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TECHNOLOGICAL ENTREPRENEURSHIP: SCALING CHALLENGES AND SOLUTIONS

Summary. *Introduction. This article examines issues related to the critical challenge of scaling technological entrepreneurship—through the lens of existing problems, typologies of barriers, and opportunities for overcoming them. The digitization of the global economy and the acceleration of technological cycles are transforming the paradigm of entrepreneurial activity, making scaling one of the defining factors of competitiveness.*

Purpose. This study focuses on identifying the structural obstacles in this process and systematizing integrated solutions at technological, organizational, financial, and market levels (with a detailed outline and characterization of relevant strategies). The author turns to the concept of “strategic platforming” as a tool for overcoming resource constraints by engaging external participants in creating value around the company's “technological core.”

Materials and methods. The literature analysis on the topic under discussion has revealed several thematic research directions. The first group of sources focuses on the mechanisms and tools of technological innovations. The second research category is centered on the connection between technological developments and the strategic growth of organizations. The third group of works focuses on the specifics of scaling. The materials presented are valuable for founders of tech startups, venture investors, corporate innovators, and researchers of the digital economy. In preparing this article, the following

methods were used: comparative analysis, systematization, content analysis, synthesis, and generalization.

Results. The quintessence of effective scaling of technological entrepreneurship is the systematic integration of technological, organizational, financial, and market strategies into a unified development ecosystem. The paradigm shift from linear growth models to exponential ones requires a fundamental rethinking of traditional business management approaches combined with the creation of adaptive mechanisms capable of operating under conditions of high uncertainty and dynamic market changes.

Further research in this area. The cognitive dissonance between the static nature of theoretical models and the dynamism of practical scaling experience among technology companies indicates the need for further conceptualization of this issue, as well as the development of integrative approaches at the intersection of: technological management, organizational psychology, strategic marketing.

Key words: *architectural modularization, two-speed organization, infrastructure as code, controlled expansion, scaling, strategic platforming, technological entrepreneurship, digital transformation.*

Statement of the problem. Technological entrepreneurship, as a driving force of the digital economy, is experiencing intense growth; however, scaling these startups is accompanied by a complex set of multi-level challenges. The key issue lies in the dichotomy between the potential for rapid growth of such companies and the structural barriers that hinder the effective scaling of their business models. Notably, 71% of enterprises experience difficulties in digital transformation, with the most common challenge being a lack of appropriate personnel or expertise (48%). By 2024, 69% of business entities had at least a basic level of digital intensity, and 21% of organizations with at least 10 employees, as well as self-employed individuals, were using artificial intelligence

technologies [11]. The convergence of digital solutions and traditional entrepreneurial practices calls for the development of an adaptive methodology to overcome scaling barriers, one that takes modern market realities into account. Despite a significant body of research in the field of entrepreneurship, the integrative analysis regarding scaling remains fragmented, highlighting the need to systematize existing concepts and formulate a holistic approach to the issue.

Analysis of recent research and publications. The literature analysis on the topic under discussion has revealed several thematic research directions. The first group of sources focuses on the mechanisms and tools of technological innovations. W. Chen [1] investigates the schemes and ways in which innovation policy influences the technological development of companies, emphasizing the role of state regulation and incentives. In the work by X. Huang [4], attention is concentrated on methods for managing investment risks in projects, where the author proposes a comprehensive model for their assessment and minimization. K. Rong [7] develops a methodological basis for evaluating enterprises' capacity for technological innovation using an enhanced algorithm, which allows for the quantitative measurement and comparison of business entities. The second research category is centered on the connection between technological developments and the strategic growth of organizations. H. Vochozka [8] examines the relationship between scientific and technological innovations and the sustainable development strategies of enterprises, proposing an integrative approach to building long-term competitiveness. Sh. Wu [10] studies the implementation of strategic asset management from the perspective of innovation, focusing on the transformation of intellectual property into a strategic resource. Yu. Jiang, J. Qin, and H. Khan [6] analyze the impact of taxation mechanisms on the entities under consideration in China, demonstrating how fiscal policy can stimulate or restrain innovative activity. The third group of works focuses on the specifics of scaling. A. Hayes [3] offers a conceptual

understanding of scalability and presents examples of successful cases, highlighting the key factors influencing this process. M. Fairlie [2] compares the mindset in startups and corporations, proposing a balanced approach that combines flexibility and systematic structure. E. Wallen [9], based on practical experience, formulates five key lessons, emphasizing the importance of an adaptive culture and strategic planning. A separate direction is represented by publications related to specific aspects of technological entrepreneurship. N. Islam, Q. Wang, Y. Marinakis, and S. Walsh [5] explore the relationship between family business and innovation, identifying the accompanying features. G. Zupan [11] analyzes statistical data on the implementation of artificial intelligence technologies, noting a marked increase in their use in recent years.

