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LIBERALISATION IN AGRICULTURAL TRADE: A STUDY OF FOOD SECURITY IN INDIA AFTER 2001

Thesis Submitted

in Partial Fulfillment of the Requirements for the

DEGREE OF DOCTOR OF PHILOSOPHY

in

ECONOMICS

by

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(Hariom Prakash Verma)

Dedication

I dedicate this research to the millions of people in India and around the world who endure the pain of hunger and malnutrition. This work is a humble tribute to their strength and a small step towards the vision of a future where no one goes to bed hungry. May it inspire efforts toward ensuring food security, equity, and dignity for all.

Candidate's Declaration

I, hereby, declare that the thesis entitled "**Liberalisation in Agricultural Trade:A Study of Food Security in India after 2001** " is my original work carried out under the supervision of Prof. Nand Kumar . This Thesis has been prepared in conformity with the rules and regulations of Delhi Technological University, New Delhi. The research- work presented and reported in the Thesis has not been submitted, either in part or full, to any other University or Institute for the award of any other Degree or diploma.

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Certificate

This is to certify that the thesis titled "**Liberalisation in Agricultural Trade:A study of Food security in India after 2001**" submitted by Mr. Hariom Prakash Verma to Delhi Technological University, for the award of the degree of Doctor of Philosophy in the Discipline of Economics, Department of Humanities is a record of Bona Fide work carried out by him. Hariom Prakash Verma has worked under my guidance and supervision, and has fulfilled the requirements for the submission of this Thesis, which, to my knowledge, has reached requisite standards.

The results contained in this thesis are original and have not been submitted to any other university or institute for the award of any Degree or Diploma.

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Liberalisation in Agricultural Trade: A Study of Food Security in India after 2001

Hariom Prakash Verma

ABSTRACT

This thesis, titled *"Liberalisation in Agricultural Trade: A Study of Food Security in India after 2001,"* examines the impacts of trade liberalisation on food security in India through three objectives: analyzing food price volatility, evaluating agricultural trade's impact on farm income, and assessing its effect on food availability. Food price volatility is studied using monthly indices (2013–2022) via ARCH and GARCH models. Volatility persists in cereals, oils, and pulses, contradicting the view that liberalisation stabilizes prices. The ARDL approach (1991–2021) reveals a long-run positive relationship between farm income (Agricultural GDP), exports, fertilizer use, and crop yield, with imports having no significant long-term effect. In the short run, imports and fertilizer use impact farm income. Dietary Energy Supply (DES) is used to assess food availability, showing strong long-term benefits from trade liberalisation, though short-term challenges persist. The study highlights the varied impacts of trade liberalisation on food prices, farm income, and food availability, emphasizing the need for nuanced agricultural policies to maximize benefits and address challenges.

Keywords: Trade Liberalisation, Food Security, Food Price Volatility, Agricultural Trade, Farm Income, India. **JEL Classification:** F14; Q17; Q18

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List of Acronyms

AGDP	Agricultural Gross Domestic Product
AEXP	Agricultural Export
AIMP	Agricultural Import
ARDL	Autoregressive Distributed Lag
ARCH	Autoregressive Conditional Heteroskedasticity
CPI	Consumer Price Index
DES	Dietary Energy Supply
ECM	Error Correction Model
EMP	Exchange Market Pressure
FAO	Food and Agriculture Organization
FTZ	Fertilizer Consumption
GDP	Gross Domestic Product
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
PDS	Public Distribution System
RO1	Research Objective 1 (Food Price Volatility)
RO2	Research Objective 2 (Farm Income)
RO3	Research Objective 3 (Food Availability)
SAP	Structural Adjustment Program
TVAR	Threshold Vector Autoregression
WTO	World Trade Organization

Chapter 1

Introduction

1.1 Agricultural Trade

Agricultural trade refers to the exchange of agricultural products and services between countries or regions. These products include raw materials like crops, livestock, and fisheries, as well as processed goods derived from these sources. Agricultural trade is a critical component of the global economy, influencing food security, rural development, and international relations. It allows countries to export surplus goods and import products they cannot efficiently produce domestically due to factors like climate or resource availability (Kirmani and MacDonald, 1982).

Key aspects of agricultural trade include:

- International Exchange: The cross-border movement of agricultural commodities, involving both raw and processed goods
- Trade Policies and Agreements: Agricultural trade shaped by international agreements, tariffs, subsidies, and regulations
- Commodity Markets: Agricultural products traded on global markets, with prices influenced by supply-demand dynamics and external factors

Agricultural trade plays a pivotal role in ensuring food availability across nations and contributes to economic growth by promoting efficient resource allocation.

Agricultural trade-related policies account for an estimated 70% of the global welfare cost of all merchandise trade distortions, even though the agricultural sector contributes only 6% of global trade and 3% of global income (Anderson and Nelgen, 2010).

1.1.1 Historical Context of Agricultural Trade Liberalization in India

India's journey toward agricultural trade liberalization represents a significant shift from the protective trade policies that characterized the post-independence era. Following independence in 1947, India adopted a highly regulated approach to agricultural trade, focusing on self-sufficiency and food security through the Green Revolution of the 1960s and 1970s. This period was marked by substantial government intervention, including input subsidies, minimum support prices, and strict controls on imports and exports.

The economic reforms of 1991 marked a watershed moment, initiating a gradual transition toward more liberal agricultural trade policies. Key reforms included the reduction of import duties on agricultural commodities, the removal of quantitative restrictions on most agricultural products by 2001, the simplification of export procedures, and the elimination of export controls, along with integration with global markets through WTO commitments. The post-2001 period has been particularly significant, characterized by increased participation in bilateral and regional trade agreements and the growth of agricultural exports, particularly in rice, cotton, and horticultural products. This period also saw the evolution of domestic support mechanisms to comply with WTO obligations and an enhanced focus on food security through targeted public distribution systems.

Notably, 2001 marked the launch of the Doha Development Agenda, which focused on the needs and interests of developing countries, particularly in agricultural trade. This agenda initiated significant agricultural negotiations aimed at reducing subsidies and improving market access for developing countries while addressing food security concerns. These developments reflect a broader transformation in India's approach to agricultural trade, shifting from protectionism toward greater integration with global markets. This historical transformation provides a vital context for understanding the complex relationships between trade liberalization and food security in contemporary India, especially in terms of price stability, farm income, and food availability.

1.2 The Gains from Trade: Theoretical Perspectives

The arguments favoring trade liberalization are highly compelling and often form the basis of policy recommendations made by international institutions to governments. These arguments are primarily rooted in Ricardian "conventional" or "neo-classical" trade theory, particularly the theory of comparative advantage, which is explained through general equilibrium models. These models analyze resource allocation across the entire economy under ideal conditions, such as perfect competition. The theory posits that differences in productivity and opportunity costs of production between countries are the fundamental reasons why trade benefits nations. Factors contributing to these differences include the role of climate in agriculture, the availability of vast arable land and abundant water resources, the presence of easily accessible natural resources like mineral deposits, and differing access to advanced production technologies, all of which impact labor productivity.

The theory further explains that labor costs, compared to capital costs, are lower in labor-abundant countries. Consequently, the price ratio of labor-intensive goods to capital-intensive goods is lower in these countries than in capital-rich nations, driving international trade. This concept forms the foundation of comparative advantage, where each country exports goods relying on its relatively abundant resources while importing goods requiring more of its scarce resources. For instance, a labor-abundant country effectively exports labor by trading labor-intensive goods for capital-intensive goods. However, since resources like labor and capital cannot move freely across borders, goods themselves must be traded instead. This framework, often called the factor proportions or factor endowment model, asserts that countries should produce goods that make intensive use of the resources they have in abundance.

As trade occurs, the prices of factors of production, such as labor and capital, tend to equalize across trading nations. This implies that real wages and other factor prices could converge over time. For labor-rich developing nations, this process could help reduce poverty by increasing the demand for labor, raising

wages, and improving workers' incomes. Proponents of free trade argue that, under perfect competition, trade maximizes global economic welfare by achieving a state where no country can improve its situation without making another worse off. In theory, those who benefit from trade could fully compensate those who lose and still come out ahead, as the overall gains from trade outweigh the losses.

Despite these theoretical strengths, there are several important caveats. First, the outcomes rely on the assumption of competitive markets, and without a level playing field, some countries may benefit more from trade restrictions. Second, the gains from trade are not evenly distributed, with relative gains depending on the terms of trade. Third, there are no guarantees that those who lose in the global market are compensated by the winners, making the theoretical gains hypothetical. Fourth, within countries, trade creates both winners and losers, leading to domestic redistribution challenges. Lastly, the model assumes that all external costs, including environmental externalities, are accounted for, which remains a subject of debate.

Empirical studies have tested the predictions of this conventional theory, particularly its factor proportion hypotheses, by analyzing the factor intensities of imports and exports. While these studies reveal that factor proportions alone cannot fully explain trade patterns, the theory provides a partial explanation, especially for trade flows between developing and industrialized nations. Various extensions to the model address its limitations by incorporating factors like externalities and imperfect competition.

Although conventional trade theory is based on simplified assumptions, it remains a robust analytical framework with clear, testable predictions. These theoretical principles underpin the trade liberalization policies advocated by international institutions, including the WTO Agreement on Agriculture. However, it is crucial to scrutinize the model's assumptions, such as perfect competition, the absence of economies of scale, and homogeneous products. Moreover, the model assumes that all second-best scenarios and externalities have been addressed, which is rarely the case.

An important question arises from this theoretical analysis: If free trade can enhance global economic welfare, why do governments frequently implement

border intervention policies? One prominent reason is the "infant industry" argument, where industries requiring economies of scale need temporary protection to compete with established foreign firms. This rationale is particularly relevant in developing countries, especially in manufacturing and primary processing industries, where transitioning from raw material exports to processed goods is a strategic goal. Political imperatives also play a role, including pressure from groups benefiting from protectionist measures and reliance on revenue from border policies in developing countries with weak tax bases. In addition, concerns about food security and rural sustainability are often cited as reasons for safeguarding domestic agriculture.

The political economy of trade policy reveals that the discrepancy between the theoretical benefits of free trade and the reality of protectionism arises from political and economic forces. These forces are especially significant in situations where the ideal conditions of perfect competition and frictionless exchange are not met, highlighting the complexities of translating trade theory into practical policy.

1.3 The Impact of Agricultural Trade on Developing Nations, with a Focus on India

Agricultural trade offers numerous benefits for developing nations like India, contributing significantly to economic growth, rural development, and food security. Agricultural exports have been identified as a key driver of economic growth in India. Studies show that agricultural exports positively impact India's GDP, making them critical for the country's economic strategy.

Agricultural trade helps improve rural livelihoods by providing farmers access to larger markets. Increased demand for agricultural products can lead to higher incomes for farmers and rural workers, contributing to poverty reduction. The ability to export surplus production can also stabilize domestic market prices, benefiting both producers and consumers.

Agricultural trade has shown resilience during global disruptions such as the COVID-19 pandemic. While other sectors faced severe challenges, India's agricultural sector continued to perform relatively well in terms of exports (Ashalatha,

2023).

1.3.1 Evolution of Agricultural Trade Policies in Developing Nations

The evolution of agricultural trade policies in developing nations has been marked by significant transitions from protectionist to more liberal approaches. These changes have been driven by:

Structural adjustment programs of the 1980s and 1990s played a pivotal role in reshaping trade and economic policies in many developing countries, emphasizing liberalization, privatization, and fiscal austerity. These reforms were complemented by efforts to integrate into global value chains, enabling countries to participate in international trade by focusing on specialized production stages. Regional trade agreements and economic partnerships further facilitated trade integration by reducing tariff and non-tariff barriers, fostering closer economic ties among neighboring countries. Additionally, the adoption of advanced technologies and agricultural modernization significantly enhanced productivity and competitiveness, enabling economies to capitalize on the benefits of global trade.

Developing nations have faced unique challenges in balancing domestic food security with trade liberalization objectives, particularly in: Managing price volatility and market risks is a critical aspect of ensuring stable agricultural markets, particularly in the face of global trade fluctuations. At the same time, protecting smallholder farmers while promoting efficiency remains a delicate balance, as policies must safeguard vulnerable producers without compromising the overall competitiveness of the agricultural sector. Developing robust agricultural infrastructure is essential to support productivity, reduce post-harvest losses, and facilitate market access. Furthermore, ensuring equitable distribution of trade benefits is vital to address disparities and ensure that the gains from trade reach all segments of the population, especially marginalized and rural communities.

1.3.2 Contemporary Challenges in Trade Liberalization

Modern agricultural trade liberalization faces several emerging challenges: Climate change impacts on agricultural productivity and trade patterns have become a

significant concern, as shifting weather conditions and extreme events disrupt traditional farming practices and global supply chains. Rising concerns about food sovereignty and local food systems further emphasize the need to prioritize self-reliance and community-based agricultural strategies to reduce dependence on global markets. Additionally, there is an increasing focus on sustainable and environmentally friendly practices to ensure long-term agricultural viability while minimizing ecological harm and addressing the challenges posed by climate change.

These challenges necessitate innovative policy responses that: Integrating environmental sustainability with trade objectives has become essential to ensure that agricultural trade supports ecological preservation while meeting global demands. Leveraging digital technologies for market efficiency is another critical focus, as innovations such as blockchain, precision agriculture, and e-commerce platforms enhance transparency, reduce transaction costs, and improve market access. Addressing emerging food safety and quality standards is crucial to meet the expectations of increasingly health-conscious consumers and to facilitate smoother international trade. Furthermore, promoting inclusive growth in agricultural trade is necessary to ensure that smallholder farmers, rural communities, and marginalized groups benefit equitably from global trade opportunities.

1.3.3 Emerging Dimensions of Food Security

Contemporary understanding of food security has expanded to encompass: Nutritional security and dietary diversity are critical components of a robust food system, ensuring that populations have access to a variety of foods that meet their nutritional needs. Environmental sustainability of food systems is equally important, as it ensures that agricultural practices preserve natural resources and reduce ecological impacts for future generations. Cultural appropriateness of food further highlights the importance of aligning food availability with the preferences and traditions of diverse communities, fostering acceptance and utilization. Additionally, resilience to climate and market shocks is essential to safeguard food systems against disruptions caused by environmental changes or economic volatility, ensuring stable access to food for all.

These dimensions reflect growing recognition that food security involves: In-

tegration of traditional and modern food systems is essential to leverage the strengths of both approaches, preserving cultural heritage while benefiting from technological advancements. Attention to micronutrient availability is critical for addressing hidden hunger and ensuring that diets provide the necessary vitamins and minerals for optimal health. Consideration of cultural food preferences plays a vital role in designing food systems that are accepted and utilized by diverse populations, respecting their traditions and practices. A focus on long-term sustainability ensures that food systems remain resilient and capable of meeting future demands without depleting natural resources or harming the environment.

1.3.4 Global Food Security Initiatives and Trade

Recent global initiatives addressing food security through trade include: The World Food Programme's market access initiatives aim to enhance smallholder farmers' connectivity to markets, enabling them to sell their produce more efficiently and improve their livelihoods. The FAO's trade and food security framework provides a comprehensive approach to aligning trade policies with global food security objectives, ensuring that trade facilitates rather than hinders access to food. Regional food security cooperation mechanisms play a crucial role in fostering collaboration among neighboring countries to address shared challenges and promote stability in food supply chains. Public-private partnerships in agricultural trade further contribute by combining resources and expertise from both sectors to drive innovation, improve infrastructure, and ensure the equitable distribution of trade benefits.

These initiatives emphasize: Market-based approaches to food security focus on leveraging market mechanisms to enhance access, availability, and affordability of food, fostering efficiency and sustainability in food systems. Capacity building in agricultural trade is essential for equipping farmers, traders, and policymakers with the skills and knowledge needed to navigate global markets and optimize trade benefits. Risk management in food supply chains is crucial to mitigate disruptions caused by climate change, economic volatility, or geopolitical tensions, ensuring stable and reliable access to food. International cooperation in food crisis response plays a pivotal role in addressing global food emergencies, promoting coordinated

efforts to deliver timely aid and build long-term resilience in vulnerable regions.

1.3.5 Research Significance in Contemporary Context

The significance of this research is amplified by current global developments:

Growing concerns about global food security have brought attention to the pressing need for strategies that ensure stable and equitable access to food for all populations. The increasing frequency of climate-related agricultural disruptions, such as droughts, floods, and unpredictable weather patterns, has further underscored the vulnerability of food systems to environmental changes. Rising importance is being placed on sustainable agricultural practices to balance the demands of food production with the preservation of natural resources and ecosystems. At the same time, emerging challenges in international trade coordination highlight the complexities of aligning diverse national policies with global trade frameworks to ensure the smooth flow of food across borders.

The study's findings contribute to:

Evidence-based policy formulation is critical for designing effective interventions that address the complex challenges of food security and trade. A comprehensive understanding of trade-food security linkages is essential to identify how trade policies impact food availability, access, and utilization, ensuring that trade contributes positively to global food security. The development of resilient agricultural systems plays a pivotal role in safeguarding food production against environmental, economic, and social shocks, while simultaneously enhancing sustainability. Additionally, the enhancement of food security frameworks is necessary to integrate diverse dimensions of food security, including nutrition, equity, and sustainability, into cohesive and actionable strategies.

1.4 Trade Liberalization

Trade liberalization refers to the removal of tariff and non-tariff barriers in international trade, having significant macroeconomic and distributional effects. It is a process of becoming open to international trade through the systematic reduction and eventual elimination of tariffs and other barriers between trading

partners. Measures of trade liberalization include reducing or eliminating tariffs, quotas, import and export licensing requirements, foreign exchange controls, export subsidies, and taxes. The Heckscher-Ohlin Trade Theorem provides the basic theoretical foundation for trade liberalization, further supported by the Stolper-Samuelson Theorem, Factor Price Equalization Theorem, and Rybczynski Theorem. These theories collectively explain the presumed favorable effects of trade liberalization on economic growth, primarily through efficiency gains in resource allocation as nations produce and trade based on comparative advantage.

However, whether trade liberalization promotes economic growth and improves overall societal welfare remains a controversial issue, particularly regarding its effects on food security (Mesfin, 2014). The Doha Round of trade negotiations in the World Trade Organization (WTO), labeled the "development round," underscores this debate. A critical component involves increasing developing countries' access to developed-country markets by reducing tariffs on agricultural commodities. Many developing countries are still major agricultural exporters, and agriculture accounts for a large share of GDP in the poorest nations. Nevertheless, two interrelated issues complicate the potential benefits for developing countries. First, the vertically linked nature of the food chain among agriculture, food processing, and retailing means that the increasing consolidation of the food industry in developed countries can influence the magnitude of the benefits derived from market access. Second, the raw agricultural component typically represents a small share of the total value of products reaching consumers. This has led many developing countries and international institutions to advocate for diversification through processing and adding value to raw agricultural commodities (Sexton, 2005).

The rationale for trade liberalization derives from "conventional" theory, emphasizing its presumed positive effect on economic growth through induced efficiency gains in resource allocation. However, its outcomes, particularly on food security and overall societal welfare, remain contested.

