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SYSTEMIC ANALYSIS OF THE INTERACTION BETWEEN PUBLIC POLICY AND FINANCIAL MECHANISMS IN THE FORMATION OF THE NATIONAL INNOVATION SYSTEM

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The article examines the role of innovation as the main driver of modern economic development. It systematises and critically analyses the evolution of economic thought, from classical theories to modern models of endogenous growth and concepts of national innovation systems. The main focus is on analysing the mechanisms of interaction between public policy and private investment in stimulating innovation activity. The theoretical rationale for public intervention, in particular the problems of 'market failures', is examined in detail, and public policy instruments are classified. Their effectiveness is assessed on the basis of empirical data and international experience. Particular attention is paid to the analysis of the financial ecosystem of innovation, including the role of venture capital, corporate investment and public-private partnerships in financing projects at different stages of their life cycle. Based on an extensive analysis of statistical data from the OECD, the World Bank and the World Intellectual Property Organisation, a comparative analysis of innovation systems in developed and developing countries is conducted. Detailed case studies of successful innovation policies in the United States, South Korea, Israel and Finland are presented. The key factors of their success have been identified, in particular the effectiveness of public-private partnerships, the development of venture capital and the flexibility of the regulatory environment. The work also identifies the main 'failures of the state' in innovation policy, which lead to the suboptimal allocation of resources. Strategic recommendations for building an effective national innovation system are formulated. The scientific novelty of the work lies in the systematic analysis of the synergistic interaction of financial mechanisms and public policy instruments aimed at stimulating innovation activity, as well as in the development of practical recommendations for building an effective national innovation system in the Ukrainian context on this basis.

Keywords: innovation policy, endogenous growth, financial ecosystem, venture capital, public-private partnership, national innovation system.

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Introduction and statement of the problem

In the context of the Fourth Industrial Revolution and the transition to a knowledge economy, the ability of states to generate, adapt and commercialise new ideas and technologies has evolved from a competitive advantage to a fundamental condition for the survival and prosperity of society. Innovation is no longer a peripheral element of economic activity, but has become its core; it is the driver of productivity growth, the creation of new markets and jobs, and the solution to global challenges such as climate change, pandemics and food security. Historical experience shows that countries that have managed to build effective mechanisms for stimulating innovation have achieved

the highest levels of prosperity and global influence. For Ukraine, which is in the midst of a full-scale war and facing post-war reconstruction, innovation-oriented development is of particular importance. The current state of the innovation system in Ukraine is characterised by significant challenges, including chronic underfunding of research and development (R&D), brain drain, weak links between academic science and the real sector of the economy, and an underdeveloped financial ecosystem, in particular the venture capital market [5, pp. 8–25]. This is confirmed by the fall in government spending on R&D to record lows and the acceleration of the brain drain, which, according to preliminary estimates, has intensified significantly since the start of the full-scale invasion. This situation requires an immediate search for effective compensatory mechanisms and strategic solutions. At the same time, there are also significant opportunities: a high level of human capital, especially in the IT sector, the rapid development of defence technologies (mil-tech) driven by the need to protect the state, and the urgent need for technological modernisation of the economy in the process of European integration and post-war reconstruction. All this creates a unique window of opportunity for transformation and makes research into effective innovation policy tools extremely relevant for Ukraine.

The evolution of economic thought reflects a paradigm shift in economic growth: while Robert Solow's neoclassical model viewed technological progress as exogenous and independent of economic decisions, modern theories of endogenous growth developed by P. Romer [2, p. 72], R. Lucas, F. Aghion and P. Howitt [3, p. 323], have convincingly demonstrated that technological change is an internal product of the economic system. This has fundamentally changed the view of economic policy: the state has ceased to be a passive observer and has become an active architect of the innovation environment. However, the mechanisms for transforming investment into innovation, and innovation into economic growth, are extremely complex and non-linear. This process, often referred to as a complex interaction of factors, involves complex interactions between various actors: universities, research centres, large corporations, small start-ups, financial institutions and government agencies. Success depends not only on the amount of funding, but also on the quality of institutions, entrepreneurial culture, economic openness, and the effectiveness of the links between these elements. This is where the key problem arises: what is the optimal design of public policy to stimulate innovation? How can a balance be found between direct government support and market mechanisms? What is the role of private investment, particularly venture capital, and how can the state promote its development? The answers to these questions are not universal and depend on a country's level of development, its institutional structure, and its historical context.

