International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

INCORPORATING THE NEWSVENDOR MODEL IN AGRICULTURAL RISK MANAGEMENT: A QUANTITATIVE APPROACH TO DECISION-MAKING

*[1]Soham Ghosh, [1]Pritee Sharma, and [2]Sujay Mukhoti

[1]Department of Economics, School of Humanities and Social Sciences, Indian Institute of Technology Indore, Indore, 453552, Madhya Pradesh, India.

[2] Operations Management and Quantitative Techniques Area, Indian Institute of Management Indore, Indore, 453556, Madhya Pradesh, India.

*Corresponding Author

DOI: https://doi.org/10.51193/IJAER.2025.11214

Received: 31 Mar. 2025 / Accepted: 08 Apr. 2025 / Published: 10 Apr. 2025

ABSTRACT

Agricultural commodity markets remain unstable due to climate change, evolving global demand, and disruptions faced due to supply chain. Improved risk management strategies are crucial to establish food security and ensuring proper income of the farmers. In this paper, we examine the application of the renowned newsvendor model to agricultural products. We demonstrate effectiveness of the model to determine optimal procurement quantity and alleviate risks associated with both shortages and overproduction. Newsvendor model has been widely applied in different discipline since its inception, determines optimal quantity by balancing shortage and overage cost. We establish significance of applying the model to India's agricultural sector to improve procurement decisions, minimizing losses. Additionally, integration of the model into policy planning also improves the effectiveness of government interventions, such as minimum support price (MSP) schemes and buffer stock management. Furthermore, we explore the application of the model to the country's agricultural export policy, particularly focusing on the African countries affected by droughts, and receive support from the United Nations. The newly developed framework effectively enhances food security in vulnerable regions along with improving India's agricultural trade and global outreach. Our findings indicate that incorporating newsvendor framework contribute towards a more stable and market-driven agricultural economy in India.

Keywords: Agricultural Risk Management; Newsvendor Model; Decision Theory; Climate Variability; Supply Chain Optimization.

1. INTRODUCTION

Markets of the agricultural production are inherently volatile, effected by several factors including climatic variability (IPCC, 2021), economic shifts across the globe (FAO, 2020), and disruptions caused by supply chain (Christopher & Peck, 2004). The climate change induced evolving weather patterns causes significant threats to agricultural production, heading to both shortages and overproduction (Lobell et al., 2011). Furthermore, due to factors including increasing population, changing dietary patterns and international trade policies, the demand for agricultural products is continuously increasing at global scale (Godfray et al., 2010). All these factors along with several other leads to price variations in both global and local markets, which have an adverse impact for both farmers (producers) and consumers. Moreover, supply chains disruptions due to geopolitical conflicts, logistical bottlenecks, and natural catastrophes further worsen the situation, causing agricultural risk management a crucial area of research and policy intervention.

Effective risk management techniques help in reducing the negative effects of market volatility by providing stable income for farmers and ensuring food security to poor peoples (Barrett, 2020). Mathematical models play an important role in reducing risks through optimal decision-making processes. One such mathematical model that has been extensively applied in different disciplines since its inception is the newsvendor model (Ghosh et al., 2021). This model determines the optimal procurement quantity by compensating the risks associated with both shortage and overage losses (Ghosh & Mukhoti, 2023). However, application of the newsvendor model remains relatively unexplored in the agricultural sector compared to the other fields (Ahumada & Villalobos, 2009). Implementation of the newsvendor model for the agricultural products provide important insights into procurement decisions, inventory management, and pricing strategies due to the perishable nature of the products and the difficulties faced during production processes.

In this paper, we examine the implementation of the newsvendor model to agricultural commodities, with a special focus to India, where agriculture sector plays a crucial role in maintaining economic stability of the country (Chand, 2019). Agriculture sector is characterized by high reliance on monsoons, disjointed supply chains, and price volatility. Indian Government introduces policies like the Minimum Support Price (MSP) scheme and buffer stock management to sustain farmers' incomes and ensure food security. However, even with these proactive measures, several factors like ineffective distribution, storage, and procurement processes causes wastage and financial losses. Incorporating the newsvendor model into policy planning can

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

significantly enhance the effectiveness of these interventions by suggesting a systematic approach for determining optimal procurement quantities.

India's condition in global agricultural trade is evolving in recent time, and the export policy plays a pivotal role in preserving economic stability and food security, both domestically and internationally. Many African nations like Zambia, Kenya, Zimbabwe, are facing recurrent droughts and food shortages. These countries majorly rely on agricultural imports to satisfy their domestic demand (FAO, 2019). The agricultural export policy of India can be strategically crafted to improve its position in international trade and alleviating the food hunger issues in these susceptible regions (Badiane & Makombe, 2015). Integrating the newsvendor model into export policy planning, India can assure that agricultural excess is distributed effectively to regions in need, thereby establishing food security in drought-prone African countries. Additionally, such initiatives can be strengthened with assistance from global institutions like United Nations (UN), creating a framework for rational agricultural commerce and humanitarian aid.

