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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

PROSPECTS FOR BUILDING A STARTUP ECOSYSTEM IN THE FOOD INDUSTRY SECTOR IN AZERBAIJAN

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Field of science:	Economic Sciences
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GENERAL CHARACTERISTICS OF THE WORK

The relevance of the topic and the degree of development. The essence and drivers of economic development have constituted one of the main research directions of economic science for many years. In modern times, the concept of economic development does not rely solely on traditional capital and labor factors, but also encompasses new components such as innovation, entrepreneurship, and the formation of startup ecosystems. The development of startups and their role in the economic system, particularly in strategic sectors such as the food industry, has become a central element of the innovative economic development model.

In the contemporary era, the impact of startups-the primary carriers of innovation and especially innovative entrepreneurship-on economic growth is being studied in greater depth. The formation of startup ecosystems and the mechanisms of their impact on macroeconomic indicators, particularly on productivity, technological progress, and human capital development, have been investigated in the context of various economic growth theories.

Throughout history, the food industry has been an essential sector for the well-being of people and the economic security of states. With the deepening of globalization, new trends and integrations have formed in the areas of production, consumption, technology, and cultural influences within the food industry. Factors such as food security, healthy nutrition, environmental sustainability, technological innovation, and taste integration have been the main drivers of changes in the food industry. The rapid development of startup activity in the food sector is a noteworthy phenomenon, and this process has taken place against the background of different economic, technological, and institutional environments across various countries. The analysis of global experience in the establishment and development of startup ecosystems in the food industry plays a vital role in formulating modern food industry strategies.

Over the past thirty years, Azerbaijan's food industry has undergone significant transformation under the influence of political,

economic, and socio-economic changes. The transition of the economy to market mechanisms, integration into the globalization process, state support for agriculture, modernization of production technologies, and shifts in the population's food consumption patterns have led to the formation of new development trends in the sector. Alongside this, factors such as the pandemic, international market risks, and constraints of domestic production have had a profound impact on the sector's sustainable development.

The development of startup ecosystems is assessed as one of the primary factors determining the innovation capacity and competitiveness of modern economies. In joining this trend, Azerbaijan has taken significant steps in recent years in the area of supporting startups in order to encourage the transition to innovation-driven economic growth. The developed legislative framework, state initiatives, and institutional mechanisms have created favorable conditions for the formation and development of Azerbaijan's startup ecosystem.

The development of an innovation-based startup ecosystem for Azerbaijan's food sector is of strategic importance in terms of economic diversification and sustainable food supply. Various methodological approaches exist for evaluating startup ecosystems and forecasting their long-term development. However, it is observed that startup activity in this field is still at an initial stage and a specific food startup ecosystem has not yet formed.

The review of existing scientific literature shows that although the impact of startup ecosystems on economic development, the formation of the entrepreneurial and innovation environment, as well as distinct directions of innovative entrepreneurship in the food industry have been studied, there remains a need for a comprehensive study that brings together the current state, economic impacts, and long-term development perspectives of the startup ecosystem in Azerbaijan's food industry sector within a unified methodological framework. In particular, the assessment of the relationship between the startup ecosystem in the food sector and macroeconomic indicators based on panel data, along with the modeling of the

ecosystem's development trajectory using the System Dynamics approach, has not been sufficiently explored.

For this reason, the dissertation evaluates the current state of the startup ecosystem in Azerbaijan's food sector both within the general entrepreneurship and innovation environment and as an independent research object. The relationship between the startup ecosystem and economic development was analyzed using panel data from 85 countries for 2019–2023, the startup ecosystem in Azerbaijan's food sector was modeled as a dynamic system, and alternative development scenarios were developed for the years 2025–2045. This approach determines the key directions that distinguish this study from existing scientific literature.

Object of the research. The object of the research is the startup ecosystem forming in the food industry sector of Azerbaijan.

Subject of the research. The subject of the research is the systemic study of the development of the startup ecosystem in Azerbaijan's food sector and the determination of the determinants necessary for its development.

The aims and objectives of the research. The objective of the research is to approach Azerbaijan's startup ecosystem, including the startup ecosystem emerging in the food sector, as a dynamic system, to assess its current state, and to forecast its long-term development.

To achieve this objective, the following tasks were carried out:

- systematizing the theoretical foundations of entrepreneurship and startup ecosystems and investigating their relationship with innovative economic development;
- conducting a comparative analysis of global trends affecting the food industry, FoodTech and AgriTech innovations, as well as the experiences of leading countries;
- assessing the current state, market size, and trends in production, consumption, imports, and exports of the food industry in Azerbaijan;
- performing a comparative evaluation of Azerbaijan's innovation and startup ecosystem based on international indicators;

- quantitatively evaluating the relationship between the startup ecosystem and economic growth using econometric and panel analysis methods;

- identifying the interactions among startups, investors, consumers, human capital, incubators and accelerators, public policy, and technological changes;

- modeling cause-and-effect relationships, stock, flow, auxiliary variable, and parameter structures in the startup ecosystem using the System Dynamics approach;

- developing 5-, 10-, and 20-year development scenarios for the startup ecosystem in the food sector and defining policy directions.

Research methods. Comparative and systemic analysis, statistical generalization, econometric methods, panel data analysis, and the System Dynamics approach were applied in the study. To evaluate the relationship between the startup ecosystem and economic growth, a balanced panel dataset comprising data for 85 countries over the period 2019–2023 was used. In evaluating long-term development directions, a System Dynamics model was constructed based on cause-and-effect relationships, stock and flow structures, auxiliary variables, and policy parameters.