Analysis of recent studies and publications

Economic thought has come a long way in explaining the sources of long-term growth. While classical economists such as Adam Smith saw progress in the division of labour, the real breakthrough came with Robert Solow's neoclassical model. It made it possible to prove mathematically that the accumulation of capital and labour alone cannot ensure sustainable growth due to diminishing returns. The key driver of prosperity turned out to be technological progress, the so-called 'Solow residual.' However, the main drawback of the model was that this most important factor remained exogenous, its source lying outside the scope of economic analysis.

Austrian economist J. Schumpeter [1, pp. 75–77] proposed a revolutionary view of capitalism as a dynamic process of 'creative destruction.' In his view, the driving force of progress is not static equilibrium, but a constant flow of innovations created by innovative entrepreneurs in pursuit of temporary monopoly profits. Schumpeter's ideas were decades ahead of their time, but laid the ideological foundation for the future. At the end of the 20th century, endogenous growth theories emerged, which finally explained technological progress as the result of conscious economic decisions.

P. Romer [2, pp. 71–102] showed that knowledge (ideas) is a non-rival good. This creates positive externalities ('knowledge spillovers') through which the market alone does not invest enough in research, justifying state support for science. R. Lucas focused on the role of human capital, proving that investment in education and skills is a powerful driver of productivity growth. F. Aghion and P. Howitt [3, pp. 323–351] mathematically formalised Schumpeter's idea of 'creative destruction' by modelling how new innovations replace old ones. Their findings demonstrate that a nation's scientific trajectory is inertial; consequently, for countries with economies in transition, such as Ukraine, state support for interdisciplinary connections is critical to overcoming technological isolation. Their work also revealed a complex, inverted U-shaped relationship between competition and innovation, which has important implications for antitrust policy. Recent scholarly works highlight the structural complexity of scientific progress and the need for adaptive management. In his work, M. Finck [11, p. 255] advocates a shift toward a culture of ('proactive management'). He argues that

the success of innovation policy in the context of rapid technological change depends on the state's ability to employ regulatory foresight and experimentation. This is complemented by a systematic mapping of global science conducted by L. Miao et al. [12, p. 1215]. Their findings demonstrate that a country's scientific trajectory is inertial in nature. Therefore, for countries with economies in transition, such as Ukraine, state support for interdisciplinary connections is critically important for overcoming technological isolation.

Thus, economic theory has shifted from viewing technology as an external gift to understanding innovation as an internal, managed process in which the state, firms and individuals play a key role. While endogenous growth theories provided a macroeconomic rationale for the role of knowledge, the concept of the national innovation system (NIS) developed by K. Freeman, B. O. Lundvall and R. Nelson [4, p. 669] offered a systematic, institutional approach to the analysis of innovation. A national innovation system (NIS) is a set of institutions, actors and relationships in a country that collectively and individually influence the creation, dissemination and use of new knowledge. This approach shifts the focus of analysis from individual elements (the amount of R&D funding or the number of patents) to the quality of the relationships and interactions between them. Scientists in this field view innovation not as a linear process leading from fundamental research to a marketable product, but as a complex, non-linear, iterative system with feedback loops. The key components of the NIS are:

– subjects: These are organisations directly involved in the innovation process. They include private firms (from large corporations to small start-ups), universities, public research institutes, financial institutions (banks, venture capital funds), and public policy-making bodies;

– institutions: These are the 'rules of the game' – formal (laws, regulations, intellectual property rights) and informal (cultural norms, business customs, level of trust in society) frameworks that regulate interactions between actors. For example, the effectiveness of patent legislation, labour market flexibility, and public attitudes towards entrepreneurial failure are critically important institutional factors;

– links: These are flows of knowledge, technology, capital and human resources between actors. The effectiveness of NIS depends largely on the intensity and quality of these links: how closely universities cooperate with industry, how quickly scientific discoveries find their way to commercialisation, how mobile researchers are between the academic and private sectors.

The NIS concept helps us understand why countries with the same level of investment in R&D can show radically different innovation performance. The answer lies in systemic differences: the quality of institutions, the development of networks, and the effectiveness of coordination. This approach provides a powerful analytical framework for diagnosing weaknesses in innovation policy and its comprehensive improvement. It emphasises that the state's task is not simply to finance science, but to build and fine-tune the entire system, acting as a moderator, coordinator and catalyst.

Purpose of the article

The purpose of this work is to conduct a multifaceted analysis of the mechanisms of innovation-oriented economic development with a focus on determining the synergistic role of state support and investment flows.

Presentation of the main material

Recognising innovation as an endogenous process and adopting a systematic approach to its analysis inevitably focuses attention on the role of the state: if market forces alone are unable to ensure an optimal level of innovation activity, and success depends on a complex system of interactions, then the state becomes a key actor responsible for creating a favourable environment and correcting market failures.