The primary objective of this study is to demonstrate the applicability of the newsvendor model in determining India's export policy to climatic vulnerable regions. Our goal is to establish the significance of determining optimal procurement quantities through the model, cutting down the overproduction losses, and improving the effectiveness of the government policies. We also focus on the implementation of the model to provide an agricultural export policy for India that coincides well with trade interests of the country while addressing international food security challenges. Our study offers a novel approach to reduce risks in international agricultural markets and establish a more stable and market-driven economy by incorporation of mathematical modelling with policy planning.

The structure of this paper is as follows: Section 2 presents a review of the existing literature on agricultural market volatility, risk management, and the newsvendor model. Section 3 discusses the relevance of the application of the newsvendor model in deciding export strategies, policy interventions, and procurement planning. Section 4 provides a critical analysis of the model's ramifications for India's agricultural sector and international food security. Finally, Section 5 concludes with key findings and recommendations for future research and policy design.

2. LITERATURE REVIEW

To ensure stability in the agricultural markets, an improved understanding of the risks is required. Such risks are majorly influenced from climate variability, economic shifts, and logistical challenges, along with the implementation of effective mitigation strategies (Gouel, 2012). The volatility in the prices of agricultural commodity arises from unpredictable climatic patterns, policy changes, and other macroeconomic conditions that effect both production and trade (Wright,

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

2011). Similar properties of agricultural yields have been addressed in the literature, with researchers focusing on the roles played by both systemic and idiosyncratic risks in evaluating market stability (Gilbert & Morgan, 2010).

2.1 Agricultural Market Volatility

Agricultural price volatility has been a topic of significant research as it has a profound impact in food security and farmer incomes, effecting overall economic stability of the country (Timmer, 2010). Deaton & Laroque (1992) investigated the association between price volatility and storage capacity, demonstrating that limited storage capacity leads to price fluctuations. Climate change and extreme weather events have a substantial impact on the production of agricultural commodities, causing supply shortages and price volatility in the international market (IPCC, 2021; Bellemare, 2015). Inconsistent nature of such climatic events introduces more uncertainty in the agricultural market. Abrupt changes in global demand, trade restrictions and export bans are also influencing price fluctuations, as observed in the 2007-08 global food crisis (Headey, 2011). Wright (2011) and Abbott et al. (2011) reported that shifting consumer preferences and biofuel policies have increased the demand of certain crops, further affecting price volatility. Barrett & Bellemare, (2011) have reported that factors like inadequate infrastructure, transportation bottlenecks exacerbate price fluctuations. In developing countries, smallholder farmers have limited access to advanced agricultural tools, reduces investments agricultural products and have negative consequence on rural livelihoods. Gilbert & Morgan (2010) demonstrated that market instability and short-term price spikes are directly linked with speculative activity in the agricultural markets. Extreme fluctuations in prices have larger consequences on economy, including inflationary pressures and trade imbalances (Anderson & Nelgen, 2012). Financial instruments such as futures contracts, crop insurance, and weather derivatives play an important part in balancing the price risks. with studies indicating that futures markets help farmers hedge against price fluctuations, though their effectiveness varies based on market participation and regulatory frameworks. Gouel and Jean (2015) suggests implementation of price stabilization mechanisms and international trade policies can successfully manage volatility by minimizing market stabilization and offering stability to both consumers and producers. Farmers can make better decisions and exacerbate market efficiency by reducing price uncertainty through improved access to market information via digital platforms (Aker, 2010). Moreover, the transmission of global commodity price shocks into local agricultural markets has been a key area of interest, with studies suggesting that developing economies are particularly vulnerable to such external influences (Headey & Fan, 2010).

