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Supply Chain Value-added Strategy for the Rice Industry in Jilin Province

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Abstract: This paper explores the application of digital technology in enhancing the rice supply chain management in Jilin Province. By integrating modern agricultural services and internet-based models, the study highlights how digital advancements can improve production efficiency, reduce costs, and optimise resource allocation. The research also emphasises the importance of constructing a value-addition system based on the lifecycle theory of rice crops, which can maximise value at each stage of the supply chain. The study addresses risk control and cost management challenges, proposing a value optimisation model incorporating traditional value innovation and new dynamics. The findings suggest that digital technology presents significant value addition and optimisation opportunities in the rice industry, ultimately leading to a more resilient and profitable supply chain. This paper provides practical solutions for overcoming existing challenges and unlocking new potentials in the rice supply chain, ensuring its growth and competitiveness in the evolving market environment.

Keywords: Digital Technology; Rice Supply Chain; Value Optimization.

1. Introduction

The agricultural sector, particularly rice production, plays a pivotal role in the economy of Jilin Province. However, the rice supply chain in this region faces numerous challenges that hinder its efficiency and value addition. This paper explores applying digital technology to enhance the rice supply chain management in Jilin Province. By leveraging modern technological advancements, the research can address existing problems and create a more resilient and efficient supply chain.

Digital technology has revolutionised various industries, and agriculture is no exception. In rice supply chain management, technologies like the Internet of Things (IoT), big data analytics, blockchain, and artificial intelligence (AI) offer significant potential for improving transparency, efficiency, and sustainability. These technologies can streamline processes from planting and harvesting to distribution and retail, ensuring that each stage of the supply chain operates optimally.

In Jilin Province, the traditional rice production and supply chain management methods have led to inefficiencies and a slow rate of value addition. Issues such as outdated planting techniques, fragmented farmland management, and insufficiently integrated supply chain operations have been identified as significant bottlenecks. Moreover, the lack of advanced marketing strategies and brand positioning research further complicates the situation.

This paper begins by examining the current state of the rice supply chain in Jilin Province, identifying critical problems in its operation. It then explores the potential applications of digital technology to address these issues. The discussion includes the benefits of adopting such technologies, the challenges that may arise, and strategies for successful implementation. By presenting a comprehensive analysis, this paper aims to provide valuable insights for stakeholders in the agricultural sector, encouraging the adoption of digital solutions to enhance the rice supply chain.

The ultimate goal is to transform the rice supply chain in Jilin Province into a more efficient, transparent, and value-added system. This transformation is essential for meeting consumers' increasing demands and achieving sustainable agricultural practices that benefit the economy and the environment. Through the strategic application of digital technology, Jilin Province can set a benchmark for other regions, showcasing the potential of modern advancements in revitalising traditional agricultural practices.

2. Problems

Modern agriculture in Jilin Province is essential to changing modes and adjusting structure. Transforming the agricultural development mode and promoting the structural reform of the farm supply side is a heavy task and a long way to go. Although the existing rice supply chain path in Jilin Province has achieved specific practical results, there are still many problems, resulting in its inability to meet and fully adapt to the requirements of the rapid development of modern agriculture, and the value-added speed is slow. The research focuses on analysing the existing problems in the operation of the rice supply chain in Jilin Province in combination with the information obtained from the actual study and analysing the reasons for them to explore the critical factors of value-address of the current rice supply chain in Jilin Province in a more comprehensive and in-depth manner. The existing problems in the rice supply chain operation in Jilin Province are summarised below.

2.1. Problems in the Upstream of the Supply Chain

2.1.1. Planting Technology is not Advanced Enough

Due to the lack of in-depth research on rice planting technology in Jilin Province, farmers do not have a comprehensive grasp of rice planting technology. They cannot make full use of advanced technological means to improve yields. Some areas still use traditional planting methods, such as dry-field planting, and lack efficient rice field remediation and rice panicle planting techniques, resulting in a low utilisation rate of rice nutrients and

difficulty improving yields. There is a lack of professional technicians in rural areas to provide technical guidance to farmers, resulting in farmers' limited ability to master and apply new technologies and untimely upgrading planting technologies [1].

2.1.2. Insufficiently Standardised Farmland Management

Most of the farmland in Jilin Province is small-scale family farms or farmers, lacking integration and unified management of the scale of farmland, resulting in fragmented farmland management and low operating efficiency. Some farmland lacks good irrigation facilities to supply sufficient water promptly, which affects the effectiveness of paddy irrigation and, thus, yields. There is a certain amount of indiscriminate use of fertilisers and pesticides by farmers, leading to soil nutrient imbalance and environmental pollution and reducing the fertility and yield of the land. In some areas, there is an irrational continuous cropping system, and constant cropping makes it challenging to repair the physical and biological structure of the soil in time, leading to land degradation and yields [1].

2.1.3. Poor Utilisation of Arable Land Resources

Some areas in Jilin Province still adopt the traditional rice farming model and lack exploration of diversified farmland use, leading to low returns on arable resources. Due to continuous cultivation and acidification, the quality of arable land in some areas of Jilin Province has gradually declined. It cannot meet the demand for high and stable yields. Part of the farmland is idle or used for non-farming purposes, resulting in a waste of land resources and reduced farmland area, affecting food production growth [2].

2.2. Problems in the Midstream of the Supply Chain

2.2.1. Farmers' Production Techniques are not Specialised Enough

Since farmers in Jilin Province primarily engage in family farming and lack professional agricultural education and training, their production technology is often relatively low. This lack of technological level leads to inefficiency and low production yield, which affects the proper functioning of the rice supply chain [3].

2.2.2. Unstable Quality of Agricultural Products

The unstable quality of farm products in the rice supply chain in Jilin Province is mainly due to the lack of scientific quality control measures in the production process, the imperfect quality testing means of agricultural products and the market's requirements for the quality of farm products. These problems affect agricultural products' sales and market competitiveness and may threaten consumers' health [3].

2.2.3. Low Degree of Product Differentiation

Currently, the degree of product differentiation in the rice supply chain in Jilin Province is relatively low, mainly due to the lack of brand building and particular industries and production bases. This low degree of product differentiation will limit the competitiveness and market value of the rice brand and, at the same time, will not be able to meet consumers' needs for diversification and personalisation. [4].