The need for the state to play an active role in the field of innovation is justified by the existence of so-called 'market failures' and 'systemic failures' [6, pp. 787–801]. These concepts explain why the rational behaviour of individual economic agents does not lead to a socially optimal outcome.

As Romer's model [2, p. 75] suggests, knowledge has the characteristics of a public good: it is non-rivalrous (the use of an idea by one person does not reduce its availability to others) and partially non-excludable (it is difficult or impossible to prevent others from using knowledge once it has become public). This generates significant positive externalities, or 'knowledge spillovers.' When a firm invests in R&D, it creates new knowledge that benefits not only itself but also other firms, competitors, related industries, and society as a whole. Employees transfer knowledge when they change jobs; scientific publications disseminate research results; analysis of competitors' products (reverse engineering) allows companies to improve their own technologies. Due to these 'spillovers,' the social rate of return on R&D investment is significantly higher than the private rate of return that the investing firm itself receives. A rational firm, when making investment decisions, focuses only on its expected private profit. As a result, the total volume of private sector investment in R&D

will be systematically lower than the level that is optimal for society. This market failure is the strongest argument in favour of public funding for basic research (where uncertainty and externalities are greatest) and the provision of subsidies or tax breaks for private R&D.

Innovative activity is inherently associated with an extremely high level of uncertainty, so private investors, especially those who are risk-averse, will avoid financing long-term, radical and breakthrough projects, preferring short-term, incremental improvements with more predictable results. This problem arises due to the uneven distribution of information between the parties to the agreement. In the field of innovation, it manifests itself in the relationship between the inventor (or start-up), who has complete information about their technology, and the potential investor (e.g., a bank or venture capital fund). It is difficult for the inventor to convey the essence and potential of their idea without revealing commercial secrets. The investor, in turn, finds it difficult to adequately assess the technical feasibility and market prospects of the project, as they are not an expert in this narrow field. This information asymmetry leads to problems of 'adverse selection' (investors, unable to distinguish between high-quality and low-quality projects, offer average financing terms that do not satisfy the owners of good projects) and 'moral hazard' (after receiving financing, the entrepreneur may not make sufficient effort). As a result, many promising projects do not receive funding. This can lead to the economy 'stuck' on its existing technological trajectory, unable to make the bold leaps necessary for radical change. The state, with its longer planning horizon and ability to diversify risks across the entire economy, can and should take on the financing of such high-risk projects that are too risky for private capital. State programmes for seed financing, expert evaluation and certification can reduce this asymmetry and signal the quality of the project to the market.

Even in the absence of classic 'market failures,' an innovation system may function inefficiently due to the absence or weakness of links between its key elements:

– infrastructure failures: Lack of necessary physical (laboratories, high-speed internet), financial (venture capital market) or educational (system for training qualified personnel) infrastructure;

– network failures: Weak links between universities and industry, between large and small firms, between domestic and foreign scientific communities. This hinders the diffusion of knowledge and technology transfer;

– institutional failures: Imperfections in the 'rules of the game,' such as weak intellectual property rights protection, excessive bureaucratic burdens, and unstable legislation, which increase transaction costs and uncertainty;

– capabilities failure: The inability of firms, especially small and medium-sized ones, to absorb new knowledge, manage innovative projects and enter global markets.

These problems, referred to as 'system failures,' require targeted efforts by the state to create technology parks and business incubators, promote the formation of clusters, support international cooperation programmes, reform education, and develop a modern financial architecture. To address the above-mentioned problems, governments around the world use a wide range of tools that can be classified according to various criteria. The most common classification is into tools that influence the supply of innovation (supply-side policies) and tools that influence the demand for innovation (demand-side policies).

Supply-side instruments are more traditional. They aim to increase the volume and quality of scientific research and development. Their goal is to reduce costs and risks for innovators, thereby stimulating the creation of new knowledge and technologies. These include grants for R&D, university funding, and tax breaks for research activities.

Demand-side instruments, on the other hand, focus on creating a market for innovative products and services. Their goal is to 'pull' innovations into the market by ensuring that there is demand for them. This is achieved through public procurement of innovative products (where the state acts as the first, 'leading' customer), the establishment of progressive technical standards or regulations that encourage the adoption of new solutions (e.g. environmental standards).

Instruments are also divided into direct and indirect (Table 1).