2.2 Risk Management Strategies in Agriculture

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

Risk management in agriculture is dependent on tools like minimum support price (MSP) schemes, forward contracts, and crop insurance (Coble et al., 2000). Farmers and agricultural firms also employ some strategies to minimize the such risks (OECD, 2009). Such strategies are required for reducing the volatilities associated with market fluctuations, weather variability and policy changes (Hardaker et al., 2015). These approaches also mitigate income uncertainty for farmers while assuring sufficient food supplies. Additionally, these programmes and targeted subsidies helps in stabilizing earning of the decision maker and protect the farmers in the periods of price volatility. Mahul & Stutley (2010) and Glauber (2004) suggested agricultural insurance as a risk management tool, safeguarding farmers against the production losses due to climatic extremes like floods, droughts, and cyclones. Weather index-based agricultural insurance scheme is introduced as a mechanism to reimburse farmers based on observed climatic scenarios compared to direct losses in production, thereby minimizing moral hazard and transaction costs (Barnett & Mahul, 2007). Adopting the climate resistant agricultural practices, the farmers can form resilience against long-term climatic conditions (Lipper et al., 2014). However, such insurance mechanisms alone may not be able to address price risks adequately, and the adoption of market-based solutions are also required (Newbery & Stiglitz, 1981). Another crucial strategy for agricultural risk reduction is crop diversification. The farmers spread the risk by cultivating multiple crops with different growth cycles and climate resilience (Di Falco & Chavas, 2009). This approach increases agricultural sustainability without being dependent on single-crop, which are more exposed to environmental shocks. In recent years, risk management strategies on supply chain have gathered attraction among the researchers. Basso & Antle (2020) suggested adoption of machine learning techniques and data analysis tools are also developing risk management strategies through real-time weather forecasting, predicting market conditions. Integration of this advanced technologies with risk management strategies allow farmers to make superior decision, better utilisation of available agricultural inputs, and reduction of probable losses. Despite the advantages offered by the strategies, effectiveness of implication these are relies on several factors like access to financial resources, institutional support, and the capability to adopt innovative agricultural techniques (Hansen et al., 2011). These strategies majorly focus on improving procurement decisions and resilience against stochastic demand distributions (Tang & Musa, 2011). Strengthening risk management mechanisms and promoting capacity-building infrastructure may increase the flexibility of agricultural systems and assure sustainable food production in presence of global challenges.

2.3 The Newsvendor Model in Agricultural Supply Chains

The newsvendor model is a well-established mathematical framework applied majorly in inventory management and operations research to determine optimal order quantity under unknown demand distribution (Arrow et al., 1951). Farmers and small agribusiness firms face continuous challenges

ISSN: 2455-6939
Volume: 11, Issue: 02 "March-April 2025"

in maintaining the inventory for agricultural products, due to the perishable nature of the products. Several studies established the effectiveness of newsvendor model in maintaining the uncertainties associated with both yield and price sides, helping the decision makers to take more informed decision regarding production planning. The model is considered as important model for agricultural risk management as it has been extended to integrate several factors government interventions, supply chain disruptions (Chavas, 2008). You & Grossmann (2008) demonstrated the advantage of implementation of newsvendor model for procurement and distribution of staple crops. In agricultural supply chains, the newsvendor model is employed for optimal procurement decisions, where short selling seasons and demand uncertainty causes significant difficulties to the decision maker (Chopra & Meindl, 2001). Cachon & Terwiesch (2019) showed that application of the newsvendor framework in agricultural supply chain helps in reducing losses due to unsold products while ensuring sufficient supply to satisfy customer demand. Governments and other organizations associated with food security programs involved policies like buffer stock and minimum support programmes (MSP). Newsvendor model is also integrated in such policies to optimize grain inventory and minimize losses due to deterioration. Application of the model in policies like contract farming and cooperative models have improved the relationship between farmers and retailers, suggesting a more stable supply chain. The relevance of the application of the newsvendor model in agriculture industry extends to policy interventions, such as MSP schemes and buffer stock management, where balancing supply and demand is crucial to ensure market stability. Ben tal et. al (2009) demonstrated the integration of real-time data analytics and machine learning techniques improves the predictive accuracy of estimation of stochastic demand distribution within the newsvendor framework. Furthermore, the model has been adapted to address supply-side uncertainties in agricultural exports, particularly in the context of global food aid and trade agreements. Despite the advantages of the application of the newsvendor model in agricultural industry faces difficulties related to limited market information, infrastructure constraints. Addressing these issues with superior digital infrastructure and capacity building initiatives can further enhance the applicability of the model in the agricultural supply chain, resolving bigger challenges like global food security and economic stability.

3. APPLICATION OF NEWSVENDOR MODEL

The newsvendor model is a fundamental tool in operations research, allowing the decision-maker to handle demand uncertainty by computing optimal order quantity (Ghosh et al., 2021). In the traditional version of the model, the stochastic demand is represented by a positive valued random variable X, with distribution function $F_\theta(\cdot)$. The expected cost function in this case is given by,

$$C(Q,X) = E_\theta[C_e(Q-X)I(X<Q) + C_s(X-Q)I(X>Q)]$$

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

Here, $I(\cdot)$ represents the indicator function and Q denotes inventory level at the initial stage of the selling period. C_e and C_s are the per unit excess and shortage cost respectively. Optimal order quantity in this scenario is given by, $Q^* = F_\theta^{-1}\left(\frac{C_s}{C_e+C_s}\right)$, that is exactly the γ^{th}quantile of the demand distribution $\left(\gamma = \frac{C_s}{C_e+C_s}\right)$.