1.4.1 The Impact of Trade Liberalization in Developing Countries

As discussed earlier, the claim that trade openness promotes economic growth, which can subsequently aid in reducing poverty and improving food security, is well-established in conventional economic theory and supported by various empirical studies. However, some critics warn that when analyzing the link between increased trade and economic growth, researchers must be cautious about drawing conclusions regarding causality.

The potential benefits of trade liberalization are not assured and may not result in improved food security for all segments of society. Specifically, there are likely to be notable differences in how trade liberalization affects small-scale and commercial farmers, rural non-farm producers, and urban consumers, both within and between countries. These distinctions must be taken into account when assessing the food security impacts of trade liberalization.

The perceived failure to spur development in many rural economies after implementing economic and trade policy reforms has sparked a broad debate. This discussion has recently expanded to include not only the effects of domestic structural adjustment programs but also the influence of global forces, such as the global trade reform agenda. A recent World Bank report examines whether globalization aids in poverty reduction and finds that while some "new globalizers" benefit from increased integration into the global economy, a large group is becoming more marginalized. One possible explanation for this disparity is the varying degrees of trade openness. For instance, Diaz-Bonilla and Reca observe a positive link between trade openness and economic growth. Sachs and Warner argue that openness partially explains the differing export performances of Asia, Africa, and Latin American Countries (LAC) in processed and high-value agricultural goods. However, they also highlight that other factors, such as population trends, climate conditions, levels of technical development, and domestic policies, play a role in these diverse outcomes.

Rodrik aligns with this view, arguing that "there is no strong evidence that trade liberalization consistently leads to economic growth." He suggests that studies claiming such evidence are "wrongly attributing broader macroeconomic

outcomes to trade policy." Rodrik finds that the only clear pattern is that countries tend to lower trade barriers as they become wealthier, and concludes that initial economic growth often occurred when trade was still protected.

SAPRIN offers a similar perspective, stating that liberalization has led to import growth outpacing export growth. This increased import exposure has been linked to a decline in domestic production capacity and a decrease in consumer purchasing power. The authors also argue that without domestic market reforms, countries may lose their competitive edge during trade reform, as production costs rise compared to those in countries that have successfully implemented such reforms. These effects can be seen in trade patterns.

While theory suggests that trade liberalization should yield overall benefits for the liberalizing country, and although many empirical studies support this view, it is evident from the discussion that such benefits are not guaranteed. Even when gains are realized, certain groups within some countries may still face disadvantages. Winters argues that although trade liberalization promotes economic growth, it " may have negative effects for some – including some poor individuals – which should be mitigated as much as possible". He contends that rather than resisting reform, efforts should be directed toward finding complementary policies to reduce these negative impacts.

Given the lack of consensus on whether liberalization consistently leads to economic growth, it is crucial to identify which reforms have had the most significant impact on growth in each country.

1.4.2 Issues with Trade Liberalization

Despite its theoretical benefits, trade liberalization poses several challenges. These include income inequality impacts, increased vulnerability to external shocks, job losses in non-competitive sectors, and difficulties faced by micro, small, and medium enterprises (MSMEs) in competing with larger global players. Moreover, while tariff reductions are a cornerstone of trade liberalization, non-tariff barriers often persist, undermining the full potential of open markets.

1.4.3 Agricultural Market Integration and Price Transmission

The integration of agricultural markets following trade liberalization has significant implications for spatial market integration, price transmission mechanisms, market efficiency, and the role of infrastructure in connectivity. Enhanced integration can lead to better price alignment between international and domestic markets and improved information dissemination, particularly through advancements in information technology. However, challenges persist, including information asymmetries among market participants, infrastructure bottlenecks in developing countries, regional disparities in market access, and the need for effective policy coordination across jurisdictions.

These dynamics illustrate the complexities of trade liberalization, especially in the agricultural sector, where benefits and challenges often intersect with broader development goals.

1.5 Food Security: Evolution and Definition

The concept of food security has evolved significantly since the 1974 World Food Conference. (Smith and Maxwell, 1993) observed that nearly 200 definitions of food security existed by the early 1990s. Food security has grown from a simple concept focused solely on food supply to a complex framework encompassing the dimensions of availability, access, utilization, and stability. This evolution can be likened to a genetic pool, diversifying to capture various aspects of food-related challenges faced by vulnerable populations.

The World Food Summit (1996) defines food security as existing "when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." This definition was further refined during the 2009 World Summit on Food Security, adding a fourth dimension, stability, which reflects the ability of food systems to withstand short-term shocks, whether natural or man-made (FAO, 2009).

The evolution of food security thinking has undergone three notable paradigm

shifts. Initially, it was viewed through the lens of food supply, focusing on global and national levels to ensure adequate production and stockpiles. However, as access disparities became more apparent, the focus shifted toward individual and household food access. Sen's *Poverty and Famines* emphasized that food insecurity often stems from a lack of access rather than insufficient supply (Sen, 1981). This shift highlighted the importance of addressing barriers to obtaining food, such as purchasing power, rather than solely increasing food production.

The second paradigm shift moved from a food-first approach to a broader livelihood-centered view. Observations, such as during the 1984-85 African famine, revealed that preserving assets and long-term livelihoods often took precedence over immediate food intake. This recognition underscored the importance of sustainable food security policies that support resilience and stability over time (Maxwell, 1996).

The third shift was from objective measures of food security to subjective perceptions, emphasizing cultural appropriateness, dignity, and autonomy in food access. This perspective stresses the need to incorporate local community perceptions and adaptive strategies into food security assessments, ensuring policies align with the lived realities of those facing food insecurity (Pinstrup-Andersen, 2009b).

In modern discourse, food security encompasses three primary components: availability, access, and utilization, with an additional focus on risk. Availability addresses food production and stockpiles but is insufficient without ensuring physical and economic access. Access highlights barriers such as economic constraints, while utilization ensures that food's nutritional value contributes to health and well-being. Finally, risk incorporates the resilience of food systems in the face of challenges like climate change, economic shocks, and conflicts (Webb and Bilinsky, 2006).

Recent developments in food security measurement, such as the U.S. Household Food Security Survey Measure (HFSSM), have further refined assessments. These tools provide more accurate insights into household behaviors and experiences, enabling better-targeted interventions to address barriers and build resilience. The integration of availability, access, utilization, and stability into food security

frameworks reflects a comprehensive approach to addressing the multifaceted nature of food insecurity.

Food security is a dynamic concept that continues to adapt to the changing needs of populations and the evolving global landscape. Understanding and addressing these dimensions are essential to crafting effective and sustainable policies that reduce vulnerability and promote resilience.

The concept of food security has evolved significantly since the 1974 World Food Conference. Smith and Maxwell (1993) note nearly 200 definitions exist. Food security has grown from a simple concept focused on food supply to a complex framework encompassing availability, access, utilization and stability.

While some argue this complexity diminishes the concept's utility, the multiple interpretations reflect diverse food-related challenges faced by vulnerable populations. This diversity helps understand food security through various lenses.

The World Food Summit (1996) defines food security as existing "when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

1.6 Four Pillars of Food Security

Ensuring sustainable food security is a pressing challenge that requires a multifaceted approach to meet the needs of a growing global population. Sustainable food security is not merely about producing more food but ensuring all people have consistent access to sufficient, safe, and nutritious food that supports an active and healthy life. To achieve this, experts have identified four essential pillars of sustainable food security: food availability, access, utilization, and stability. Each pillar relies on a network of factors and interconnections, and all must be addressed simultaneously to achieve the ultimate goal of sustainable global food security.

1.6.1 Food Availability: The Foundation of Food Security

Food availability is the cornerstone of food security, ensuring that enough food is produced and accessible to meet the nutritional needs of a population. While food availability may seem straightforward, it is influenced by complex variables such as population growth, climate change, biofuel production, and urbanization. Population growth significantly drives food insecurity, as expanding populations intensify the need for sustainable increases in food production, which often strains agricultural resources and production capacities, particularly in developing regions with limited infrastructure and technology. Climate change is one of the most critical factors affecting food availability, as it disrupts agricultural production through changes in temperature, precipitation patterns, and increased frequency of extreme weather events such as droughts and floods. Beyond reducing crop yields, climate change degrades soil quality and water resources, essential components for successful food production. Urbanization also affects food availability by increasing the demand for land for housing and infrastructure, often at the expense of farmland. Urban sprawl degrades agricultural land, increases pollution, and reduces access to locally grown food, thereby increasing reliance on imports that may not always be reliable or affordable. Additionally, the diversion of crops such as corn, soybeans, and sugarcane for biofuel production has raised concerns about competition for land and water resources. This competition often reduces food supplies and drives up prices, affecting both the availability and affordability of food for consumers. Addressing food availability requires sustainable land and water management, technological innovations, and policies that balance food production with environmental conservation.

1.6.2 Food Access: The Economic and Social Dimension

Food access, the second pillar of food security, emphasizes that even if food is available, it does not guarantee that everyone can obtain it. Food access is influenced by economic conditions, social factors, and policies that promote equitable distribution. Income levels play a central role, as higher-income households can afford diverse and nutritious foods, while low-income households often struggle to

meet basic dietary needs. Income disparity is a significant barrier, particularly for rural populations lacking employment opportunities or fair wages. Global food prices also affect access, as price volatility, caused by supply chain disruptions, climate events, or market speculations, creates challenges for households in managing food expenses. When staple food prices rise unexpectedly, vulnerable populations often suffer reduced access to adequate nutrition. Political conflict further exacerbates food insecurity by disrupting food production, supply chains, and market access, while displacing communities and straining humanitarian aid systems. Food aid, though necessary in emergencies, faces challenges such as high administrative costs, inefficiencies in procurement, and poor targeting. Effective food aid programs must be responsive to local needs, ensuring that they support sustainable local food systems rather than fostering dependency. Additionally, demographics such as gender and age influence food access within households. Women and girls in some societies have less access to nutritious food compared to men and boys, and specific food needs of elderly individuals and children may not always be prioritized. Ensuring food access requires comprehensive strategies to improve household incomes, stabilize food prices, and implement inclusive policies addressing the unique needs of all demographic groups.

1.6.3 Food Utilization: The Quality and Safety of Food

Food utilization focuses on whether individuals can derive nutritional benefits from the food they consume, highlighting the significance of food quality and safety. A diverse diet is essential for providing the necessary nutrients for a healthy life, yet many low-income households rely on a limited range of staple foods, often lacking critical micronutrients. This lack of dietary diversity can lead to malnutrition, which has long-term effects on health and productivity. Beyond the presence of nutrients in food, nutrient bioavailability—whether the body can absorb and utilize these nutrients—plays a crucial role. Bioavailability can be affected by inhibitors in certain foods, infections, and overall health status, making it especially important for vulnerable populations such as children, pregnant women, and individuals with compromised health. Health conditions, such as HIV/AIDS, can impair nutrient absorption, resulting in deficiencies.

Similarly, parasitic infections can reduce nutrient absorption, undermining the effective utilization of available food. Paradoxically, food insecurity can correlate with obesity, particularly in high-income countries, where individuals may rely on cheaper, calorie-dense but nutrient-poor foods. This results in excessive calorie consumption but insufficient nutrient intake, contributing to poor health outcomes. Advances in genetic engineering, such as biofortified crops like Vitamin A-enriched rice, offer potential solutions to address nutrient deficiencies. However, concerns surrounding environmental impacts, ethical issues, and long-term health effects remain. Improving food utilization requires public health interventions, education on nutrition, and innovations that enhance the nutrient content of staple foods.

1.6.4 Food Stability: Ensuring Long-Term Access to Food

The final pillar, food stability, underscores the importance of ensuring consistent access to food over time. Stability integrates the elements of availability, access, and utilization, requiring resilience to shocks and long-term planning. Stability in global markets is essential for maintaining steady food prices and supply, particularly for countries heavily reliant on food imports, which are vulnerable to price fluctuations. Policies that promote stable and fair international trade, coupled with adequate food reserves, can help mitigate market-driven food insecurity. Agricultural biodiversity plays a critical role in ensuring stability by supporting ecosystem services essential for agriculture, such as pollination and pest control. Biodiversity also enables crop diversity, reducing dependence on a few staple crops and enhancing resilience to shocks. Ecological intensification, which emphasizes sustainable agricultural practices like integrated pest management and reduced tillage, supports productivity while conserving environmental resources. Stable economic policies promoting public goods such as rural infrastructure, education, and healthcare contribute to long-term food security by reducing poverty and increasing access to resources. Cultural practices and education also shape food security outcomes by influencing dietary habits, agricultural practices, and community responses to food insecurity. Education empowers individuals with the knowledge to manage nutrition, agriculture, and resources effectively, building resilience to food insecurity. Stability, therefore, requires a cohesive integration of

policies, resilience-building measures, and long-term planning to sustain global food security.

1.7 Food Indicators

Key indicators include:

Status Quo gap refers to the difference between projected food supplies and base period consumption levels, providing a measure of how current trends compare to past benchmarks. The Nutrition gap, on the other hand, measures the difference between projected food supplies and the minimum nutritional requirements necessary for maintaining health, highlighting areas where food availability may fall short of essential needs. Another important indicator is the ratio of food import requirements to agricultural export earnings, which evaluates the balance between a country's ability to generate income through exports and its dependence on food imports. Similarly, the ratio of cereal import requirements to total merchandise trade offers insights into the extent to which a country's trade portfolio is influenced by its reliance on cereal imports, reflecting the broader dynamics of trade and food security.

1.8 The Relation Between Trade Reform and Food Security

Trade reform and food security are closely interconnected, particularly for developing countries, forming the basis of critical discussions in the Doha Round of international trade negotiations. This connection operates on a global dimension, where trade policies impact both international food supply and national food availability. National food availability is influenced by a combination of imports and domestic production, while food imports are further affected by trade policies' impact on foreign exchange earnings. Trade policy also influences food security through its effects on income and spending patterns, as changes in trade regulations directly impact rural and urban incomes, employment, and income distribution. Furthermore, government revenues, particularly from import duties,

are affected, which in turn influences national food availability and households' access to food through their income levels.

1.8.1 Food Security and Trade Liberalization

Trade liberalization alters the relative prices of traded and non-traded goods within a previously protected economy. These price changes encourage a reallocation of resources among various activities, leading to adjustments in both subsectoral and overall production levels. As resources are utilized more efficiently, aggregate income levels are expected to rise, which can contribute to poverty reduction and enhance food security by improving food access for the poor. However, in the short term, agricultural sectors in developing countries may face challenges in capitalizing on the opportunities presented by trade liberalization. This is often due to rigid production structures, limited market access, underdeveloped institutions, and inadequate capacity to respond to new incentives. Food-importing countries may also experience higher import costs in the short run, potentially worsening food security during the transition period.

Strategies to enhance food security often focus on two approaches: food self-sufficiency and food self-reliance. Food self-sufficiency aims to produce a level of food supply from national resources that exceeds what would occur under free trade. While this strategy seeks to ensure that domestic production meets a significant portion of consumption needs, it does not guarantee equitable access to food across all households. In contrast, food self-reliance relies on international trade patterns and their associated benefits and risks. This approach suggests that reallocating resources towards non-food export crops while importing staple foods can improve food security and achieve efficiency gains. The effectiveness of these strategies depends on several factors, including producers' responsiveness to price signals and countries' capacity to use income gains to procure food from international markets.

1.8.2 Public Stockholding for Food Security

India has long argued that rigid World Trade Organization (WTO) rules restrict its ability to procure food grains from farmers at guaranteed prices and maintain

stockpiles for distribution to its citizens. The G33, a coalition of developing countries, has also advocated for easing WTO constraints to allow stockpiling for food security purposes. These concerns gained prominence after the 2007-08 global food price spikes, which heightened awareness of food security vulnerabilities. During the 2013 Bali WTO negotiations, India secured a peace clause preventing other WTO members from challenging stockholding practices for food security. However, India continued to push for a permanent solution, arguing that temporary measures were insufficient to address long-term food security needs. Economists have questioned whether price support policies effectively address food insecurity, noting that such measures often raise prices for consumers and may not significantly benefit small-scale farmers. More direct interventions, such as targeted food subsidies or income support, have been proposed as more efficient alternatives for addressing food access issues without distorting market prices.

1.9 Food Security at the National and Household Levels

Food security is a multi-faceted concept that encompasses concerns ranging from global food supply to individual nutrition and well-being. At the national level, food security discussions focus on the availability of adequate food supplies to meet the population's nutritional needs, while household food security emphasizes equitable access to sufficient and nutritious food for all household members.

1.9.1 Food Security at the National Level

Global food insecurity remains a significant challenge despite advancements in food availability. Between 1960 and 1996, food availability for direct human consumption grew by 19 percent to 2,720 kcal per day, exceeding the estimated minimum daily requirement of 2,200 kcal per day. However, this growth has been uneven. For example, in sub-Saharan Africa, average caloric intake increased marginally from 2,050 kcal per day to 2,150 kcal per day over three decades, while South Asia experienced a more significant rise from 2,000 kcal per day to 2,350 kcal per day in the same period. Additionally, per capita world agricultural

production slowed during the 1990s, with world cereal output declining from 342 kg per person in the mid-1980s to 311 kg per person in 1993-95, before rising to 323 kg per person in 1996-98. Despite these fluctuations, the Food and Agriculture Organization (FAO) estimated that 820 million people were undernourished in 1995-97, with 790 million residing in developing countries.

The Committee on World Food Security recognizes food security as a tripartite concept, encompassing availability, access, and stability. Efforts to measure food security include indicators such as the "Status Quo" gap, reflecting the shortfall between food supplies and baseline consumption, and the "Nutrition" gap, representing the deficit relative to minimum nutritional standards. These indicators highlight the challenges of bridging the gap between production, imports, and the nutritional needs of vulnerable populations. Financial constraints, such as limited foreign exchange reserves, often restrict countries' ability to address food import requirements, particularly in regions like sub-Saharan Africa.

1.9.2 Household Food Security

Household food security is influenced by various factors, including income levels, resource endowment, and vulnerability to economic or social shocks. Vulnerable households often include those with limited income-generating opportunities, inadequate resource bases, or heightened susceptibility to sudden price increases for staple foods. The concept of household entitlement, as proposed by Amartya Sen, emphasizes the ability of households to secure food through production, labor, trade, or transfers. Entitlement encompasses both access to food and the ability to utilize available resources effectively. However, achieving household food security also requires addressing intra-household distribution and ensuring equitable access to food for all members, as disparities in allocation can lead to varied nutritional outcomes.

Efforts to improve household food security include promoting income-generating activities, enhancing access to productive resources, and investing in infrastructure to support food storage and marketing. Policies aimed at diversifying income sources and strengthening resilience to shocks are critical for ensuring sustainable food security at the household level. Additionally, targeted interventions, such as

food transfers or subsidies, play a vital role in augmenting household entitlements, particularly for vulnerable populations.

1.9.3 Role of International Organizations in Agricultural Trade

International organizations play crucial roles in shaping agricultural trade:

The World Trade Organization (WTO) provides a framework for international trade rules, ensuring that trade policies are transparent, predictable, and fair across member countries. The Food and Agriculture Organization (FAO) offers technical assistance and policy guidance to support countries in aligning their agricultural trade strategies with food security goals. The World Bank plays a crucial role in infrastructure development and capacity building, enabling countries to enhance their trade potential and integrate into global markets. Regional development banks complement these efforts by providing financial support for trade facilitation projects, particularly in developing regions, to improve market access and promote sustainable economic growth.