Direct support involves the direct provision of state financial resources to entities within the innovation system. One of the key instruments in this context is grants and contracts for R&D. This is targeted funding for specific research projects, provided on a competitive basis to universities, research institutes or private companies. Grants are usually aimed at supporting fundamental and exploratory research, where the outcome is not guaranteed, while government contracts are more often used to solve specific applied problems in areas of strategic importance to the state, such as defence, health care or energy. A key factor in the effectiveness of this instrument is the project selection procedure, which is based on independent

expert evaluation. Another important area is direct funding of public research institutions and universities, which takes the form of basic institutional funding to cover researchers' salaries, infrastructure maintenance and fundamental research without immediate commercial application. Such funding is the foundation of the entire scientific system of the country, on which future applied developments are based. In addition, the state can promote innovation by creating state venture funds or funds of funds, acting as a direct investor in start-ups in sectors that are strategically important but risky for private capital.

Table 1

Classification of state innovation policy instruments

Category	Type of instrument	Examples with details	Advantages	Disadvantages / Risks
Direct support (Supply-side)	R&D funding	Research grants: competitive funding for fundamental and applied projects. Government contracts: funding for developments for specific government needs (defence, medicine).	Targeted support for strategic areas, high efficiency for fundamental science.	Risk of 'state failure', bureaucracy, complexity of 'selecting winners', political influence.
	State funds	State venture funds: direct investments in start-ups. 'Funds of funds' (Yozma model): the state invests in private venture funds, requiring co-financing.	It can catalyse the private equity market and fill investment niches.	Risk of politicisation of investments, insufficient experience of state managers, displacement of private investors.
Indirect support (Supply-side)	Tax incentives	Tax credit: deduction of 10-30% of R&D costs directly from the tax amount. Super-deduction: deduction of 130-200% of R&D costs from the tax base	A market-neutral instrument that is easy to administer and stimulates R&D in all sectors.	Risk of abuse (misuse), less impact on start-ups that are not yet profitable.
	Regulation and institutions	Protection of intellectual property rights (IPR): patents, copyright. Antitrust policy: supporting a competitive environment to stimulate innovation	Establishing stable 'rules of the game', reducing transaction costs, creating incentives for investment in innovation.	The difficulty of finding a balance (too strong protection of IP rights may hinder the diffusion of knowledge), the risk of bureaucratisation.
Infrastructure instruments (Supply/Demand-side)	Networks and clusters	Technology parks, business incubators, accelerators: creating physical space and ecosystems for companies to interact and grow. Promoting exports of innovative products.	Creating synergies, facilitating access to resources and knowledge, and stimulating technology diffusion.	High cost of creation, risk of becoming 'immovable property' without real innovative activity, need for qualified management.
Demand-side instruments	Innovative public procurement	Pre-commercial procurement (PCP): the state finances R&D to develop solutions that do not yet exist on the market. Public procurement of innovative solutions (PPI): the state acts as the first buyer of innovative products.	Creating a guaranteed market for innovation, accelerating commercialisation, solving social problems.	High demands on the competence of public procurement officers, risk of corruption and lobbying, complexity of procedures.

Source: summarised by the authors based on data from [6, pp. 787–801; 7, pp. 19–20]

A more common and effective model is the creation of 'funds of funds,' where the state invests jointly with private investors in independently managed venture capital funds, which catalyzes market development (a striking example is the Yozma programme in Israel).

Unlike direct financing, indirect instruments do not provide companies with money directly, but instead reduce the cost and risks of innovation, leaving commercial decisions to the business itself, which is a market-oriented approach that preserves the autonomy of firms.

The most common tool in this category is tax incentives for R&D, which can take the form of a tax credit, allowing a company to deduct a certain percentage of R&D expenses directly from its tax liability, or an enhanced deduction, which allows more than 100% of actual expenses to be deducted from the tax base. The advantage of such incentives is their horizontality and neutrality, although their effectiveness largely depends on their design. This toolkit is complemented by depreciation policy: by allowing companies to accelerate the depreciation of equipment and assets used for R&D, the state reduces the tax burden in the early years of an investment project, increasing its net present value (NPV) and stimulating investment in the latest technologies.

Indirect support instruments are aimed not at financing, but at establishing fundamental 'rules of the game' that promote innovation. A key element of such a policy is the protection of intellectual property rights (IPR), primarily through patents. By granting inventors a temporary monopoly on the use of their inventions, the patent system allows them to recoup their R&D investments and make a profit, which creates a powerful incentive for innovation, although the system itself is not without its flaws. At the same time, education policy that promotes the development of human capital – the main resource of the knowledge economy – is of critical importance. Antitrust regulation plays a complex, dual role in this context, with the task of maintaining a 'golden mean': dynamic competition that forces companies to innovate, but at the same time allows them to profit from successful innovations.