To illustrate the practical implication of the model we consider the case of tomato farmers in Karnataka, India, during the 2020 COVID-19 lockdown. Due to limited access to market information and logistical disruptions, a substantial part of the produced perished or was sold at distress prices (Tripathi et al., 2023). In such a scenario, the farmer producer organizations (FPOs) or local cooperatives can employ the newsvendor model to decide the optimal order quantity for the production to minimize overstocking. Depending on the expected selling price and spoilage cost, the model suggests a conservative harvest quantity matching with local consumption patterns and transport availability. Incorporating the model helps in mitigating losses, establishing the procurement decision based on stochastic demand supports risk-averse decision-making in fluctuating agri-markets scenarios.

The classical newsvendor model has a number of simplifying assumptions, but in spite of that the model offers valuable insights for procurement and planning under uncertainty. These assumptions include a single-period decision framework, fixed shortage and overage costs. Majority of newsvendor literature assumes the demand distribution is completely known to the vendor (Ghosh et al., 2021). In real-world agricultural contexts, demand distributions may be partially observed or dynamically evolving. Additionally, cost parameters are difficult to estimate properly. The model assumes centralized decision-making and immediate realization of costs, which may not fully capture decentralized or delayed-response settings common in agriculture. Acknowledging these limitations provides a clearer view of the model's applicability and highlights directions for further refinement and adaptation. In spite of these limitations, the formulation enables the decision maker to implement the newsvendor model in export strategies, policy interventions, and procurement planning.

3.1 Application in Export Strategies

Supply commitments in the presence of uncertain global demand are required for exporting the agricultural commodities. Application of the newsvendor model allows the exporters in evaluating the optimal shipment quantities by reducing the risks related to under-supply and over-supply (Ledari et al., 2018). Integration of the advanced forecasting techniques and historical demand data will also enable the exporters improving the decision. Seasonal trends, trade agreements, and market fluctuations are the major factors shaping the mango export policy of India to Europe

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

(Kawale et al., 2024). Exporters are required to estimate the demand distribution to determine the optimal export volumes applying the newsvendor model after the integration of such factors (Manikas & Kroes, 2015). Risk-sharing contracts among international buyers helps in mitigating the risks associated with demand uncertainty (Cachon & Lariviere, 2005).

3.2 Application in Policy Interventions

Stability of the agricultural markets depends on intervention of the governments through implementation of policies like price controls, buffer stocks, and export regulations. Newsvendor model helps in determining the procurement levels for Minimum Support Price (MSP) and other strategic policies. Government agencies have to decide optimum buffer stock level to assure the sufficient supply during demand rises while minimizing inventory costs. Application of the model helps the agencies in assessing the probability of the demand exceeding or falling a threshold level and have an optimal reserve decision. Additionally, trade policies like tariff adjustments and bans on export can be structured through application of the newsvendor model. The policymakers can estimate the probability of shortages and predict the export volumes accordingly. This implementation is particularly relevant for staple grains, whose price fluctuates due to sudden supply shocks from climatic extreme events.

3.3 Application in Procurement Planning

Farmers and small agribusiness farms depend on efficient procurement planning for minimizing shortage and ensure a stable supply chain. Procurement managers face difficulties in the planning due to uncertainty in the demand resulted from factors like consumer preferences and seasonal variation. They get benefited by the application of newsvendor model in making better purchase decision by reducing the financial hardships of maintaining unsold inventory (Schweitzer & Cachon, 2000). Determination of optimal procurement level gets improved through the application of probabilistic demand forecasts and optimizing procurement schedules. Incorporation the advanced machine learning techniques along with the newsvendor model enhances the real-time decision-making (Fisher et al., 2000).

Despite of the advantages, application of the model also has some drawbacks for real-world agricultural applications. The assumption of single period model does not perfectly fits with the real world multi period supply chain dynamics. Data availability is also another important concerns for developing countries. Extensions such as dynamic newsvendor with multi-echelon inventory decision and investment in digital agriculture will help in addressing these issues effectively (Zipkin, 2000).

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

4. NEWSVENDOR MODEL FOR INDIAN AGRICULTURE AND GLOBAL FOOD SECURITY

Application of the newsvendor model for the agricultural sector, particularly in India, and the larger impact on global food security necessitate critical examination. Agricultural production face challenges due to high uncertainty arising from weather variability, price volatility, and policy interventions. Classical deterministic models fail to explain the stochastic nature of agricultural production. For example, wheat export quantity in India is restricted due to domestic inflation concerns in 2022 and this policy effect the African importers (Udhayan et al., 2023). Export strategy based on newsvendor model allow decision makers to pre-allocate domestic and international supply under cost-risk scenarios, enhancing food security both locally and globally. Newsvendor model appears as a fascinating framework for analysing supply and demand inequalities. We provide a critical review for the consequence of applying the newsvendor model the Indian agricultural landscape with unique challenges arising from global food security.