Their contributions include: The development of trade standards and protocols is essential to ensure consistency, fairness, and transparency in international trade, facilitating smoother transactions across borders. Capacity building in developing nations plays a pivotal role in equipping these countries with the tools and expertise needed to engage effectively in global trade. Research and policy analysis provide critical insights into the dynamics of trade and its impacts, enabling evidence-based decision-making to address emerging challenges. Additionally, dispute resolution mechanisms are vital for maintaining trust and cooperation among trading partners, offering structured processes to resolve conflicts and uphold trade agreements.

1.10 The Interrelation Between Agricultural Trade Liberalization and Food Security

Trade reform and food security are closely linked, particularly for developing countries. This connection operates through:

Global food supply impacts are a critical aspect of understanding how trade policies influence the availability and distribution of food on an international scale. At the national level, food availability is affected by both imports and domestic production, with trade policies playing a significant role in shaping these dynamics. Changes in income and spending patterns, driven by trade regulations, directly impact household access to food, influencing both rural and urban populations. Additionally, government revenue effects, such as those stemming from changes in import duties, further shape national food security policies by affecting the resources available for public investment in food systems and social support programs.

Trade liberalization influences relative prices of traded goods, leading to resource reallocation and production changes. While potentially increasing aggregate income, short-term challenges exist for developing countries' agricultural sectors due to rigid production structures and institutional limitations.

Countries pursue two main approaches to food security: Food self-sufficiency refers to the strategy of producing a level of food supply from national resources that exceeds what would typically be expected under free trade conditions. This approach aims to ensure that domestic production meets a significant portion of consumption needs, reducing dependency on external markets. In contrast, food self-reliance focuses on leveraging international trade patterns to achieve food security, emphasizing the benefits of participating in global markets to import staple foods while reallocating resources toward the production of non-food export crops. Both strategies offer distinct pathways to addressing food security, depending on a country's economic and agricultural priorities.

1.11 Motivation and Background

The study of trade liberalization's impact on food security in India is motivated by several critical factors. Existing models often impose structural restrictions and assumptions that may not reflect India's economic reality. There is also a notable gap in literature regarding continuous analysis of these relationships in the Indian context beyond 2008. Additionally, the increasing integration of India's agricultural markets with global trade necessitates understanding how liberalization affects food security outcomes.

The dramatic changes in India's agricultural trade policies and food security challenges since economic reforms began make it an important case study. Understanding these relationships has become more crucial given rising food price volatility and concerns about food security among vulnerable populations (Kumar, 2023).

1.12 Challenges

This research faces several key challenges:

Data limitations and consistency issues across different time periods pose significant challenges in analyzing the relationship between trade policies and food security. The complex interactions between trade policies, agricultural markets, and food security outcomes further complicate the analysis, as these elements are influenced by a wide array of interdependent factors. Isolating the effects of trade liberalization from other policy changes adds another layer of difficulty, as overlapping reforms and external factors often obscure causal relationships. Measurement challenges in quantifying food security at different levels, from households to national scales, make it harder to draw definitive conclusions. Additionally, accounting for India's diverse agro-climatic zones and farming systems is crucial, as these regional variations significantly influence how trade policies impact agricultural productivity and food security outcomes.

1.13 Problem Statement

This study addresses the following research questions:

1. How has agricultural trade liberalization affected food price volatility in India?

2. What is the relationship between agricultural trade and farm income in India?

3. How does agricultural trade influence food availability across different regions?

4. What policy measures can enhance positive impacts while mitigating negative effects?

The research aims to provide empirical evidence on these relationships while developing policy recommendations for improving food security outcomes in the context of trade liberalization. This research makes several important contributions:

This study provides a comprehensive empirical analysis of the impact of trade liberalization on food security in India, offering valuable insights into the complex dynamics at play. It develops new methodological approaches for analyzing trade-food security relationships, addressing existing gaps in the literature and improving the precision of such analyses. The research offers evidence-based policy recommendations for managing the linkages between trade and food security, ensuring that trade policies are aligned with the goal of enhancing food availability, access, and utilization. Additionally, it contributes to the theoretical understanding of how trade policies affect food security outcomes, advancing the broader discourse on the interplay between global trade and agricultural development.

The findings will benefit: This research is particularly relevant for policymakers involved in designing trade and food security policies, as it provides insights to align trade strategies with food security objectives. It is also valuable for researchers studying agricultural trade and development, offering a robust framework for analyzing the interplay between trade policies and food systems. International

organizations working on food security can benefit from the findings to inform global initiatives and regional interventions. Additionally, agricultural sector stakeholders, including farmers and traders, can use the insights to adapt to trade changes and enhance their participation in evolving markets.

This research addresses critical gaps in understanding how trade policies affect food security, particularly in developing country contexts. The findings have important implications for policy design and implementation aimed at enhancing food security while pursuing trade liberalization.

1.14 Organisation of the Study

This thesis is organized into five chapters that systematically examine the relationship between agricultural trade liberalization and food security in India:

The structure of this study is organized into five chapters. **Chapter 1: Introduction** introduces the context of agricultural trade, providing theoretical perspectives on the gains from trade, its impacts on developing nations with a particular focus on India, aspects of trade liberalization, and the concept of food security. It also outlines the motivation for the study, the challenges addressed, the problem statement, and the significance of the research. **Chapter 2: Literature Review** examines key themes including agricultural trade liberalization, the concept of food security, the impact of trade liberalization on agricultural trade and food security, the relationship between agricultural trade and farm income, and the influence of trade liberalization on food availability. It also identifies research gaps and defines the objectives of the study. **Chapter 3: Methodology** describes the conceptual framework and provides details about data sources and variables. It outlines the analytical methods employed, including ARCH/GARCH models for analyzing price volatility, the ARDL framework for examining farm income, and techniques for assessing food availability. The chapter also discusses the empirical strategy and highlights the limitations of the study. **Chapter 4: Result and Findings** presents the results, focusing on food price volatility during liberalization, the impact of agricultural trade on farm income, the relationship between agricultural trade and food availability, and synthesizes findings across the defined objectives. Finally, **Chapter 5: Conclusion, Policy Prescriptions**

and Future Research synthesizes the key findings of the research, provides policy recommendations for stabilizing food prices and enhancing food security, discusses the limitations of the study, and suggests directions for future research.

The thesis includes comprehensive references and appendices containing detailed statistical outputs, methodological notes, and supplementary data supporting the analysis.

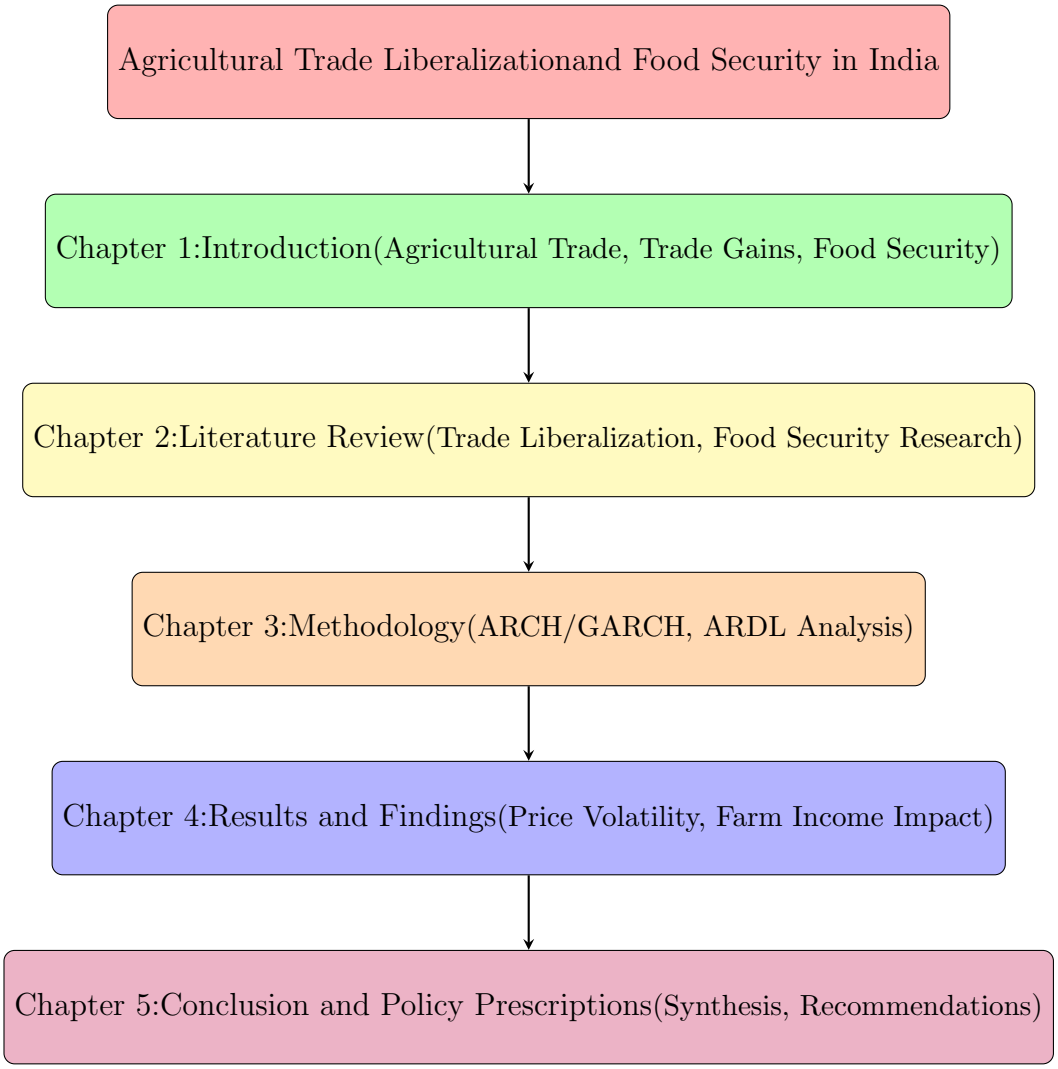

Figure 1.1: Thesis Structure and Organization

Chapter 2

Literature Review

This chapter reviews the existing literature on the liberalization of agricultural trade, its impacts on food security, and related economic and policy aspects. The review is divided into thematic sections for clarity.

2.1 Liberalization in Agricultural Trade

The liberalization of agricultural trade has been a focal point of global economic discourse, particularly for its anticipated benefits and complex impacts on developing economies. Dornbusch (1992) provides a foundational analysis of trade liberalization, arguing that while the precise effects on economic growth are challenging to quantify, liberal trade policies generally enhance economic efficiency through improved resource allocation. By reducing tariffs, countries can foster consumer welfare, lower prices, and allocate resources according to comparative advantage, especially in developing economies (Dornbusch, 1992). This benefit aligns with Harberger's 1959 classic theory on welfare gains from reduced trade restrictions. Moreover, Dornbusch (1992) highlights that liberalization provides access to a broader range of intermediate goods and inputs, leading to productivity improvements and expanding technological potential, a point supported by Romer (1990)'s growth models.

The Uruguay Round, as elaborated by Brandão and Martin (1993), marked a pivotal moment in multilateral trade negotiations by incorporating agriculture into the GATT framework, highlighting the sector's long-standing exclusion from international trade reform. Brandão and Martin (1993) emphasize the complex dynamics of agricultural trade discussions, which were often delayed due to conflicting national policies and interests among developed and developing nations. Prior to these reforms, agricultural policies were largely insular, leading to what **?**

describe as a "disarray" of distortionary policies that hindered global agricultural trade integration.

The uneven effects of agricultural trade liberalization, particularly across developing nations, are discussed in Bureau and Matthews (2006). They argue that while trade liberalization could open markets, it may also erode preferential access for certain regions, such as African and Caribbean nations, to markets in Europe and North America. These regions, which currently benefit from preferential duty-free access, could face disadvantages as multilateral liberalization removes these special provisions. Furthermore, Bureau and Matthews (2006) underscore the importance of addressing non-tariff barriers, such as sanitary and phytosanitary standards, which present significant obstacles for developing nations attempting to access international markets.

Davis (2004) explores the role of institutional frameworks and issue linkage in facilitating agricultural trade liberalization. He argues that connecting agricultural liberalization discussions to broader economic negotiations can help overcome domestic resistance by expanding the range of issues on the table. This institutionalized approach, particularly as seen in Japan and Europe, has reduced agricultural trade barriers over time, advancing the Doha Round's development agenda and fostering more open global trade relations.

Storm (2003) presents a critical analysis of agricultural trade liberalization in India, noting the sector's unique economic and social implications. Since agriculture employs two-thirds of India's workforce, rapid liberalization poses distributional concerns, as shifts in agricultural prices could affect the livelihoods of small-scale farmers reliant on market-purchased food. Storm (2003)'s dynamic general-equilibrium model suggests that a gradual approach to liberalization, supported by productivity-enhancing policies, is crucial to mitigate potential negative effects on rural communities. This incremental approach aligns with broader global trends that recognize the sensitivity of agricultural sectors to rapid policy shifts.

Fabiosa and Kruse (2005) provide insights into the anticipated impacts of agricultural liberalization under the WTO's Doha Round. Their study finds that liberalization could significantly alter global trade flows, particularly in

commodities such as dairy, meat, and sugar, benefiting competitive agricultural exporters like Argentina, Australia, and New Zealand. Conversely, net agricultural consumers in less protected markets, such as India, may experience price increases that could act as a consumption tax. Despite these complexities, Fabiosa and Kruse (2005) argue that liberalization holds the potential to reduce consumer costs in highly protected markets by aligning trade flows with countries' comparative advantages.

Overall, the literature reveals that while agricultural trade liberalization promises substantial benefits, especially in terms of productivity and resource allocation, the sector's inherent complexities necessitate careful consideration of country-specific challenges and socioeconomic factors. Developing countries, in particular, face unique vulnerabilities related to market access, price volatility, and income distribution that must be addressed through tailored policy frameworks.

2.2 Concepts of Food Security

The concept of food security has evolved significantly since the 1970s, reflecting changes in global economic conditions, social values, and priorities in development thinking. Scholars have identified three major shifts in food security thinking post-1974, aligning with broader post-modern perspectives on development. These shifts moved the focus from a global and national perspective to a micro-level view, prioritizing households and individuals, and emphasized a livelihood-based approach rather than a strictly food-centric one. Additionally, there was a shift from using objective indicators alone to incorporating subjective perceptions, allowing for a more nuanced understanding of food security experiences. Maxwell advocates for food security policies that respect diversity and empower households through flexibility and self-determination, challenging the notion of imposing one-size-fits-all frameworks on diverse populations.

Building on these evolving perspectives, Ecker and Breisinger (2012) outline the four core pillars of food security established by the FAO—availability, access, utilization, and stability—and introduce a systems-based approach that links food security with nutrition security. Their framework distinguishes between macro (national) and micro (household) levels, arguing that food security at the national

level does not guarantee nutritional adequacy at the individual level. Ecker and Breisinger (2012) emphasize that while food security includes ensuring food availability, it also encompasses the broader economic and political stability needed to maintain reliable access to nutritious food. This framework also differentiates between transient food security, which pertains to temporary disruptions, and permanent food security, where access and adequacy are sustained over the long term.

To accurately assess food security, Frongillo Jr (1999) evaluates the U.S. Food Security Supplement, a measure grounded in biological, nutritional, social, and economic dimensions. Frongillo Jr (1999) emphasizes the importance of validating food security measures across diverse contexts to ensure applicability beyond the U.S., suggesting that contextually adapted measures provide a more realistic picture of food security. Building on this, nuanced indicators that focus on "inadequate access" to food rather than just availability are essential. Emphasizing subjective measures and direct metrics helps capture subtle levels of food insecurity often overlooked by objective assessments, enabling more targeted and effective interventions.

In their study, Melgar-Quinonez and Hackett (2008) examine the adaptation and validation of the U.S. Household Food Security Supplemental Module (HFSSM) across global contexts, applying methods such as Rasch modeling and Cronbach-Alpha Coefficient to ensure reliability. While the HFSSM has been instrumental in standardizing food security measurement, Melgar-Quinonez and Hackett (2008) note limitations and call for the continued refinement of these tools to maintain both flexibility for regional adaptation and comparability at a global level. Similarly, Headey and Ecker (2013) compare four indicator classes—calorie deprivation, monetary poverty, dietary diversity, and subjective indicators—and find dietary diversity to be the most effective for food security assessment. Dietary diversity, they argue, is a strong predictor of both economic status and nutritional outcomes, sensitive to shocks and seasonality, making it a valuable tool for assessing food security dynamics.

In analyzing food security through the lens of vulnerability, Dilley and Boudreau (2001) critique traditional food security frameworks for their broad

definitions of vulnerability, which often lack specificity. They recommend adopting a disaster risk framework to assess vulnerability based on specific economic or environmental shocks. Through a case study in Tanzania, they show how focusing on the economic options available to meet food needs allows for a more precise identification of households vulnerable to specific shocks, enabling targeted preventive interventions.

Finally, Pinstrup-Andersen (2009a) underscores the limitations of household-level food security measures in capturing individual-level security. He argues that household behaviors, such as food allocation and prioritization within families, can obscure true nutritional needs, particularly in contexts with inadequate sanitation or healthcare infrastructure. Pinstrup-Andersen (2009a) advocates for combining food security indicators with anthropometric measures for children and household behavior analysis to provide a more comprehensive understanding of individual nutritional security, ensuring that interventions are effectively targeted to address both food and health needs.

2.3 Impact of Trade Liberalization on Agricultural Trade and Food Security

This section reviews significant studies examining the effects of WTO policies and trade liberalization on agricultural trade and food security, particularly in developing countries. Konandreas and Greenfield (1996) discuss the Agreement on Agriculture's (AoA) provisions, noting that ambiguities in domestic support rules allow developed countries to benefit more from the agreement than developing countries, which face financial and structural limitations in leveraging available provisions. Similarly, Safadi and Laird (1996) predict gains for developing countries in terms of trade, investment, and welfare from the Uruguay Round Agreement, although they acknowledge that food-importing nations might face initial trade disadvantages. Parikh (1997) explore the impacts of trade liberalization on India using an applied general equilibrium model, finding that non-agricultural trade liberalization can be as beneficial as agricultural trade reform, especially for growth.

Several studies focus specifically on the Indian context. Sharma (2001) and Rao (2001) emphasize that WTO policies have exposed Indian agriculture to international market risks, suggesting that public investment in infrastructure and technologies is essential for boosting productivity and resilience. Hoda and Gulati (2002) argue that liberalization increases India's agricultural integration in global markets, potentially threatening food security through price volatility and reduced domestic food availability. Gulati (2002) supports this view, emphasizing that economic access to food is critical for India's food security, and advocates for careful policy adjustments in international negotiations to support local food needs.

Other research, such as Gonzalez (2002), critiques the WTO's support mechanisms, contending that they disproportionately benefit industrialized nations, while developing countries lack sufficient resources to use available exemptions. Bhalla (2004) and Ackerman (2005) offer critical views on the perceived economic benefits of liberalization, with Ackerman (2005) questioning the predictive accuracy of general equilibrium models that overlook the complexities of rural economies and employment shifts.