2.2.4. Insufficient Depth and Breadth of the Distribution Chain

The existing circulation scale of rice products in Jilin Province is small, lacking diversified channels, and the large-scale circulation system is insufficient. Due to the rice packaging level, freshness, storage, and other services being insufficient for rice product trading and circulation. Most sales are still based on spot transactions. The object of the transaction is mainly primary products in a "small market" with a "small base" of a small economic situation. The depth of the extension of the rice industry's development constrains the rice industry's development. Due to the lack of appropriate economies of scale and scope of the economy, coupled with the current green traceability system and standards in Jilin Province not sound enough, rice advanced science and technology, and relatively backward equipment do not match the scarcity of relevant professionals in Jilin Province, resulting in the development of the processing link the breadth and depth of the development of the lack of expansion, to be further improved [5].

2.3. Problems in the Downstream of the Supply Chain

The brand influence of rice in Jilin Province is relatively weak, and its popularity and market competitiveness need to be improved. Various reasons, such as insufficiently proactive brand marketing, insufficiently attractive product packaging and publicity, etc., have led to Jilin Province Rice's inability to gain a better position and sales in the market.

2.3.1. Market Demand and Competitive Environment

Jilin Province is one of the vital grain production bases in China, and the rice planting area and production have been growing steadily. Research on the demand and competition in the rice market has become increasingly intense under the current market environment. Consumers' demand for rice no longer stops at basic nutritional needs but focuses more on health, safety, quality and taste. At the same time, other rice brands at home and abroad are also actively expanding their markets, including some high-profile rice brands such as Northeast Rice and Nanyang Rice [6].

2.3.2. Brand Positioning and Construction

From the brand building point of view, "Jilin rice" brand construction and management of the lack of a unified top-level design, that is, the brand growth of the lack of leading enterprises to pull, the brand has not yet formed a synergistic advantage of brand dissemination, which affects the value-added effect of rice products. In addition, some small and medium-sized rice processing enterprises may have 3 to 4 brands to distinguish better researched different rice product grades, resulting in Jilin Province rice products. The homogeneity of the competition is relatively intense, which is not conducive to brand building and brand recognition of rice products. The famous rice brand needs a good platform and diversified publicity and promotion channels. The research aims to identify the external publicity of the current "Jilin rice" brand, and the lack of modern brand marketing platform creative support resulting in Jilin rice brand identity and effective promotion is not enough to make the management of rice brand building in Jilin Province not standardised [7].

2.4. Problems in Linkage Articulation

From the supply chain perspective, the rice supply chain in Jilin Province has problems such as irregular linkage and loss of trust in the linkage process, and the pattern of vertical integration has not yet been formed. Due to the protection of the national storage price, rice farmers focus on producing rice products and pay little attention to the quality of the phenomenon, resulting in varying processing out of the

quality of rice products. It is challenging to meet the current consumer subject of the growing demand for value, so the rice supply chain of the production link and the consumer link interface is relatively the research. In addition, due to the rice supply chain in Jilin Province, in the middle and downstream nodes of the information system, to improve the leading business distribution efficiency, the degree of cooperation is not enough and other factors for the continuous updating of the rice market information, Jilin Province, rice farmers to grasp the accuracy and timeliness of the information is not enough so that the rice production and operation conditions and logistics activities are subject to certain restrictions, with spontaneous blindness. This makes the rice supply chain a value-added process better researched of the nodes. There are a variety of limitations and risks. The research also led to the Jilin province rice material supply cycle being longer, the utilisation rate of facilities being less researcher, and the lack of defence to deal with the supply chain convergence risk ability. Due to the limitations of the scale of each link, the procurement of production materials and the sale of rice products are mostly decentralised, resulting in wasted costs and resources and restricting linkage and management [8].

3. Strategies

3.1. Constructing a Value-addition System

According to Zhenxiao (2022) [9], applying life cycle theory to rice crops reveals four main stages in the rice supply chain: cultivation, growth, maturity, and stability. The current state of the rice industry in Jilin Province indicates it is transitioning from the growth stage to the maturity stage. As an open system, the value promotion evolution of the rice supply chain exhibits non-linear characteristics.

The value-addition system comprises six components, with the Derivative Product being central. This module enhances value through the structural optimisation and innovation of rice's primary and by-products. The economy of scope is particularly noteworthy, combining asset management and capital operation to optimise value promotion paths [10].

Modern Agricultural Services represent a crucial innovation, driving the rice supply chain's transformation, upgrading, and integration by introducing new services and expanding horizontally and vertically [11].

The Information Innovation Platform acts as the crucial information transmission link. Leveraging the "Internet plus" platform associated with modern agricultural services can significantly improve supply chain efficiency, achieving online and offline dual value promotion. This module fosters optimal resource allocation across the supply chain's upstream, middle, and downstream links, enhancing the overall resource allocation capacity through improved organisational management, supply chain upgrades, and optimised layouts. The value-added system constituted by these six modules can be represented by the "DETAIL" net model diagram.

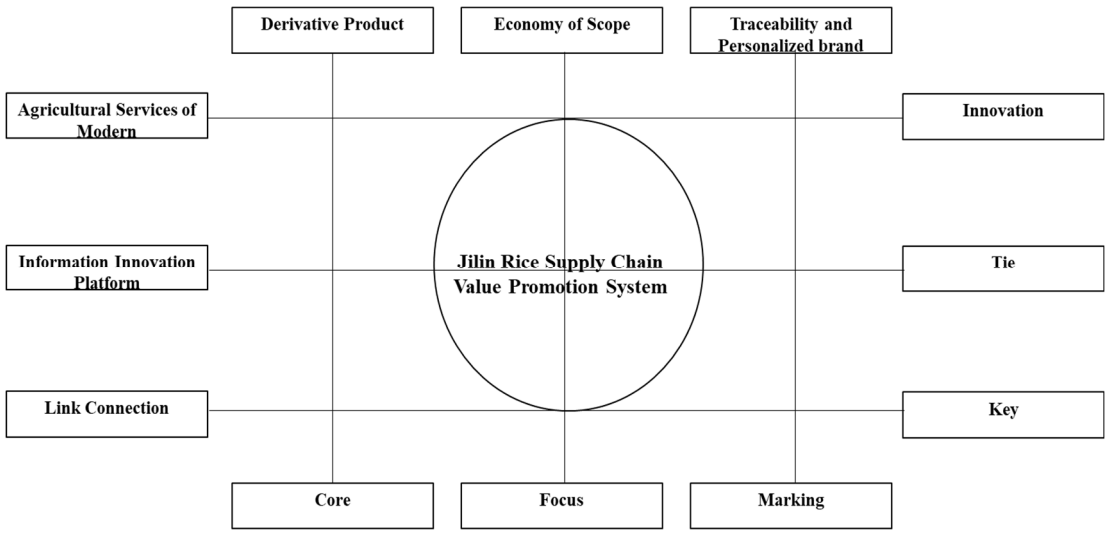

Figure 1. The "DETAIL" model of Jilin's rice supply chain value promotion system

The "DETAIL" model is a net structure formed by connection instructions, representing the various entities and their interconnections. Its data organisation is generally of the many-to-many type. The individual nodes in the framework diagram represent data records, and the connecting lines describe the systematic relationships between the researchers and the data at the different nodes.