Taking into account the limitations of statistical data in the food sector, the model utilized accessible indicators and simplified functional relationships, evaluating alternative development scenarios for the years 2025–2045.

The main provisions put forward for defense

- R&D expenditures, technology adoption, human capital, and the quality of the business environment are fundamental factors for innovative economic development and the formation of a startup ecosystem.

- By affecting labor and capital productivity, knowledge diffusion, human capital development, and innovation processes, startups facilitate the strengthening of economic dynamism.

- The expansion of startup activity in the food industry is significant in terms of food security, technological renewal of the sector, and economic sustainability. Although growth in food

industry production is observed, import dependency and structural constraints persist.

- Azerbaijan's innovation and startup indicators point to weak positions in international comparisons. In 2024, the country ranked 95th in the Global Innovation Index and 80th in the Global Startup Ecosystem Index, while Baku was recognized as a leading startup hub in the Caucasus region[1].

- Based on panel data for 85 countries across 2019–2023, a statistically significant positive relationship was identified between the GSEI score and GDP per capita. In the fixed effects model, the GSEI coefficient was 318.66.

- In Azerbaijan, incubation and acceleration centers, grant programs, and digital platforms support startup activity; however, access to venture capital, investor infrastructure, and international connectivity remain limited.

- The System Dynamics model explains the development of the startup ecosystem in the food sector through the interaction of investment, revenue, human capital, support infrastructure, public policy, and internationalization factors. According to the model, scenarios of 15–18 active startups in 2025–2030, 40–50 in 2030–2035, and 100–120 in 2035–2045 were evaluated.

The scientific novelty of the research

- the distinguishing features of the concepts of entrepreneurial ecosystem and startup ecosystem were systematized, and their role in innovative economic development was synthesized within a unified theoretical framework;

- the channels through which startups impact economic growth were comparatively systematized on the basis of classical, neoclassical, endogenous growth, and Schumpeterian approaches;

- the long-term development of Azerbaijan's food industry market and structural changes based on production, consumption, import, and export indicators were evaluated, and the sector's main development constraints were identified;

[1] . World Intellectual Property Organization (WIPO), Global Innovation Index 2024; StartupBlink, Global Startup Ecosystem Index 2024.

- the international standing, strengths, and weaknesses of Azerbaijan's innovation and startup ecosystem were evaluated based on GII, GSEI, StartupBlink, and Startup Genome indicators;

- the statistical relationship between the startup ecosystem and economic growth was quantitatively evaluated using panel data for 85 countries, with the GSEI coefficient determined to be 318.66 in the fixed effects model;

- the interaction mechanisms of institutional, financial, human capital, and innovation factors affecting the development of the startup ecosystem in Azerbaijan were modeled within the framework of System Dynamics;

- a System Dynamics model comprising stock, flow, auxiliary variable, and parameter elements was constructed to assess the long-term development of the startup ecosystem in Azerbaijan's food sector, and development scenarios for 2025–2045 were elaborated.

Theoretical and practical significance of the research. The theoretical significance of the study is associated with the investigation of the relationship between startup ecosystems and economic development within a unified framework based on diverse economic theories and the System Dynamics approach. From a practical perspective, the obtained results can be utilized in supporting startups in the food sector, developing incubation and acceleration infrastructure, expanding access to venture capital, strengthening university-industry collaboration, and evaluating long-term policy scenarios.

Approbation and application of research results. The main findings of the dissertation work are reflected in articles published in 11 domestic and foreign journals, and presentations on the results of the research were delivered at 3 national and 3 international conferences.

Name of the organization where the dissertation work was conducted. The dissertation work was carried out at Azerbaijan Technological University, in the Department of "Organization of the Tourism Industry."

Total volume of the dissertation indicating the separate volume of its structural divisions. The dissertation consists of an

introduction, three chapters comprising nine sections, a conclusion and recommendations, and a list of references.

The introduction contains 14339 characters, Chapter I – 68346 characters, Chapter II – 72154 characters, Chapter III – 67226 characters, the conclusion and recommendations – 17285 characters, and the list of references – 22918 characters.

The total volume of the dissertation, excluding tables, diagrams, charts, figures, appendices, and references, is 239350 characters.

The dissertation includes 14 tables, 8 diagrams, 26 charts, and a list of references comprising 149 sources.

TABLE OF CONTENTS OF THE DISSERTATION WORK

INTRODUCTION

CHAPTER I. THEORETICAL AND METHODOLOGICAL FOUNDATIONS FOR STUDYING THE FORMATION OF A STARTUP ECOSYSTEM

1.1. Innovative economic development, entrepreneurship, and startups

1.2. Various approaches to the macroeconomic impacts of startup ecosystems

1.3. Global experience of the startup ecosystem in the food industry

CHAPTER II. CURRENT STATE OF THE FOOD INDUSTRY AND THE STARTUP ECOSYSTEM IN AZERBAIJAN

2.1. Current state of Azerbaijan's food industry

2.2. Assessment of the entrepreneurship ecosystem and the level of innovative development in the food industry sector

2.3. Impacts of the startup ecosystem on economic development and the current state of the startup ecosystem in Azerbaijan

CHAPTER III. DEVELOPMENT PERSPECTIVES OF THE STARTUP ECOSYSTEM IN AZERBAIJAN'S FOOD SECTOR

3.1. Startups and the startup ecosystem in Azerbaijan

3.2. System Dynamics modeling of startup ecosystems in Azerbaijan's food sector

3.3. Development perspective of startup ecosystems in Azerbaijan's food sector

CONCLUSION AND RECOMMENDATIONS

LIST OF REFERENCES

MAIN CONTENT OF THE RESEARCH WORK

The introductory section of the dissertation substantiates the relevance and degree of elaboration of the topic, and presents the object and subject of the research, goals and tasks, research methods, main provisions submitted for defense, scientific novelties, theoretical and practical significance, theoretical-methodological and data base, approbation, personal contribution of the applicant, the institution where the work was carried out, and its structure and volume.