Empirical studies highlight diverse regional outcomes. For instance, Salima and Hossain (2006) show that trade reform modestly increased farm efficiency in Bangladesh, while Pyakuryal (2009) report improved food availability in Nepal. Similarly, Ghosh (2010) find mixed evidence of price volatility effects on different Indian crops, reinforcing that liberalization impacts are context-specific. Anwar (2010) demonstrate that trade openness has positively influenced cotton exports in Pakistan, while Taylor (2010) report that agricultural tariff reductions under CAFTA have reduced welfare for some Central American rural communities.

More recent studies extend these findings. Sharma (2018) highlight the disparity in policy space available to India and China compared to developed countries, advocating for a more balanced global trade environment. Zhu (2016) and Thow (2019) emphasize the importance of food security policies that align with local needs, especially regarding public stockholding provisions. Farrukh (2020) identify knowledge gaps in food security research in South Asia, suggesting that more context-specific studies are needed to inform policy.

Collectively, this body of literature underscores the need for nuanced, flexible policy frameworks that account for the unique challenges of food security in developing countries. While trade liberalization has potential benefits, it also presents significant risks that policymakers must mitigate to protect vulnerable populations.

2.3.1 Agricultural Trade Liberalization Studies in India

Trade liberalization has significantly impacted Indian agriculture since the 1990s. Gulati et al. (2012) analyzed policy shifts in Indian agriculture, documenting how reduced trade barriers affected commodity prices and farm incomes. Narayanan (2014) examined agricultural trade patterns post-liberalization, finding increased market integration but also heightened price volatility.

2.3.2 Food Security and Market Integration

Research shows complex relationships between trade openness and food security. Davis et al. (2017) used household survey data to demonstrate varied impacts of trade liberalization on food security across different income groups. Dorosh and Rashid (2016) found that trade policies significantly influence domestic price stability and food access.

Indian studies by Krishna and Mehta (2017) revealed regional variations in food security outcomes following trade reforms. Chand (2007) documented how market integration affected price transmission across agricultural commodities.

2.3.3 Price Volatility in Agricultural Markets

Price volatility remains a critical concern post-liberalization. Ghosh (2013) analyzed monthly price data for major food commodities in India, showing increased volatility during 2000-2010. Kumar and Sharma (2017) examined volatility transmission between international and domestic markets.

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2.4.3 Price Volatility in Agricultural Markets

Food price volatility has emerged as a critical factor influencing food security, particularly in developing countries where a significant portion of the population is vulnerable to price shocks. Numerous studies have explored the negative consequences of agricultural price volatility on household welfare, economic growth, and food security, particularly in regions where agricultural production and food consumption are tightly linked.

The volatility of food prices poses a critical challenge for policymakers, especially in developing countries where food security is precarious. Timmer (2000) underscores that high food prices jeopardize the food security of vulnerable net food buyers, while low prices can adversely affect farmers who depend on food sales for their livelihoods. Recent years have seen surges in global food prices, notably in 2008, 2011, and 2022, which have prompted governments to seek ways to stabilize domestic food prices through trade policies like export restrictions and tariff adjustments (Paolo Giordani and Ruta, 2016; Martin and Anderson, 2011). This literature review explores the role of trade policies in mitigating food price volatility, assessing their impact on both international and domestic markets and examining potential reforms for improved stability.

An essential function of international food trade is to diversify food supplies, which can significantly reduce the volatility of staple food availability and lessen a population's vulnerability to food supply shocks (Burgess and Donaldson, 2010). When countries open their markets to food imports and exports, they can buffer their domestic prices from fluctuations in world prices. For example, exporters may impose export restrictions to curb domestic prices when world prices rise, while importers may lower tariffs to prevent domestic prices from escalating in

line with global trends (Paolo Giordani and Ruta, 2016). Conversely, when world prices drop, countries often raise import tariffs or use export subsidies to sustain domestic prices (Martin and Anderson, 2011). These interventions, however, can amplify the impact of primary shocks—such as those stemming from weather events or geopolitical conflicts—on global food prices, both upward and downward (Martin and Minot, 2022).

Paolo Giordani and Ruta (2016) provide a theoretical basis for countries' tendencies to insulate their markets for staple foods. Unlike traditional political-economy models, their approach incorporates loss aversion, suggesting that those who experience losses due to price shifts are more motivated to seek compensatory policies than those who gain seek to retain their benefits. This model aligns with risk aversion as an explanation for price insulation policies, as proposed by Pieters and Swinnen (2016), and supports Timmer (2010)'s observation that policymakers in developing countries often feel compelled to stabilize staple food prices domestically. Similar pressures have been observed in developed countries, where Anderson and Nelgen (2012) noted reductions in protection for rice and wheat during the 1972–74 price hikes and increases in protection during the 1984–86 price depression.

There are two primary strands of literature regarding food trade policies: one focuses on the political-economy forces shaping equilibrium protection levels (Grossman and Helpman, 1994; Gorter and Swinnen, 2002), while the other examines changes in protection due to food market disturbances (Martin and Anderson, 2011; Paolo Giordani and Ruta, 2016). These responses are interlinked; shifts in protection levels in response to world price fluctuations disrupt the political-economy equilibria that tend to maintain positive protection in some countries and negative protection in others (Anderson, 2009). To analyze policy impacts and establish accurate parameter estimates, a comprehensive model that integrates efforts to stabilize domestic prices with the political-economy equilibrium of protection is required.

Research by Martin and Anderson (2011) and Paolo Giordani and Ruta (2016) indicates that systematic responses to global price changes often correlate across countries, amplifying the effects of global shocks on food prices. However,

idiosyncratic national policy shocks primarily impact domestic prices and tend to cancel out at the global level, similar to the way that diversified assets mitigate risk in investment portfolios (Elton and Gruber, 1997). These idiosyncratic shocks have significant domestic effects, impacting the welfare of less diversified producers and consumers. Notably, Will Martin and Ivanic (2017) suggest that although price insulation appears to be a zero-sum policy—where nations insulating more than the average reduce domestic price volatility relative to global free trade—findings indicate it is often a negative-sum game, exacerbating volatility for most countries involved.

Shenggen Fan and Zhang (2014) examined the effects of agricultural price volatility on food security in China, finding that volatility particularly affected rural households and those with low incomes, leading to a decline in food security. Similarly, Demetriades and Law (2016) analyzed the relationship between food price volatility and food security in sub-Saharan Africa, highlighting that price fluctuations had a severe impact, especially in countries dependent on food imports. These findings align with Naylor and Falcon (2010), who emphasized the causes of price volatility, such as macroeconomic policy, exchange rates, and petroleum prices, which have caused significant fluctuations in global food prices, particularly after 2000.

The effects of food price volatility on household welfare are further supported by Benni and Finger (2013), who found that volatility significantly harmed welfare, especially in urban areas with low-income populations. Similarly, Fafchamps and Minten (2012) highlighted how market liberalization in Ethiopia led to increased price volatility and worsened welfare outcomes, particularly for subsistence farmers who are highly vulnerable to price fluctuations. Thurlow and Dorosh (2012) also emphasized that agricultural price volatility had a detrimental effect on Ethiopia's economic growth and household welfare, recommending interventions such as price stabilization mechanisms and social protection programs.

The role of agricultural subsidies in mitigating the effects of price volatility has been explored by several researchers. Catherine Ragasa and Manyong (2013) reviewed literature on agricultural input subsidies in Africa and found that while subsidies can boost agricultural productivity and reduce price volatility,

their effectiveness is often hindered by poor implementation and corruption. Bekele Shiferaw and Gulati (2014) conducted a similar study in Ethiopia and found that subsidies led to increased productivity and reduced food insecurity. However, they cautioned about the sustainability of such measures over the long term.

In India, Laha and Sinha (2021a) examined the implications of food price shocks on food security indicators, noting that the declining per capita availability of food grains in the post-reform period could be linked to export encouragement. This policy, driven by India's comparative advantage in the global market, led to reduced food availability domestically, amplifying food insecurity, especially among low-income groups. Allen and Atkin (2022) explored the relationship between trade and volatility in the context of Indian agriculture, suggesting that while trade can lead to specialization gains, the risks associated with volatility can undermine these benefits.

Barrett and Headey (2014) provided a comprehensive review of the relationship between agricultural price volatility and food security, advocating for policy responses that include investments in agricultural research, social protection programs, and market-based interventions to mitigate the negative effects of price instability. Sarris and Zlatka (2013) examined the role of trade policies in exacerbating or mitigating food price volatility, concluding that measures like import tariffs and export restrictions often worsen price fluctuations and contribute to food insecurity.

Overall, these studies collectively highlight that food price volatility poses significant challenges to food security, especially in developing countries. They suggest that while trade and market liberalization can provide economic benefits, these must be carefully managed to prevent exacerbating price fluctuations and undermining food security. Effective policy responses, including price stabilization, subsidies, social protection, and improved risk management, are essential to address the adverse impacts of food price volatility on vulnerable populations.

2.5 Impact of Agricultural Trade on Farm Income

International trade is a crucial engine of economic growth for many nations. However, the impact of free trade and regional cooperation on agriculture varies based on the extent of trade creation versus trade diversion (Clausing, 2001a). For example, Solomon Anwor and Onuoha (2013) studied Nigeria's agriculture sector, finding that trade liberalization positively impacted agricultural exports. Conversely, Yusida and Matheus (2021) showed that increased food crop imports alone could reduce farmer incomes, although this negative impact could be offset if accompanied by growth in non-agricultural exports and production.

Focusing on the effects of free trade in developing economies, Anderson and Martin (2006a) argue that transitioning to free merchandise trade enhances agricultural output and export levels, fostering rural development. However, findings from Pakistan illustrate a complex picture: Khan and Ullah (2021) discovered that trade liberalization does not reduce income inequality, especially in the short term. Trade agreements that prioritize agriculture may improve income equality by reducing non-farm urban income, revealing mixed effects across sectors.

In India, Dhar (2023a) highlights challenges stemming from WTO agreements, which restrict domestic agricultural support mechanisms, such as minimum support prices and export subsidies, thereby constraining food security measures. Similarly, Faridi (2012) found that in Pakistan, agricultural exports surprisingly hindered economic growth, while non-agricultural exports, especially textiles, spurred development, suggesting the need to diversify export products beyond agriculture.

Several studies emphasize the importance of agricultural productivity and related factors in driving farm income. For example, Mehdi (2011a) showed that investments in human capital and the agriculture sector boosted value addition in Iran's agriculture from 1970 to 2007. In Ethiopia, Alemayehu Shita and Eshetu (2019) demonstrated that adopting agricultural technologies, expanding arable land, and real GDP growth improved productivity. Likewise, Udah and Nwachukwu (2014) identified productivity and infrastructure as critical for agri-

cultural expansion in Nigeria, while Ahmad and Heng (2012b) pointed to fertilizer use, human capital, and agricultural credit as key factors enhancing productivity in Pakistan.

In the Indian context, Kannan (2011) identified irrigation, capital formation, rainfall, and fertilizer as essential for growth in agricultural GDP. Similarly, Tripathi and Prasad (2009) found that land, labor, and capital were primary drivers of productivity. Solanki (2017) highlighted public investment, terms of trade, and minimum support price as beneficial, though fertilizer subsidies negatively impacted agricultural GDP. Kamat and Chand (2007) suggested that institutional credit and wheat support prices improved productivity, while net irrigated area had a limited impact.

Ramesh Chand and Mittal (2015) showed fluctuations in farm income across different decades, with notable growth from 2004 to 2012. Further, Das and Kumar (2017) identified optimal farm sizes and diversification levels for maximizing income, finding that excessive diversification could lead to income declines. Dev (2020) emphasized that in India, the success of recent farm laws relies on addressing market imperfections and shifting from cereal-centric policies to diversified agricultural growth strategies.

Finally, Singh (2020a) found that neoliberal policies have not led to improved agricultural development or food security in India, instead intensifying existing challenges. Rajeev Kumar and Mishra (2021) corroborated this by identifying certified seeds, fertilizer consumption, irrigated areas, and pesticide use as key long-term determinants of agricultural GDP, underscoring the multifaceted impact of trade on farm income and agricultural performance.

2.5.1 Estimation of Policy Support to Agricultural Producers in India and WTO Agreement on Domestic Support

India's complex and extensive agricultural economy has been the subject of numerous studies that estimate policy support for agricultural producers. These studies often focus on evaluating the extent of support provided to Indian agricultural producers through both budgetary measures and market or border regulations,

which ultimately influence input and output prices. Based on the pioneering work of Josling (1973), the Organization for Economic Cooperation and Development (OECD) developed the Producer Support Estimates (PSE) model in 1986, which has since been applied across multiple countries. Although the OECD's PSE does not cover India, researchers like (David Orden and Roe, 2007; Pursell and Gulati, 2009; Raju, 2013) have developed estimates of support for India's agricultural producers by adapting similar methodologies. However, due to methodological variations, these estimates may not align directly with OECD's standard estimation techniques.

The concept of combining budgetary and price support as a measure for agricultural support was institutionalized within the World Trade Organization's (WTO) Agreement on Agriculture (AoA), formalized during the Uruguay Round (Organization, 1994). The Agreement introduced guidelines and limits for domestic support in agriculture, obliging WTO members to adhere to specified rules. Domestic support, defined within the AoA, encompasses all non-border measures, such as payments and price controls, but excludes support purely based on border measures, like import tariffs or export subsidies. In practice, domestic support often relies on border measures to be effective. The Agreement also mandates that any non-exempt domestic support is subject to specific limits to prevent distortions in international trade.

A major challenge in applying these rules is the lack of updated and consistent domestic support data for many countries, including India. The diversity in methodological interpretations has led to varied opinions on how countries are meeting their WTO obligations. For India, these discrepancies are evident from its original domestic support data at the end of the Uruguay Round (WTO AGST data) and in subsequent WTO notifications (Organization, 1998, 2002, 2011). Analysts such as (Bhalla, 2011; Hoda and Gulati, 2007, 2013; Gopinath, 2011, 2012; Narayanan, 2013) have explored these inconsistencies and provided insights into India's evolving domestic support practices.

Under the AoA, domestic support is quantified through Aggregate Measurement of Support (AMS), as defined in Article 1(a) of the Agreement. AMS includes both product-specific and non-product-specific support measures, where product-

specific AMS targets support for individual agricultural products, while non-product-specific AMS encompasses support for the agricultural sector as a whole. Certain types of support—typically measures meeting the criteria of Annex 2 of the Agreement, known as the "green box"—are excluded from AMS calculations. While AMS technically measures support provided to "producers", it is often analyzed in terms of its impact on products or the agricultural sector overall. The "aggregate",nature of AMS reflects the consolidation of various policy supports, such as direct payments and price supports across different agricultural products.

2.5.2 Nutritional Intake Patterns and Socioeconomic Influences on Dietary Choices in India

Recent studies present nuanced insights into India's dietary patterns, exploring how rapid economic growth, income changes, and shifting priorities in household expenditure have impacted nutrient intake, particularly calories, proteins, and fats. The data shows a complex picture: while per capita income has risen, there has been an unexpected stagnation or even decline in calorie consumption, prompting researchers to investigate the underlying causes.

One key observation is the decline in calorie intake alongside increased economic growth and real per capita income. Drèze and Deaton (2008) point to a noticeable decrease in per capita calorie consumption, attributing this to possible dietary shifts rather than purely economic factors. Patnaik (2007), however, argues that rural deflation has led to suppressed rural incomes, especially at lower economic levels, leading to reduced calorie intake. Contrarily, Deaton and Drèze (2008) challenge this view, suggesting that National Sample Survey (NSS) data indicate a rise in rural per capita income, particularly among lower-income groups, thereby questioning the deflationary impact on rural calorie intake.

Other studies reveal more about the diet diversification trends within these consumption patterns. Mazumdar and Sarkar (2007) emphasize that the increase in real per capita consumption in rural areas is most pronounced within the lowest consumption quintiles, indicating that even poorer households have seen an increase in real spending. Nonetheless, this rise in average per capita expenditure has not resulted in a parallel increase in calorie intake. Instead, there is a shift

within the types of calories consumed, with a clear reduction in cereal intake and an increase in fat consumption (Deaton and Drèze, 2008). The reduction in calories from cereals is more marked among higher-income groups, suggesting a diversification of the diet, where cereals are being replaced with other, often higher-fat, foods.

Research by Viswanathan and Meenakshi (2007) highlights a positive expenditure elasticity of energy intake, particularly among economically disadvantaged regions and groups, showing that increased consumption generally results in higher energy intake. However, this relationship is complicated by the growing allocation of household budgets to essential non-food expenses, including health, education, and transport (Mazumdar and Sarkar, 2007). These competing expenses are believed to be "squeezing" the food budget, potentially offsetting any gains from increased income.

Further analysis suggests the need for policy interventions to address the gaps in nutrient intake. Deolalikar and Dubey (2008) argue that overcoming nutrient deficiencies will require a substantial dietary shift away from cereal-dominated diets to a more balanced, diversified diet. Deaton and Drèze (2008) tentatively suggest that the decline in calorie consumption might also be due to reduced physical activity levels and improved health, resulting in lower energy requirements. Nonetheless, it is evident that non-caloric nutritional deficiencies persist, and improving food security will require a focus on increasing dietary diversity, specifically in terms of vitamins, minerals, and balanced macronutrients, as outlined by Viswanathan and Meenakshi (2007).

In summary, the literature highlights a complex interplay between rising income, non-food expenditure priorities, and changing dietary preferences. While economic growth has improved expenditure capabilities, the shift towards diversified diets and increased non-food spending has led to a stagnation in calorie intake, underscoring the need for policy measures to ensure nutritional adequacy in the face of changing economic and dietary landscapes.

2.6 Conclusion

This review highlights the complex interplay between trade liberalization, agricultural development, and food security. While liberalization offers potential benefits, it also presents significant risks, particularly for developing nations. Tailored policy responses are essential to address these challenges and safeguard food security.

