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Assessing the impact of innovations in the food industry on labour productivity

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ABSTRACT

The research aims to assess the degree of dependence between innovation and productivity of medium-sized enterprises to further improve Kazakhstan's innovation policy and identify ways to implement it. In the process, methods of analysis were used with the help of an open-source statistical program "gretl", and data comparison from the position of positive innovation effect concerning the segment of medium-sized enterprises. The results demonstrate that innovation (production and process) is positively influenced by the internal costs of research and development, as well as the availability of patents and the size of the enterprise itself.

Keywords: *Technological efficiency; qualitative growth; food production; econometric model; medium-sized enterprise.*

1 Introduction

In almost every branch of the modern world, in every sphere of human activity, the role of innovation is paramount. Technology is developing at an increasing rate, and every enterprise needs to keep abreast of these changes and make use of them (Tachie et al., 2023). This is especially important for the food industry, since fighting hunger and providing all regions of the Earth with affordable food is still one of the key tasks of mankind. This predefines the research aim, which is to study the impact of innovation on the development of the food industry in the Republic of Kazakhstan. The most important component of this industry is the agro-industrial complex of Kazakhstan, the capacity of which is estimated at 7.4 trillion KZT (Official information resource…, 2022), which makes it one of the guarantors of the country's economic security and the key to the growth of living standards.

A detailed analysis and study of the production processes of this industry are especially relevant considering the implementation of the state programme of industrial-innovative development of the Republic of Kazakhstan for 2020-2025. The application of innovative technologies, as the most important factor in productivity growth, is designed to ensure Kazakhstan's leading role in the future system of global food security (Maira et al., 2020). Currently, there is no unambiguous definition of innovation recognised by the expert community, and usually, this term is understood as the development of new technologies or modification of existing ones, while Eurostat, in its annual review of the Organisation for Economic Cooperation and Development (OECD), emphasises the introduction of marketing processes as the most important aspect of innovation. At the same time, according to several authors, innovation is also impossible without the correct organisation of the workplaces of all participants in production (Jukšs, 2021; Sinaj and Vela, 2022).

The study by Zickafoose et al. (2012) is aimed at streamlining the conceptual framework and exploring the latest trends in the agri-food sector, proposing a consensus definition of product innovation and forecasting market trends for the next few years. Based on the opinion of several experts, a ranking of the most promising areas for the development of the agricultural sector was created, in which the development of plant-based alternatives to meat, the creation of individual nutrition complexes, the production of natural products, and the breeding of more productive crops of genetically modified organisms are leading (Shahri et al., 2023; Iskakova et al., 2022; Zheleuova et al., 2021). This expert evaluation should determine the vector of development, on the one hand, for research work, and, on the other hand, become a reference point for small and medium-sized enterprises. Their ability to quickly change assortment policies should give them an advantage at the start in comparison with large, relatively inertial businesses. Among the features of innovation in the food industry are the growing time lag between costs and the effect, the strategic importance of developing the food industry as a component of national security, and the dependence on the effectiveness of national R&D activities on investment in R&D abroad (Khabibov, 2021; Osmonov, 2020; Mehdi, 2021).

Since innovation is more than just the production of new goods and services, it is necessary to proceed with a broader definition that includes all the above aspects. Despite the practical application of innovations in the economy of Kazakhstan, the detailed structure of such innovations and the extent of their impact on efficiency in the area of food production have not yet been properly studied (Mamaeva et al., 2020). Baymoldayeva (2016) demonstrates important yet still generalised relationships between innovative cluster technologies and development, and Shakirtkhanov (2013) provides a professional but broad assessment of the principles of innovation policy formation in the Republic of Kazakhstan. Thus, the focus on innovation in the food industry predefines the relevance of the research.

The research aims to assess the degree of dependence between innovation and productivity of medium-sized enterprises in Kazakhstan's food industry. The following objectives have been set:

1. To analyse the current level of innovation activity in Kazakhstan's food industry;
2. To develop econometric models evaluating the impact of different types of innovation (product, process, marketing, organizational) on labour productivity in medium-sized food enterprises;
3. To provide recommendations to improve Kazakhstan's innovation policy and implementation strategies based on the research findings.

2 Literature Review

Romer (1990) studied the theoretical and methodological foundations of economic growth and labour productivity. The researcher reveals a clear relationship between innovation and productivity growth, which is expressed in the combination of the social division of labour with an increase in the volume of productive resources. In this century, this important topic—the relationship between innovation and enterprise performance—has attracted even more attention, both from individual experts and specialised analytical agencies (Trusova et al., 2021a).

The OECD, which regularly conducts a detailed analysis of the innovation activities of enterprises from two dozen countries based on microeconomic data and publishes annual reports, makes a great contribution to the study of the

role of innovation (OECD, 2009). However, due to the peculiarities of certain states, the specificity of accounting models in certain industries, and different approaches to the concept of economic privacy, the results of such national studies are not always comparable. Mathematical statistics and empirical data analysis are widely used in many works that study the impact of innovation on commodity relations (Young et al., 2023).