In the first chapter of the dissertation titled **"Theoretical and Methodological Foundations for Studying the Formation of a Startup Ecosystem,"** the theoretical foundations of the startup ecosystem, macroeconomic impact mechanisms, and global experience in the food industry are examined.

The chapter highlights the role and importance of startup ecosystems in the development of an innovation-driven economy. The experiences of various countries are presented comparatively, particularly examining the experience of leading ecosystems such as the USA, Israel, the United Kingdom, Germany, the Netherlands, and others as examples. Based on these experiences, the structure and management mechanisms of successful ecosystems are identified. In conclusion, the chapter proves that an in-depth study of the scientific foundations of the startup ecosystem and the application of appropriate methodological approaches play an essential role in the development of this field.

Another reporting source used for the comparative evaluation of global food startup ecosystems is the Global Innovation Index (GII). It should be noted that this index can be useful for any activity or entity for which innovation is considered a primary indicator. For example, the GII can be used to assess the entrepreneurial ecosystem, all types of startup ecosystems, or levels of technological development. Developed by the World Intellectual Property Organization (WIPO), this index measures a country's innovation capabilities and results across seven pillars: a) institutions; b) human capital; c) infrastructure; d) market sophistication; e) business sophistication; f) knowledge; g) creative outputs. When calculating

the GII, a) R&D expenditures; b) number of researchers; c) ease of starting a business; d) knowledge diffusion; and e) environmental sustainability are included in the calculation as key indicators. The GII is useful for understanding the baseline innovation environment in which startups, including food innovation and technology, can thrive. However, as noted, the GII can be utilized to evaluate not only the startup ecosystem, but also the entrepreneurial ecosystem as a whole, as well as the level of technological development[2].

The theoretical generalization conducted demonstrated that although the impact of startups on economic growth is explained through different mechanisms across various theoretical schools, these mechanisms complement one another. In the classical approach, more efficient allocation of resources and productivity play the key role; in the neoclassical approach, capital accumulation and technological progress; in endogenous growth theory, knowledge and human capital; and in the Schumpeterian approach, innovation and the mechanism of "creative destruction." In the study, these approaches were synthesized into a unified theoretical-methodological framework and adapted to the specificities of the food sector.

An analysis of global experience shows that in countries where food startups are developing rapidly, innovation infrastructure, venture capital, university-business cooperation, research opportunities, and flexible regulatory mechanisms complement each other. The USA, Israel, the United Kingdom, The development of FoodTech and AgriTech startups in the USA, Israel, the United Kingdom, Germany, the Netherlands, and other countries has created conditions for the emergence of new business models in areas such as alternative protein sources, smart agriculture, digital supply chains, functional foods, resource efficiency, and e-commerce. This experience was evaluated not as a direct transfer of a ready-made model for Azerbaijan, but as a set of principles that can be adapted, taking into account the size of the local market, financial capabilities, ties to agriculture, and institutional features.

[2] World Intellectual Property Organization (WIPO), Global Innovation Index 2024: Conceptual and Measurement Framework, Geneva, 2024.

In the dissertation's second chapter, titled **"The Current State of the Food Industry and Startup Ecosystem in Azerbaijan**," the current state of the food industry, the entrepreneurial and innovation environment, the impact of the startup ecosystem on economic development, and Azerbaijan's current position were analyzed.

First, the overall state of Azerbaijan's food industry, its place in the economy, key production sectors, and export potential are studied at. The performance of local production enterprises, their technological level, competitiveness, and openness to innovation are evaluated. Regional differences in the development of the food industry and the state's support for this sector are specifically highlighted.

The chapter also analyzes the structure and development stages of Azerbaijan's startup ecosystem. It reviews government programs, innovation centers, tech parks, incubators, and accelerators, as well as the role of the private sector and international organizations. The distribution of Azerbaijani startups by sector and the number and impact of innovative projects related to the food industry are analyzed.

Based on statistical data, the number of food startups operating in the country, the volume of investment, the challenges they face, and their development opportunities are assessed. At the end of the chapter, existing opportunities and strategic recommendations for expanding the application of startups in the food industry are proposed.

Chapter II analyzes the current state of Azerbaijan's food industry and startup ecosystem, the sector's production and consumption characteristics, innovation indicators, and the relationship between startup activity and economic development.

The Global Innovation Index (GII), as well as the Global Competitiveness Report, allows for a comparative analysis of the country's existing ecosystem based on indicators such as innovation capacity, R&D spending, infrastructure, human capital, market size, etc. Porter's "Diamond Model" analyzes the country's existing ecosystem by comparing it based on indicators such as a) factor conditions, including infrastructure, human capital, and natural resources; b) demand conditions, including consumer demand and market demands; c) related and supporting sectors, including

logistics, packaging, and financial services; and d) the intensity of competition, including domestic competitors, government support, and so on. By evaluating these four key elements in Azerbaijan's food industry, the strengths and weaknesses of the country's startup ecosystem can be revealed[3] .

The Global Innovation Index is an annual report by the that assesses the innovation potential and the effectiveness of innovation activities in various countries. This index is prepared by the World Intellectual Property Organization (WIPO), the Catholic University of Portugal, and Cornell University. The GII methodology is built on innovation inputs and innovation expenditures, and innovation outcomes or innovative product outputs. Each country is assessed on two main sub-indices[4] .