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Materials and methods. The first group of sources focuses on the mechanisms and tools of technological innovations. The second research category is centered on the connection between technological developments and the strategic growth of organizations. The third group of works focuses on the specifics of scaling. The materials presented are valuable for founders of tech startups, venture investors, corporate innovators, and researchers of the digital economy. In preparing this article, the following methods were used: comparative analysis, systematization, content analysis, synthesis, and generalization.

Presentation of the main material of the research. Technological entrepreneurship represents a symbiosis of innovative activity and the commercial implementation of corresponding solutions under conditions of high market uncertainty. Unlike traditional forms, technological ventures are characterized by a specific developmental trajectory that includes a "tipping

point" — the moment of transition from a local business model to expansive growth [1; 2; 7; 9].

According to analysis of US venture capital data, two-thirds of a company's value is created when it scales to capture a significant share of its target market [3].

The duality of the process under analysis is evident in the need to simultaneously develop the product ecosystem and transform internal business operations, which places considerable strain on the startup's resource base.

Barriers to scaling in the examined enterprises can be differentiated into the following groups: technological, organizational, financial, market.

For example, the infrastructure, which serves as the "foundation" for scaling, is subject to critical limitations amid rapid growth in the user base. The architectural rigidity of early technical solutions transforms into "technical debt," necessitating the reengineering of core systems. The paradox is that the technological flexibility required for iterative product development in the early stages often contradicts the stability requirements during mass deployment.

The surge in infrastructure load demands not only a linear increase in computing power but also a fundamental revision of approaches. Distributed systems, microservices architecture, and containerization become not merely tools, but strategic imperatives.

Regarding organizational obstacles, the triad "people – processes – culture" represents the most challenging aspect of scaling. The cognitive dissonance between the startup mentality and corporate discipline generates turbulence. The phenomenon of the "organizational ceiling" manifests as a decline in decision-making speed proportional to the company's growth. Simultaneously, a "communication saturation" problem arises when the number of potential communication channels increases relative to the number of employees,

significantly reducing the efficiency of information exchange and creating conditions for the fragmentation of corporate knowledge.

Financial aspects of scaling are characterized by an asymmetry between capital needs and investors' willingness to take risks at various stages of a business's development. The monetization models of tech companies often rely on deferred profitability in favor of expansion, creating tension between market share and financial sustainability. The dichotomy of "growth versus profitability" requires a thoughtful approach to planning and investment policy.

Market expansion is accompanied by the effect of "local optimization," where a product that is successful in its initial market shows reduced effectiveness when entering new geographic or demographic segments. The cultural heterogeneity of target audiences necessitates a differentiated approach to adapting the value proposition.

The paradox of the competitive environment is that successful scaling attracts not only additional users but also competitors capable of replicating the business model with lower transactional costs. This phenomenon is exacerbated by information asymmetry in technological markets and the lowering of entry barriers thanks to cloud solutions and service-based infrastructure models.

Next, strategic approaches to overcoming these barriers are considered. Among them, the technological group is highlighted (see Fig. 1).