Infrastructure tools of state innovation policy (supply/demand-side) form the basis for the long-term development of the innovation ecosystem. This involves the creation of technology parks, business incubators, accelerators, innovation clusters and networks that provide enterprises with access to resources, expertise and partnerships. Their key advantage lies in creating synergies between science, business and the state, which facilitates faster transfer of knowledge and technology. At the same time, infrastructure tools are capital-intensive and require high-quality management: in the absence of transparent rules, they can turn into formal 'real estate projects' without any real innovative dynamics. For Ukraine in the post-war reconstruction period, the development of innovative infrastructure can become the basis for regional clustering and attracting investment in high-tech industries.

Demand-side instruments operate on the principle of creating a guaranteed market for innovative products and services. The most common are public innovation procurement, which allows the government to act as the 'first customer' of new technologies, as well as regulatory mechanisms – the introduction of technical standards and environmental norms that stimulate business to innovate. Their effectiveness lies in accelerating the commercialisation of developments and reducing risks for private investors. At the same time, these instruments are associated with high demands on the competence of customers, the risk of corruption pressure and the complexity of procedures. For Ukraine, demand-side policy can be particularly effective in the areas of defence technologies, energy efficiency and digitalisation, where the needs of the state and society coincide with global technological trends. As a critical analysis of the financial ecosystem of innovation in the context of global challenges shows, financial development is not a self-sufficient factor of growth. In S. Khan's [13, p. 8] work, in countries with emerging markets, technological innovations become a driver of sustainable development only if institutions are of high quality and "green" financial instruments are available. Therefore, it is not enough for Ukraine to simply increase the volume of venture capital. The primary task is to align financial incentives with the environmental and social priorities of post-war reconstruction.

In this context, it is critically important to recognise the systemic role of financial infrastructure as a key prerequisite for innovative development. The financial ecosystem performs the function of redistributing resources and ensuring the viability of innovative projects at all stages of their cycle – from idea to scaling. Its stability and adaptability determine the ability of the institutional environment to support the dynamics of technological renewal in the face of global competition.

Each stage of the innovation process, from the inception of an idea to its entry into the global market, is characterised by a different level of risk and requires specific sources and instruments of financing. At the initial stage (seed stage), when the project exists at the level of an idea or prototype, the level of uncertainty

is at its highest, making access to traditional bank lending impossible. Therefore, the founders' own capital (bootstrapping) and non-repayable financial assistance in the form of state and international grants play a key role. An important source of capital is angel investors – private investors who invest their own funds in exchange for a stake in the company, while providing valuable expertise. This ecosystem is complemented by incubators and accelerators, which provide start-ups not only with seed investments, but also with mentoring support and educational programmes for the rapid development of their business models.

When a start-up moves into the early stage, with a finished product and its first customers, it needs significantly more investment to scale up, which is provided by venture capital in the form of long-term, high-risk investments in young, innovative companies. Unlike banks, venture capital funds do not require collateral, but become co-owners of the business, receiving a share in the capital and taking an active part in strategic management. The goal of a venture investor is to significantly increase the company's capitalisation within 5-10 years in order to subsequently sell their stake at a profit. Since most start-ups fail, the profit from one successful project must cover all the losses in the portfolio. Due to the high risks involved, the state often stimulates the development of this market by applying the 'fund of funds' model.

At the growth stage, when a company demonstrates stable income, it raises capital to enter new markets or acquire competitors. The sources of funding are the following, larger rounds of venture financing, as well as corporate investments from large companies interested in accessing new technologies. At this stage, private equity funds also get involved, investing in more mature companies.

The final stage is late-stage/exit, which allows investors and founders to realise their profits. The most common exit strategy is to sell the company to a strategic investor through a merger and acquisition (M&A) process. An alternative, albeit more complex, route is an initial public offering (IPO), where the company issues its shares for free sale on the stock exchange, which allows it to raise significant capital but requires a high level of transparency. In some cases, the company may also buy out investors' shares using its own profits.

Despite powerful theoretical justifications for state intervention, state policy itself can be ineffective or even harmful. This phenomenon is known as 'government failures' [6, pp. 787–801], which are particularly acute in the Ukrainian context, becoming one of the key obstacles to innovative development. They arise for several reasons. Firstly, there is information asymmetry and the problem of 'picking winners', as government officials rarely have complete information about technological trends and market prospects, which creates the risk of wasting taxpayers' money by supporting unpromising companies. in Ukraine, this is exacerbated by the lack of transparent expert assessment mechanisms. Secondly, political pressure and lobbying have a significant impact, as decisions on support are made not on the basis of economic expediency, but in the interests of certain groups, leading to the preservation of outdated technologies. Thirdly, bureaucratic inertia and corruption risks are significant obstacles: the slowness of state structures, complex procedures and excessive reporting create barriers for innovative companies and a favourable environment for corruption. Recognition of these risks leads to the conclusion that public policy must be carefully thought out, transparent and based on clear criteria, using market mechanisms rather than replacing them.