Innovation inputs quantify the resources and conditions available in a country for creating innovation. This assessment is built on 5 key pillars: a) Institutions, i.e., political stability, regulatory environment, and business environment; b) Human Capital & Research, i.e., the country's level of education and available research infrastructure; c) Infrastructure, i.e., ICT infrastructure, energy efficiency, and environmental sustainability; d) Market Sophistication, i.e., financial markets and investment opportunities; e) Business Sophistication, i.e., the number of innovative companies, university-business collaboration, etc.

Innovation outputs measure the innovation outcomes achieved by the country. This assessment is built on 2 main pillars: a) Knowledge & Technology Outputs, i.e., patents, high-tech exports, scientific articles; b) Creative Outputs, i.e., brands, designs, and cultural and creative industries.

To estimate the impact of the startup ecosystem on economic growth, a balanced panel dataset covering 85 countries from 2019 to 2023 was compiled, and a Panel Least Squares fixed-effects model was applied based on 425 observations. In the model, the coefficient

[3] Porter, M.E. The Competitive Advantage of Nations. New York: Free Press, 1990; WIPO, Global Innovation Index 2024.

[4] World Intellectual Property Organization (WIPO), Global Innovation Index 2024, Appendix I: Conceptual and Measurement Framework.

for the Global Startup Ecosystem Index (GSEI) was 318.66, the p-value was 0.0000, and the R^2 was 0.9849. The result indicates that, all else being equal, a 1-unit increase in the GSEI index is associated with an average increase of 318.66 units in GDP per capita. In alternative panel specifications, the coefficient remains in the interval of , indicating the robustness of the result.

Table 1. Key results of the panel analysis of the relationship between GSEI and GDP per capita

Period	Number of Countries	Observation	GSEI coefficient	p-value	R^2
2019-2023	85	425	318.66	0.0000	0.9849

Source: Author's calculations based on StartupBlink's Global Startup Ecosystem Index reports (2019–2023) and World Bank's World Development Indicators data[5] , [6]

A comparative analysis of Azerbaijan's innovation position has also revealed structural constraints in the ecosystem. In 2024, Azerbaijan ranked 95th out of 133 countries in the Global Innovation Index, ranking 82nd for innovation "inputs" and 101st for "outputs." This gap indicates a need to increase the efficiency of converting available resources for innovation into commercialized outcomes. The weakness of venture capital, foreign direct investment, and high-tech exports has been identified as one of the key factors limiting the development of the startup ecosystem.

Chapter II assesses the long-term dynamics of the food industry in terms of production, consumption, imports, exports, entrepreneurial structure, and innovation indicators. The analysis showed that the sector experienced significant changes during the transition to a market economy, and in the subsequent phase, production and export capacities expanded. Additionally, instability in raw material supply, access to financial resources, quality

[5] StartupBlink, Global Startup Ecosystem Index reports, 2019-2023; World Bank, World Development Indicators, GDP per capita (current US$). Panel calculations were conducted by the author.

[6] WIPO, Global Innovation Index 2024, Azerbaijan economy profile: overall rank 95, innovation inputs rank 82, innovation outputs rank 101.

standards, a shortage of qualified personnel, logistics, and the market position of imported products were identified as s limiting sustainable development. While micro and small enterprises dominate in number within the entrepreneurial structure, the role of medium and large enterprises is significant in generating value added, investment, and employment. This situation makes the integration of food startups into the existing production and supply system a significant policy issue.

Azerbaijan's startup ecosystem has been separately evaluated based on international indicators and local institutional data. Although the increase in the number of entities receiving startup certificates from 2021 to 2025 indicates an expansion of the ecosystem, the sectoral structure is uneven and the number of projects in food technologies is limited. KOBIA data shows that 199 startups received certification by 2025. The mapping of projects related to the food sector has shown the emergence of areas such as AgriTech, FoodTech, e-commerce, food delivery, water ordering, smart vending, and waste processing. At the same time, the weakness of venture capital, limited investor networks, and insufficient mentorship and access to international markets make it difficult for startups to scale[7] .

To assess the statistical relationship of the startup ecosystem with economic growth, a balanced panel dataset covering 85 countries from 2019 to 2023 was compiled. The per capita GDP indicator was taken from the World Bank database. In the fixed effects model, the coefficient on the GSEI was 318.66, the p-value was 0.0000, and the R-squared was 0.9849. In alternative specifications, the coefficient remained in the interval 318-330, indicating that the direction of the result is robust. This result was interpreted not as an increase in the GSEI causing a commensurate increase in GDP, but as a statistically significant positive relationship between the two indicators in observations across countries and over time. Such an approach allows for a more cautious and

[7] StartupBlink, Global Startup Ecosystem Index reports, 2019-2023; World Bank, World Development Indicators, GDP per capita (current US$).

methodologically sound presentation of the economic substance of the model's results.

In the dissertation's third chapter**,** titled **"Development Prospects of the Startup Ecosystem in Azerbaijan's Food Sector**,**"** the current structure of the startup , the System Dynamics model, and long-term development scenarios for the food sector were developed.

In Chapter III, titled "Development Prospects of the Startup Ecosystem in Azerbaijan's Food Sector," the current state of the food industry in the Republic of Azerbaijan and the development opportunities for the emerging startup ecosystems in this sector are analyzed comprehensively. The main objective is to determine the role and potential of startups in the innovation-driven transformation of the food industry.

The System Dynamics approach was applied to assess the long-term development of the startup ecosystem. This approach allows for tracking accumulations, flows, auxiliary variables, and feedback loops within the ecosystem as a single system.