Berger (2010) reveals the relationship between innovation and productivity. This relationship was analysed by comparing econometric models of enterprises in Thailand and a sample from the OECD. The author shows that firm characteristics affect both the number of resources spent on innovation activities and the amount of innovation output. Roper et al. (2008) developed a model of the innovation value chain in a large group of manufacturing firms in Ireland and Northern Ireland, highlighting the drivers of innovation, productivity, and organisational growth. Lorenz and Schmutzler (2015) also looked into a fascinating aspect of innovation efficiency in businesses in Latin America. Their study was based on the hypothesis that the personal predisposition of employees has a positive impact on the innovative work of the enterprise, as it breaks personal psychological barriers and fears and promotes interaction within the team. Moreover, the results of the study showed that such a relationship also has its national peculiarities.

An analysis of innovation in the modern world is also impossible without considering the experience of China. Zhang and Lu (2022) studied the impact of innovation on food security in this large and technologically advanced economy. Based on six key impact indicators (availability, distribution, utilisation, vulnerability, sustainability, and regulation), they assessed the current situation in the region and the near prospects in the context of the crisis caused by the pandemic, demographics, and climate change. Baymoldayeva (2016) studied the specifics of cluster technologies and the impact of innovation on the development of the industrial sector and agro-industrial complex of Kazakhstan and justified the development of a long-term innovation strategy for the state, and Shakirtkhanov (2013) is devoted to the assessment of innovation and technological potential of the industry and the formation of the innovation policy of the Republic of Kazakhstan.

However, most of these studies do not focus on the specifics of innovation in small and medium-sized enterprises. Based on the line of research on interrelations set out in the study of Mukhametzhanova et al. (2019b), the present research fills this gap. The study is based on the hypothesis that the presence of innovation in the production, process, organisational, and marketing areas is a determinant of productivity for small and medium enterprises in Kazakhstan.

In addition, although a number of studies have examined the relationship between innovation and productivity, few have focused on medium-sized firms in the food industry in Kazakhstan. Current research on innovation in Kazakhstan focuses on important but broad topics, including cluster technologies, principles of innovation policy and the assessment of innovation potential. However, a thorough study of the composition of innovation and its direct impact on labour productivity in the food industry is still lacking.

Studies of innovation in small and medium-sized firms around the world offer valuable frameworks, but may not cover country-specific subtleties. This study intends to conduct an econometric analysis using recent data for Kazakhstan to quantify the relationship between different types of innovation and labour productivity. The results of the study are intended to offer customized, data-driven insights for improving innovation strategies and unlocking the potential of food processing enterprises in Kazakhstan.

3 Materials and Methods

The data used in the analytical work were taken from open sources (Bureau of National Statistics, 2022; BEEPS Environmental Performance, 2020). The European Bank for Reconstruction and Development, with the help of the World Bank, started the regular collection of statistical data under the BEEPS (Bank Business Environment and Enterprise Performance Survey) project. The sample consisted of 1583 enterprises of various forms of ownership, representing 30 countries with economies in transition, including Kazakhstan. In addition, the survey results of CEOs of Kazakhstan enterprises were used in the research (Kazakhstan edition of the..., 2018).

Statistical correlation and regression analyses were carried out based on the data obtained. At the same time, labour productivity, calculated according to the annual reports of enterprises, was the basis of the econometric model. During the description of the research mechanisms used, the questionnaire method should be prioritized. With its help, two key parameters were determined: the share of innovative products in the assortment of the enterprise and the types of innovations implemented at the enterprise for the previous three years (marketing, production, and organizational). The most important tool for calculating labour productivity is still the Cobb-Douglas production function, or, as it is also called, the utility function:

$$Q = A * L^a * C^b \quad (1)$$

where, *Q* – production volume; *A* – total productivity index; *L* – labor costs; *α* – labor elasticity coefficient; *C* – capital costs; *b* – capital elasticity coefficient.

An analysis based on regression models was also conducted, where the dependent variables are $Innovation_{ij}$, reflecting the fact that a new service or product has been introduced during the previous three years, and $Productivity_j$, reflecting the productivity of companies. The development of econometric models was carried out with the application of four principles of their specification, addressing which the specification of the innovation model has the following form:

$$\begin{cases} Innovation_{ij} = \alpha_0 + \sum_{k=1}^{N} x_{jk}\,\alpha_k + \varepsilon_j \\ E(\varepsilon_j) = 0 \\ D(\varepsilon_j) = \sigma^2 \end{cases}, \quad (2)$$

where, $Innovation_{ij}$ – a function of innovation, the economic sense of which is the fact of implementation of various types of innovations in the activities of the food industry enterprise.