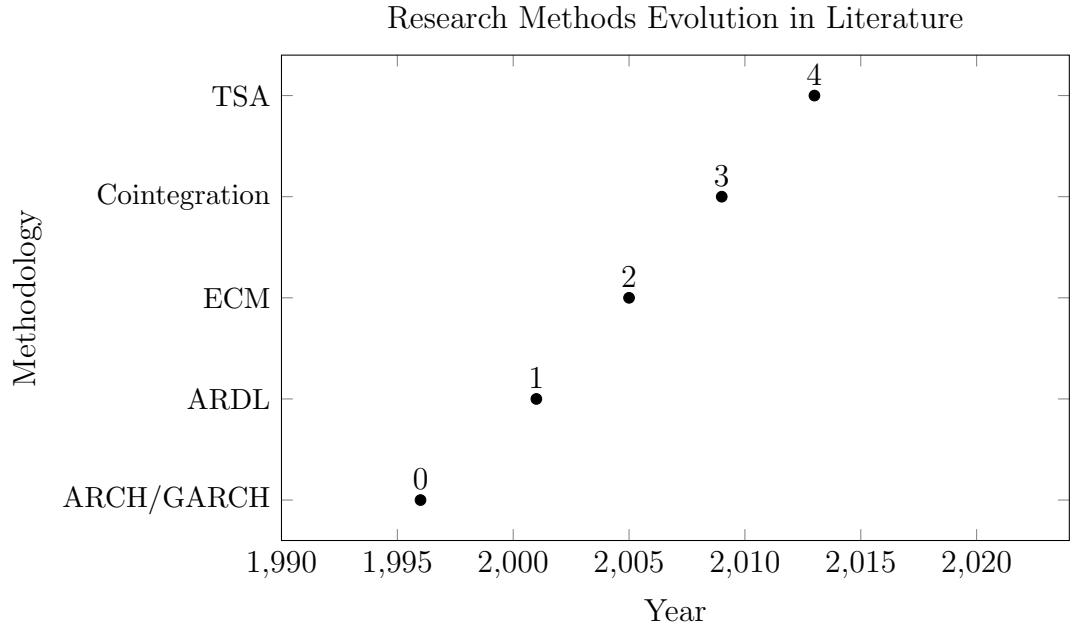


Figure 2.1: Evolution of Research Methodologies in Trade-Food Security Studies

2.7 Research Gap

Despite extensive research on agricultural price volatility and food security, there remains a significant gap in studies that specifically address the impact of liberalized agricultural trade on the volatility of domestic agricultural commodity prices in India. Moreover, the application of advanced econometric models, such as ARCH and GARCH, in this context has been minimal. While the broader implications of food security have been examined, there is limited exploration of how trade-induced price volatility directly affects economic access to food for different population segments in India. Additionally, comparative analyses of price behavior and volatility patterns before and after the implementation of trade

liberalization policies in the Indian context are notably scarce.

Although the effects of trade liberalization on agricultural productivity and broader economic outcomes have been widely studied, there is a lack of focused research examining how liberalized agricultural trade influences farmers' income in India using advanced econometric approaches like the ARDL model. Previous studies have highlighted diverse outcomes of trade liberalization in global and regional contexts (Clausing, 2001b; Anwar et al., 2015; Anderson and Martin, 2006b), but their findings do not adequately address the unique dynamics of the Indian agricultural sector, particularly concerning farm income (Dhar, 2023b; Singh, 2020b).

Existing literature has employed econometric models to analyze factors influencing agricultural growth (Mehdi, 2011b; Ahmad and Heng, 2012a; Raza and Siddiqui, 2014). However, the ARDL approach remains underutilized in studying the specific relationship between agricultural trade liberalization and farmers' income. This methodological gap represents an opportunity to adopt the ARDL model for a nuanced understanding of income changes resulting from trade liberalization (Vu, 2020; Bouri and Jain, 2021).

Furthermore, the direct effects of trade-induced price volatility on farmers' income have not been sufficiently investigated in the Indian context (Nair, 2013; Laha and Sinha, 2021b). Most studies focus on broader themes such as food security and productivity without addressing how price fluctuations, driven by liberalized trade, impact farmers' economic well-being. Comparative analyses of farmers' income before and after trade liberalization policies are also largely absent, leaving a critical gap in understanding the implications of these policies on the financial stability of Indian farmers (Bouët and Laborde, 2010).

Addressing this gap can provide valuable insights into how liberalization policies have transformed the economic landscape for farmers over time. The existing literature provides a broad understanding of the impacts of trade liberalization on economic growth and agricultural productivity. However, there is a critical need for research that specifically investigates the impact of agricultural trade on food availability in India. This gap is particularly relevant given the importance of food availability as a key dimension of food security. Addressing this research gap

will contribute to more informed policy-making aimed at enhancing food security in the context of ongoing trade liberalization

2.8 Research Question

This study addresses several critical questions to understand the interplay between agricultural trade and food security. First, it examines whether food prices have been volatile during the period of liberalization, providing insights into the stability of food markets in a changing trade environment. Second, it investigates how agricultural trade has impacted farm income, analyzing the economic implications of trade policies on agricultural livelihoods. Finally, it explores whether food availability has been affected by agricultural trade during the period of liberalization, shedding light on the broader implications of trade reforms on food security.

2.9 Objectives of the Study

RO 1 To study the food prices volatility during the period of Liberalisation

RO 2 To study the impact of agricultural Trade on farms income

RO 3 To examine the effect of Agricultural Trade on food availability

Chapter 3

Methodology

An effective research methodology is critical to conducting a meaningful empirical study, as it ensures the rigor and reliability of its outcomes. This chapter presents the methodological approach adopted to evaluate the impact of agricultural trade liberalization on India's food security post-2001, offering a structured plan for the study.

The chapter begins by exploring the evolution of India's agricultural trade policies, particularly the reforms introduced during the liberalization era, and their potential implications for food security. This discussion sets the stage for the empirical analysis. The research strategy is then described, highlighting the data sources, selection of variables, and justification for focusing on specific time periods.

Key food security dimensions—such as food availability, accessibility, utilization, and stability—are identified, alongside critical agricultural trade variables like exports, imports, and domestic production. The statistical and econometric tools employed in this study are introduced, including volatility models like ARCH/GARCH, ARDL frameworks for long-term analysis, and diagnostic tests to validate the models.

The methodology is based on empirically measuring food price volatility, farm income trends, and food availability, with a focus on their theoretical bases and econometric implementation. The approach for identifying crisis thresholds and analyzing structural breaks is also detailed.

To ensure the robustness of the results, the chapter discusses the diagnostic tests used to address econometric challenges, including stationarity, multi-collinearity, autocorrelation, and heteroscedasticity. Techniques to manage potential endogeneity issues are also explained.

Finally, the chapter reflects on the obstacles faced during the research process, such as data availability and methodological challenges, and the steps taken to address these issues. This systematic methodology lays a solid groundwork for the empirical analysis and policy discussions that follow in later chapters.

3.1 Conceptual Framework

This section provides the foundational concepts and definitions necessary to understand the study. It outlines key terms, discusses indicators of food security, and examines the role of agricultural trade in ensuring food security.

3.1.1 Definition of Key Terms

Food Security: Food security refers to a state in which all individuals have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. It encompasses four main dimensions: availability, accessibility, utilization, and stability. **Liberalization:** Liberalization in the context of agricultural trade involves the removal or reduction of trade barriers, such as tariffs, quotas, and subsidies, to facilitate the free flow of agricultural goods across borders. It aims to integrate domestic markets with global markets, enhancing competition and efficiency. **Volatility:** Volatility refers to the degree of variation in agricultural prices or outputs over time, often influenced by external shocks, market dynamics, and policy changes. High volatility can pose significant challenges to food security by destabilizing markets and incomes.

3.1.2 Indicators of Food Security

Food security is assessed using the following indicators: **Availability:** Availability refers to the physical presence of sufficient quantities of food, whether produced domestically or imported, to meet the nutritional needs of the population. **Accessibility:** Accessibility is the ability of individuals to obtain food either through economic means, such as affordability, or social mechanisms, such as distribution systems. **Utilization:** Utilization pertains to the effective use of food to meet

dietary requirements, which depends on factors like food quality, diversity, and the health conditions of individuals. **Stability:** Stability involves the consistency of food availability, access, and utilization over time, ensuring resilience against potential shocks such as economic crises, climatic events, or policy shifts.

3.1.3 Relevance of Agricultural Trade in Food Security

Agricultural trade plays a critical role in ensuring food security by: **Diversifying Food Supply:** Diversifying food supply involves enhancing access to a variety of foods that may not be locally produced, thereby improving dietary diversity and nutritional outcomes. **Supplementing Domestic Production:** It also includes addressing gaps in domestic production through imports, particularly during periods of scarcity, ensuring that food availability is maintained. **Stabilizing Prices:** Trade plays a critical role in stabilizing prices by integrating domestic markets with global markets, which helps reduce price volatility and spreads risks across a larger economic system. **Economic Benefits:** Additionally, trade contributes to economic benefits such as increased farm income through exports and fostering economic growth, which indirectly supports food accessibility and stability.

This conceptual framework establishes the key ideas and relationships that guide the study, providing the basis for the empirical analysis that follows. “‘

3.2 Data Sources and Variables

This section outlines the sources of data utilized in the study and describes the key variables selected for analysis. The choice of data sources and variables is guided by the objectives of the study, focusing on the interplay between agricultural trade liberalization and food security in India post-2001.

3.2.1 Sources of Data

The data for this study is sourced from reliable and well-established organizations to ensure accuracy and credibility. The primary sources include: **Ministry of Agriculture and Farmers Welfare:** The Ministry of Agriculture and Farmers

Welfare provides data on agricultural production, crop yields, and related policy measures, offering valuable insights into the domestic agricultural landscape. **Directorate of Economics and Statistics:** The Directorate of Economics and Statistics offers comprehensive statistics on agricultural trade, domestic market trends, and economic indicators, supporting detailed analysis of market dynamics. **Reserve Bank of India (RBI):** The Reserve Bank of India (RBI) supplies macroeconomic data, including exchange rates, interest rates, and inflation trends, which are critical for understanding trade dynamics and their impact on agricultural markets. **FAOSTAT (Food and Agriculture Organization):** FAOSTAT provides global and regional data on food price indices, trade volumes, and agricultural inputs, enabling cross-country comparisons and insights into global agricultural trade patterns.

3.2.2 Data Quality and Reliability Measures

To ensure data integrity:

The study employs several data preprocessing and quality control procedures to ensure the reliability of the analysis. Data preprocessing includes cross-validation of data sources to verify the accuracy and consistency of the information, treatment of missing observations to address gaps in the dataset, adjustment for inflation in price data to account for temporal changes in economic conditions, and standardization of measurement units to ensure comparability across variables. Quality control procedures involve thorough data consistency checks to identify and correct discrepancies, the application of outlier detection methods to manage extreme values that could skew results, verification of data with alternative sources to ensure robustness, and meticulous documentation of any data adjustments made during the preprocessing phase. These steps collectively ensure the integrity and reliability of the data used in the study.

3.2.3 Variables

The study focuses on three key objectives, and the variables selected for each objective are outlined below:

3.2.3.1 Variables for Objective 1, RO1

To analyze food price volatility, the primary variable used is: **Monthly Consumer Price Index of Food and Beverages (CPI-FB):** The Monthly Consumer Price Index of Food and Beverages (CPI-FB) measures the price movements of food and beverage items on a monthly basis. It serves as a key indicator of food price volatility, providing critical insights into trends and fluctuations in the cost of essential food items over time.

3.2.3.2 Variables for Objective 2, RO2

To assess the impact of agricultural trade on farm income, the following variables are used: **Agricultural GDP (AGDP):** Agricultural GDP is used as a proxy for farm income, representing the economic contribution of agriculture to the overall economy. **Agricultural Export (EX):** Agricultural export measures the value of agricultural goods exported, reflecting the performance of trade in the agricultural sector. **Agricultural Import (IM):** Agricultural import measures the value of agricultural goods imported, indicating a country's reliance on international markets to meet its agricultural needs. **Fertilizer Consumption (FTZ):** Fertilizer consumption represents the total usage of fertilizers, which is a critical input for enhancing agricultural productivity. **Crop Yield (YLD):** Crop yield refers to the output per unit area of agricultural land, serving as an indicator of efficiency and technological advancement in agricultural practices.

3.2.3.3 Variables for Objective 3, RO3

To examine the effect of agricultural trade on food availability, the following variables are considered: **Dietary Energy Supply (DES):** Dietary Energy Supply measures the per capita availability of dietary energy, serving as an indicator of food availability and nutritional security. **Agricultural Export (AEXP):** Agricultural export represents the value of agricultural products exported, reflecting trade performance and market access. **Agricultural Import (AIMP):** Agricultural import reflects the value of agricultural products imported, highlighting reliance on international markets to meet domestic demand. **Crop Yield (CY):** Crop yield indicates the productivity per unit area of agricultural land,

providing insights into agricultural efficiency and technological advancements. **Agricultural GDP (AGDP):** Agricultural GDP serves as an economic indicator of agricultural output, linking agricultural performance to food availability and overall economic contributions.

These variables comprehensively capture the dimensions of food price volatility, farm income, and food availability, aligning with the study's objectives.

3.3 Analytical Methods

This section outlines the econometric methods employed in the study to achieve its objectives and address the research questions and objectives discussed in the literature review chapter.

3.3.1 Methodology for Objective 1 (RO1)

To achieve the first research objective (RO1), which is to analyze food price volatility during the period of liberalization, the study employs econometric models specifically designed to capture and quantify time-varying volatility. The dependent variable for this objective is the **Monthly Consumer Price Index of Food and Beverages (CPI-FB)**.

3.3.1.1 Data and Variables

The variable used for this analysis is: **Dependent Variable:** The Monthly Consumer Price Index of Food and Beverages (CPI_FB_t) serves as the dependent variable, representing food price levels at time t. It captures price movements and volatility over time, providing insights into market dynamics. **Independent Variables:** The model includes lagged values of the squared residuals (ε^2_{t-i}) as independent variables, which capture the impact of past shocks on current volatility. Additionally, lagged values of conditional variance (σ^2_{t-j}) are incorporated to reflect the persistence of volatility over time, emphasizing the influence of historical patterns on current price behavior.

3.3.1.2 Econometric Approach

To examine volatility, the study employs the **Autoregressive Conditional Heteroskedasticity (ARCH)** model and its extension, the **Generalized ARCH (GARCH)** model.

ARCH Model Specification: The ARCH model captures time-varying volatility based on past squared residuals and is specified as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2, \tag{3.3.1}$$

where: σ_t^2 represents the conditional variance of CPI_FB_t at time t, serving as a measure of volatility in food prices. ε_{t-i}^2 denotes the lagged squared residuals, capturing the influence of past price shocks on current volatility. The parameters α_0 and α_i are to be estimated, providing insights into the contributions of past shocks and other factors to the conditional variance.

GARCH Model Specification: To account for both past residuals and persistence in volatility, the GARCH model is used, defined as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2, \tag{3.3.2}$$

where: σ_t^2 represents the conditional variance of CPI_FB_t, providing a measure of the variability in food prices at time t. ε_{t-i}^2 refers to the lagged squared residuals, capturing the effects of past price shocks on current volatility. σ_{t-j}^2 denotes the lagged conditional variance, reflecting the persistence of volatility over time. The parameters α_0, α_i, and β_j are to be estimated, offering insights into the contributions of past shocks and the persistence of volatility to the conditional variance.

3.3.2 Methodological Considerations for Price Volatility Analysis

The analysis of food price volatility requires careful consideration of:

The analysis involves the careful selection of an appropriate time series length to effectively capture volatility patterns in food prices over time. Seasonal variations in price data are addressed to ensure that recurring patterns do not distort the results. Handling outliers and extreme price movements is critical to prevent skewed interpretations of volatility, particularly during periods of market instability. Additionally, the study accounts for policy intervention periods, recognizing their potential influence on price behavior and volatility patterns.

Specific considerations for ARCH/GARCH modeling include: The analysis incorporates model specification tests to ensure that the chosen model adequately captures the dynamics of food price volatility. Lag length selection criteria are employed to determine the optimal number of lags for accurate representation of the data's temporal structure. Volatility persistence is measured to evaluate the extent to which past price volatility influences current price behavior. Additionally, the study tests for asymmetric effects in price movements, examining whether upward and downward price changes exhibit differing impacts on market dynamics.

3.3.2.1 Model Estimation and Interpretation

The ARCH and GARCH models are estimated using Maximum Likelihood Estimation (MLE). The estimated conditional variance (σ_t^2) is used to identify periods of high and low volatility in food prices. These results provide insights into the stability of food prices and the potential effects of liberalization policies.

3.3.2.2 Diagnostic Tests

Before applying the ARCH/GARCH models, the following diagnostic tests are conducted to ensure the appropriateness of the models: **Stationarity Tests:** The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are employed to determine whether the CPI_FB_t series is stationary or requires transformation to achieve stationarity. Ensuring stationarity is a crucial prerequisite for accurate modeling and analysis of time series data. **ARCH Effect Test:** The ARCH-LM test is applied to detect the presence of heteroskedasticity in the residuals. The detection of such effects justifies the use of ARCH/GARCH models, which are specifically designed to handle time-varying volatility in the data.

3.3.3 Variable Selection Criteria

The process of variable selection involved:

The selection of variables for the analysis is guided by a strong theoretical justification, ensuring that each included variable aligns with the underlying economic and statistical framework. This process is informed by findings from a comprehensive literature review, which highlights the relevance and significance of specific variables in similar studies. Statistical testing is employed to evaluate the relevance of the chosen variables, ensuring their contribution to the robustness of the model. Additionally, the availability and quality of data are considered to ensure that the analysis is based on reliable and consistent information.

3.3.4 Variable Transformation and Standardization

Data preparation procedures included:

Logarithmic transformations are applied to scale the data, reducing skewness and ensuring that relationships between variables are more linear. Seasonal adjustments are performed on time series data to account for recurring patterns and fluctuations, allowing for more accurate analysis of underlying trends. Normalization of variables is conducted where necessary to bring them to a comparable scale, facilitating meaningful comparisons and interpretations. Extreme values and outliers are carefully treated to prevent distortions in the results, ensuring the robustness and reliability of the analysis.

3.3.5 Control Variable Framework

Selection and implementation of control variables considered:

Macroeconomic factors, such as exchange rates, inflation, and global market trends, significantly influence agricultural trade, shaping both export and import dynamics. Policy intervention periods, including subsidies, tariffs, and trade agreements, play a crucial role in determining market behavior and trade flows. Seasonal and weather-related factors, such as monsoons, droughts, and harvest cycles, impact agricultural production and trade patterns, introducing variability into the data. Structural changes in agricultural markets, including shifts in

supply chains, technological advancements, and changes in consumer demand, further affect the dynamics of agricultural trade, requiring careful consideration in the analysis.

3.3.6 Addressing Endogeneity Concerns

Steps taken to address potential endogeneity:

The analysis identifies potential endogenous relationships to ensure that causality is correctly attributed and that the results are not biased by reciprocal influences between variables. Appropriate instrumental variables are selected to address endogeneity concerns, providing a robust framework for isolating the effect of independent variables on the dependent variable. Control variables are implemented to account for confounding factors that might influence the outcomes, enhancing the precision of the model. Additionally, testing for reverse causality is conducted to verify the direction of the relationships, ensuring the validity of the conclusions drawn from the analysis.

3.3.7 Time Series Properties Investigation

Detailed examination of time series characteristics:

Unit root testing under structural breaks is conducted to assess the stationarity of time series data while accounting for potential structural changes that could affect the results. Seasonality analysis and adjustment are performed to identify and remove recurring patterns, ensuring that the analysis captures underlying trends rather than seasonal fluctuations. Cointegration relationship testing is utilized to examine the long-term equilibrium relationships between variables, providing insights into their interdependence over time. Non-linearity testing procedures are applied to detect and account for potential non-linear dynamics, ensuring the model adequately represents the complexities of the data.