The model allows for the comparison of long-term scenarios. The possible impact of variables such as government support, investment, human capital, incubation infrastructure, and international cooperation has been evaluated within the same analytical framework.

The model considers the number of startups, investors, human capital, and incubation infrastructure as key stock variables, while new startups, investor entry and exit, financial flows, and personnel movement are considered flow variables.

The application of the System Dynamics approach allows for the comparison of long-term outcomes of policy decisions in the form of scenarios and the joint assessment of risks and development opportunities.

The stages of problem identification, description of cause-and-effect relationships, creation of the stock-flow structure, and scenario assessment were applied sequentially during the model's development.

The cause-and-effect diagrams took into account the relationships between the number of startups, funding, investor interest, market attractiveness, human capital, incubation support, and government policy.

The fact that Azerbaijan's startup ecosystem is in its formative stage and the limitations of the database made it necessary to build the model based on simplified indicators.

In the model's structure, stock, flow, and auxiliary variables are grouped to encompass the ecosystem's main economic and institutional components.

Based on the interrelationship of the stock and flow indicators, as well as the auxiliary variables, a simplified System Dynamics model of the startup ecosystem in the food sector was developed.

Policy parameters such as the public investment budget, tax incentives and subsidies, funds allocated to incubators and accelerators, entrepreneurship education, and international cooperation programs were incorporated into the model.

The interaction of these indicators was used as the basis for assessing the development scenarios of the startup ecosystem in the food sector.

Table 2. Key Structural Elements of the System Dynamics Model

Element	Key indicators used in the model
Stocks	Number of active startups; active investors; qualified human capital; incubator and accelerator infrastructure
Inflows	New startups; new investors; financial inflow; new talent; new incubators/accelerators; international experts
Outflow	Failed and exiting startups; investor exits; brain drain; closing support institutions
Auxiliary variables and parameters	Investment volume, exit percentage, revenue, internationalization, ranking, and attractiveness; state budget, tax incentives, education, and international cooperation programs

Source: Compiled by the author based on the structuring of the System Dynamics model[8] .

[8] Sterman, J.D. Business Dynamics: Systems Thinking and Modeling for a Complex World. Boston: Irwin/McGraw-Hill, 2000. The model structure was adapted by the author.

In the model, the relationships between variables are structured as reinforcing and balancing feedback loops. The first key loop is the "investment-startup development" mechanism: as the number of startups and successful projects increases, investor interest and financial flow rise; the expansion of capital accessibility stimulates the creation of new startups. In parallel, the increase in the number of startups raises sector revenues, and high revenue creates a positive market signal for new entrepreneurs, increasing new entries into the ecosystem.

The second feedback mechanism relates to the ecosystem's attractiveness. Successful market exits of startups increase international rankings and recognition, which in turn boosts the interest of foreign investors and experts. The expansion of financial and expert support facilitates the creation of new startups and subsequent successful exits. A successful exit is not just the result of a single company; it serves as a systemic element that ensures the recirculation of capital and entrepreneurial experience throughout the entire ecosystem.

The third mechanism is related to human capital: the growth in the number of startups and jobs increases the demand for qualified personnel, which in turn stimulates the expansion of education and training programs in entrepreneurship, technology, and food technology. The increase in the pool of qualified personnel, in turn, increases the likelihood of new startups emerging. In the model, brain drain is considered one of the main balancing factors that weakens this cycle.

The fourth key mechanism is the effectiveness of incubators and accelerators. The increase in the number of startups raises the demand for support services, encourages the creation of new incubators and accelerators, improves mentorship and access to finance, and increases the number of successful startups. Additionally, factors such as failure and exit, investor exodus, brain drain, and market saturation were incorporated into the model as negative/balancing relationships that reduce accumulations.

The limitations of available statistical data for quantifying the model's scenario parameters in the food sector were taken into

account, and simplified functional relationships were applied to the available indicators. In the base scenario, R&D expenditures were taken at 0.2% of GDP, an average annual increase of 5% in investments was assumed, and economic freedom, R&D, and the direction of brain drain were considered in the formation of the GSEI indicator. The purpose of the model is less about providing an exact deterministic "number" and more about illustrating how policy variables translate into long-term system outcomes and comparing alternative development trajectories.

Table 3. Scenario-Based Forecast of Startup Ecosystem Development in the Food Sector

Indicator	2025-2030	2030-2035	2035-2045
Number of active startups	15-18	40-50	100-120
Nature of development	Stable, weak growth relying on government support and the local market	Innovation-based development with access to regional markets	Competitive, export-oriented, and innovative ecosystem
Basic Conditions	R&D and grant support; initial specialized infrastructure	Investor and diaspora capital; university-industry collaboration	International investment, export networks, and mature FoodTech/AgriTech infrastructure

Source: Compiled based on the author's scenario calculations for System Dynamics[9] .

The forecast scenarios considered key conditions such as increasing the share of R&D expenditures in GDP from 0.2 percent

[9] Scenario indicators were developed based on the calculations of the System Dynamics model built by the author for their dissertation.

to 0.5 percent, expanding government programs, improving access to international markets, strengthening local innovation networks, and attracting foreign investors.

In Chapter III, the startup ecosystem in the food sector is justified not as a simple sum of individual institutions, but as a dynamic system where the factors of investment, revenue, human capital, support infrastructure, government policy, internationalization, and risk interact with each other.

In the System Dynamics model for the food sector, the key accumulations are represented by the number of active startups, active investors, qualified human capital, and incubator-accelerator infrastructure. The inputs to the flows included new startups, new investors, financial flows, new personnel, and new support institutions, while the outputs included failed startups, investor exits, brain drain, and closing support structures. Investment volume, the share of successful market exits, revenue, internationalization, ecosystem attractiveness, the state budget, tax incentives, educational programs, and international cooperation were included in the model as auxiliary variables and parameters. This structure allows for tracking the direct and indirect effects of a change in one indicator on the other components of the ecosystem.