E is the vector of random perturbations of the regression model. Suppose a random perturbation has zero mathematical expectation $E(\varepsilon j)=0$ and constant variance $D(\varepsilon j)=\sigma^2$. The specification of the model for the labor productivity function is presented by the formula:

$$\begin{cases} Productivity_j = \beta_0 + \sum_{k=1}^{K} x_{jk} \cdot \beta_k + \sum_{i=1}^{4} c_i \cdot Innovation_{ij} + \xi_j \\ E(\xi_j) = 0 \\ D(\xi_j) = \sigma^2 \end{cases}, \quad (3)$$

where, $Productivity_j$ – the productivity of food enterprises of region *j*; *ξ* – the vector of random perturbations. The lower index *i* in formula (3) corresponds to the type of innovation (Table 1).

Table 1.
Innovation type

i	**Innovation type**
1	Product
2	Process
4	Marketing technology
5	Organizational technology

Index *j* corresponds to the region of Kazakhstan; *xij* – external factors affecting the company's decision to implement innovations in production.

A complete list of factors is given below (Table 2). Table 2 shows that the regressors of the models include both individual characteristics of the enterprise – in particular, the number of employees, firm size, the amount of its capital and innovation activity – and external variables characterizing the level of product exports, total R&D and investment in the Kazakh economy.

4 Results

4.1 Innovation impact on food sector productivity

To understand the optimal conditions for productivity growth in the Republic of Kazakhstan and its potential, it was necessary to determine, first, the actual level of innovation activity (IA) of the country, which is calculated by the formula:

$$IA = \frac{IP}{IO} * 100\%, \quad (4)$$

where *IP* – the number of enterprises with implemented innovations; *IO* – the average number of innovations in the industry.

Table 2.
Variable list

Variable *xij* name	Meaning in the model equation	Explanation, value
Innovative activity	*IA*	The ratio of the number of industry enterprises that use innovative developments in their production to the average number of innovations in the industry, %
Food industry organizations	*M*	Several organizations in the *j* region sphere, pcs.
Investments	*I*	Kazakhstan's economic investments, millions of KZT
Capital	*K*	Main organization capital (millions of KZT),
Number of employees	*N*	Number of employees in the food industry
Organization scale	*Size*	Micro – up to 5 people Small – from 5 to 19 included Medium – from 20 to 99 included Large – from 100 and more
Export	*Exp*	Food industry production export
Research and Development	*R&D*	Research and Development processes
Innovative products	*Innov*	Innovative new or significantly improved products, % of annual sales
Scientific developments	*Sc*	Inventions, patents, know-how
Labor	*L*	Amount of production per year

In the case of Kazakhstan, this value is 11%. Since in developed countries, the IA indicator reaches 50%, it was determined that the state has tremendous potential for development in this direction. In a sense, in the wake of the experience of Western countries, Kazakhstan has a historical opportunity to avoid many of the "pioneer" mistakes and take advantage of their positive experience. At the same time, it is obvious that the work on the introduction of innovations is already underway, and if the indicator is taken in dynamics, from 2004 to 2018, IA in Kazakhstan grew by more than 4 times, which indicates the correct vector of innovative activity (Figure 1).

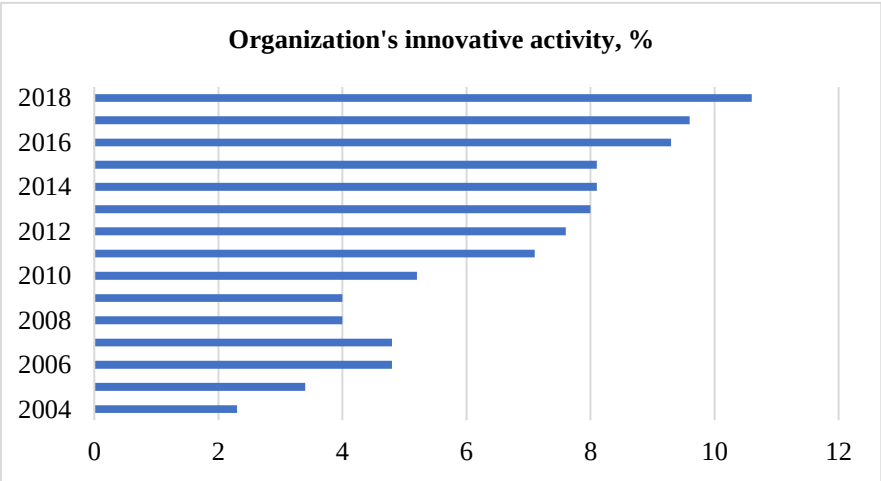

Figure 1. Graph of innovation activity of enterprises in Kazakhstan in the period from 2004 to 2018

The data from 2020-2022 should not be considered, as the pandemic and its consequences cast doubt on the objectivity of the trends of this period. A good illustration of the properly realized innovative potential of the country is also the share of innovative products in the total GDP (Gross Domestic Product) of Kazakhstan (Figure 2).