3.3.8 Robustness Checks for ARDL Analysis

To ensure the reliability of farm income analysis:

Multiple specification testing is employed to ensure the robustness of the model

by examining alternative formulations and validating the chosen specification. Alternative lag structure analysis is conducted to explore the impact of different temporal dependencies, ensuring that the model captures the dynamics accurately. Sensitivity analysis for different time periods is performed to assess the consistency of results across various temporal segments, verifying the generalizability of the findings. Bootstrap simulations are utilized to test the stability of parameter estimates, providing additional confidence in the reliability and robustness of the model's conclusions.

diagnostic tests are conducted to evaluate the adequacy of the model by checking for issues such as autocorrelation, heteroskedasticity, and normality in the residuals. Parameter stability tests are applied to ensure that the estimated coefficients remain consistent over time, indicating the reliability of the model. Structural break analysis is performed to detect and account for significant changes in the data that could affect the relationships between variables. Specification error tests are utilized to identify potential misspecifications in the model, ensuring that the chosen formulation accurately captures the underlying dynamics of the data.

3.3.8.1 Differentiating RO1 from Other Objectives

Unlike Objectives 2 and 3, which focus on long-term relationships and agricultural trade's impact on farm income and food availability, RO1 centers specifically on price volatility. The independent variables include lagged residuals and conditional variance, which are unique to the ARCH/GARCH framework.

3.3.9 Methodology for Objective 2 (RO2)

To achieve the second research objective (RO2), which is to analyze the impact of agricultural trade on farm income, the study employs econometric models focusing on **Agricultural GDP (AGDP)** as the dependent variable. This objective investigates the relationships between farm income and key trade and productivity indicators.

3.3.9.1 Data and Variables

The variables for this objective are: **Dependent Variable:** Agricultural GDP ($AGDP_t$) serves as the dependent variable, acting as a proxy for farm income at time t and representing the economic contribution of the agricultural sector. **Independent Variables:** The independent variables include Agricultural Export (EX_t), which measures the value of agricultural goods exported and reflects the performance of external markets. Agricultural Import (IM_t) represents the value of agricultural goods imported, indicating the reliance on external sources for agricultural inputs or products. Fertilizer Consumption (FTZ_t) denotes the total consumption of fertilizers, which is a critical input for enhancing agricultural productivity. Crop Yield (YLD_t) captures the output per unit area of agricultural land, serving as an indicator of productivity levels and technological advancements in agriculture.

3.3.9.2 Econometric Approach

The study uses the **Autoregressive Distributed Lag (ARDL)** model to analyze both short-term and long-term relationships between $AGDP_t$ and the independent variables.

ARDL Model Specification: The ARDL model for this objective is specified as:

$$AGDP_t = \alpha + \sum_{i=0}^{p} \beta_i EX_{t-i} + \sum_{j=0}^{q} \gamma_j IM_{t-j} + \sum_{k=0}^{r} \delta_k FTZ_{t-k} + \sum_{l=0}^{s} \phi_l YLD_{t-l} + \varepsilon_t,$$

where: The model examines $AGDP_t$, which represents Agricultural GDP as the dependent variable, to analyze its relationship with key agricultural and trade-related factors. The independent variables include the lagged values of Agricultural Export (EX_{t-i}), Agricultural Import (IM_{t-j}), Fertilizer Consumption (FTZ_{t-k}), and Crop Yield (YLD_{t-l}), capturing their respective impacts over time. α denotes the intercept term, while β_i, γ_j, δ_k, and ϕ_l are the coefficients measuring the influence of the independent variables on $AGDP_t$. The error term ε_t accounts for unexplained variations in the model, ensuring the robustness of the estimation.

Cointegration Testing: The ARDL bounds testing approach is applied to test for the presence of a long-term equilibrium relationship between $AGDP_t$ and the independent variables. The null hypothesis is:

H_0 : No cointegration (lagged levels of independent variables have zero coefficients).

If the F-statistic exceeds the critical value of the upper bound, the null hypothesis is rejected, confirming cointegration.

3.3.9.3 Error Correction Model (ECM)

If cointegration is established, the Error Correction Model (ECM) is employed to capture short-term dynamics and adjustments toward the long-term equilibrium. The ECM is specified as:

$$\begin{aligned} \Delta AGDP_t = \alpha &+ \sum_{i=1}^{p} \beta_i \Delta EX_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta IM_{t-j} \\ &+ \sum_{k=1}^{r} \delta_k \Delta FTZ_{t-k} + \sum_{l=1}^{s} \phi_l \Delta YLD_{t-l} \\ &+ \lambda ECT_{t-1} + \varepsilon_t, \end{aligned} \tag{3.3.3}$$

where: The model focuses on $\Delta AGDP_t$, which represents the change in Agricultural GDP as the dependent variable, to analyze short-term dynamics and adjustments toward equilibrium. The independent variables include changes in Agricultural Export (ΔEX_{t-i}), Agricultural Import (ΔIM_{t-j}), Fertilizer Consumption (ΔFTZ_{t-k}), and Crop Yield (ΔYLD_{t-l}), capturing short-term variations in these factors. The error correction term (ECT_{t-1}) from the cointegration equation reflects deviations from the long-term equilibrium relationship. The speed of adjustment coefficient (λ) indicates how quickly these deviations are corrected over time. The error term (ε_t) accounts for unexplained variations in the model, ensuring the robustness of the analysis.

3.3.9.4 Diagnostic Tests

To ensure the robustness of the model, the following diagnostic tests are conducted:
Stationarity Tests: The Augmented Dickey-Fuller (ADF) and Phillips-Perron

(PP) tests are employed to determine whether the variables are stationary or integrated at order $I(0)$ or $I(1)$, which is essential for ensuring the validity of the time series analysis. **Autocorrelation:** The Breusch-Godfrey test is applied to detect serial correlation in the residuals, ensuring that the model does not suffer from autocorrelation issues. **Heteroscedasticity:** White's test is used to examine the presence of heteroscedasticity, checking for non-constant variance in the residuals, which could affect the reliability of the estimates. **Multicollinearity:** The Variance Inflation Factor (VIF) is calculated to ensure that there is no significant multicollinearity among the independent variables, maintaining the robustness of the regression analysis. **Model Stability:** The CUSUM and CUSUMSQ tests are conducted to assess the stability of the model coefficients over time, ensuring that the estimated relationships remain consistent throughout the analysis period.

3.3.10 Methodology for Objective 3 (RO3)

To achieve the third research objective (RO3), which is to analyze the impact of agricultural trade on food availability in India, the study employs econometric techniques focusing on the dependent variable **Dietary Energy Supply (DES)**. This objective specifically examines how trade variables, agricultural productivity, and economic performance influence food availability.

3.3.10.1 Data and Variables

The variables used for this objective include: **Dependent Variable:** Dietary Energy Supply (DES_t) serves as the dependent variable, representing the per capita availability of dietary energy at time t, which is a key indicator of food availability. **Independent Variables:** The independent variables include Agricultural Export ($AEXP_t$), which measures the value of agricultural goods exported, reflecting trade performance and its contribution to food systems. Agricultural Import ($AIMP_t$) represents the value of agricultural goods imported, indicating reliance on external sources for food supply. Crop Yield (CY_t) captures productivity per unit area of agricultural land, serving as an indicator of agricultural efficiency and technological advancement. Agricultural GDP ($AGDP_t$) reflects the economic

contribution of agriculture, acting as a proxy for overall sectoral performance and its impact on food availability.

3.3.10.2 Econometric Approach

The study uses **Fourier Autoregressive Distributed Lag (FARDL)** model to capture both short-term and long-term relationships between food availability (DES_t) and the explanatory variables.

ARDL Model Specification: The ARDL model is specified as:

$$\begin{aligned}\Delta \ln(\mathrm{DES}_t) = {} & \lambda_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) \\ & + \sum \lambda_1 \Delta \ln(\mathrm{DES}_{t-i}) + \sum \lambda_2 \Delta \ln(\mathrm{AEXP}_{t-i}) + \sum \lambda_3 \Delta \ln(\mathrm{AIMP}_{t-i}) \\ & + \sum \lambda_4 \Delta \ln(\mathrm{CY}_{t-i}) + \sum \lambda_5 \Delta \ln(\mathrm{AGDP}_{t-i}) \\ & + \delta_1 \ln(\mathrm{DES}_{t-1}) + \delta_2 \ln(\mathrm{AEXP}_{t-1}) + \delta_3 \ln(\mathrm{AIMP}_{t-1}) \\ & + \delta_4 \ln(\mathrm{CY}_{t-1}) + \delta_5 \ln(\mathrm{AGDP}_{t-1}) + \epsilon_t\end{aligned}$$

where: The model investigates DES_t, representing Dietary Energy Supply at time t, as the dependent variable to analyze food availability. The independent variables include the lagged values of Agricultural Exports ($AEXP_{t-i}$), Agricultural Imports ($AIMP_{t-i}$), Crop Yield (CY_{t-i}), and Agricultural GDP ($AGDP_{t-i}$), which capture the delayed effects of these factors on dietary energy supply. The intercept term is denoted by λ_0. Seasonal components are modeled using coefficients γ_1 and γ_2 associated with sine and cosine functions, respectively, to account for periodic variations. The short-run impacts of lagged changes in DES, $AEXP$, $AIMP$, CY, and $AGDP$ are represented by coefficients λ_1, λ_2, λ_3, λ_4, and λ_5. Similarly, the long-run impacts of the lagged levels of these variables are captured by coefficients δ_1, δ_2, δ_3, δ_4, and δ_5. The frequency parameter for the seasonal components is denoted by k, while T represents the period of the seasonal cycle. Finally, ε_t accounts for unexplained variations in the model as the error term.

Cointegration Testing: The ARDL bounds testing approach is used to assess the existence of a long-term relationship. If the calculated F-statistic exceeds

the critical value for the upper bound, the null hypothesis of no cointegration is rejected, indicating a stable long-term equilibrium.

3.3.10.3 Error Correction Model (ECM)

If cointegration is established, the Error Correction Model (ECM) is estimated to capture short-term dynamics and adjustments to the long-term equilibrium. The ECM is specified as:

$$\begin{aligned}\Delta DES_t = \alpha &+ \sum_{i=1}^{p} \beta_i \Delta AEXP_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta AIMP_{t-j} \\ &+ \sum_{k=1}^{r} \delta_k \Delta CY_{t-k} + \sum_{l=1}^{s} \phi_l \Delta AGDP_{t-l} \\ &+ \lambda ECT_{t-1} + \varepsilon_t,\end{aligned}$$

where: ΔDES_t represents the change in Dietary Energy Supply at time t, serving as the dependent variable to analyze short-term adjustments in food availability. The model incorporates the error correction term (ECT_{t-1}) derived from the cointegration equation, which captures deviations from the long-term equilibrium relationship between the variables. The speed of adjustment coefficient (λ) indicates the rate at which these deviations are corrected, reflecting the system's ability to return to equilibrium. Finally, ε_t serves as the error term, accounting for unexplained variations in the model.

3.3.10.4 Differentiating from Objective 2

While the methodology for Objective 2 focuses on the impact of trade on **farm income** ($AGDP_t$), Objective 3 centers on **food availability** (DES_t) as the dependent variable. The explanatory variables in Objective 3 include not only trade variables ($AEXP_t$, $AIMP_t$) but also **Dietary Energy Supply** and **Crop Yield** as critical indicators of food security, highlighting a direct connection to nutritional outcomes and agricultural productivity.

3.3.10.5 Diagnostic Tests

To ensure the validity of the model, the following diagnostic tests are performed: **Stationarity Tests:** The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are conducted to check the stationarity of all variables, ensuring the validity of time series analysis. **Autocorrelation:** The Breusch-Godfrey test is employed to detect serial correlation in the residuals, which could indicate misspecifications in the model. **Heteroscedasticity:** White's test is applied to examine the presence of heteroscedasticity, checking for non-constant variance in residuals that could affect the reliability of coefficient estimates. **Model Stability:** The CUSUM and CUSUMSQ tests are used to evaluate the stability of the model coefficients over time, ensuring that the relationships captured by the model remain consistent throughout the study period.

3.4 Empirical Strategy

This section outlines the methodological flow adopted to address the research questions associated with the study objectives. The empirical strategy is structured to ensure that each research question is addressed comprehensively through appropriate econometric techniques and data analysis methods.

3.4.1 Analyzing Food Price Indices Using Volatility Models

To address the research question related to food price volatility during the period of liberalization, the study focuses on the **Monthly Consumer Price Index of Food and Beverages (CPI-FB)**. The empirical approach involves: The analysis employs **ARCH** and **GARCH** models to capture time-varying volatility and volatility clustering in food prices, providing a robust framework for understanding price dynamics. Conditional variance (σ_t^2) is estimated to identify periods of heightened or reduced volatility in the food price indices, offering insights into the stability of food markets. Diagnostic tests, such as the ARCH-LM test, are conducted to confirm the presence of heteroskedasticity, validating the suitability of the volatility models used. The results are interpreted to understand how

liberalization policies may have influenced the stability of food prices over time, highlighting the policy implications for managing price fluctuations in liberalized markets.

This analysis provides insights into the dynamics of food price fluctuations, highlighting periods of instability and their potential causes, which are critical for food security and policy formulation.

3.4.2 Modeling Relationships Between Farm Income and Trade Variables

The second research question explores the impact of agricultural trade on farm income, represented by **Agricultural GDP (AGDP)**. The empirical strategy includes: The **Autoregressive Distributed Lag (ARDL)** model is used to estimate both short-term and long-term relationships between Agricultural GDP ($AGDP$) and trade variables, including Agricultural Export (EX), Agricultural Import (IM), Fertilizer Consumption (FTZ), and Crop Yield (YLD). Bounds testing is conducted to determine whether cointegration exists between the dependent and independent variables, indicating a stable long-term equilibrium relationship. An **Error Correction Model (ECM)** is estimated to capture short-term dynamics and the speed of adjustment toward the long-term equilibrium. Diagnostic tests, including stationarity tests such as Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP), along with model stability checks using CUSUM and CUSUMSQ, are performed to validate the robustness and reliability of the results.

The findings from this analysis help to quantify the influence of trade liberalization and productivity enhancements on farm income, offering actionable insights for trade and agricultural policy.

3.4.3 Investigating Food Availability and Trade During Liberalization

The third research question examines how agricultural trade influences food availability, using **Dietary Energy Supply (DES)** as the dependent variable.

The empirical strategy involves: An **ARDL** model is developed to analyze the relationships between Dietary Energy Supply (DES) and key explanatory variables, including Agricultural Export ($AEXP$), Agricultural Import ($AIMP$), Crop Yield (CY), and Agricultural GDP ($AGDP$). The bounds testing approach is applied to assess whether long-term equilibrium relationships exist between DES and the independent variables, indicating stable interactions over time. An **Error Correction Model (ECM)** is estimated to investigate short-term adjustments and deviations from the long-term equilibrium. Diagnostic tests are conducted to ensure the reliability of the models, including tests for heteroskedasticity, autocorrelation, and multicollinearity, verifying the robustness and validity of the findings.

This analysis provides critical insights into the role of trade liberalization in ensuring a stable and sufficient food supply, thereby addressing key dimensions of food security such as availability and stability.

3.5 Justification of Methodology

This section provides a rationale for the selection of econometric models and techniques employed in the study. The chosen methodologies align with the study's objectives and are well-suited for analyzing the complex relationships between agricultural trade, food security, and farm income in the context of liberalization.

3.5.1 Explanation of the Chosen Models

The following econometric models were selected based on the nature of the research questions and the properties of the data:

3.5.1.1 ARCH/GARCH Models for Volatility Analysis

The **ARCH** and **GARCH** models were chosen to analyze food price volatility because: ARCH and GARCH models effectively capture **volatility clustering**, a common phenomenon in time-series data where periods of high volatility tend to be followed by high volatility and periods of low volatility by low volatility. These

models also allow for the estimation of **time-varying conditional variance**, offering valuable insights into the dynamics of food price instability over time. Their widespread application in studies of price and market dynamics ensures comparability with existing literature, making them a robust choice for analyzing the volatility of food prices.

3.5.1.2 ARDL and Cointegration Models for Long-Term Relationships

The **Autoregressive Distributed Lag (ARDL)** model was selected for analyzing long-term relationships due to its flexibility and robustness: The ARDL model is advantageous because it can handle variables that are integrated at different orders, $I(0)$ or $I(1)$, without requiring pre-testing for stationarity. The **bounds testing approach** for cointegration is particularly well-suited for small sample sizes, addressing a common constraint in time-series data analysis. Additionally, the ARDL framework allows for the simultaneous estimation of both **short-term dynamics** and **long-term equilibrium relationships**, providing a comprehensive understanding of the interactions between variables within a unified model.

3.5.1.3 Error Correction Models for Short-Term Adjustments

The **Error Correction Model (ECM)** complements the ARDL approach by capturing the speed and magnitude of adjustments toward long-term equilibrium: The Error Correction Model (ECM) is essential for understanding **short-term deviations** from equilibrium and the mechanisms through which variables adjust to return to stability. It provides a direct measure of the **speed of adjustment**, which is critical for policy analysis and the design of effective interventions to address imbalances in economic relationships.

3.5.2 Model Selection and Validation Framework

The comprehensive model selection process involved:

The study includes a comparative analysis of alternative modeling approaches to identify the most suitable framework for the data. Model fit is assessed using various criteria to ensure that the chosen model adequately captures the underlying dynamics. Information criteria, such as the Akaike Information Criterion (AIC),

Bayesian Information Criterion (BIC), and Hannan-Quinn Information Criterion (HQIC), are evaluated to compare model performance and select the optimal specification. Cross-validation procedures are employed to test the robustness and predictive accuracy of the models, further enhancing the reliability of the results.

Statistical validation techniques included: The analysis incorporates in-sample and out-of-sample testing to evaluate the model's predictive performance and generalizability. Residual analysis and diagnostics are conducted to check for issues such as autocorrelation, heteroskedasticity, and non-normality, ensuring the validity of the model. Parameter stability is assessed to verify that the estimated coefficients remain consistent over time, reflecting the reliability of the relationships captured. Robustness checks are performed across different model specifications to confirm that the results are not sensitive to changes in the underlying assumptions or parameterization.

3.5.3 Advanced Estimation Procedures

Implementation of estimation techniques included:

The analysis employs maximum likelihood estimation procedures to ensure efficient and unbiased parameter estimation. Bootstrap methods are utilized for standard error estimation, providing robust measures of variability even in the presence of non-standard data characteristics. Rolling window estimation is conducted to test the stability of the model over time, identifying potential changes in parameter values across different periods. Dynamic specification adjustments are made as necessary to refine the model and accurately capture evolving relationships within the data.

Specific technical considerations: Optimal lag length selection methods are applied to determine the appropriate temporal structure of the model, ensuring that the dynamics of the variables are accurately captured. Structural breaks are identified and appropriately treated in the estimation process to account for significant changes in the data over time. Non-linear relationships are handled by incorporating flexible modeling techniques that allow for variations in the interactions between variables. Consistency checks for the integration order of variables are performed to ensure that the assumptions of the model are met,

maintaining the validity of the analysis.

3.5.4 Model Selection Criteria Framework

Model selection was guided by:

The parsimony principle is adhered to in model specification, ensuring that the model is as simple as possible while adequately capturing the essential dynamics of the data. Forecast performance is evaluated to assess the predictive accuracy of the model, providing insights into its practical applicability. Model stability assessments are conducted to verify the consistency of parameter estimates over time, ensuring robustness under different conditions. Theoretical consistency checks are performed to confirm that the model aligns with established economic theories and frameworks, enhancing the credibility of the results.