4.1 Challenges in Indian Agricultural Sector

Agricultural production in India is majorly dominated by smallholder farmers and they often facing difficulties in accessing information on credit, storage, and market scenarios (Pingali, 2012). Inventory decision for agricultural commodities often encounters challenges due to perishable nature of the products as compared to other industries, where inventory decisions are adjusted frequently. Although the application of the newsvendor framework in the agricultural industry suggests interesting insights related optimal storage under stochastic demand, but the limitation of such implementation is the asymmetric risk faced by the farmers. Overproduction causes post-harvest spoilage and price crashes, while underproduction leads to food scarcity and economic instability. The price elasticity of agricultural products add a further layer to this decision-making process, making it difficult to achieve a proper balance between supply and demand.

Several government intervention policies including minimum support prices (MSPs), input subsidies, and procurement decisions effects the Indian agricultural sector. These policies are introduced to stabilize farmer earnings, but they often distort market scenarios, causing inefficiencies that the newsvendor model may not able to address fully. For instance, MSPs create a price threshold that neglect the assumption of the stochastic demand underlying the model. In such a situation, the effectiveness of the model gets relatively reduced for determining the optimal production levels. Additionally, the existence of public procurement agencies and the distribution of food grains through the Public Distribution System (PDS) complicate the applicability of a newsvendor framework in the Indian context.

4.2 Application in Global Policy

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

From the international perspective, the applicability of the model is extended to address bigger issues like global food security, especially in the developing countries where food production and distribution remain highly uncertain. The model indicates that optimizing the production decisions under uncertain demand could mitigate food wastage and also improve efficiency of the supply chain. However, a critical issue for the application of the model is the role of supply chain disruptions, as observed during the recent COVID-19 pandemic, where logistical hinderance cause food shortages despite availability of sufficient production storages (Laborde et al., 2020). One of the assumptions of the model is independent decision-making by the suppliers, whereas agricultural supply chains are highly interconnected with each other, and it requires coordination among different stakeholders. Without an integrated planning and buffer mechanisms, the implementation of the model in food security policies may be relatively less effective.

Furthermore, climate change causes another major challenge to the effectiveness of the model in the agricultural domain. Events increasing temperature levels, unpredictable rainfall, and frequent occurrence of extreme weather events introduce additional volatility into agricultural production. The classical version of the newsvendor model does not account for such climate-induced risks. An improved version of the model is required with modifications integrating such climate-related parameters. Researchers indicate the incorporation of probabilistic approach in climate models along with newsvendor frameworks is requited to improve decision-making under uncertain demand distribution. However, the practical implementation of such complex advanced probabilistic models remains limited, particularly in regions with restricted data availability and institutional capacity.

India emerges as a primary producer and exporter of staple crops like rice and wheat, plays a significant role in global food markets. The application of newsvendor model to export-oriented agriculture emphasizes on the balance between domestic food security and international market stability. Policy decisions related to bans and restrictions on export led to domestic food shortage. Such policies also disrupt global supply chains and exacerbate food insecurity among nations which majorly relies on agricultural imports (Headey, 2011). Another assumption of the model is a single decision-maker maximizing the profit or minimizing the losses does not match with the real-world scenarios, where governments are making trade decisions dependent on political and social conventions. This also raises questions about the implementation of the model in international policy-driven agricultural markets.

The newsvendor framework provides important insights related to agricultural supply chain optimization, especially in minimizing food wastages and enhancing the efficiency of agricultural logistics. Chen & Simchi-Levi (2012) suggests integration of predictive analytics and machine learning based approaches in the optimization framework provides a more dynamic

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

implementations of the model. Such incorporation allows for real-time decision-making based on market conditions. Recent research demonstrates that the digital platforms aggregating data from farmers, wholesalers, and retailers have improved the practical relevance of the model in agriculture. However, the major challenge in the implementation remains in ensuring equal access to these technologies, particularly to small-scale farmers who do not have the resources to utilize such technologies effectively.

Newsvendor model provides a useful analytical tool for resolving the supply-demand uncertainties in agriculture. The real-world applicability is restricted by the unique structural properties of agricultural markets. In Indian context, several factors such as policy interventions, climate uncertainty, and smallholder-dominated farming activities introduce complexities that necessitates modifications from the classical framework. The applicability of the model for international food-security relies on coordinated supply chain strategies and climate-induced adaptive mechanisms that consider systemic risks. Stochastic optimization techniques with climate risk assessment and policy analysis are required to develop a comparatively robust model that aligns well with the real-world scenarios related to agricultural production and distribution.