3.2. Applying the Value-added Principle

The traditional value-added process in the rice supply chain focuses on allocating value from income, transformation, and output perspectives. As the rice supply chain in Jilin Province evolves from a chain family model to a chain network, the complexity of its value-added pathways increases. Consequently, the value-added effect has heightened requirements for chain competitiveness among core entities, degree of contractualization, construction of information circulation and sharing platforms, and service capabilities related to agricultural modernisation.

In the rice market, assuming the seller represents rice production and the buyer represents rice consumption, value-added income can be calculated by subtracting the production cost from the product's expected value to the consumer in Jilin Province.

Therefore, the market value V_0 formed on the traditional market industry chain can be calculated as follows:

$$V_0 = E_i - \mathrm{C}_i = (E_{i-}P) + (P - C_i) \quad (1)$$

= Increase in the value of the consumer plus increase in the value of the enterprise

= return on investment of consumer entities plus business benefits

In the above formula1, E_i represents the consumer's expectation value of rice products: the consumption perceived value gained in rice products. C_i represents the cost formed in the rice production transaction, and P represents the rice product's actual transaction price during the market sale process. As a result, the market value composition of the rice supply chain in Jilin Province is shown in Figure 2.

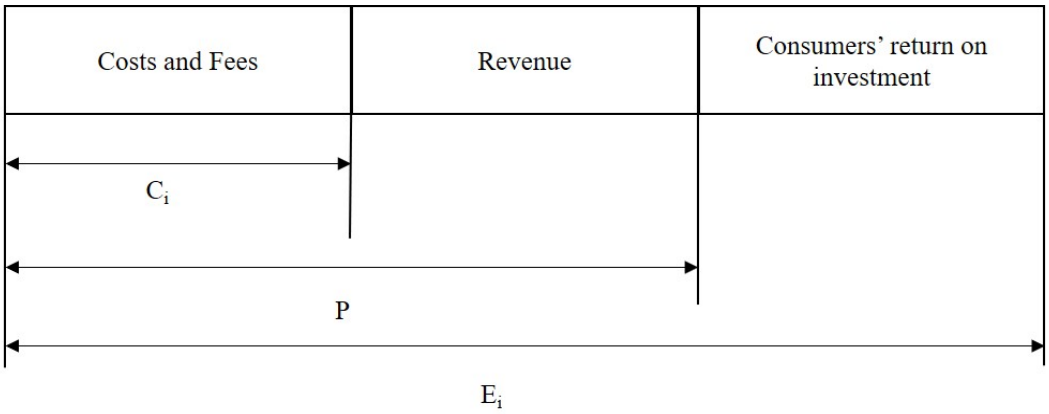

Figure 2. Traditional market value composition map of the rice industry chain

The traditional value formation process in Jilin Province's rice supply chain has limitations, particularly in value-added distribution and risk control. This process primarily focuses on income, transformation, and output, neglecting comprehensive aspects of value creation and the industrial chain's connotation. This approach does not align with the needs of the modern market.

The value-added process of the rice supply chain is complex and requires a more nuanced approach. This paper proposes incorporating additional potential value-added elements from a supply chain value "increment" perspective. By considering the value pursuit goals of the rice supply chain and the current development of the three existing models in Jilin Province, a more accurate optimisation model can be developed to enhance the value-added composition of the rice supply chain, as illustrated in Figure 3.

The fundamental design of value-added should focus on allocating the increment of the supply chain rather than the value stock of the traditional industrial chain. This approach emphasises reducing the overall cost of the chain, increasing enterprise benefits, and improving consumer returns on investment [11].

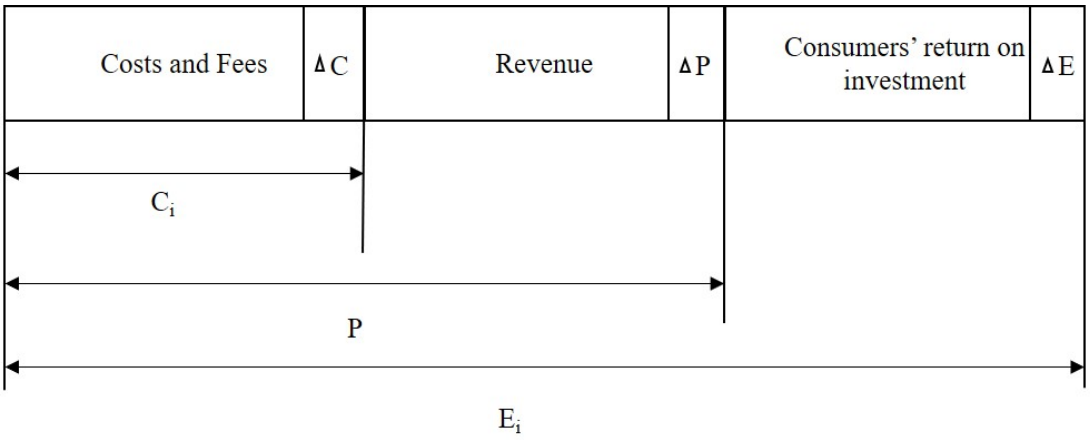

Figure 3. Value-added Composition of Rice Supply Chain

In Figure 3, the value-added basic composition analysis diagram of the rice supply chain, ΔC is the operating entity of the rice supply chain.

In the process of production and trading, the cost-benefit increment obtained from the reduction of costs; ΔP is the brand premium of rice products, that is, the income increment received in the process of brand building of rice products and modern agricultural services; ΔE is the consumption The value surplus obtained by the subject, that is, the return on investment received by the consumer subject after paying for the product.

This research will build a basic model of rice supply chain value optimisation in Jilin Province, focusing on the needs of the main body of the supply chain and the system composition of the six value-added modules.