A thorough analysis of theoretical approaches and a summary of international experience allow us to assess the specifics of applying relevant tools in the Ukrainian context, particularly taking into account the challenges that determine the vulnerability and limitations of the national innovation system. With regard to state support programmes, Ukraine has a number of relevant tools, but their effectiveness is often limited by systemic problems. Key examples include the activities of the National Research Fund of Ukraine (NRFU), which provides grant support for scientific projects, and the Ukrainian Startup Fund (USF), which finances early-stage innovations. Although these institutions are a step in the right direction, their activities are hampered by limited budgetary funding, which does not allow them to meet existing demand, so the results of their work are noticeable but insufficient to bring about a radical change in the situation.

The financial ecosystem for innovation in Ukraine remains structurally vulnerable, which is particularly evident in the underdevelopment of venture financing instruments and public-private partnership mechanisms. The venture capital sector is fragmented: the number of domestic investment funds is minimal, and the volume of investment in technology projects lags significantly behind not only EU countries but also Eastern European countries. Due to limited access to financial resources, Ukrainian start-ups are often forced to register legal entities outside the country in order to attract international capital, which leads to a loss of intellectual potential and a reduction in revenues to the national budget [10].

In the process of transitioning from theoretical understanding of the nature of innovation to the formation of effective mechanisms for improving the efficiency of the national innovation system, it is critically important to rely on thoroughly studied international experience. It is precisely the comparison of different models of innovative development that makes it possible to identify not only universal factors of success, but also specific institutional configurations that have led to breakthrough results in individual countries. In this context, a methodology for the targeted selection of countries for case analysis has been reasonably applied, based on a combination of criteria of institutional effectiveness, diversity of strategic approaches to innovation policy, and relevance of conditions for comparison with the Ukrainian situation.

The list of selected cases includes the United States, South Korea, Israel, and Finland. These countries represent typologically different models of innovative development, each of which can serve as a source of applied solutions for modernising Ukraine's institutional environment.

The American model is based on the predominance of market mechanisms, the dominance of private capital, and a developed venture capital sector, which ensures a constant flow of resources to technology start-ups. The Korean strategy demonstrates the effectiveness of state coordination and support for innovation through cooperation with powerful corporate structures that have become the driving force behind technological breakthroughs. Israel has formed a unique system of innovative reproduction, in which the initial impetus is provided by the state, and the development of the venture market and technology transfer from the military-defence sector has contributed to the rapid growth of the start-up segment. Finland, in turn, is an example of a highly effective Scandinavian model that combines a policy of institutional inclusion, clustering and long-term partnerships between the state, business and science.

Each of the selected cases includes an analysis of the institutional prerequisites for innovative breakthroughs, including an assessment of the role of public policy, business initiatives, the scientific and educational environment, and the system of coordination between sectors. A comparative analysis of quantitative indicators of innovative development (Table 2) allows not only to compare the structural parameters of national systems, but also to objectively determine Ukraine's current place in the global innovation landscape. This creates a basis for formulating targeted recommendations for improving the financial, institutional and coordination infrastructure, taking into account the real challenges and transformational barriers facing the Ukrainian economy.

Table 2

Key indicators of innovation activity in selected countries (2022-2023)

Indicator	Ukraine	United States	South Korea	Israel	Finland
R&D expenditure (% of GDP)	0,3%	3,5%	4,9%	5,6%	3,0%
Patent applications (PCT, 2023)	41st place	2nd place	4th place	15th place	16th place
Venture capital investments (2023, billion $)	~$1-1.5	~$170	~$6.2	~$7	~$1.3
Global Innovation Index (2023)	55th place	3rd place	10th place	14th place	6th place

Source: summarised by the authors based on data from [7, pp. 19–20; 8; 9, pp. 19–203; 10, p. 6]

An analysis of typologically distinct innovation models reveals a systemic gap between Ukraine and the leaders in terms of both financial parameters and the quality of institutional architecture. Israel and South Korea consistently maintain the highest shares of R&D expenditure, making innovation a top political priority [7, pp. 19–20]. The United States dominates in terms of the scale of venture financing and patent activity, reflecting the maturity of market institutions, depth of capital, and established mechanisms for commercialising knowledge [9, pp. 19–203]. Finland and Israel demonstrate exceptional patenting intensity commensurate with the size of their economies, which proves the effectiveness of the 'science-business-market' channels [9, pp. 19–203]. Ukraine, on the other hand, is an outsider: low R&D spending reflects chronic underfunding of science [7, pp. 19–20], weak patent dynamics – low returns from the research sector and insufficient incentives for technology transfer [9, pp. 19–203], and an undeveloped venture market reflects a lack of internal financial 'escalators' for start-ups [10, p. 6]. Full-scale war has exacerbated these imbalances, shifting budget priorities and increasing risks for private investors.