5. CONCLUSION AND FUTURE SCOPE

Our study demonstrates the importance of integrating risk, demand variations, and uncertainty into the agricultural supply chain leveraging the newsvendor framework. Relevance of the newsvendor framework for agricultural sector of India highlights issues with pricing volatility, seasonality, climate variability, and policy interventions. These challenges substantially affect decision-making of farmers, small agribusiness farms, and policymakers. Despite these challenging scenarios, the model presents a structured approach by accounting the demand uncertainties to address the inefficiencies in agricultural supply chains. Such applicability of the model contributes to the increased food security, reduced wastage. However, the implementation of the model requires careful examination of the risk parameters and also require consideration of regional disparities in agricultural productivity, and real-time market information for effective decision-making. The implementation of the newsvendor framework is extended beyond the Indian context to global food security. Optimizing inventory levels helps in reducing shortages, stabilize prices, and promote equitable food distribution in regions vulnerable to climate-induced shocks. The applicability of the model in global agricultural trade policies is particularly prominent in developing countries. For such nations, factors like supply chain inefficiencies, logistical constraints, and post-harvest losses influence food insecurity. Improved demand forecasts, advanced machine-learning drive predictive analytics, and incorporating the government policies, the model are suitable for adaption to various economies with context-specific changes. Our study also demonstrates the requirement for interdisciplinary collaboration among economists,

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

agronomists, policymakers, and data scientists to improve the predictive accuracy and applicability of the model to real-world scenarios. The newsvendor framework indicates a superior theoretical foundation for controlling the uncertainties associated with agricultural supply chain. The successful implementation necessitates continuous refinement, collaboration among the stakeholders, and the policies based on dynamic market conditions and evolving climate risks.

The present study demonstrates the application of the classical single-period version of the newsvendor model. Future studies can extend this traditional framework into a dynamic, multi-period setting. Decisions in the real-world agricultural systems are frequently made over multiple growing seasons. Such decisions should taken by accounting the evolving nature of weather patterns, market demand, and input prices. A dynamic model will enable the decision-maker for sequential decision-making under this uncertain weather patterns and market demand. Optimal inventory or production decisions in one period will influence the outcomes in the following periods. Integration of factors like carry-over stock, crop rotation schedules, and adaptive price signals, a multi-period newsvendor formulation will demonstrate superior performance compared to the standard newsvendor model. The dynamic multi-period model reflects the complex, intertemporal risks faced by farmers. The model will also enable the decision makers for a more accurate modelling of perishability, storage costs, and delayed market responses. Decisions based on such framework will enhance the robustness and importance for long-term agricultural planning and resilience building. Multi-crop farming systems can be included in the future studies. In order to diversify risk and maximize returns, the farmers often cultivate a variety of crops. Adding the portfolio optimization approach and newsvendor model aids in determining the best way to distribute both resources and across a combination crops. This version of the newsvendor model will involve equating the shortage and overage costs for not just the individual crop but across the entire. This strategy incorporates interdependencies such as shared inputs, market correlations, and agronomic constraints. This adaptation improves the applicability of the model in mixed farming environments and support a more comprehensive decision-making under uncertain demand and yield.

Applicability of the newsvendor framework improves by the integration of the quantitative insights from stakeholders such as farmers, agronomists, and policymakers. Their viewpoint will enable the researchers in calibrating the model parameters. The assumptions regarding risk preferences, and trade-offs encountered in real-world agricultural supply chains. Engaging stakeholders through surveys or expert elicitation helps in aligning the model with actual field conditions and policy objectives, increasing its adoption and impact. Future research can also explore complex modelling approaches that account real-time climate data, and climate risk driven probabilistic demand forecasting. The applicability of our study confirms the requirement of proactive supply chain management strategies that balance economic, social, and environmental objectives. Such

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

model will foster resilient agricultural systems and ensure international food security in an increasingly uncertain world.

ACKNOWLEDGEMENTS

This research is supported by DST-INSPIRE Fellowship Grant, Department of Science and Technology, Govt. of India (Grant no.: 190728) awarded to the first author.

REFERENCES

[1]. IPCC (2021). Climate Change 2021: The Physical Science Basis. Intergovernmental Panel on Climate Change.

[2]. FAO (2020). Agricultural Commodity Markets and Trade: The Global Outlook. Food and Agriculture Organization.

[3]. Christopher, M., & Peck, H. (2004). Building the resilient supply chain. The International Journal of Logistics Management, 15(2), 1-14. https://doi.org/10.1108/09574090410700275

[4]. Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. Science, 333(6042), 616-620.

[5]. Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., and Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. science, 327(5967), 812-818.

