EVALUATING THE EFFICIENCY OF SCIENCE AND INNOVATION FUNDING

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In today's context of globalization and a knowledge-based economy, science and innovation are becoming primary factors ensuring nations' economic growth, competitiveness, and technological advancement. The rapid development of digital technologies, artificial intelligence, biotechnology, green energy, robotics, and high-tech manufacturing further underscores the significance of financial resources directed toward research and development. Consequently, alongside expanding the volume of funding for science and innovation, objectively evaluating the efficiency of resource utilization and determining the impact of financial resources on scientific and economic outcomes are emerging as critical scientific and practical imperatives.

The efficiency of science and innovation funding refers to the extent to which financial resources directed toward R&D and innovative activities translate into concrete scientific, technological, economic, and social outcomes. In this context, the primary evaluation metric must extend beyond merely increasing funding volumes or absorbing funds within designated allocations to focus on the actual results achieved through these expenditures. Specifically, outputs such as new scientific developments, patents, technologies, prototypes, academic publications, startups, commercialized innovations, job creation, and economic value added serve as vital indicators reflecting funding efficiency.

Global experience demonstrates that developed nations are progressively shifting away from expenditure-based approaches toward results-based performance evaluation systems for science and innovation funding. In these frameworks, metrics such as the ratio of R&D expenditure to GDP, researcher headcounts, scientific publications, patent grants, high-tech product yields, technology transfers, innovative enterprises, and commercialized scientific outputs are analyzed interdependently. This approach enables a precise determination of the real scientific and economic yields generated by financial resources.

Establishing a cohesive chain of "capital – scientific activity – scientific output – innovative product – economic impact" is crucial when evaluating the efficiency of science and innovation funding. Financial resources invested in research may not yield immediate economic returns, particularly in fundamental research where economic impacts unfold over long horizons. Therefore, evaluation

methodologies must comprehensively account for the short-, medium-, and long-term impacts of scientific outputs.

In recent years, Uzbekistan has devoted substantial attention to advancing science, education, and innovation, funding scientific projects on a grant basis, modernizing scientific infrastructure, and supporting young researchers. At the same time, determining the efficacy of funds allocated to science, comparatively evaluating the efficiency of various scientific organizations and projects, converting research outputs into economic value, and maximizing the efficiency of state financial resource utilization remain highly pressing issues.

In evaluating the efficiency of science and innovation funding, it is expedient to form a system based on the synthesis of financial and non-financial metrics. Financial indicators may include the expenditure per single scientific output, investment efficiency of the research project, revenue generated from commercialization, licensing royalties, and additional financial resources attracted. Non-financial indicators encompass scientific articles, patents, inventions, new technologies, prototypes, international partnerships, and outputs related to scientific workforce training.

Furthermore, utilizing investment performance indicators is crucial when evaluating innovation projects. Specifically, metrics such as return on investment, net present value, internal rate of return, and profitability index serve to determine the financial viability of innovative projects possessing commercialization potential. However, due to the limitations of applying such metrics directly to fundamental research, they must be employed alongside scientific performance evaluation criteria.

Another critical direction for increasing funding efficiency lies in staged project financing and continuous performance monitoring across each phase. Establishing distinct performance criteria for the stages of project conception, fundamental research, applied research, experimental design, prototype development, and commercialization ensures that financial resources are targeted toward high-potential avenues.

Simultaneously, the participation of the private sector and international funding sources must be factored into the efficiency evaluation of science and innovation financing. Co-leveraging corporate investments, international grants, venture capital, and commercialization revenues alongside public funding provides a clear measure of a research project's alignment with market demands.

Evaluating the efficiency of science and innovation funding constitutes an essential component of state financial policy in a modern economy. Increasing

allocations for R&D and innovation does not automatically guarantee high scientific or economic returns. The key lies in identifying how allocated financial resources translate into concrete scientific results, technological advancements, innovative products, and economic yields. Consequently, transitioning from expenditure absorption toward results-based performance evaluation is imperative in assessing science funding efficiency.

Based on the research findings, establishing a comprehensive system for evaluating the efficiency of science and innovation funding is highly expedient. In this framework, financial, scientific, technological, innovative, and social metrics should be applied harmoniously. While financial indicators assess funding volumes, expenditure rates, cost per scientific output, commercialization revenues, and external capital leveraged, scientific indicators measure published articles, patents, inventions, and research developments.

When evaluating innovation efficiency, particular emphasis must be placed on indicators such as newly developed technologies, prototypes, software products, startups, developments implemented in production, and technology transfers. Indeed, a primary objective of modern science—beyond generating new knowledge—is transforming this knowledge into innovative products and services tailored to the needs of the economy and society. From this standpoint, the degree to which scientific outputs are commercialized should serve as a vital criterion for reflecting funding efficiency.

In this regard, evaluating all scientific disciplines based on identical criteria would be inappropriate. The outcomes of fundamental research often manifest over long-term horizons. Therefore, for fundamental sciences, priority must be given to criteria such as scientific novelty, international publications, citations, the formation of scientific schools, the development of new research avenues, and the training of highly qualified academic personnel. Conversely, in applied and innovative research, a higher weighting should be assigned to indicators such as patents, prototypes, technologies, industrial implementation, commercialization revenues, and job creation.

Utilizing economic efficiency metrics is also of vital importance in evaluating the efficiency of science and innovation funding. For innovative projects with commercialization potential, indicators such as return on investment, net present value, internal rate of return, profitability index, and payback period can be deployed. These metrics help determine the future financial yield of funds allocated to research projects. Furthermore, staged project financing serves as a key mechanism for enhancing efficiency. Clear, quantifiable outputs must be

established for each stage—progressing from project conception to fundamental research, applied research to experimental design, and prototyping to commercialization. Conditioning subsequent funding phases on the achievements of preceding stages prevents the prolonged allocation of resources toward underperforming projects.

Diversifying funding streams is equally critical to raising the efficiency of science and innovation financing. Alongside state budget allocations, the extensive engagement of private sector capital, international grants, corporate contracts, venture capital, internal university funds, and commercialization revenues enhances the financial sustainability of scientific initiatives. In particular, private sector involvement aligns research activities more closely with market demand.

In Uzbekistan, establishing a unified, comprehensive indicator system to evaluate the efficiency of science and innovation funding is highly expedient. Within such a system, funding volumes, scientific outputs, patents, technologies, commercialization metrics, international grants, private investments, economic impacts, and social outcomes can be evaluated interdependently. Consequently, this creates opportunities to benchmark the performance of research institutions and universities, identify high-performing projects, and reallocate financial resources toward strategic priorities.

Additionally, digitizing the evaluation processes of scientific funding is essential. Monitoring the capital allocated, work performed, interim results, final scientific products, and commercialization indicators for every project within a single electronic platform will enhance transparency and accountability. Through this system, real-time tracking of both financial and output performance across scientific projects will be enabled, allowing for the timely identification of underperforming initiatives.