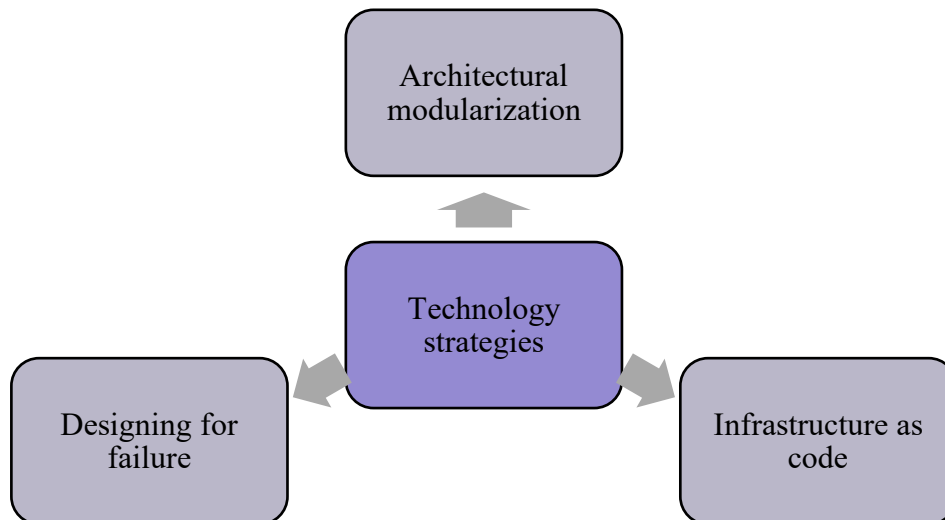


Fig.1. Technological strategies for overcoming scaling barriers

Source: compiled by the author based on [4; 6-8; 10]

Thus, architectural modularization is a key approach. The decomposition of monolithic applications into functional microservices with clearly defined interfaces enables independent scaling of individual components according to actual load.

The concept of “infrastructure as code” transforms the deployment and management of technological resources, ensuring reproducibility and version control of solutions. This approach minimizes human-related risks and creates a foundation for automating operational processes.

The “design for failure” methodology represents a paradigmatic shift—technological systems designed with the inevitability of partial failures in mind demonstrate increased resilience during scaling through the isolation of problematic components and the automatic redistribution of load.

The next group is represented by organizational strategies.

Within the “two-speed organization” concept, a company is segmented into a “core of stability” and peripheral innovative units. This approach helps maintain a balance between the predictability of operational activities and the flexibility of innovative initiatives. In turn, the fractal teams methodology is based on creating

self-sufficient cross-functional groups possessing all the required competencies to implement a specific product direction. This structure minimizes reliance on centralized resources and reduces communication costs during scaling.

A system of distributed decision-making with clearly defined zones of responsibility preserves organizational flexibility as the business grows. A key factor in the success of this approach is the creation of transparent performance metrics and mechanisms for synchronizing strategic priorities.

Regarding financial strategies, the following options can be highlighted (see Fig. 2):

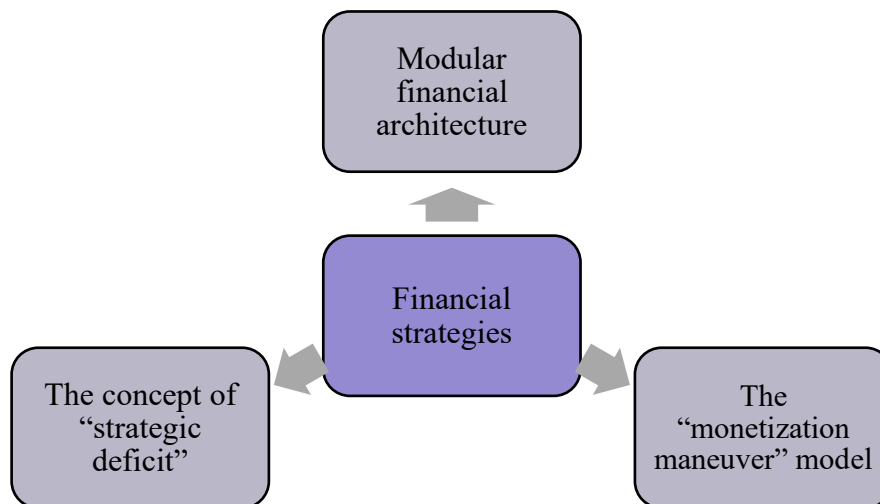


Fig. 2. Financial strategies for overcoming scaling barriers

Source: compiled by the author based on [4; 6-8; 10]

Taking into account the modular architecture, the business is segmented into separate financial units with their own performance indicators. This enables the differentiation of investment strategies depending on the stage of development of a particular business area and optimizes the allocation of resources.

The concept of “strategic deficit” represents a counterintuitive approach to financing growth, wherein deliberately limiting available funds stimulates the search for effective solutions and mitigates the risks of premature scaling of unoptimized processes.