Based on the data taken in 2018, the share of such products reached 2% (red line). Nevertheless, in addition to quantitative indicators, agricultural enterprises need to work on the quality of innovation, primarily in the search and implementation of the unique selling proposition (USP), which will become the calling card of each company and will be the key to its competitiveness. In this case, such a peculiarity of the development of USP as guaranteed by the state protection of intellectual property is important. Such guarantees are also necessary, for example, in marketing, advertising, and music business, but in the sphere of industrial innovations, this issue is particularly acute. Consequently,

for the further development of innovative activity, the increased attention of the state to the observance of the rights of inventors and innovators and a clearly formulated and well-established patent law is necessary.

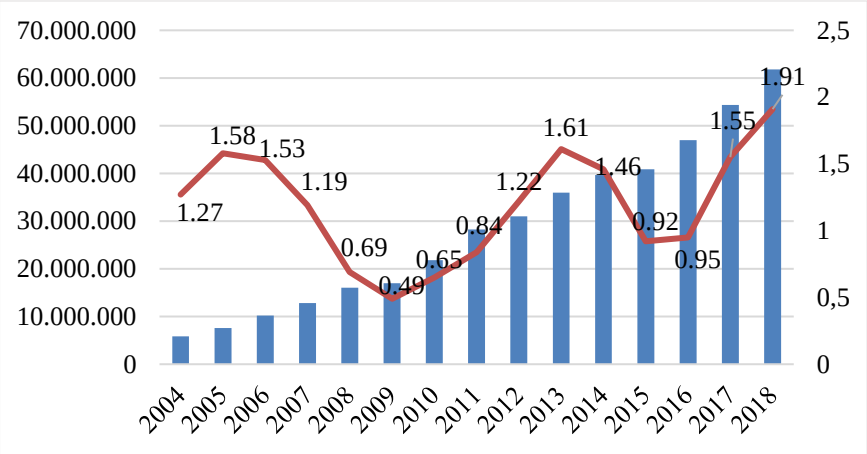

Figure 2. Share of innovative products in GDP for 2004-2018
Source: Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (2022).

The study of the impact of innovation on labour productivity was conducted using statistical panel data from open sources such as the World Bank website and the official site of the Kazakhstan stock exchange, KASE, as well as data from BEEPS. The results of the model were estimated using the statistical program of econometric analysis "gretl". It is a cross-platform software package for econometric analysis. Gretl provides tools for performing various statistical and econometric analyses, including regression analysis, time series analysis, panel data analysis, etc. The technical characteristics of the evaluated models are shown below (Table 3).

Table 3.
Summary table of models

Model name	Model specification	R^2
Innovative product implementation	$Y_1 = 32.7 - 1.9 * NIOKR - 18.4 * Innov + 11.9 * \text{Size} + \varepsilon$	0.87
Innovative process implementation	$Y_2 = 1.4 + 0.06 * \text{Sc} + \varepsilon$	0.21
Labor productivity model 1	$L_1 = 34.5 + 0.0003 * K + 0.0001 * I - 7 * 10^{-5} * NIOKR + \varepsilon$	0.07
Labor productivity model 2	$L_2 = 40.3 - 6 \cdot 10^{-5} * NIOKR - 0.34 * IA + 0.02 * M + +7 * 10^{-5} * I + 0.0001 * K - 5 * 10^{-5} * N - 2 * 10^{-5} * Exp + \varepsilon$	0.92
Marketing innovation implementation	$Y_4 = -0.4 + 0.6 * \text{Size} + \varepsilon$	0.04
Organizational innovation implementation	$Y_5 = 0.74 + 0.2 * \text{Size} + \varepsilon$	0.01

Source: BEEPS Environmental Performance Review of Businesses and Enterprises (2020).

As can be seen from Table 3, unambiguous conclusions about the degree of influence of firm size on the introduction of innovation can be made only based on model Y_1 – Introduction of innovative products. The coefficient of determination for this model (0.87) demonstrates the readiness of 87% of managers of food industry companies to introduce new innovative products into their production. Moving the company to another category by the number of employees increases managers' readiness to introduce new products by an average of 12 units per year. In the following model Y_2 (Innovation Process Implementation), the coefficient of determination R^2=0.21. In other words, 21% of managers' readiness to implement innovative processes is related to inventions, patents, or know-how, while the remaining 79% is related to other factors. For the models "implementation of marketing innovation" Y_4 and "implementation of organizational innovation" Y_5 both coefficients of determination R^2 are close to zero, which corresponds to the very low explanatory power of both models. Specifically, the model for Y_4, where R^2=0.04 shows that marketing innovation is only 4% related to firm size, while the remaining 96% of the dependent variable will be related to other factors. In the Y_5 model, where R^2=0.01, only 1% of organizational innovation is due to firm size, and the remaining 99% is due to other factors.