The model distinguishes four main feedback mechanisms. In the investment and startup development cycle, increased capital availability stimulates the creation of new projects, while the growth of successful projects strengthens investor interest. In the relationship between revenue and new startups, the sector's revenue opportunities create a market signal for new entrepreneurs. In the human capital cycle, the growth of startups and jobs increases the demand for qualified personnel, while the expansion of education and training programs strengthens the ecosystem's talent pool. The development of incubators and accelerators enhances mentorship, networking, and funding opportunities. Failure, investor exit, brain drain, and market saturation are considered counterbalancing factors that weaken these positive relationships.

The limited availability of initial data was separately considered in the scenario assessment. The purpose of the model is

not to announce a fixed and precise figure for 2045, but to compare how policy variables are transmitted through the system under different assumptions. The baseline trajectory is built on the conditions of increased R&D spending, expanded government programs and grants, strengthened university-industry collaboration, attracting foreign and diaspora investors, and improved access to international markets. When these conditions are met, the number of active food startups is projected to be 15-18 in 2025-2030, 40-50 in 2030-2035, and 100-120 in 2035-2045, respectively. A weakening of these conditions was associated with a lower growth trajectory and a higher risk of failure.

KEY MODEL DIAGRAMS FOR CHAPTER III

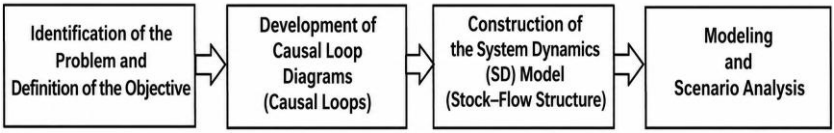


Figure 1. Simplified algorithm for building the System Dynamics model

Source: Complied by the author

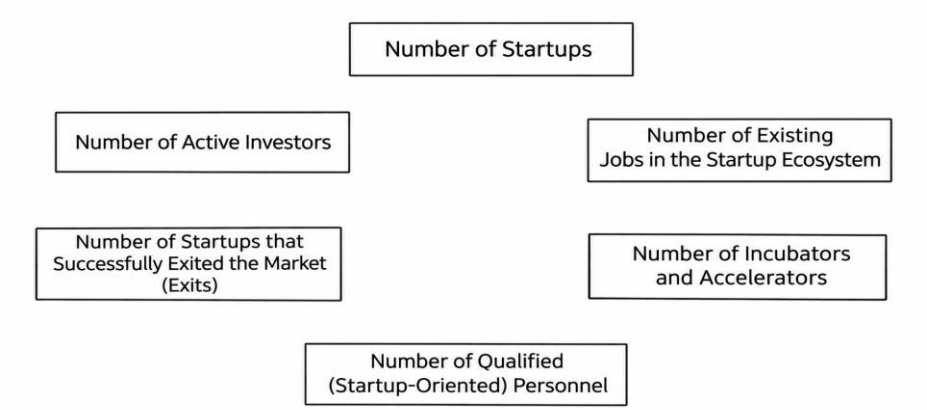


Figure 2. Key stocks in the Azerbaijani startup ecosystem

Source: Complied by the author

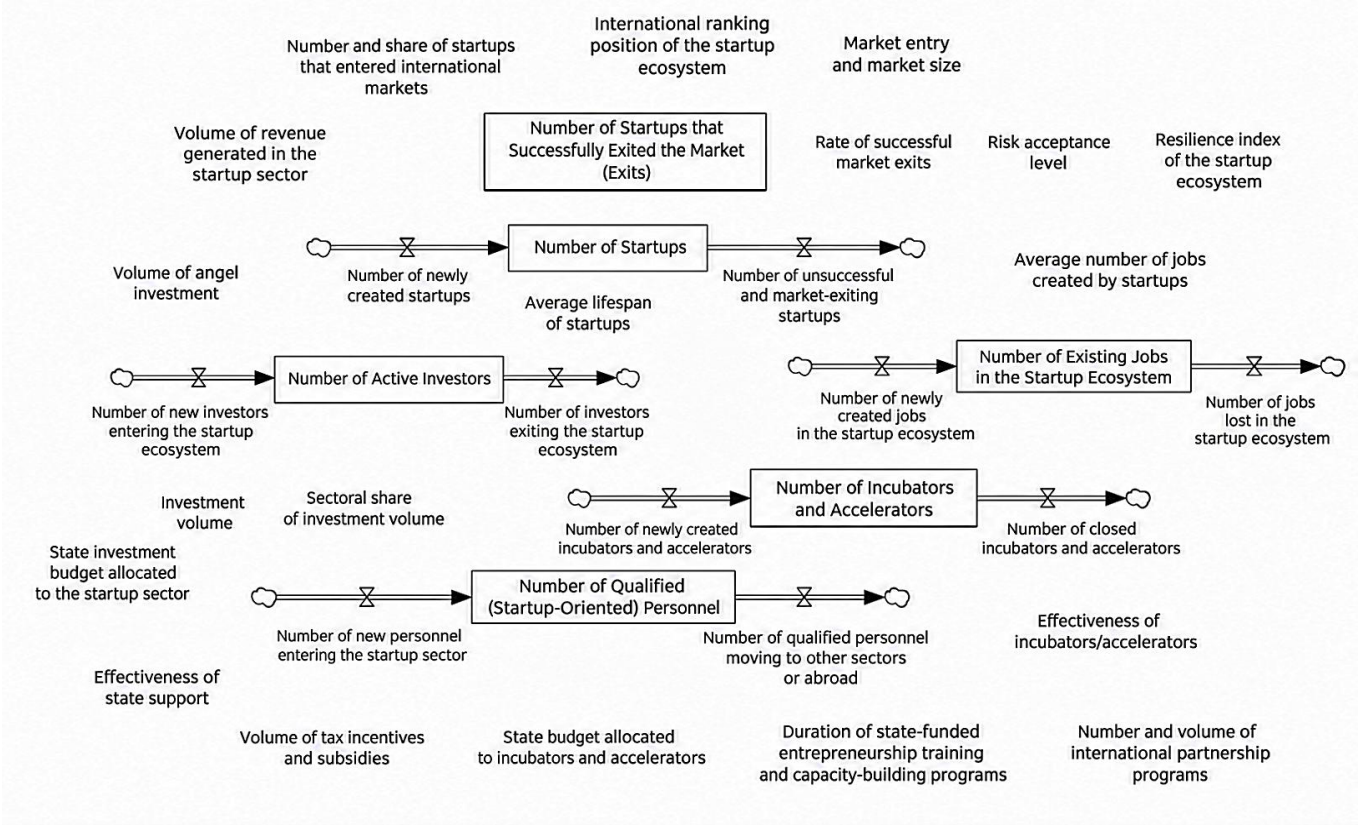


Figure 3. Interaction of stocks, flows, auxiliary indicators, and parameters

Source: Complied by the author

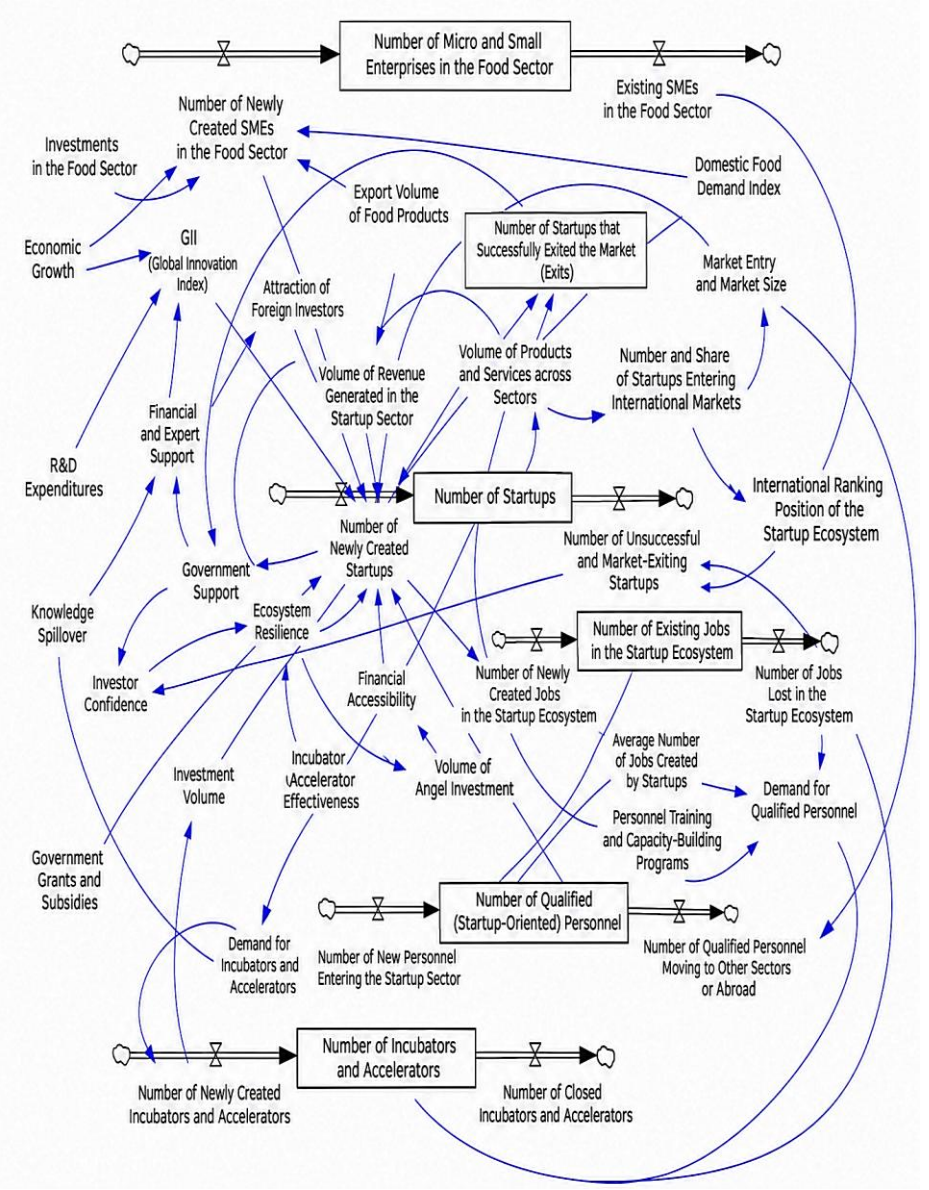


Figure 4. System Dynamics model for the prospective development of the startup ecosystem in the food sector

Source: Complied by the author

SYSTEMATIZATION OF SCIENTIFIC RESULTS FOR CHAPTER III

Table 4. Key feedback mechanisms in the model

No.	Mechanism	System outcome
1	Investment - startup development	Investor interest and financial flow strengthen the emergence of new startups.
2	Revenue - new startup	Growth in sector revenues increases market attractiveness and new entries.
3	Ecosystem attractiveness - exit	Successful exits strengthen the interest of the rating agencies, investors, and experts.
4	Human Capital	The growth of startups expands the demand for qualified personnel and educational programs.
5	Incubator/accelerator	Support infrastructure increases the number of successful startups and exits.
6	Balancing risks	Failure, investor exit, brain drain, and market saturation reduce accumulations.