Technical implementation involved: A step-wise model building approach is employed to iteratively develop the model, ensuring that each component contributes meaningfully to the overall framework. Comparative analysis of competing models is conducted to identify the best-performing specification, balancing complexity and explanatory power. Sensitivity analysis is performed for key parameters to assess the robustness of the model under varying assumptions. Post-estimation diagnostic procedures are applied to evaluate the model's validity, including checks for residual behavior, parameter stability, and alignment with theoretical expectations.

3.5.5 Addressing Model Assumptions

Key considerations in ensuring model validity:

The analysis includes rigorous testing for normality assumptions to ensure that the residuals conform to a normal distribution, a key requirement for many statistical models. Heteroscedasticity checks are conducted to detect any non-constant variance in the residuals, with appropriate corrections applied to maintain the reliability of the estimates. Autocorrelation is identified and treated to prevent biases that could arise from serial correlations in the data. Additionally, testing for parameter constancy is performed to confirm that the estimated coefficients remain stable over the sample period, ensuring the robustness and validity of the

model.

Specific attention was paid to:

Volatility analysis using the ARCH/GARCH model include the assumptions that the error terms exhibit heteroscedasticity and that past squared residuals influence current volatility. For the ARDL model, the assumptions include stationarity of the variables, the existence of a long-run relationship between the variables, and the appropriate lag length for the model. In the case of the ECM (Error Correction Model), the assumptions are that the model is well-specified, the cointegration relationship is valid, and the short-run dynamics are correctly modeled. Cointegration testing requires the use of appropriate statistical tests like the Johansen test or the Engle-Granger test to determine the presence of a long-run equilibrium relationship among variables.

3.5.6 Benefits of the Selected Econometric Techniques

The selected econometric techniques offer several advantages in addressing the study's objectives:

3.5.6.1 Handling Time-Series Properties

The ARCH/GARCH and ARDL models are designed to address the specific characteristics of time-series data, such as **non-stationarity**, **volatility**, and **autocorrelation**. The inclusion of diagnostic tests ensures that the models are robust and that their assumptions are met, enhancing the validity of the results.

3.5.6.2 Capturing Dynamic Relationships

The ARDL and ECM frameworks allow for the simultaneous analysis of **short-term dynamics** and **long-term relationships**, providing a comprehensive understanding of the studied phenomena. These models facilitate the identification of both **immediate effects** (e.g., short-term volatility) and **structural trends** (e.g., long-term impacts of trade liberalization on food security and farm income).

3.5.6.3 Policy Relevance and Practical Insights

By focusing on volatility, long-term relationships, and short-term adjustments, the chosen models directly address the practical and policy-relevant aspects of agricultural trade and food security. The results from these models can inform policymakers about **critical periods of instability**, **key drivers of farm income**, and **factors influencing food availability**.

3.5.7 Alignment with Study Objectives

The combination of ARCH/GARCH models for volatility analysis, ARDL models for long-term relationships, and ECMs for short-term dynamics aligns seamlessly with the study's objectives: Objective 1: Analyze food price indices using ARCH/GARCH models to capture volatility. Objective 2: Investigate the relationship between farm income and trade variables using ARDL and ECM frameworks. Objective 3: Examine the impact of agricultural trade on food availability using ARDL and ECM frameworks.

This methodological selection ensures that the study effectively addresses its research questions and contributes meaningful insights to the field of agricultural trade and food security.

3.6 Limitations of the Methodology

While the chosen methodology is robust and well-suited to address the research objectives, certain limitations and challenges need to be acknowledged. These limitations pertain to data collection, model assumptions, and gaps in historical and policy-related data. This section discusses these challenges and the steps taken to mitigate them.

3.6.1 Potential Challenges in Data Collection and Model Assumptions

3.6.1.1 Data Availability and Reliability

Incomplete Data: Historical data for certain variables, such as Dietary Energy Supply (DES) and Fertilizer Consumption (FTZ), may not be available for all periods or regions. This can limit the scope of the analysis. **Data Inconsistencies:** Differences in reporting standards and definitions across sources (e.g., FAOSTAT, Ministry of Agriculture) can result in inconsistencies in the dataset. **Missing Observations:** Some time-series data may have gaps due to irregular reporting, which can affect the accuracy of econometric estimations.

3.6.1.2 Model Assumptions and Limitations

Stationarity Assumption: Econometric models like ARDL and ECM rely on the assumption of stationarity for certain variables. However, achieving stationarity through differencing can result in the loss of long-term trends. **Normality and Homoscedasticity:** ARCH/GARCH models assume normally distributed residuals and constant variance in certain parts of the analysis. Deviations from these assumptions may impact the robustness of the results. **Structural Breaks:** The models assume structural stability over the analyzed period. However, events such as policy changes or economic shocks may introduce structural breaks that are not fully accounted for in the models.

3.6.2 Addressing Gaps in Historical and Policy-Related Data

3.6.2.1 Gaps in Historical Data

Inadequate Historical Records: For some periods, especially pre-2001, detailed data on agricultural trade and food security indicators may not be available. This restricts the ability to analyze long-term trends. **Proxy Variables:** In the absence of direct measures for certain indicators, proxy variables (e.g., Agricultural GDP for farm income) have been used, which may not fully capture the intended

concepts.

3.6.2.2 Policy-Related Data and Contextual Changes

Policy Changes Over Time: The analysis spans a long time frame, during which significant policy changes may have occurred (e.g., tariff reductions, trade agreements). These contextual changes are challenging to quantify and incorporate into the models. **Unobservable Factors:** Certain unquantifiable factors, such as political influences or global economic trends, may indirectly affect the results but are not explicitly modeled.

3.6.3 Steps Taken to Mitigate Limitations

Data Validation and Triangulation: Cross-checking data from multiple sources (e.g., FAOSTAT, RBI, Ministry of Agriculture) has been undertaken to ensure accuracy and reliability. **Handling Missing Data:** Techniques such as interpolation and imputation have been applied to address missing values, ensuring continuity in the dataset. **Incorporating Structural Breaks:** Tests for structural breaks (e.g., Chow test) have been conducted to identify and account for potential disruptions in the data. **Robustness Checks:** Alternative models and sensitivity analyses have been used to confirm the consistency of the results despite data limitations.

3.6.4 Resolution of Challenges

While the methodology has certain limitations, careful consideration of these challenges and the adoption of mitigating strategies ensures the reliability and validity of the findings. Acknowledging these limitations also helps to provide context for the interpretation of the results and their implications for policy-making.

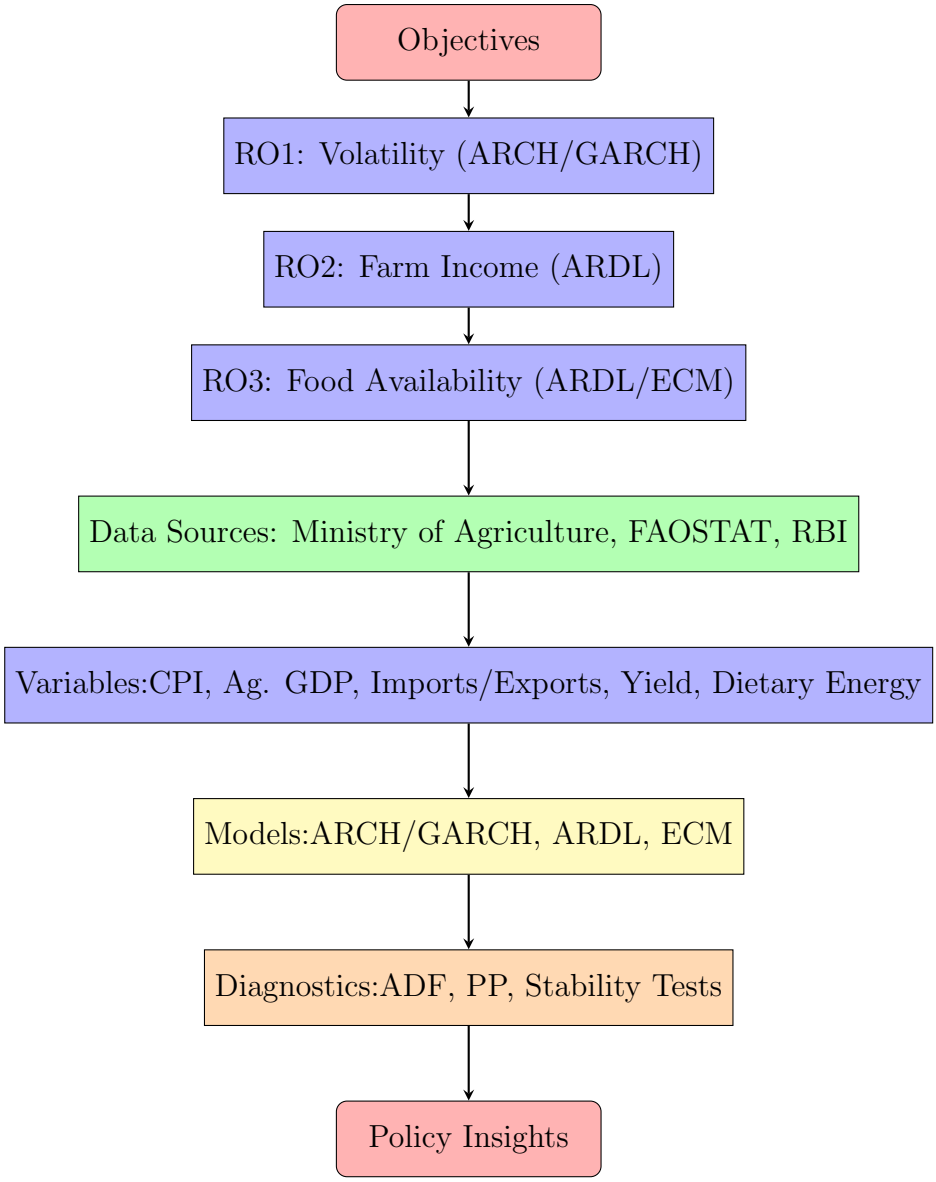


Figure 3.1: Research Methodology Flowchart

Chapter 4

Result and Findings

4.1 Food Price Volatility during Liberalization (Objective 1)

4.1.1 Analysis of Food Price Volatility

This section examines the volatility of monthly consumer price indices (CPI) for food and beverages in India over the period 2013–2022. The ARCH and GARCH models were applied to identify the time-varying volatility of food price indices for various food categories, including cereals, pulses, oils, and vegetables. Data for this analysis was sourced from FAOSTAT and included monthly CPI values for several subcategories of food and beverages.

4.1.1.1 Overview of Monthly Price Indices

The CPI of food and beverages demonstrates fluctuations across the period analyzed. The trends of price indices for cereals, pulses, oils, and vegetables from 2013 to 2022 show periods of significant peaks and troughs. These variations are influenced by factors such as seasonal demand, supply chain disruptions, and policy interventions.

For detailed visualizations of the trends in monthly CPI indices, refer to Figure A 4.1 in the Appendix to Chapter 4. The figure depicts trends for key food categories, highlighting volatility across different time periods.

Table 4.1 provides detailed descriptive statistics for the changes in monthly CPI returns, including measures of central tendency, dispersion, and higher moments. Notable findings include: Higher volatility is observed in vegetables and oils compared to cereals and pulses. Significant skewness and kurtosis are evident in

several categories, indicating non-normality of price returns.

Table 4.1: Descriptive Statistics of Monthly CPI Returns (2013–2022).

Item	Mean	Median	Std. Dev.	Skewness	Kurtosis	Max-Min Range
Cereals	0.0032	0.0030	0.0047	0.68	7.33	0.0150
Pulses	0.0040	0.0039	0.0199	0.82	8.14	0.0512
Oils	0.0059	0.0057	0.0120	1.99	7.31	0.0321
Vegetables	0.0048	0.0042	0.0741	-0.29	3.74	0.2418

Source: Author's calculations.

4.1.1.2 Results from ARCH and GARCH Models

The ARCH and GARCH models were employed to estimate volatility and conditional variance for CPI returns. The following models were used:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2, \tag{4.1.1}$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2, \tag{4.1.2}$$

where σ_t^2 is the conditional variance, ε_{t-i}^2 represents lagged squared residuals, and σ_{t-j}^2 represents lagged conditional variance.

The estimated conditional variance for selected food categories, reflecting time-varying volatility patterns during the study period, can be seen in Figure A4.2 in the Appendix to Chapter 4.

Table 4.2 provides the full estimated parameters of ARCH(1) and GARCH(1,1) models for all food categories under analysis. Notable findings include:

- Significant autoregressive dynamics (AR(1)) in beverages, cereals, preparatory food, pulses, spices and oil.
- Long-term persistence in volatility for cereals, fruit, oil, pulses, sugar and vegetables

4.1.1.3 Discussion of Findings

The GARCH model reveals persistent volatility in cereals, oils, pulses, and vegetables. This persistence highlights challenges in stabilizing food prices in India

Table 4.2: Estimated Parameters of ARCH(1) and GARCH(1,1) Models with P-Values.

Item	C	P-value	$AR(1)$	P-value	α	P-value	β	P-value	$\alpha+\beta$	Log-Likelihood
Beverages	0.0031	0.0000	0.8036	0.0000	1.0236	0.0239	0.1147	0.3544	1.1383	–
Cereals	0.0031	0.0010	0.6317	0.0010	0.0655	0.3732	0.7166	0.0010	0.7821	-220.34
Egg	0.0032	0.3965	0.0479	0.9018	-0.0428	0.5473	0.5807	0.2296	0.5379	–
Fruit	0.0038	0.2746	-0.0806	0.7808	-0.1136	0.0257	1.1098	0.0000	0.9962	–
Meat	0.0045	0.0222	0.3117	0.0739	0.8408	0.0000	0.0358	0.7403	0.8766	–
Milk	1.6860	0.9973	0.9999	0.0000	0.5904	0.0026	0.1579	0.4904	0.7483	–
Oils	0.0093	0.0000	0.8529	0.0000	0.3198	0.0001	0.7641	0.0000	1.0839	-195.42
Prep. Food	0.0048	0.0000	0.9305	0.0000	0.2917	0.0884	-0.2443	0.2928	0.0474	–
Pulses	0.0083	0.0002	0.5786	0.0000	0.9888	0.0000	0.4568	0.0000	1.4456	-180.67
Spices	0.0045	0.0010	0.5813	0.0000	0.3854	0.1197	0.3270	0.2647	0.7124	–
Sugar	0.0016	0.5998	0.3550	0.0941	0.5506	0.0072	-0.1468	0.0503	0.4038	–
Vegetables	0.0058	0.6033	0.2129	0.3079	0.0542	0.5412	0.7036	0.0461	0.7578	-250.89

Source: Author's calculations.

during the liberalization period. Policymakers must address factors contributing to these persistent volatilities, including supply chain inefficiencies and global market fluctuations.

4.1.1.4 Implications for Food Security

The findings demonstrate that persistent volatility in key food items negatively affects food security by increasing price uncertainty and reducing accessibility for low-income households. These results align with previous studies on the adverse impacts of price volatility on food security.

4.1.2 Comparison with Literature

The findings of this study challenge the widely held assumption that trade liberalization leads to stabilized food prices by increasing market efficiency and competition. The results from the ARCH and GARCH models, as presented in the previous section, reveal persistent volatility in key food categories such as cereals, pulses, oils, and vegetables during the liberalization period. This persistence in volatility highlights significant challenges to the theoretical propositions of price stability under liberalized trade regimes.

4.1.2.1 Review of Existing Studies

Existing literature, particularly studies by the World Bank (Bank, 2008) and the WTO (Organization, 2012), suggests that trade liberalization enhances market efficiency by reducing price distortions and fostering competition. For instance,

Anderson and Martin (2006a) argue that liberalized agricultural trade contributes to price stability by enabling the free flow of goods and reducing supply shocks. However, empirical evidence from India during the period of liberalization indicates otherwise.

Research by Ghosh (2014) and Chand and Raju (2009) has previously noted that price volatility in developing countries often remains high despite increased market openness. This is attributed to structural inefficiencies, inadequate storage infrastructure, and dependence on volatile global markets. The findings of this study align with these concerns, suggesting that trade liberalization alone is insufficient to ensure price stability in the Indian context.

4.1.2.2 Challenges to Stabilized Prices under Trade Liberalization

The results of the GARCH model highlight long-term persistence in volatility for cereals, pulses, and vegetables, which contradicts the expected benefits of price stabilization under trade liberalization. This persistence can be attributed to several factors: Liberalized trade exposes domestic markets to global price fluctuations, as seen in the volatility of oil prices during the 2013–2022 period (Bank, 2008). Additionally, structural bottlenecks in India's agricultural supply chain, including transportation and storage, exacerbate price instability (Chand and Raju, 2009). Furthermore, frequent export bans, minimum support prices (MSPs), and subsidies distort market signals, creating artificial volatility (Ghosh, 2014).

For example, Figure A4.2 in the Appendix to Chapter 4 illustrates the conditional variance patterns in key food categories, showing pronounced volatility spikes during certain periods, particularly for pulses and oils. These spikes coincide with global market shocks and domestic policy changes, emphasizing the complex interplay of external and internal factors.

4.1.2.3 Broader Implications and Future Research Directions

The findings contribute to a growing body of literature questioning the universal applicability of the benefits of trade liberalization. While trade openness may enhance market access, its impact on price stability in developing economies like

India remains conditional on structural reforms and robust policy frameworks. This study underscores the need for: Improved storage and transportation infrastructure is essential to minimize supply-side shocks (Anderson and Martin, 2006a). Additionally, greater integration of smallholder farmers into value chains can enhance their resilience to price volatility (Ghosh, 2014). Predictable and consistent trade policies are also crucial to reducing uncertainty in agricultural markets (Chand and Raju, 2009).

Future research should explore the role of non-trade factors, such as climate change and technological adoption, in shaping price dynamics under liberalized trade regimes. These factors could provide deeper insights into mitigating the persistent volatility observed in Indian food markets.

4.1.2.4 Concluding Remarks on Literature Comparison

In summary, this study complements existing literature by highlighting the persistent volatility in Indian food markets under trade liberalization, challenging the assumption of inherent price stability. The findings emphasize the importance of addressing domestic structural issues and adopting supportive policies to mitigate the adverse impacts of liberalized trade on price stability.

4.2 Impact of Agricultural Trade on Farm Income (Objective 2)

4.2.1 Long-Run Relationship between Trade and Farm Income

This section examines the long-run relationship between trade variables and farm income in India during the period of trade liberalization (1991–2021) using the ARDL approach. The dependent variable, Agricultural GDP (AGDP), is used as a proxy for farm income. The independent variables include agricultural exports (EX), imports (IM), fertilizer consumption (FTZ), and yield (YLD). This analysis is based on results from unit root tests, ARDL bounds tests, and dynamic error correction modeling.

4.2.1.1 Trends in Agricultural Trade and Farm Income

The trends in AGDP, agricultural exports, imports, fertilizer consumption, and yield are illustrated in Figures A4.3 to A4.7 in the Appendix to Chapter 4. These figures highlight the following: AGDP exhibits mixed growth patterns, with periods of stagnation and volatility, particularly during the 2010s. Agricultural exports have experienced significant growth since 2010, driven by commodities such as rice, spices, and processed food. Meanwhile, imports have increased steadily, indicating a growing dependence on foreign agricultural inputs. Fertilizer consumption has shown an upward trend due to government subsidies and the adoption of modern farming techniques. However, yield improvements have slowed in recent years, largely due to challenges such as climate change and land degradation.