4.2 Investment, research and development, and productivity

Next, two models were developed for the labor productivity function *L*. The first one is a pooled regression model using the least squares method. The Model 1 statistics and obtained values presented in Tables 4 and 5 (Number of observations – 48; number of objects – 16; length of the time – 3; dependent variable – *L*).

Table 4.
Statistical Model 1

	Factor	Error coefficient	*z*	*P*-value
	32.1079	5.23732	6.131	<0.0001
K	0.000252142	0.000116853	2.158	0.0309
R&D	−7.0002e-05	3.12368e-05	-2.241	0.025
Inv	9.87147e-05	3.80728e-05	2.593	0.0095

Table 5.
Acquired Model 1 values

Criteria	Value
Average change level	35.575
Balance square sum	14337.43
R-square	0.065556
F (3.15)	3.05172
Logic correlation	-204.8953
Schwarz criteria	425.2754
rho parameter	0.810198
Variation constant	18.068
Model error criteria	18.05134
R-square	0.001844
P-value (*F*)	0.061018
Akiake criteria	417.7906
Hennan-Quinn criterion	420.6192
Durbin-Watson criterion	0.209815

All variables are significant at a 10% error probability (the crossover coefficient is significant at any reasonable level of significance), and the quality of Model 1 specification by the *F*-test can be considered high at a 10% error probability. At the same time, following the results of the Durbin-Watson test, the Model 1 uncorrelations have autocorrelation of the first order, which indicates a violation of the Gauss-Markov theorem premise and the negative properties of the model coefficient estimates.

In addition, the explanatory power of the model, as determined by the value of the adjusted R^2 determination coefficient, is very small, less than 1%. Such results can be explained by the panel nature of the empirical data, especially since the parameter *rho*=0.81 is close to one, indicating the presence of fixed or individual effects in the model.

Consequently, it is necessary to estimate the following model considering the fixed effects due to the nature of the data. The statistics and obtained values of the calculated Model 2 of labor productivity are presented in Tables 6 and 7 (*L=f*; number of observations – 48; number of objects – 16; length of the period – 3; dependent variable – *L*).

Table 6.
Statistical Model 2

	Factor	Error coefficient	*t*	*P*-value
	40.3222	10.0195	4.024	0.0005
R&D	−5.59223e-05	2.65846e-05	-2.104	0.0456
Inn_act	-0.338574	0.478216	-0.7080	0.4855
EnterP	0.0286856	0.0256290	1.119	0.2737
Inv	6.62847e-05	3.76702e-05	1.760	0.0907
K	0.000110949	0.000113079	0.9812	0.3359
N	−4.66719e-05	7.40256e-05	-0.6305	0.5341
Exp	−2.07288e-05	0.000105864	-0.1958	0.8463

Table 7.
Acquired Model 2 values

Criteria	Value
Average change level	35.575
Balance square sum	1304.174
LSDV R-square	0.915
F (22.25)	12.23266
Logic correlation	-147.36
Schwarz criteria	383.7577
rho parameter	-0.532031
Variation constant	18.068
Model error criteria	7.222671
LSDV *R*-square limits	0.208911
P-value (*F*)	1.58e-08
Akiake criteria	340.7201
Hennan-Quinn criterion	356.984
Durbin-Watson criterion	1.927595

Joint test on named regressors:

1. Test statistics: *F*(7.25)=0.943141.
2. *P*-value=*P*(*F*(7.25)>0.943141)=0.491985.

A test for the difference of constants in groups:

1. The null hypothesis: groups have common constants.
2. Test statistics: *F*(15.25)=15.626.
3. *P*-value = *P*(*F*(15.25)>15.626)=4.13245e-009.

Test for normal distribution of errors:

1. The null hypothesis: errors are distributed according to the normal law.
2. Test statistics: Chi-square (2)=3.32576.
3. *P*-value=0.189592.

Plots of the conformity of the distribution of the residuals of models 1 and 2 to the normal law of distribution are shown in Figures 3 and 4.