Comparative analysis allows us to identify institutional configurations that transform resources into a sustainable stream of innovation. The American model is based on a combination of stable government funding for fundamental research (NIH, DARPA), targeted support for small innovative firms (SBIR/STTR), the scale of private R&D, and a powerful venture capital market integrated with university-industry links institutionalised through the Bayh-Dole Act.

The Korean trajectory demonstrates the effectiveness of strategic planning and selective support for knowledge-intensive industries with the participation of corporate 'locomotives' and systemic investments in STEM education; a sustainable mechanism for coordination between government, industry and academia is crucial. Israel shows how a state 'start-up impulse' (Yozma as a fund of funds) can shape the venture market, relying on the defence-technology complex as a source of personnel and solutions, as well as on a culture of risk-taking and close integration with global markets. Finland represents an institutionally mature Scandinavian model: specialised development agencies (in particular Business Finland) combine financing, expertise and internationalisation, while clusters and transparent public-private partnership mechanisms create long 'chains of trust' between regional ecosystems, business and science [8, pp. 32–37].

The synthesis of these approaches outlines a set of priority levers for Ukraine, without which it is impossible to move from fragmented initiatives to comprehensive financial and institutional support for innovation. Firstly, this involves restoring and securing stable public funding for fundamental and applied research as a basic condition for generating a flow of commercialised results. secondly, the creation of targeted instruments for small innovative companies based on the logic of 'public money crowds in private money' (analogous to SBIR/STTR) with clear performance metrics and intellectual property rights regime that stimulates partnerships between universities and businesses; thirdly, the institutional launch of an internal venture market through a combination of a 'fund of funds', co-financing with private investors, guarantees and insurance against military and political risks, in order to reduce the cost of capital and retain jurisdiction over company registration.

Additionally, regulatory mechanisms are needed to bring technologies to market quickly (regulatory 'sandboxes,' express procedures for critical technologies, tax incentives for R&D), as well as policies to support national technology 'champions' in priority areas, particularly in mil-tech, with a focus on scalable demand chains.

Institutional coordination is key to the effectiveness of financial instruments. A specialised innovation development agency with a mandate to combine grants, convertible loans, co-investments and internationalisation services should provide a single entry point for projects and be accountable for results. The regional level requires a cluster policy capable of connecting universities, companies, and local investor networks, forming portfolios of projects for joint financing. At the same time, the defence-industrial complex can act as a systemic generator of dual-use technologies, provided that there are channels for rapid transfer to civilian markets and export instruments (export credit agency, export risk insurance).

Therefore, the practical conclusion from the comparative analysis is not to simply replicate other countries' decisions, but to develop a coordinated set of financial and institutional mechanisms that transform limited resources into a predictable flow of innovation: stable public funding for research; targeted incentives for small innovative firms; internal venture capital infrastructure with risk reduction; regulatory flexibility and intellectual property rights protection; clusters and an effective development agency to ensure coordination. It is this configuration that creates the basis for the transition from theoretical models to specific recommendations for supporting innovation and improving the quality of its financial support in Ukraine.

Conclusions

The study confirms that in today's economy, innovation is not just one of many factors, but a central element of long-term economic growth and national competitiveness. Building an effective national innovation system is a complex, long-term process that requires focused, coordinated and consistent action on the part of the state, business and the scientific community.

An analysis of theoretical models [1, 2, 3], statistical data [7, 8, 9, 10] and international experience has led to several key conclusions. First, there is no single 'ideal' model of innovation policy. Successful countries such as the United States, South Korea, Israel and Finland have used different combinations of instruments adapted to their unique contexts, but their success stories have common features: strategic focus of the state, strong investment in human capital and a favourable environment for entrepreneurship. Second, the state plays an indispensable role as a catalyst, capable not only of correcting 'market failures' but also of actively shaping new markets and technological trajectories. Thirdly, the financial ecosystem is the 'lifeblood' of innovation, and Ukraine's lag in venture capital is one of the main obstacles forcing start-ups to seek funding abroad [10, p. 6]. Finally, 'state failures' in the Ukrainian context,

in particular bureaucracy and corruption risks, are no less significant obstacles than 'market failures,' undermining the effectiveness of even well-conceived initiatives [6, pp. 787–801].