U_1 represents the rice product premium, C_1 represents the rice production cost, α and β represent coefficients, and the ratio $\frac{\alpha U_1}{\beta C_1}$ indicates the enhancement of the traditional value of the upper, middle and low, the research reaches of the supply chain in Jilin Province, mainly expressed through the improvement of rice production technology, the extension of product lines, the strengthening of product functions, and the enhancement of brand awareness and consumer body loyalty; while U_2 denotes the premium generated by the equipment and management processes corresponding to the production process of rice products, C_2 represents the costs generated by equipment, management and other links, and (1-k) denotes the coefficient of value impairment influenced by a number

of factors The ratio $\frac{(1-k)U_2}{C_2}$ represents the reduction in value gain or loss, expressed through the improvement and replacement of equipment and management processes for rice production in Jilin Province; U_3 represents the premium generated by technological innovation, market development, new system innovation and product development, etc., and C_3 represents the cost caused technological innovation, market development, new system innovation and product development, etc., and the ratio $\frac{U_3}{C_3}$ represents Additional value-added innovation, mainly expressed through Jilin rice seed R&D, technological innovation, market development, innovation in the construction of new standards and product development, etc.

The rice supply chain faces numerous threats as the market environment becomes increasingly complex, leading to multiple internal and external risks. These risks contribute to low production efficiency and safety issues, hindering the supply chain from achieving its desired value-added objectives.

Based on a comprehensive evaluation of the value-added capacity of the Jilin rice supply chain, cost control and risk control are currently ranked relatively low. These areas represent a "short board" in the new wooden barrel principle, indicating significant potential for improvement. Therefore, the value optimisation model for the rice supply chain in Jilin Province must consider key risk factors [12].

Assuming a risk factor of $f_i(R)$ for each link, the overall risk factor of the rice supply chain can be expressed quantitatively using the following equation.

$$R_0=\sum_{i=1}^{n}\frac{E_i(1-f_i(R))}{C_i} \quad (2)$$

In the above formula 2, R_0 represents the overall risk of the rice supply chain, E_i is the expected return of the operating agent, $f_i(R)$ represents the risk coefficient borne by the agent in each link of the supply chain, and C_i is the cost of each link.

In summary, the overall value added to the supply chain results from a comprehensive measurement of the value utility of each link. This chapter combines the formation, impairment and re-creation of the value of the core links based on the contents of the six value-added modules of the rice supply chain. It aims to reflect the increase in value of each link's operating agents while considering the traditional value innovation, loss reduction, exploration of new dynamic energy, total cost reduction and each link's potential key risk points. The following formula can express an optimised value model for the value-added rice supply chain in Jilin Province, V_G.

$$V_G=V_B-R_0$$

$$=\frac{\alpha U_1}{\beta C_1}+\frac{U_3}{C_3}-\left\{\frac{(1-k)U_2}{C_2}+\sum_{i=1}^{n}\frac{E_i(1-f_i(R))}{C_i}\right\} \quad (3)$$

In formula 3, V_G represents the value-added optimisation model after considering several factors, and $\left\{\frac{(1-k)U_2}{C_2}+\sum_{i=1}^{n}\frac{E_i(1-f_i(R))}{C_i}\right\}$ in the equation represents the sum of the value loss achieved by the various actors in the rice supply chain in Jilin Province, including both cost loss and risk loss. That is, the optimisation model as a whole takes into account both the cost savings and revenue enhancement factors in the basic value-added model of the Jilin rice supply chain, as the research as traditional value innovation, loss reduction and exploration of new dynamics in the operation of the whole industry chain, while also taking into account the control of potential key risk points. The components in this formula show that the operators' value objectives in each rice supply chain segment are expected revenue maximisation, cost minimisation and risk minimisation. Therefore, the abovementioned V_G model can be used as a mathematical optimisation model for value addition in the rice supply chain. Combined with the corresponding data, the value-added effect of each link of the existing rice supply chain in Jilin Province can be measured and compared with the optimised value-added impact, providing a model basis for the subsequent proposal of value-added path optimisation strategies.

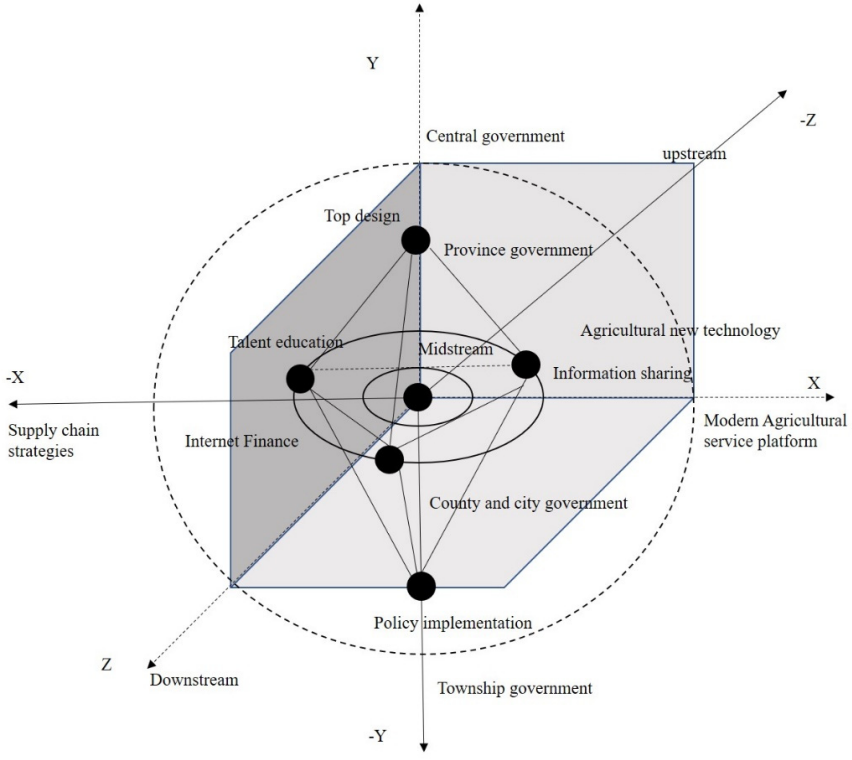

Figure 4. A 'three-dimensional' diamond optimisation model for adding value to the rice supply chain

Michael Porter proposed the Diamond Model in 1990 to analyse how a thing, country or system can develop an overall advantage to be more competitive internationally. Combining the operational characteristics of the whole industrial chain upstream, midstream and downstream, the study draws on the diamond model to qualitatively describe the value-added strategy optimisation model of the rice supply chain in Jilin Province. The three dimensions of the X_{-axis}, Y_{-axis} and Z_{-axis} represent the production factors, demand conditions, related supporting industries, top-level design, talent cultivation, market competition, scientific and technological innovation and modern agricultural information services in each link of the rice supply chain, to construct a "three-dimensional" diamond optimisation model of Jilin's rice supply chain value-added. This is shown in Figure 4.