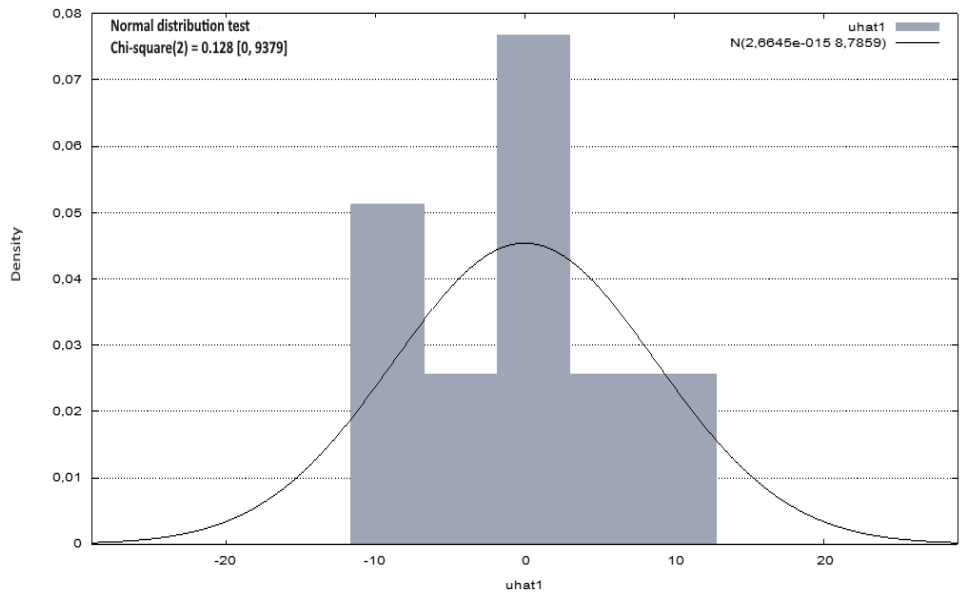

Figure 3. Graph of the normal distribution of innovation errors (new or significantly improved products) according to Model 1.

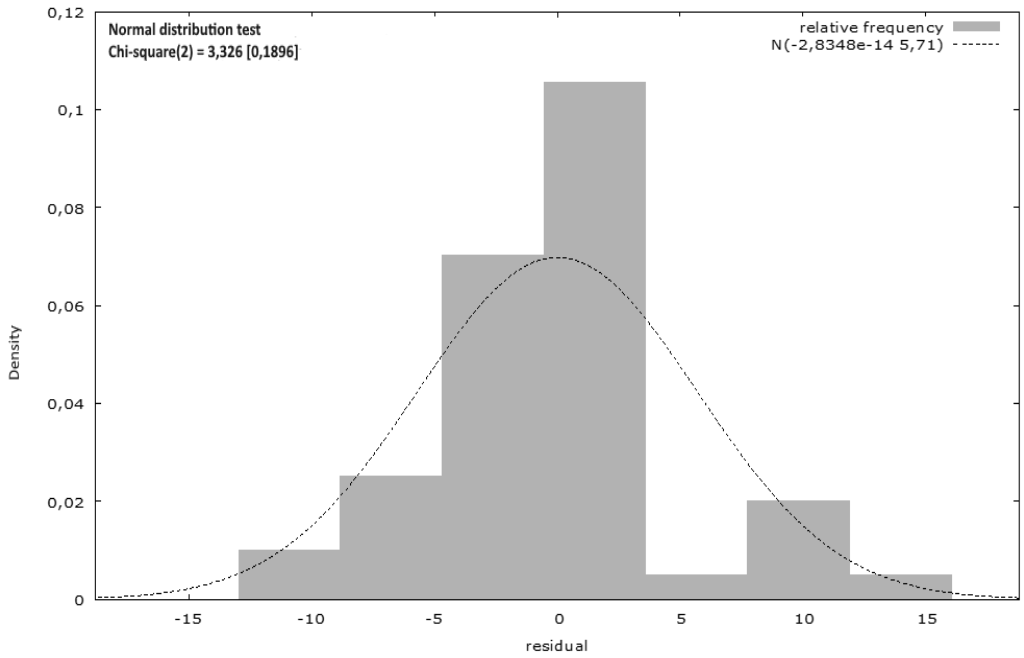

Figure 4. Graph of the normal distribution of innovation errors (new or significantly improved products) according to Model 2.

Analysis of the modeling results presented in Table 6 shows that the explanatory power of the fixed-effects model compared to the results of the least squares methodology for Model 1 increased significantly to 92%. The quality of model specification according to the results of *the F*-test is high, and there is no autocorrelation of residuals. Thus, we can conclude that an increase in investment in the industry by 1 million KZT will increase labor productivity by 70 million KZT (7*10-5 is the value of the coefficient with variable *I* in Model 2).

At the same time, the growth of R&D costs and innovation activity of representatives of small and medium-sized enterprises in the food industry leads to a decrease in labor productivity, which can be explained by too high costs of innovation, which medium-sized companies are not able to implement. The data of econometric analysis obtained as a result of the study testifies to the unconditional influence of innovations on labor productivity in the food industry of the Republic of Kazakhstan. Due to such factors as the attraction of additional financial influences, the introduction of new, more efficient algorithms of labor, the renewal of product range in favour of more modern and technological products, the growth of industry, and, consequently, the increase of economic influence of the state in the world food market is achieved.

At the level of individual enterprises, the phenomenon has a self-sustaining cyclic nature: the introduction of innovation increases the efficiency of the company and leads to an increase in profits, which, in turn, increases investment in the subsequent stages of innovation and provides access to new tools and programmes of the company. Thus, a properly formulated science and technology policy presupposes the continuity of innovation activity. A certain paradox lies in the fact that companies with significantly outdated fixed assets and equipment have more innovation potential, as they simply have to replace worn-out and dilapidated resources with newer and more technologically advanced ones. At the same time, companies whose production base does not show critical signs of ageing continue to operate, pushing back the moment of their technological re-equipment.