[6]. Barrett, C. B. (2020). Overcoming global food security challenges through science and solidarity. American Journal of Agricultural Economics, 102(2), 283-295. *https://doi.org/10.1111/ajae.12160*

[7]. Ghosh, S., Sahare, M., & Mukhoti, S. (2021). A new generalized newsvendor model with random demand and cost misspecification. In Strategic Management, Decision Theory, and Decision Science: Contributions to Policy Issues (pp. 211-245). Singapore: Springer Singapore. *https://doi.org/10.1007/978-981-16-1368-5_14*

[8]. Ghosh, S., & Mukhoti, S. (2023). Non-parametric generalised newsvendor model. Annals of Operations Research, 321(1), 241-266. *https://doi.org/10.1007/s10479-022-05112-5*

[9]. Ahumada, O., & Villalobos, J. R. (2009). Application of planning models in the agrifood supply chain: A review. European Journal of Operational Research, 196(1), 1-20. *https://doi.org/10.1016/j.ejor.2008.02.014*

[10]. Chand, R. (2019). Transforming Indian agriculture for challenges of 21st century. Think India Journal, 22, 26.

[11]. FAO (2019). The State of Food Security and Nutrition in the World. Food and Agriculture Organization of the United Nations.

[12]. Badiane, O., & Makombe, T. (2015). Beyond a Middle-Income Africa: Transforming African Economies for Sustained Growth with Rising Employment and Incomes. International Food Policy Research Institute.

[13]. Gouel, C. (2012). Agricultural price instability: A survey of competing explanations and remedies. Journal of Economic Surveys, 26(1), 129–156.

[14]. Wright, B. D. (2011). The economics of grain price volatility. Applied Economic Perspectives and Policy, 33(1), 32-58. https://doi.org/10.1093/aepp/ppq033

[15]. Gilbert, C. L., & Morgan, C. W. (2010). Food price volatility. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 3023–3034. https://doi.org/10.1098/rstb.2010.0139

[16]. Timmer, C. P. (2010). Reflections on food crises past. Food Policy, 35(1), 1–11.

[17]. Deaton, A., & Laroque, G. (1992). On the behavior of commodity prices. The Review of Economic Studies, 59(1), 1-23. https://doi.org/10.2307/2297923

[18]. Bellemare, M. F. (2015). Rising food prices, food price volatility, and social unrest. American Journal of Agricultural Economics, 97(1), 1–21. https://doi.org/10.1093/ajae/aau038

[19]. Headey, D. (2011). Rethinking the global food crisis: The role of trade shocks. Food Policy, 36(2), 136–146. https://doi.org/10.1016/j.foodpol.2010.10.003

[20]. Abbott, P. C., Hurt, C., & Tyner, W. E. (2011). What's driving food prices in 2011? Farm Foundation Issue Report. http://doi.org/10.22004/ag.econ.37951

[21]. Barrett, C. B., & Bellemare, M. F. (2011). Why food price volatility doesn't matter. Foreign Affairs, 90(6), 103–111.

[22]. Anderson, K., & Nelgen, S. (2012). Agricultural trade distortions during the global financial crisis. Oxford Review of Economic Policy, 28(2), 235–260. https://www.jstor.org/stable/43741295

[23]. Gouel, C., & Jean, S. (2015). Optimal food price stabilization in a small open developing country. World Bank Economic Review, 29(1), 72–101. https://ssrn.com/abstract=1983104

[24]. Aker, J. C. (2010). Information from markets near and far: Mobile phones and agricultural markets in Niger. American Economic Journal: Applied Economics, 2(3), 46–59. https://www.jstor.org/stable/25760219

[25]. Headey, D., & Fan, S. (2010). Reflections on the global food crisis: How did it happen? How has it hurt? And how can we prevent the next one? Research Monograph, International Food Policy Research Institute.

[26]. Coble, K. H., Heifner, R. G., & Zuniga, M. (2000). Implications of crop yield and revenue insurance for producer hedging. Journal of Agricultural and Resource Economics, 25(2), 432-450. https://www.jstor.org/stable/40987069

ISSN: 2455-6939

Volume: 11, Issue: 02 "March-April 2025"

[27]. OECD (2009). Managing risk in agriculture: A holistic approach. Organisation for Economic Co-operation and Development.

[28]. Hardaker, J. B., Huirne, R. B., & Anderson, J. R. (2015). Coping with risk in agriculture. CABI.

[29]. Mahul, O., & Stutley, C. J. (2010). Government support to agricultural insurance: Challenges and options for developing countries. World Bank Publications.

[30]. Glauber, J. W. (2004). Crop insurance reconsidered. American Journal of Agricultural Economics, 86(5), 1179-1195.

[31]. Barnett, B. J., & Mahul, O. (2007). Weather index insurance for agriculture and rural areas in lower-income countries. American Journal of Agricultural Economics, 89(5), 1241–1247. *https://doi.org/10.1111/j.1467-8276.2007.01091.x*

[32]. Lipper, L., Thornton, P., Campbell, B. M. (2014). Climate-smart agriculture for food security. Nature Climate Change, 4(12), 1068–1072. *https://doi.org/10.1038/nclimate2437*

[33]. Newbery, D. M., & Stiglitz, J. E. (1981). The theory of commodity price stabilization: A study in the economics of risk. Oxford University Press.