In the "three-dimensional" diamond optimisation model shown in Figure 4, the X_{-axis} is the modern agricultural path dimension, representing the integration of the rice industry development with the development of current agricultural services, information sharing and internet finance to promote horizontal value-added the Y_{-axis} is the top-level design policy dimension, representing the development of the rice industry from the central government - provincial and municipal governments - county and municipal governments in the context of rural revitalisation provincial and municipal governments-county and municipal governments-township governments to support and guarantee policies for the development and innovation optimisation of the rice supply chain in Jilin Province, and to supervise the smooth implementation; the Z_{-axis} is the chain dimension of the rice supply chain, representing the vertical chain value-added of the rice supply chain, including the upstream production chain led by supply chain-related business enterprises, the midstream processing and distribution chain, and the downstream sales chain value-added. On the whole, the development of Jilin's rice industry and modern agricultural services (X_{-axis}) and the co-ordinated planning and policy protection of governments at all levels (Y_{-axis}) need to run through all the links of the rice supply chain (Z_{-axis}), and the intersection points indicate that the development of the rice industry needs to rely on the modern agricultural services platform built by the core enterprises of the supply chain to provide scientific and technological services, financial services, talent services, information services, etc. The cluster effect of "three-dimensional" structure optimisation is formed in the region. The shape of the chain connection becomes more and more diversified. The nodal enterprises increasingly transmit production and operation information through the platform, promoting the extension of the X_{-axis}, the expansion of the Y_{-axis}, and the enrichment of the connotation of the Z_{-axis}, influencing each other, competing with each other, and adding value together.

3.3. Strategies for Supply Chain Value-added Path Optimisation

3.3.1. Internet plus New Operating Model

(1) Value Addition Path of "Internet plus Jilin Rice Supply Chain"

By innovating concepts and technologies, it can restructure material, capital, and information flows. In this context, the rice supply chain in Jilin Province can harness internet-based principles to organise its various components. By doing so, it can create room for the integration of rice production materials and sales markets, establish a new rice supply chain under the "Internet plus Jilin Rice Supply Chain" model, and consequently construct a fresh distribution channel for the four critical segments of the rice industry: production, payment, logistics, and marketing. This innovation caters to the diverse needs of customers and forms a new business system [13].

(2) "Internet plus E-commerce" Value-Added Path

The emerging marketing model within the downstream segment of the rice supply chain in Jilin Province leverages leading enterprises to play a pivotal role in utilising the local e-commerce integrated service network and diverse rural e-commerce platforms with valuable resources. These are instrumental in guiding and assisting new business entities in the online marketing rice products, thus paving the way for the "Internet plus E-commerce" value-added path. This approach significantly broadens the sales channels for rice products. Simultaneously, it involves the development of rural e-commerce platforms. Through methods such as "O2O" and capitalising on the region's agricultural resource advantages, the marketing avenues for rice products in Jilin Province are expanded. This establishes direct connections with end-consumer groups, propelling the rapid development of the "production and marketing" integration model [14].

(3) "Enterprise Plus Village Collective Plus Cooperative Plus Poor Household" Value-Added Path for Precise Poverty Alleviation

As precision poverty alleviation efforts deepen, the benefits of the rice supply chain model driven by leading enterprises in Jilin Province have become increasingly evident. In 2021, Jilin Province strategically combined "rectification" and "attack," successfully integrating poverty alleviation with rural revitalisation, intensifying poverty alleviation efforts. In particular, optimising the rice supply chain path uses new agricultural management entities to enhance their capacity to uplift impoverished households with limited management abilities. Through government support and collaboration with leading enterprises committed to participating in industrial poverty alleviation, operation modes such as "enterprise plus cooperative plus poor household" and "enterprise plus village collective plus cooperative plus poor household" are promoted. The government extends its support to leading enterprises with the will and capacity to engage in industrial poverty alleviation, which helps to enhance industry organisation. Furthermore, with government policies backing, new agricultural business entities in Jilin Province, demonstrating the willingness, capability, and potential to alleviate poverty, will receive priority recommendations for support and recognition. Their activities, whether driving poor households or providing substantial employment opportunities for impoverished individuals, will be acknowledged as vital contributions to improving precision poverty alleviation via the "Enterprise Plus Village Collective Plus Cooperative Plus Poor Households" value-added path, representing an innovative approach [15].

3.3.2. Modern Agricultural Services Plus Technological Innovation

(1) Integration of Modern Agricultural Technology Services and Expert Think-Tank Services

This approach encourages the synergistic and complementary functioning of the industry-supporting service system within the supply chain to standardise the rice supply chain and enhance the standardisation of businesses

within it. It seeks to apply modern agricultural science and technology to achieve economies of scope and scale in rice production in Jilin Province. By cooperating with foreign capital, this model strategically leverages international resources and technology, enhancing global market entry and the value-added aspect of modern agricultural services. Additionally, modern agricultural technology services are integrated with expert think-tank services, providing current technology services for rice supply chain production, warehousing, and sales in Jilin Province. For example, "JINONG RICE HIGH TECH" is a crucial platform for transforming scientific and technological advancements in rice in the Provincial Academy of Agricultural Sciences. It offers expert think tank services to rice supply chain businesses. It acts as an "international think tank" for developing the rice industry in Jilin Province, promoting the integration of modern agricultural technology services and expert think tank services [16].

(2) Enhance the Industry-Supporting Service System

To enhance the quality of agricultural services at various links within the rice supply chain in Jilin Province, there is an increased need for research investment. This requires analysing consumer concepts and the shifting demand patterns of leading consumers. Moreover, it involves combining Jilin's regional ethnic customs and cultural elements to create unique supporting services. These services will be tailored to guarantee the value-added supply chain service. Industrial supporting services encompass agricultural insurance, property rights management, new technology promotion, online education and training for rice producers and promoters, and dynamic management of all members. These services rely on new technologies to fulfil the functions of agricultural research and teaching, management consulting, and technology promotion. This results in online problem-solving capabilities regarding the operation and management of the rice supply chain. Furthermore, an international cooperation model of "scientific research plus enterprise" is deployed to promote the integration of science and technology, emphasising the equal importance of the productive service industry and living service industry, as the research as the balance better researched the traditional service industry and modern service industry [17].