The models described and their analysis suggest predictability in terms of public policy. In addition to the general loyalty to small and medium-sized enterprises and the corresponding legislative framework, the state should maintain a balance in conducting R&D. Thus, a sharp increase in the volume of state financing in this sphere may lead to the so-called “crowding-out effect” when budget expenditures aimed at innovations will fall on the same enterprises through the forced increase in the tax burden. In this regard, a balanced assessment by the expert community and the state regulator is necessary to observe the balance of interests and avoid sharp fluctuations in the investment policy concerning the implementation of innovations (Ijabadeniyi, 2023). This will make it possible to provide small and medium-sized enterprises with the necessary legislative support. At the same time, there is also an inverse relationship: the systematic introduction of innovations at the level of private enterprises and small and medium-sized businesses positively influences the elasticity of public developments and research. Experience with innovative products and technologies gained by employees of individual firms increases the overall susceptibility to innovation and contributes

to the introduction of modern advances at the level of the public sector. This positive relationship between business research and public (in particular, university) developments is a good stimulus for private innovation activities.

5 Discussion

5.1 Comparative analysis and innovation dynamics

The research results concerning the development of innovation in small and medium-sized food enterprises in Kazakhstan are comparable with the results of Hoffman et al. (1998), who structure knowledge about small and medium enterprises on the example of the British market and investigate innovation in the context of loyal policies aimed at encouraging and facilitating the functioning of innovation processes.

They can also be compared with the already mentioned work of Zickafoose et al. (2022), who identified the most promising areas for product innovation in the coming years and defined the conditions for the economic resilience of small and medium-sized agricultural enterprises. Once again, it was confirmed that to increase the level of innovative activity of enterprises, IA should be aimed primarily at expanding the production of new or significantly improved products, as well as being competitive in the market using new technologies. At the same time, it is necessary to consider the effects of food neophobia. This fear of the new is characteristic of a significant number of people around the world and is determined in each case by such factors as level of education, age, the multiculturalism of a particular community, and ideology. On a subjective level, neophobia makes it difficult to introduce various innovative products and technologies, such as 3D-printed food, GMOs, cold plasma or ultrasound treatment, and ionising irradiation (Balji, 2023). Moreover, even familiar products, for example, under a new brand name, cause involuntary rejection in most conservative consumers (Mukhametzhanova et al., 2019a).

Siddiqui et al. (2022) studied this phenomenon of conscious rejection of advanced technologies and developed several recommendations aimed at solving the problem. So, the desire of consumers to try new things should be stimulated as part of a properly built marketing strategy, and new revolutionary products should preferably be released under already familiar and trusted brand names. It is also important to have a verified information system containing accurate and adequate data that is disseminated by producers and aimed at the consumer (Chen et al., 2022). A feedback system and focus groups of representatives of the target audience will enhance the effect of such events and contribute to the early introduction of new products. An additional effect of trust can be achieved by inviting authoritative opinion leaders or just famous people to promote new products, because the peculiarity of the human psyche is that the opinion of even an extramural acquaintance causes more trust than impersonal slogans or statistical data (Teymurova et al., 2023).

5.2 Models of innovation impact and sectoral comparisons

Comparing the results of the modeling for the food industry in Kazakhstan conducted in this paper with the results of the OECD project conducted from 2006 to 2008 with refinements made in 2020 based on microdata from participating countries, several important parallels must be made (OECD, 2009). First, unlike research conducted by the OECD, which found that large international companies have a higher probability of implementing innovations in their operations, the degree of this influence is low (less than 4%) for Kazakhstani enterprises (OECD, 2009). That, introduction of marketing and organizational innovations in small companies does not increase their productivity, while in large companies, on the contrary, it has a positive impact on production. Second, in contrast to the expectations expressed in the OECD project (OECD, 2009), where the econometric model found no evidence of a positive effect of technological innovation on productivity in any country, the opposite has been proven for enterprises in the food industry in Kazakhstan. For medium and small enterprises, innovation activity and spending on R&D, including expenditures on personnel, materials, and fixed assets, harm labor productivity (Burova et al., 2022).

The practice of mathematical modelling also echoes the recent work of Mehdi (2021), where the effect of innovation on labour productivity factors was studied using a regression model. According to Kumar (2015), the econometric method is the best way to calculate the balance between the potential profitability of the enterprise and the risk of investment. Some specific areas of innovation in the food industry are also noteworthy. For example, Khouryieh (2021), studying the technologies used in the US food industry, determined the advantages of non-thermal processing and identified the strengths and weaknesses of methods such as high-pressure processing and the use of pulsed electric fields.

