research funding and industry-university-research cooperation. In addition, they should also promote the transformation of scientific research results from universities into practical applications, providing more opportunities for the enhancement of new-quality productivity. As an important force in promoting the development of new-quality productivity, universities have made tremendous contributions to the scientific and technological progress and economic development of society through their advantages in scientific research, education, and industry-university-research cooperation. The development of new-quality productivity is inseparable from the support of universities, and universities will continue to play an irreplaceable role in this process [7, 15].

REFERENCES

[1] L. Lin, T. Gu, and Y. Shi, "The Influence of New Quality Productive Forces on High-Quality Agricultural Development in China: Mechanisms and Empirical Testing," Agriculture, vol. 14, no. 7, p. 1022, Jun. 2024, doi: 10.3390/agriculture14071022.

[2] X. Gao and X. Liu, "Empowering New-Quality Productivity Development through Artificial Intelligence: Impact Mechanisms and Spatial Spillover."

[3] D. Castro-Ceacero and G. Ion, "Changes in the University Research Approach: Challenges for Academics' Scientific Productivity," High Educ Policy, vol. 32, no. 4, pp. 681–699, Jul. 2018, doi: 10.1057/s41307-018-0101-0.

[4] C. Shao, H. Dong, and Y. Gao, "New Quality Productivity and Industrial Structure in China: The Moderating Effect of Environmental Regulation," Sustainability, vol. 16, no. 16, p. 6796, Aug. 2024, doi: 10.3390/su16166796.

[5] C. Shao, H. Dong, and Y. Gao, "New Quality Productivity and Industrial Structure in China: The Moderating Effect of Environmental Regulation," Sustainability, vol. 16, no. 16, p. 6796, 2024.

[6] X. Yang and Y. You, "How the World-Class University Project Affects Scientific Productivity? Evidence from a Survey of Faculty Members in China," High Educ Policy, vol. 31, no. 4, pp. 583–605, Nov. 2017, doi: 10.1057/s41307-017-0073-5.

[7] W. F. Massy, T. A. Sullivan, and C. Mackie, "Improving measurement of productivity in higher education," Change: The magazine of higher learning, vol. 45, no. 1, pp. 15–23, 2013.

[8] M. A. T. Quimbo and E. C. Sulabo, "Research productivity and its policy implications in higher education institutions," Stud. High. Educ., vol. 39, no. 10, pp. 1955–1971, 2014.

[9] J. Zhang, Y. Shan, S. Jiang, B. Xin, Y. Miao, and Y. Zhang, "Study on the coordinated development degree of new quality productivity and manufacturing carbon emission efficiency in provincial regions of China," Environ Dev Sustain, Aug. 2024, doi: 10.1007/s10668-024-05321-x.

[10] Radło, Mariusz-Jan and A. F. Tomeczek, "Factors influencing labor productivity in modern economies: A review and qualitative text analysis," WSEAS Transactions on Environment and Development, vol. 18, 2022.

[11] Y. Rao, "Evaluation of high-quality industrial development in Guangdong Province from the perspective of new quality productivity," Population, Resources & Environmental Economics, vol. 5, no. 2, pp. 112–121, 2024.

[12] C. Chen and C. Zhang, "Cultivation Path of Innovation and Entrepreneurship Personnel Training Driven by New Quality Productive Forces," in Lecture Notes on Data Engineering and Communications Technologies, Cham: Springer Nature Switzerland, 2024, pp. 417–426. doi: 10.1007/978-3-031-72017-8_38.

[13] Y. Liu and Z. He, "Synergistic industrial agglomeration, new quality productive forces and high-quality development of the manufacturing industry," Int. Rev. Econ. Finance, vol. 94, p. 103373, Jul. 2024, doi: 10.1016/j.iref.2024.103373.

[14] Rohács, J, "The Role of Universities in Technology Transfer," Naucno Strucni Skup Vozduhoplovstvo, vol. 97, pp. E11–E16, 1997.

[15] Y. Dai, "An empirical study on the influence of new quality productivity development on the degree of rural revitalization," AJHSS, vol. 7, no. 7, 2024, doi: 10.25236/ajhss.2024.070701.