(3) Rice Supply Chain Information Sharing and "Financial Technology" Service Matching

Financial technology (Fintech) is recognised as a novel value-added model that combines finance and technology. It leverages big data, artificial intelligence, blockchain, and cloud computing to enhance the efficiency of financial services while reducing costs. In the rice supply chain context, the information and financial services rely on an information service system to gather, collate, and analyse information related to rice production, processing, logistics, market transactions, and product marketing. Additionally, the system leverages the precise analysis of customer data to obtain valuable insights. This approach aligns with the goal of "order-based" production and planning distribution between producers and sellers within the supply chain. By integrating and innovating credit and financial service businesses within the rice supply chain, it utilises the resources of agricultural financing and guarantee institutions. This method involves assessing credit status and screening credit customers effectively to realise the objective of "order-based" production and planning distribution between producers and sellers within the supply chain. The ultimate aim is establishing a credit and financial services system for Jilin Province rice supply chain members. This system provides reasonable and precise financial support for supply chain development [18].

3.3.3. Value-Added Chain-Wide plus Green Information Platform

(1) Creating a Green Circulation Environment via the "Internet plus Grain Trading and Logistics" Platform

In line with the principles of green and sustainable development, the modern agriculture sector in Jilin Province is advancing toward green, ecological, and efficient development. The "Internet plus grain trading and logistics" platform underpins the rice supply chain by offering low-cost, high-efficiency logistics services. This platform coordinates online trading for rice products with offline logistics and value-added services. It establishes a comprehensive online-offline interaction, including process supervision, capital oversight, and service tracking for rice electronic trading. This effort also includes the development of logistics nodes within Jilin Province, enhancing railway container transport capabilities, promoting uniform quality and safety supervision for rice, and post-management and maintenance. This endeavour aims to create a high-quality rice project. To further promote green logistics channels for rice resources across different regions and improve the overall environmental impact of the rice supply chain, Jilin Province is encouraged to foster green driving factors in the core nodes of the supply chain. The goal is to minimise the environmental footprint of the rice supply chain during the circulation process while increasing its overall value. In pursuing rice supply chain optimisation, Jilin Province should embrace a circular economy, promote green production methods, create eco-brands using green agricultural technology, and reduce waste to increase the value within the supply chain [19].

(2) Innovative Rice Information Development Platform in Jilin Province

The optimisation pathway for the supply chain should align with current trends, connecting rice trading in Jilin Province with international standards. This effort accelerates the development of green grain traders with global competitiveness, fostering a new pattern of industrial economic development and multilateral cooperation. The goal is to create a green rice supply chain information innovation platform, offering a green supply chain environment. The rice supply chain information technology innovation platform integrates recycling agriculture, creative agriculture, agricultural experience, and eco-agriculture modes such as sightseeing and tourism. This approach promotes value-added services through the new platform [20].

3.4. Industry Cluster Plus Brand Value-Added

3.4.1. Promoting the Integration of the "Three Industries" to Support the Rice Industry Cluster in Jilin Province

In the ongoing process of promoting industrial structural upgrades and optimising the rice distribution landscape within Jilin Province, there is a continuous drive to foster the organic unity of "three industries" integration and fine-tune the path of "three industries" integration to facilitate the development of rice industry clusters. This narrative unfolds as the research optimises "three industries" integration. By harnessing the advantageous resources and favourable conditions within each region, Jilin Province has given rise to

thriving rice industry clusters, effectively converting resource advantages into economic gains and harnessing the potential of burgeoning industrial entities. This synergy is two-fold: firstly, integrating the "three industries" catalyses the creation of more robust and diversified industrial clusters within the rice supply chain. These clusters yield more pronounced comparative advantages and elevate comprehensive competitive strengths, igniting robust developmental momentum. Secondly, industrial clusters significantly impact the amalgamation of the "three industries." In addition, they significantly influence the progression of integration into the "three industries". Industrial clusters, primarily through the realisation of production cost reductions via economies of scale or scope economy benefits, play a pivotal role in building a modern agricultural industrial system [21].

3.4.2. Enhancing the Popularity of the "Made in Jilin" Rice Brand and Strengthening the Traceability System

Firstly, it is imperative to expedite the optimisation of rice production bases. This includes judiciously expanding the scale of rice production, setting up national and provincial agricultural standardisation demonstration bases, and promoting brand certifications such as the "three products and one standard." Furthermore, there should be active endeavours to develop freshness, storage, grading, packaging, cold chain warehousing, and logistics technology. Leading enterprises should be encouraged and guided to collaboratively establish standardised rice production bases, processing bases, and warehousing and logistics centres.

Secondly, capitalising on Jilin's regional advantages and seizing business opportunities is crucial. This involves optimising the layout of rice product imports and exports and diversifying the product variety structure. Ensuring the green traceability of agricultural products and effectively promoting rice product branding is essential. Collaboration with well-known enterprises like Zhengda, Tongrentang, Evergrande, and various other entities should be intensified to expand their influence on the leadership and promotion of the "Made in Jilin" rice brand. By diversifying the "Made in Jilin" rice products in the market, the brand's reach and impact are broadened, enhancing its effectiveness and value-added attributes [22].

3.4.3. Advancing Research and Development Capabilities for Key Technologies and Facilitating the Transformation of Achievements

Agricultural science and technology innovation play a pivotal role in ensuring food security and driving the continuous advancement of the rice supply chain. Optimising the research and development capabilities of critical technologies and core equipment is essential to foster sustained growth in production and connotative value-added improvements within the rice supply chain in Jilin Province [23].

Rice farmers should shift away from traditional business models as stakeholders and beneficiaries. They should establish new agricultural business entities in alignment with market demand, actively participate in the benefit-sharing mechanism within the rice supply chain, contribute to the pool of resources for scientific and technological innovation, engage in the development of new rice varieties based on scientific and technical innovations, and evolve into active participants in supply chain operations. This transition is pivotal for successfully transforming scientific and technological achievements, ultimately enhancing the value-added attributes of scientific and technological innovations within the rice supply chain [24].