An important aspect of food innovation is also a certain conflict between the need to improve production technology and traditions in the making of national dishes (Amrahov et al., 2023). Guine et al. (2020), in their study of the relationship between consumers and food innovations, elaborate on this problem and emphasise that, despite the obvious contradiction between “old” and "new," technological developments can significantly improve the quality of traditional dishes through such tools as improved ease of transportation, increased shelf life, and control of compliance

with sanitary standards. At the same time, innovations in logistics and brand protection help small and medium-sized businesses gain additional benefits in the eyes of customers (Miethlich, 2022).

Competition among small and medium-sized enterprises is also a factor spurring innovation. Following Distanont and Khongmalai (2018), who studied the characteristics of competition in the Asian market using the example of Thailand, the external factors that lead to the introduction of innovations can be divided into two levels: the micro level, which covers customers and suppliers, and the macro level, which is responsible for certain features of government regulation. Competitive advantages, used at both levels, become an effective tool to maintain their market share or gain a new one.

5.3 Technological advances and future directions

Carmela Annosi et al. (2020) raised the issue of digitalization in agribusiness, which is also an integral part of innovation. As the original hypothesis suggested, a structured analysis of specialised sources showed that the implementation of digital innovation has a positive effect on production growth but is limited by the human factor. Weaknesses and problems in the use of programme management in small and medium-sized enterprises were identified, which provided some groundwork for subsequent researchers on this topic.

Di Vaio et al. (2020) also looked into a related subject: the reliance of businesses in the agro-food system on contemporary digital technology. Having considered the issue from the perspective of creating sustainable business models using artificial intelligence (AI), the authors confirmed that this technology increases the level of production efficiency in the food industry. In particular, the introduction of AI can fill labour shortages, increase system reliability, and improve predictability throughout the production chain (Trusova et al., 2021b). For example, the use of AI algorithms in the processes of automatic soil fertilisation and crop irrigation systems significantly reduces the negative impact on the ecology of arable land (Kerimkhulle et al., 2022; Ospanov et al., 2020).

When discussing innovations in food production, the topic of packaging cannot be ignored. Modern technology is now able to offer something that only ten years ago seemed unattainable (Musiy et al., 2017). Studying the concepts of “smart packaging,” Drago et al. (2020) mention already existing in practice concepts of edible packaging and even edible sensors for detecting irregularities in the transportation or storage of products. This kind of sensor, which is made up of a pectin matrix and red cabbage extract as a colorimetric indicator, can tell when the concentration of amines in a product rises and warns people in time that the contents are not safe to eat.

The results of the study are consistent with and extend the existing literature on innovation and performance. The results confirm the direct relationship between innovation and business performance, especially for product innovation. This study reveals the favourable impact of technical developments on production in the Kazakhstan context. The study supports the use of econometric modelling to assess innovation outcomes. The study's models demonstrate the subtle paths of the impact of different types of innovation on the productivity of medium-sized food companies in Kazakhstan. The findings emphasize the need for tailored innovation policies to address the unique challenges faced by these firms.

This study offers an early quantitative assessment of the relationship between innovation and productivity in one of Kazakhstan's most important industries, despite certain limitations in the quality of available innovation data. Future research can refine these methodologies and make new discoveries using expanded datasets. Concepts and suggestions can help improve innovation ecosystems and stimulate technological progress in Kazakhstan's food industry. The study emphasizes the importance of implementing policies that promote local innovation to achieve the goals of quality growth and food security.

6 Conclusions

The analysis of the models developed in the research allows to recommend the application of the obtained results in the process of managerial decision-making. With the intensive development of the world economy and the orientation of the economic vector of Kazakhstan towards the raw materials sector, there is a clear reluctance of some enterprises to participate in the technological competition, both in the domestic and foreign markets. At this stage, unfortunately, Kazakhstan does not pay special attention to the problems of the relationship between innovation and productivity of enterprises in the sphere of food production, which excludes their impact on ensuring the economic sovereignty of the country. Further economic development and strengthening of the state require not only stable profitability of production, but also structural changes designed to lead to the growth of key indicators. The features of the global and regional markets given in the article can be the basis for further planning in the operation of small and medium-sized enterprises and their search for their unique offer for the market.

The research results also demonstrate that, based on the forecasts of econometric models, the determinants of economic factors suggest a positive effect of innovation on the productivity of small and medium enterprises in the food industry of Kazakhstan. Especially important was a such indicator as the introduction of innovative products. At

the same time, such modeling to a high degree depends on the reliability and quality of the original statistics of innovation studies, which, in the case of Kazakhstan, sometimes contain insufficient information on the characteristics of enterprises, especially enterprises of the food industry. This causes some problems with the allocation of exogenous variables (for example, labor productivity based on sales rather than value-added) in the specification of econometric models. In this sense, modeling requires a compromise between the quality of the specification of the models developed and the ability to compare its results with international indicators. Such research results encourage further research in the future on the relationship between innovation and productivity, which will allow to better identify new dependencies and cause-effect relationships in this industry.

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