[34]. Di Falco, S., & Chavas, J. P. (2009). On crop biodiversity, risk exposure, and food security in the highlands of Ethiopia. American Journal of Agricultural Economics, 91(3), 599–611. *https://doi.org/10.1111/j.1467-8276.2009.01265.x*

[35]. Basso, B., & Antle, J. (2020). Digital agriculture to design sustainable agricultural systems. Nature Sustainability, 3(4), 254–256.

[36]. Hansen, J. W., Marx, S. M., & Weber, E. U. (2011). The role of climate perceptions, expectations, and forecasts in farmer decision making: The Argentine Pampas case. Climatic Change, 104(3-4), 441–461. *https://doi.org/10.7916/D8N01DC6*

[37]. Tang, C. S., & Musa, S. N. (2011). Identifying risk issues and research advancements in supply chain risk management. International Journal of Production Economics, 133(1), 25-34. *https://doi.org/10.1016/j.ijpe.2010.06.013*

[38]. Arrow, K. J., Harris, T., & Marschak, J. (1951). Optimal inventory policy. Econometrica, 19(3), 250-272.

[39]. Chavas, J. P. (2008). On the economics of agricultural production. Australian Journal of Agricultural and Resource Economics, 52(4), 365–380. https://doi.org/10.1111/j.1467-8489.2008.00442.x

[40]. You, F., & Grossmann, I. E. (2008). Integrated multi-echelon supply chain design with inventories under uncertainty: MINLP models, computational strategies. AIChE Journal, 54(7), 1811–1832. https://doi.org/10.1002/aic.12010

[41]. Chopra, S., & Meindl, P. (2001). Strategy, planning, and operation. Supply Chain Management, 15(5), 71-85.

[42]. Cachon, G., & Terwiesch, C. (2019). Matching supply with demand: An introduction to operations management. McGraw-Hill.

[43]. Ben-Tal, A., Ghaoui, L. E., & Nemirovski, A. (2009). Robust optimization. Princeton University Press. Tripathi, A., Bharti, N., Sardar, S., & Malik, S. (2023). "Covid-19, disrupted vegetable supply chain and direct marketing: experiences from India." Journal of Agribusiness in Developing and Emerging Economies, 13(1), 1-15. *https://doi.org/10.1108/JADEE-04-2021-0095.*

[44]. Ledari, A. M., Pasandideh, S. H. R., & Koupaei, M. N. (2018). A new newsvendor policy model for dual-sourcing supply chains by considering disruption risk and special order. Journal of Intelligent Manufacturing, 29, 237-244. https://doi.org/10.1007/s10845-015-1104-y

[45]. Kawale, P. K., & Valilai, O. F. (2024, December). Barriers to Prosperity: Evaluating the Challenges of Agricultural Export from India to the European Union. In 2024 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM) (pp. 332-337). IEEE. https://doi.org/10.1109/IEEM62345.2024.10857135

[46]. Manikas, A. S., & Kroes, J. R. (2015). A newsvendor approach to compliance and production under cap and trade emissions regulation. International Journal of Production Economics, 159, 274-284. *https://doi.org/10.1016/j.ijpe.2014.09.010*

[47]. Cachon, G. P., & Lariviere, M. A. (2005). Supply chain coordination with revenue-sharing contracts: Strengths and limitations. Management Science, 51(1), 30-44. *https://doi.org/10.1287/mnsc.1040.0215*

[48]. Schweitzer, M. E., & Cachon, G. P. (2000). Decision bias in the newsvendor problem with a known demand distribution: Experimental evidence. Management Science, 46(3), 404-420. *https://doi.org/10.1287/mnsc.46.3.404.12070*

[49]. Fisher, M. L., Raman, A., & McClelland, A. S. (2000). Rocket science retailing is almost here: Are you ready? Harvard Business Review, 78(4), 115-124.

[50]. Zipkin, P. H. (2000). Foundations of Inventory Management. McGraw-Hill.

[51]. Udhayan, N., Naik, A. D., Naik, B. K., Kerur, N. M., & Dolli, S. S. (2023). Export of wheat from India: Destinations and competitiveness. *The Pharma Innovation Journal*, *12*(7), 2754-2758.

[52]. Pingali, P. (2012). Green revolution: Impacts, limits, and the path ahead. Proceedings of the National Academy of Sciences, 109(31), 12302-12308. https://doi.org/10.1073/pnas.0912953109

[53]. Laborde, D., Martin, W., & Vos, R. (2020). COVID-19 risks to global food security. Science, 369(6503), 500-502. https://doi.org/10.2499/p15738coll2.134229

[54]. Chen, X., & Simchi-Levi, D. (2012). Coordinating inventory control and pricing strategies with random demand and fixed ordering cost: The finite horizon case. Operations Research, 60(2), 566-580. *https://doi.org/10.1287/opre.1040.012*