The scientific novelty of the work lies in the systematic analysis of the interaction between financial mechanisms and public policy instruments in the context of the national innovation system. Unlike studies that focus on individual aspects, this work considers them as interrelated elements of a single system. Thus, it fills a gap in Ukrainian economic literature by offering a comprehensive analysis that combines the theoretical foundations of endogenous growth, the practical experience of leading countries, and the adaptation of this knowledge to the specific challenges facing Ukraine, particularly in the context of war and post-war reconstruction.

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СИСТЕМНИЙ АНАЛІЗ ВЗАЄМОДІЇ ДЕРЖАВНОЇ ПОЛІТИКИ ТА ФІНАНСОВИХ МЕХАНІЗМІВ У ФОРМУВАННІ НАЦІОНАЛЬНОЇ ІННОВАЦІЙНОЇ СИСТЕМИ

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В статті досліджується роль інновацій як основного драйвера сучасного економічного розвитку. Систематизовано та критично проаналізовано еволюцію економічної думки, від класичних теорій до сучасних моделей ендогенного зростання та концепцій національних інноваційних систем. Основна увага приділяється аналізу механізмів взаємодії між державною політикою та приватними інвестиціями у стимулюванні інноваційної активності. Детально розглядаються теоретичні обґрунтування державного втручання, зокрема проблеми «провалів ринку», та класифікуються інструменти державної політики. На основі емпіричних даних та міжнародного досвіду оцінюється їхня ефективність. Окрему увагу приділено аналізу фінансової екосистеми інновацій, включаючи роль венчурного капіталу, корпоративних інвестицій та державно-приватних партнерств у фінансуванні проєктів на різних стадіях їх життєвого циклу. На основі розширеного аналізу статистичних даних з джерел ОЕСР, Світового банку та Всесвітньої організації інтелектуальної власності проведено порівняльний аналіз інноваційних систем розвинених країн та країн, що розвиваються. Представлено детальні кейс-стаді успішних інноваційних політик США, Південної Кореї, Ізраїлю та Фінляндії. Виявлено ключові фактори їхнього успіху, зокрема ефективність державно-приватного партнерства, розвиток венчурного капіталу та

гнучкість регуляторного середовища. У роботі також ідентифіковано основні «провали держави» в інноваційній політиці, що призводять до неоптимального розподілу ресурсів. Сформульовано стратегічні рекомендації для розбудови ефективної національної інноваційної системи. Наукова новизна роботи полягає в системному аналізі синергетичної взаємодії фінансових механізмів та інструментів державної політики, спрямованої на стимулювання інноваційної активності, а також у розробці на цій основі практичних рекомендацій для розбудови ефективної національної інноваційної системи в українських реаліях.

Ключові слова: інноваційна політика, ендогенне зростання, фінансова екосистема, венчурний капітал, державно-приватне партнерство, національна інноваційна система.

SYSTEMIC ANALYSIS OF THE INTERACTION BETWEEN PUBLIC POLICY AND FINANCIAL MECHANISMS IN THE FORMATION OF THE NATIONAL INNOVATION SYSTEM

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The article examines the role of innovation as the main driver of modern economic development. It systematises and critically analyses the evolution of economic thought, from classical theories to modern models of endogenous growth and concepts of national innovation systems. The main focus is on analysing the mechanisms of interaction between public policy and private investment in stimulating innovation activity. The theoretical rationale for public intervention, in particular the problems of 'market failures', is examined in detail, and public policy instruments are classified. Their effectiveness is assessed on the basis of empirical data and international experience. Particular attention is paid to the analysis of the financial ecosystem of innovation, including the role of venture capital, corporate investment and public-private partnerships in financing projects at different stages of their life cycle. Based on an extensive analysis of statistical data from the OECD, the World Bank and the World Intellectual Property Organisation, a comparative analysis of innovation systems in developed and developing countries is conducted. Detailed case studies of successful innovation policies in the United States, South Korea, Israel and Finland are presented. The key factors of their success have been identified, in particular the effectiveness of public-private partnerships, the development of venture capital and the flexibility of the regulatory environment. The work also identifies the main 'failures of the state' in innovation policy, which lead to the suboptimal allocation of resources. Strategic recommendations for building an effective national innovation system are formulated. The scientific novelty of the work lies in the systematic analysis of the synergistic interaction of financial mechanisms and public policy instruments aimed at stimulating innovation activity, as well as in the development of practical recommendations for building an effective national innovation system in the Ukrainian context on this basis.

Keywords: innovation policy, endogenous growth, financial ecosystem, venture capital, public-private partnership, national innovation system.

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