The "monetization maneuver" model involves the iterative adaptation of the monetization strategy in line with changes in market conditions and the stage of the company's development. The phased transition from prioritizing the user base to optimizing the user's economic model represents a critical moment in the transformation of a technological business.

Among market strategies, those presented in Fig. 3 are particularly noteworthy.

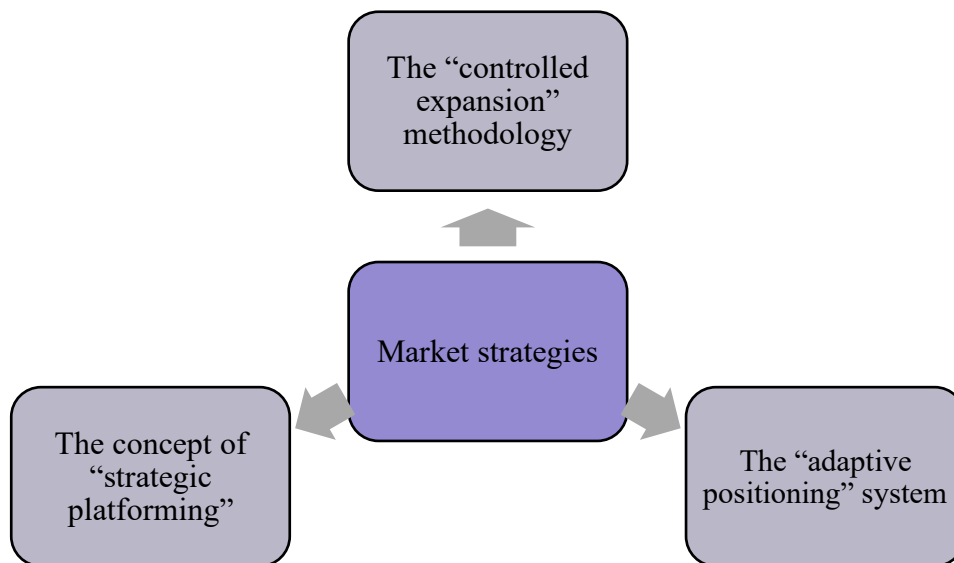


Fig. 3. Market strategies for overcoming scaling barriers

Source: compiled by the author based on [4; 6-8; 10]

Thus, the "controlled expansion" methodology is based on the sequential conquest of adjacent market segments with a high level of transfer of existing competencies. This approach mitigates the risks of resource dispersion and helps capitalize on accumulated experience in new market contexts. The concept of "strategic platforming" involves transforming the product offering into an open ecosystem that enables third parties to create additional value based on the core technological assets of the enterprise. The platform model ensures exponential growth through network effects and reduces dependence on the internal resource base. Finally, the "adaptive positioning" system is based on the flexible adjustment of the value proposition according to the characteristics of local

markets while maintaining a unified "technological core." This approach offers the possibility to overcome cultural barriers during geographic expansion and to optimize marketing investments.

It appears that the synergistic effect of combining these strategies provides the "foundation" for the formation of a new paradigm in technological entrepreneurship. The essence of this synergy lies in the fact that the combination of technological, organizational, financial, and market steps creates not merely the sum of their individual capabilities, but a new qualitative level of development in which each component reinforces and complements the others. The technological aspect provides the basis for the implementation of innovations and improves process efficiency; the organizational aspect represents a flexible structure capable of responding promptly to changes; the financial aspect supplies the necessary resources for executing large-scale projects; and the market aspect helps build interaction with consumers and maintain competitiveness.

As a result, such integration gives rise to an ecosystem in which the exchange of knowledge and resources among various elements achieves significant synergistic effects. These effects manifest as accelerated adaptation processes, reduced costs through the optimization of business processes, enhanced competitive advantages, and the formation of sustainable growth models that are difficult to realize under fragmented strategies.

Conclusions of this research and prospects for further research in this area. The quintessence of effective scaling of technological entrepreneurship is the systematic integration of technological, organizational, financial, and market strategies into a unified development ecosystem. The paradigm shift from linear growth models to exponential ones requires a fundamental rethinking of traditional business management approaches combined with the creation of adaptive mechanisms capable of operating under conditions of high uncertainty and dynamic market changes.

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