3.5. Standardised Process plus New Dynamic Energy

3.5.1. Development of a Standardized Process for Supply Chain Operations

Formulating supply chain process standards that reflect local characteristics and market competitiveness within Jilin Province is pivotal. This effort aims to bolster the prominence of high-quality rice products in the region, establishing precise production management and product quality control systems. It expedites the implementation of high-quality grain initiatives. This process addresses every facet of the rice supply chain, including upstream, midstream, and downstream operations and their core components. Creating technologies for graded standardised production and processing tailored to accommodate diverse consumer needs is essential. It maximises the advantages and implements standardised production and operation procedures for rice products. Consequently, this gradual process elevates rice products' production and management standards. Including insurance, property rights management, and skills training, combined with targeted industrial support, advances the standardisation of supply chain operations. In tandem with this, efforts are intensified to fortify the protection and responsible use of arable land and agricultural biological resources within Jilin Province. The efficient utilisation of agricultural water resources is likewise emphasised, with initiatives such as water-saving agrarian projects through water usage control and quota management. The widespread adoption of high-efficiency technologies like integrated water-fertilizer management, straw incorporation, deep ploughing, and protective tillage is encouraged to enhance the sustainability of rice cultivation. These measures aim to improve the quality and efficiency of rice cultivation at the source, ultimately promoting green development [25].

3.5.2. Cultivating New Sources of Energy for Economic Growth in the Rice Industry

Jilin Province, initially, should increase financial expenditure directed towards technological innovation in rice production and processing. This expenditure should emphasise scientific and technological innovation and the vigorous development of new industries. Furthermore, it should involve the cultivation of clusters within strategic emerging industries, promoting high-tech content product incubation, and fostering upgrading and adding value to the rice supply chain.

Secondly, it can explore emerging rice-related projects and focus on promoting high-value-added projects. This strategy leads to the development of industrial clusters. It stimulates the synergistic effect associated with upstream and downstream industries in surrounding counties and cities, thereby tapping into fresh sources of economic growth. The comprehensive supply capacity of green and high-quality agricultural products is enhanced by expanding the planting area for green rice. This is achieved by supporting leading enterprises, cooperative financial institutions, family-owned ranches, professional breeding companies, and the joint establishment of breeding bases and high-tech industrial parks [26].

Lastly, the implementation of an innovation-driven development strategy is crucial. This entails fostering the transformation and enhancement of existing and new

industries like supply chain finance. These efforts yield new economic growth points and stimulate domestic demand, elevating consumption patterns and promoting innovative management practices.

3.6. Chain-wide Risk Early Warning plus Monitoring

3.6.1. Enhancement of the Rice Supply Chain Risk Mitigation System

The intrinsic nature of food product consumption underscores the necessity for the rice supply chain to be risk-averse. By identifying the key factors influencing the rice supply chain in Jilin Province, it is evident that critical risk points mainly encompass natural, market, operational, and technical risks. Through the prevention and control of these key risk points, the accuracy of risk analysis within the rice supply chain can be elevated, allowing for the measurement of the existing risk level. This proactive approach is instrumental in reducing the likelihood of risk occurrences and boosting the chain's resilience and adaptability to risks. A risk management framework can be delineated by establishing a dedicated department for value-added risk control within the supply chain. This department would possess the authority to conduct preliminary oversight of pertinent business operations, enabling timely reporting and appropriate interventions. This strategy aims to foster comprehensive coordination and balanced scrutiny across all core links in the supply chain, ensuring a secure and quality-oriented guarantee for the value-added aspect of the rice supply chain in Jilin Province. Creating a rice supply chain risk mitigation system should also encompass risk identification and risk-sharing mechanisms, with leadership primarily led by the government and core enterprises. Risk mitigation is achieved by employing price protection, agricultural insurance, and risk funds to preclude potential natural, market, and technological risks within the supply chain, ultimately minimising losses [27].

3.6.2. Implementation of a Risk Early Warning Regulatory System for the Rice Supply Chain

(1) Data Collection Sub-System

The data collection sub-system is the foundation of the risk early warning system. It uses systems engineering theory and risk early warning principles to gather and organise external environmental data related to the rice supply chain in Jilin Province. This includes internal supply chain knowledge, such as international and domestic policy trends, economic conditions, social and cultural factors, and market competition. The data collected helps identify developmental patterns and characteristics of the rice industry, refining the database of environmental risk sources, sensitive targets, ecological emergency response capabilities, and contingency plans.

(2) Risk Early Warning Indicator Identification Sub-System

This subsystem forms the core of the early warning system. It creates a second-level indicator system for risk early warning based on identified risk indicators for the rice supply chain in Jilin Province. The research sightings are assigned to secondary indicators derived from different risk factors. The system aggregates these indicators to assess the likelihood of supply chain risk occurrences, establishing a standardised system for risk early warning.

(3) Risk Analysis Sub-System

The risk analysis sub-system provides risk monitoring and diagnostic functions. Risk assessments are conducted using single-level or multi-level fuzzy comprehensive evaluation techniques. A fuzzy evaluation matrix and vector fuzzy algorithms are used to produce comprehensive evaluations of the current risk status of the rice supply chain. In high-risk status, the sub-system identifies the primary risk origins and analyses corresponding secondary indicators to mitigate and prevent risk factors.

(4) Risk Management Sub-System

The risk management subsystem evaluates early warning signals and proposes programs, contingency plans, and corrective measures for key risk points. Measures are implemented to minimise losses from significant risks within the rice supply chain. Action plans are developed to enhance the operations of the research links in the supply chain, preventing the recurrence of similar risks.

(5) Risk Dynamic Monitoring Sub-System

This sub-system maintains a comprehensive database of sample information programs for the early warning system. The database, containing thousands of sample records, is continually updated and improved as the rice supply chain in Jilin Province evolves. The early warning platform generates signals when specific indicators reach critical thresholds, prompting interventions and improvements as outlined in pre-established programs. This enhances the resilience of the rice supply chain against risks and promotes value addition throughout the industry [28].

4. Achieved Effects

4.1. Building a Modern Rice Industrial Park

In May 2019, Lishu County approved the establishment of a green rice modern agricultural industrial park, with a cumulative investment of nearly 300 million yuan. The park has built a green rice standardised planting base of 300,000 mu.