Source: Author's compilation based on the System Dynamics model of the study[10] .

This systematization shows the core scientific logic of the model: the development of the ecosystem is determined not only by the increase in the number of startups, but by the interplay of channels for finance, revenue, human capital, infrastructure, and risk.

[10] Feedback mechanisms are systematized based on the author's System Dynamics model; for the methodological approach, see: Sterman, J.D., 2000.

SCIENTIFIC NOVELTY - RESULT - APPLICATION ONNECTION

Table 5. Application areas of the study's main scientific results

Scientific Direction	Main Result	Potential for Application
Conceptual model	The food startup ecosystem is structured as an integrated system of nterdependent elements.	Development of a sector strategy
Panel evaluation	A statistically significant positive correlation was identified between GSEI and economic growth.	Annual performance monitoring
Innovation diagnostics	GII's import-export imbalance and weak capital/export channels were identified.	Prioritization of innovation policy
Systems Dynamics	Stock-Flow-Feedback structure and policy parameters have been established.	Test of alternative policy scenarios
Long-term forecast	A phased development trajectory has been determined for the 2025-2045 period.	Medium and long-term planning
Food sector focus	Financial, human resources, infrastructure, and export constraints for FoodTech /AgriTech have been systematized.	Specialized support programs

Source: Compiled by the author based on the systematization of the research's scientific findings[11] .

[11] The table was prepared based on the author's systematization of the scientific findings obtained in the dissertation.

MAIN IMPACT CHANNELS BY POLICY AREAS

Table 6. Model-driven policy variables and expected impact channels

Policy variable	Direct effect channel	Expected system effect in the model
R&D expenditures	Innovation potential and technology transfer	GSEI and the growth of new innovative startups
Grants and venture capital	Expanded access to capital	Increased rate of new startup creation
Incubator/accelerator support	Mentorship, networking, and commercialization	Increased likelihood of survival and successful exit
Staff training	Expansion of the skilled workforce	Mitigating the negative impact of the brain drain
International cooperation	Foreign investor, expert, and market access	Increased ecosystem attractiveness and export opportunities
Annual monitoring and SD update	Improved data quality	Adjustment of policies to actual results

Source: Author's compilation based on the systematization of the model's controllable policy variables[12] .

CONCLUSION AND RECOMMENDATIONS

Research shows that the expansion of startup activity in the food industry is significant in terms of innovation, food security, and the sector's competitiveness. Although Azerbaijan's food industry has demonstrated gradual development in the long term, challenges such as raw material supply, access to finance, quality standards, a shortage of qualified personnel, and dependence on imports persist.

[12] The table was prepared based on the policy variables and impact channels envisioned by the author in the System Dynamics model.

An analysis of Azerbaijan's innovation and startup indicators shows that the ecosystem has limited access to finance, innovation infrastructure, and international market opportunities. The expansion of AgriTech and FoodTech in the food sector, and increasing the use of local raw materials and technological innovations, are considered important development directions.

Panel data for 85 countries from 2019 to 2023 shows a statistically significant positive relationship between the GSEI and GDP per capita. In the constant effects model, the GSEI coefficient was 318.66. This result should be interpreted as a statistical association, rather than a causal relationship, as other conditions are held constant.

The System Dynamics model shows that the startup ecosystem develops through feedback loops between the factors of investment, revenue, human capital, incubation infrastructure, government support, and internationalization. Given the data limitations, the model is intended for scenario assessment and is not presented as an exact deterministic forecast.

Although the number of startups in the food sector is limited, the model estimates a scenario of 15-18 active startups between 2025-2030, 40-50 between 2030-2035, and 100-120 between 2035-2045. This trajectory is contingent on increased R&D spending, specialized support infrastructure, investor attraction, and expanded access to international markets.

Key recommendations arising from the research findings

1. Creation of specialized FoodTech and AgriTech incubators and accelerators for the food sector, and regular evaluation of their performance based on startup survival, investment attraction, and market entry metrics.

2. Phased increase of the share of R&D expenditures in GDP from 0.2 percent to 0.5 percent in line with the model scenario, strengthening university-industry cooperation and technology transfer mechanisms.

3. Expansion of venture capital funds and public-private partnership instruments, and improvement of legal and tax incentives to attract diaspora and foreign investors.

4. Increase support for food startups' access to international markets through export, logistics, certification, foreign exhibition, and global acceleration programs.

5. Expanding training in entrepreneurship, technology, food engineering, and agritech, and implementing programs that support the retention and attraction of qualified specialists to the ecosystem.

6. Creation of a unified data collection and sharing mechanism among government agencies, universities, investors, and startups, and preparation of an annual monitoring report aligned with the GII, GSEI, and other international methodologies.

7. Regularly updating the System Dynamics model with new data, evaluating scenarios of state investment, tax incentives, grants, human capital, and internationalization using the model, and aligning policy decisions with those results.

Author's published scientific works on the dissertation topic

1. Mammadova U.D. The Role of the Circular Economy and Startups in the Food Industry // ADAU Scientific Works. 2023, Vol. 5, No. 5, pp. 94-101.

2. Mammadova U.D. Global practices of the startup ecosystem in the food industry // Journal of Economics and Management. 2023, Volume 5, No. 2, pp. 45-52.

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