The core area of the leading rice industry set up in Lujiazui Town has built an e-commerce platform and traceability system, a rice field leisure and sightseeing area, an industrial park logo publicity board, and four major projects in the core area of the industrial park, forming a rice industry cluster with rice enterprises, cooperatives, and family farms as the core, and integrating rice seedling, planting, processing, productive services, and trading circulation, etc. It has cultivated several leading enterprises and farmers' professional co-operative organisations with demonstration and driving roles, driven 4,000 new business subjects of rice planting to become the leading force in the construction of the park, integrated human, financial and material resources in the field of rice, and accelerated the popularisation and application of new varieties and new technologies in the rice industry. In order to accelerate the application of information technology, Internet of Things technology and other new technologies in the rice industry, to achieve the traceability of rice from planting to the dinner table in all aspects, the green rice modern agricultural industrial park construction of the e-commerce docking development platform, and the line of significant purchasing operators win-win co-operation, the formation of an integrated green rice product quality and safety of product quality and safety of the traceable information network, can be queried from the production of rice to the circulation of the whole process, product Flow can be traced, storage and transportation information can be queried, rice from planting to the table in all aspects of the traceability sub-system at a

glance, to achieve on-line and off-line interoperability, capital flow, logistics, information flow synchronisation, drive the overall improvement of the rice industry in Lishu County [29].

4.2. Make High-quality Rice into an Advantageous Industry

Zhenlai County, relying on the ‘saline land - arable land in the pollution-free virgin land’ and unique water resources advantages, make every effort to promote green ecological efforts, optimise varieties on the layout, seek development in brand building, and promote the implementation of the whole industry chain, and strive to build the ‘first big rice county in Jilin Province’. ‘The first rice county in Jilin Province’.

Zhenlai County is located in the north, the researchers part of Jilin Province, which is located in Heilongjiang, Jilin, Inner Mongolia, three provinces (regions) junction, Nenjiang River, Taol River, Hulda River, and Erlongtao River. In 2023, the rice planting area reached 1.55 million acres, with an output of 1 million tonnes, to achieve the ‘planting area and production of double broken million’. Rice yields increased from 300kg per mu in 1983 to 651kg, especially the super rice yields exceeded 760kg.

Zhenlai County, the primary selection of the following varieties: small-grain aromatic rice (national) quality rice, such as Ji-Japonica 816; Ji-Da 158; Ji-Hong 6, etc.; long-grain aromatic rice and ordinary long-grain rice national quality rice, such as rice 1-5, Song Japonica 22; Ha 417, etc.; super rice quality rice, such as Hongke series, Qinglin series, Jiu rice series; early rice series, such as White Japonica 1 (long grain) or varieties with a fertility period of no more than 130 days.

Through ‘order production’, farmers planting rice per acre can increase earnings by more than 50 yuan; by statistics of the county's existing rice processing enterprises 53, the total design processing capacity of 1.5 million tonnes of enterprises, the actual processing capacity of 550,000 tonnes, the annual sales revenue of 1.8 billion yuan; Zhenlai County vigorously develop the existing ‘Zhenlai Rice’, “Nenjiang Bay”, “Nenjiang Pearl”, “Jiguang” and other high-quality rice brands. Through the 150,000 acres of national green food raw materials rice standardised production base construction, there have been three agricultural processing enterprises and more than 20 cooperatives; family farms to apply for certification of green rice brand was certified 83, distributed in Zhenlai County, the eastern paddy townships, in addition to encouraging the eight processing enterprises relying on the county's 150,000 acres of standardised raw material base to apply for certification, and is now through the provincial certification body review and national audit. Zhenlai County, through the green brand certification, cultivates ‘Zhenlai rice’ quality construction, strengthens the green food raw materials rice standardised production base construction, encourages enterprises and farmers to sign orders, and strives to build a large county of rice into a strong county of green high-quality rice.

From 2016 in Zhenlai County to carry out the relevant high-quality, productive and efficient varieties screening research, 2023, has been successfully screened from more than 200 varieties of high-quality, efficient and productive cold-resistant rice varieties and supporting the corresponding mechanised cultivation technology, screened on behalf of the varieties of tiny grains of fragrant varieties of Jiji-Japonica 816, by the Chinese modern rice industry technology system of the Northeast Central Rice Area Japonica Rice Improvement Post Scientist The team bred a new high-quality flavourful rice variety, which passed the validation in 2018 and was successfully planted on a trial basis in Zhenlai County in 2019, and the application of the project's supporting essential cultivation techniques in the demonstration area of the Yingtai Agricultural and Mechanical Farmers' Professional Co-operative in Zhenlai County can save water by 10.3%-12.6% per hectare, reduce the application of nitrogen fertilizer by 10.8%-15.2%, and increase the income of demonstrators by more than 3,000 yuan per hectare [30].

5. Conclusion

This study investigates the transformative impact of digital technology on rice supply chain management in Jilin Province, focusing on value optimisation through various innovative strategies. The research highlights several critical areas where digital technology can significantly enhance the efficiency and effectiveness of the rice supply chain.

Firstly, the application of digital technology in the rice supply chain has shown considerable promise in improving production efficiency and reducing costs. Integrating modern agricultural services and internet-based models, such as "Internet plus Jilin Rice Supply Chain" and "Internet plus E-commerce," offers new pathways for value addition. These models enable better coordination and management across the supply chain, leading to optimised resource allocation and enhanced market reach.

Secondly, the study identifies the importance of constructing a value-addition system that incorporates the lifecycle theory of rice crops. By understanding the stages of cultivation, growth, maturity, and stability, stakeholders can better manage the supply chain to maximise value at each stage. The "DETAIL" model proposed in this research is a comprehensive framework for enhancing value through structural optimisation and innovation of rice products and by-products.

Moreover, the research emphasises the role of modern agricultural services in transforming and upgrading the rice supply chain. The introduction of new services and the expansion of existing ones, both horizontally and vertically, are crucial for driving innovation and improving supply chain efficiency. The information innovation platform, leveraging "Internet plus" technology, is particularly effective in enhancing online and offline supply chain operations.

The study also addresses the challenges of risk control and cost management in the rice supply chain. By developing a value optimisation model that considers traditional value innovation, loss reduction, and exploration of new dynamics, the research provides a robust framework for minimising risks and maximising returns. This model helps stakeholders understand the interplay between the research and cost savings, revenue enhancement, and risk control, ultimately leading to a more resilient and profitable supply chain.

In conclusion, integrating digital technology in rice supply chain management presents significant value addition and optimisation opportunities. The strategies and models proposed in this study offer practical solutions for overcoming existing challenges and unlocking new potential in the rice industry. As the market environment continues to evolve, continuous innovation and adaptation will be essential for sustaining the growth and competitiveness of the rice supply chain in Jilin Province.

Conflicts of Interest

The research has no conflict of interest.

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