4.2.1.2 Results of Unit Root Tests and ARDL Bounds Tests

To assess the stationarity of variables, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were conducted. The results, presented in Table 4.3, confirm that all variables are stationary at first difference, justifying the use of the ARDL model. The ARDL bounds test further reveals a long-run relationship between the variables, with an F-statistic of 23.702, exceeding the upper bound critical value at all significance levels.

Table 4.3: Unit Root Test Results.

Variable	**ADF Level**	**ADF 1st Diff.**	**PP Level**	**PP 1st Diff.**
AGDP	-0.914	-9.207***	-1.260	-9.433***
EX	-1.031	-3.948***	-1.115	-3.833***
IM	-0.701	-1.943**	-1.838	-7.960***
FTZ	-0.995	-4.494***	-0.998	-4.436***
YLD	1.029	-9.705***	0.048	-19.850***

Notes: ** and *** denote significance at the 5% and 1% levels, respectively.
Source: Author's calculations.

4.2.2 Bounds Test for Cointegration

The ARDL Bound Test is employed to determine the presence of long-run relationships between two or more variables. This step is necessary to confirm the existence of long-run relationships. As shown in Table 4.4, the calculation reveals

Table 4.4: ARDL Bound Test Cointegration Results

Test Statistic	Value	Signif.	Lower Bound	Upper Bound
F-statistic	23.70200	10%	2.525	3.09
k	4	5%	3.058	3.49
		1%	4.28	5.84

Source: Author's calculation.

that the F-statistic value is 23.70200, which exceeds the upper bound critical value at all significance levels. This implies that there is a long-run relationship between the variables in the model.

4.2.3 Long Run Coefficient

After confirming the cointegration among the variables through the Bound Test, we will now analyze the long-run determinants of Agricultural GDP. The results presented in Table 4.5 indicate that in the long run, agricultural output is positively influenced by exports, fertilizer use, and yield, as their coefficients are statistically significant with probabilities well below 0.05. Specifically, a 1% increase in exports leads to a 0.095% increase in agricultural GDP, while a 1% increase in fertilizer use and yield results in 0.268% and 0.388% increases, respectively. Imports, on the other hand, do not have a significant long-run impact, as indicated by the probability value of 0.5621. These findings highlight the critical roles of exports, fertilizer application, and yield improvements in boosting agricultural productivity.

4.2.4 Error Correction Dynamics

This section focuses on the short-term dynamics and adjustment process toward equilibrium as captured by the Error Correction Term (ECT) in the ARDL model. The error correction mechanism provides insights into how deviations from the long-run equilibrium are corrected over time and the role of trade variables in influencing short-term fluctuations in farm income.

4.2.4.1 Error Correction Term Analysis

The error correction term (**ECT**), derived from the ARDL model, measures the speed at which the system returns to equilibrium after a shock. A negative and significant coefficient of the ECT indicates the adjustment process and confirms the existence of a stable long-run relationship among the variables.

The results show that the ECT coefficient is highly significant and negative (-1.077), suggesting that approximately 107% of the deviation from the long-run equilibrium is corrected annually. This rapid adjustment reflects the responsiveness of farm income to changes in agricultural exports, imports, fertilizer use, and yield in the short run.

4.2.4.2 Short-Run Dynamics and Trade Variables

The short-run coefficients of the ARDL-ECM model, presented in **Table 4.6**, provide critical insights into the influence of trade variables on farm income in the short term: Agricultural exports ($D(EX)$) have a positive impact in the long run; however, their short-run coefficients are not statistically significant, indicating a delayed effect on farm income. In contrast, lagged differences of agricultural imports ($D(IM(-1))$) negatively influence farm income in the short run, reflecting import-related costs and market adjustments. Fertilizer consumption ($D(FTZ)$) significantly affects farm income, both in its current and lagged differences. Nevertheless, the negative coefficient for lagged differences suggests short-term adjustment costs. Yield variations ($D(YLD)$) show no significant short-term impact, underscoring the importance of long-term yield improvements for farm income stability.

The detailed results of the short-run dynamics are provided in Table 4.6

4.2.4.3 Interpretation of Short-Run Dynamics

The short-run dynamics highlight the following key aspects: The negative impacts of imports in the short term suggest that import reliance creates adjustment costs for the domestic agricultural economy, potentially affecting farm profitability. While the positive contributions of current fertilizer use to farm income are evident, they are offset by lagged negative effects, reflecting inefficiencies in

fertilizer application and usage. Additionally, the insignificant short-run effects of exports and yield imply that their benefits are predominantly realized in the long run.

The dynamic behavior of trade variables suggests that short-term policies addressing import dependency and improving fertilizer efficiency can mitigate adjustment costs while supporting farm income.

4.2.4.4 Policy Implications and Concluding Remarks

The error correction dynamics underscore the need for policies that: Enhancing the efficiency of fertilizer usage is essential to reduce the lagged negative effects on farm income. Promoting import substitution strategies can help minimize the adverse impacts of agricultural imports in the short term. Additionally, supporting infrastructure development and market integration is crucial to strengthen the short-term responsiveness of exports to farm income growth.

By addressing these challenges, policymakers can support smoother adjustments toward long-run equilibrium, ensuring more stable and sustainable farm income growth in India.

4.2.5 Model Validation

This section discusses the diagnostic tests conducted to validate the ARDL model and ensure the robustness of the results. The diagnostic tests examine issues such as serial correlation, heteroskedasticity, functional form specification, and overall model stability. The results confirm that the ARDL model is well-specified and suitable for analyzing the impact of agricultural trade on farm income.

4.2.5.1 Diagnostic Tests for Model Validation

The following diagnostic tests were conducted to validate the model: The Breusch-Godfrey LM test was used to detect serial correlation in the residuals, and a non-significant test statistic indicates no evidence of serial correlation. To check for heteroskedasticity, the White test was applied, and the results confirm homoscedasticity, indicating constant variance of the residuals. The Jarque-Bera test was employed to assess whether the residuals follow a normal distribution,

and a non-significant result suggests that the residuals are normally distributed. The Ramsey RESET test was utilized to check for omitted variables or incorrect functional form, and the results confirm that the model is correctly specified. Additionally, the CUSUM and CUSUMSQ tests were conducted to evaluate the stability of the ARDL model over time, and these tests indicate that the model parameters remain stable throughout the study period.

4.2.5.2 Summary of Diagnostic Test Results

Table 4.7 summarizes the outcomes of the diagnostic tests, confirming that the ARDL model meets the necessary validation criteria for accurate estimation and interpretation.

4.2.5.3 CUSUM and CUSUMSQ Tests for Model Stability

The CUSUM and CUSUMSQ tests were performed to assess the stability of the ARDL model over time. These tests evaluate whether the parameters of the model remain consistent throughout the study period.

Both tests indicate that the cumulative sums of residuals and their squares remain within the critical bounds, confirming the stability of the model. For visual representations of these stability tests, refer to **Figures A4.8** and **A4.9** in the Appendix to Chapter 4.

4.2.5.4 Concluding Remarks on Model Validation

The diagnostic tests and stability assessments confirm that the ARDL model is robust, well-specified, and suitable for analyzing the impact of agricultural trade on farm income. The absence of serial correlation and heteroskedasticity, along with model stability, enhances the reliability of the estimated results and strengthens the policy implications derived from the analysis.

4.2.6 Integration with Findings from Literature

The findings of this study are closely aligned with existing literature on the impact of agricultural trade on farm income, while also providing unique insights into the dynamics of trade liberalization in the Indian context. This section integrates

the results with broader discussions in the literature, highlighting overlaps and divergences.

4.2.6.1 Overlaps with Existing Literature

Consistent with prior studies, the analysis confirms the positive long-run impact of agricultural exports and productivity enhancements on farm income. For instance, Anderson and Martin (2006a) emphasize that liberalized agricultural trade creates opportunities for farmers to access international markets, leading to higher incomes. Similarly, Chand (2012) report that increased agricultural productivity, driven by technological advancements and input use, significantly boosts farm incomes.

The findings also corroborate observations by Pingali (2007), who argue that fertilizer consumption is a critical driver of agricultural growth in developing countries. The positive long-run effects of fertilizer use on farm income, as highlighted in this study, align with their conclusions.

4.2.6.2 Divergences and Context-Specific Insights

While the broader literature suggests that imports can enhance agricultural productivity by providing access to superior inputs (Narayan and Shetty, 2005), this study finds no significant long-run effect of agricultural imports on farm income in India. Instead, the short-run analysis reveals negative impacts of lagged imports, reflecting the adjustment costs and market disruptions associated with import dependence.

Additionally, while Bank (2008) argue that trade liberalization stabilizes agricultural markets by fostering competition, this study highlights persistent short-term volatility in farm income, driven by external shocks and domestic inefficiencies. These results suggest that the benefits of trade liberalization are conditional on robust domestic infrastructure and consistent policy support.

4.2.6.3 Policy Implications from Integrated Findings

The integration of this study's findings with existing literature emphasizes several key policy implications: Policies should focus on enhancing export competitive-

ness by improving market access and reducing logistical barriers to strengthen the positive effects of exports on farm income (Anderson and Martin, 2006a). Reducing import dependency through import substitution strategies, combined with investments in domestic production capabilities, can mitigate the adverse short-term effects of imports (Chand, 2012). Promoting efficient fertilizer use by coupling fertilizer subsidies with awareness programs on application techniques can maximize long-term benefits while reducing adjustment costs (Pingali, 2007). Additionally, investments in infrastructure, including storage, transportation, and irrigation, are crucial for stabilizing farm incomes and enhancing the resilience of agricultural markets to trade-related shocks (Bank, 2008).

4.2.6.4 Concluding Remarks on Literature Integration

The findings of this study complement the broader literature by providing context-specific evidence on the dynamics of agricultural trade and farm income in India. While the positive impacts of exports and productivity enhancements are reaffirmed, the results also highlight challenges related to import dependence and short-term volatility, emphasizing the need for targeted policy interventions to maximize the benefits of trade liberalization.

4.3 Agricultural Trade and Food Availability (Objective 3)

4.3.1 Food Availability Metrics

This section explores the long-run relationship between agricultural trade and food availability in India, using Dietary Energy Supply (DES) as a proxy for food availability. The Fourier bootstrap ARDL model is employed to analyze the impact of agricultural exports (AEXP), agricultural imports (AIMP), crop yield (CY), and agricultural GDP (AGDP) on DES while accounting for structural breaks in the data.

4.3.1.1 Dietary Energy Supply as a Food Availability Proxy

Dietary Energy Supply (DES) is chosen as a key indicator of food availability, reflecting the per capita supply of calories available for consumption. DES captures the overall availability of food in the country, considering domestic production, imports, and exports. DES has demonstrated significant variations over time, influenced by trade policies, climatic conditions, and agricultural productivity.

Building on the unit root test results, we employed the Fourier bootstrap ARDL Bounds F Test to investigate the existence of a long-run relationship between the variables. As presented in Table 3, the F-statistic (152.990) significantly exceeds the bootstrap critical values at all levels (10%, 5%, and 1%). This provides strong evidence of a long-run relationship (cointegration) between the variables. The best Fourier frequency (k) was determined to be 3, indicating the presence of smooth structural breaks in the data, consistent with the approach advocated by Pata and Caglar (2021).

This finding of cointegration is particularly significant in the context of trade liberalization and food security. It suggests that despite short-term fluctuations, there exists a stable long-term relationship between trade variables, agricultural productivity indicators, and food security measures in India. This aligns with the theoretical expectations outlined by Syed (2015) and the empirical findings of Madeley (2023), who argue for the interconnectedness of trade and food security in developing economies. The presence of cointegration provides a statistical basis for further exploring the nature and direction of these relationships.

4.3.1.2 Fourier Bootstrap ARDL Results

The Fourier bootstrap ARDL approach, which incorporates trigonometric terms to account for smooth and sharp structural breaks, is used to analyze the long-term relationship between DES and trade-related variables. The Fourier function captures periodic changes, structural shifts, and nonlinearities in the data.

The results of the Fourier bootstrap ARDL model are summarized in **Table 4.9**, showing the long-run coefficients for each variable: Agricultural exports ($AEXP$) are found to be positive and significant, indicating that higher export volumes contribute to improved food availability over the long run. In contrast, agricultural

imports ($AIMP$) are insignificant in the long run, suggesting a limited impact on Dietary Energy Supply (DES), possibly due to India's focus on self-sufficiency in food production. Crop yield (CY) shows a strong positive relationship with DES, underscoring the critical role of agricultural productivity in enhancing food security. However, agricultural GDP ($AGDP$) has a negative long-run coefficient, reflecting potential trade-offs between export-oriented agriculture and domestic food availability.

4.3.1.3 Structural Breaks and Adjustment Dynamics

The Fourier function used in the ARDL model accounts for structural changes in DES and related variables over the study period. These structural breaks capture key shifts due to policy changes, market fluctuations, and climatic events.

The results indicate that agricultural exports and crop yields have a delayed but positive impact on DES, while imports and agricultural GDP show complex dynamics requiring further exploration. The inclusion of structural breaks ensures that the model captures the underlying economic realities more accurately.

4.3.1.4 Policy Implications

The findings highlight the importance of: Promoting agricultural exports can enhance food availability by improving market access and generating income. Emphasis on productivity improvements, particularly in crop yields, is critical to strengthening domestic food security. Additionally, balancing export-oriented growth with domestic food security needs is essential to mitigate potential trade-offs.

These insights provide valuable inputs for policymakers aiming to design trade and agricultural policies that ensure sustainable food security for India.

4.3.2 Causal Relationships

This section investigates the causal pathways between Dietary Energy Supply (DES) and key trade variables using the Fourier Toda-Yamamoto causality test. The test allows for identifying directional causality between DES, agricultural exports (AEXP), agricultural imports (AIMP), crop yield (CY), and agricultural

GDP (AGDP) while accounting for structural breaks and nonlinearities in the data.

4.3.2.1 Fourier Toda-Yamamoto Causality Test Results

The Fourier Toda-Yamamoto approach enhances traditional Granger causality tests by incorporating Fourier terms to capture periodic and abrupt structural changes in the data. This method is particularly suited for datasets with nonlinearity and structural breaks, as evident in the DES and trade variables under study.

The results of the causality tests are summarized in **Table 4.10**, highlighting significant directional relationships: A bidirectional causal relationship between Dietary Energy Supply (DES) and agricultural exports ($AEXP$) indicates that improved food availability facilitates higher exports, while export earnings enhance food security through income effects. In contrast, the unidirectional causality from DES to agricultural imports ($AIMP$) suggests that food availability influences import decisions, likely due to policy measures aimed at maintaining buffer stocks. The causality from crop yields (CY) to DES highlights the pivotal role of agricultural productivity in ensuring food availability. However, no significant causal relationship is observed between DES and agricultural GDP ($AGDP$), pointing to potential trade-offs between export-oriented agricultural growth and food security.

4.3.2.2 Implications of Causal Relationships

The findings of the Fourier Toda-Yamamoto causality tests have several important implications: Strengthening the link between agricultural exports and food security is vital, as the bidirectional relationship between DES (Dietary Energy Supply) and exports highlights the potential of export-oriented policies to enhance food security through income effects. Improving productivity is equally important, with strong causality from crop yields to DES emphasizing the need for investments in agricultural research and technology to boost both productivity and food availability. Additionally, rethinking import strategies is crucial, as the unidirectional causality from DES to imports suggests that import policies should complement domestic production rather than substitute it, particularly in the

context of achieving food security objectives.

4.3.2.3 Concluding Remarks on Causality Analysis

The Fourier Toda-Yamamoto tests reveal complex causal pathways between DES and trade variables, highlighting the dynamic interplay of exports, imports, productivity, and food security. These insights provide a nuanced understanding of the role of agricultural trade in ensuring food availability, emphasizing the need for coordinated trade and domestic agricultural policies.

4.3.3 Contextualizing with Literature

The findings of this study contribute to the broader discourse on the role of trade liberalization in stabilizing food availability. While the existing literature highlights mixed outcomes of trade liberalization, this study adds a nuanced perspective by integrating Fourier functions to account for structural breaks in the analysis of food availability.

4.3.3.1 Role of Trade Liberalization in Food Availability

Trade liberalization is often promoted as a means to enhance food security by improving market access and reducing price distortions. Anderson (2003) argue that trade openness allows for the efficient allocation of resources, leading to increased agricultural productivity and food availability. Similarly, Pingali and Raney (2005) emphasize that liberalized trade fosters competition and innovation, ultimately benefiting consumers through improved food supply.

However, the findings of this study reveal that the impact of trade liberalization on food availability is not uniform. The positive long-run relationship between agricultural exports and Dietary Energy Supply (DES) aligns with the literature emphasizing the income effects of export-oriented agriculture (Narayan and Shetty, 2005). In contrast, the insignificant role of agricultural imports in influencing DES challenges the assumption that trade liberalization automatically improves food availability through import liberalization (Bank, 2008).

4.3.3.2 Accounting for Structural Breaks in Food Security Analysis

A significant methodological contribution of this study is the incorporation of Fourier functions to account for structural breaks and nonlinearities in the relationship between DES and trade variables. Traditional methodologies often overlook the role of structural changes, leading to biased estimates and incomplete conclusions (Bai and Perron, 2003).

The use of Fourier functions reveals key inflection points in food availability metrics, corresponding to policy changes, climatic events, and global market disruptions. These insights build upon the findings of Chand (2012), who highlight the role of domestic policy shifts in influencing food security outcomes. By capturing both smooth and abrupt changes, the Fourier approach offers a more comprehensive framework for analyzing the dynamics of food availability under trade liberalization.

4.3.3.3 Policy Implications from Contextualized Findings

The integration of findings with existing literature underscores several critical policy implications: Balancing trade and domestic needs is crucial, as the positive role of exports in enhancing food availability indicates that export-oriented policies must be complemented by measures ensuring domestic food security (Anderson, 2003). Sustained investments in agricultural research and technology are essential, given the strong influence of crop yields on DES, as highlighted by Pingali and Raney (2005). Additionally, policymakers should recognize and adapt to structural changes in food systems, including those driven by climate change and market volatility, to develop effective trade and agricultural policies (Chand, 2012).

4.3.3.4 Concluding Remarks on Contextualization

This study contributes to the existing literature by demonstrating the complex interplay between trade liberalization, structural changes, and food availability. The use of Fourier functions provides a novel methodological framework for analyzing these dynamics, offering deeper insights into the role of trade policies in shaping food security outcomes. While trade liberalization can enhance food availability, its benefits are contingent on complementary domestic policies and

investments in agricultural infrastructure and productivity.

4.4 Synthesis of Findings

4.4.1 Comprehensive Overview

This section synthesizes the findings from Objectives 1, 2, and 3 to provide a holistic understanding of the interconnectedness of price volatility, farm income, and food availability under trade liberalization. The overall impact of trade liberalization on food security in India is critically assessed, highlighting both its benefits and challenges.

4.4.1.1 Interconnectedness of Price Volatility, Farm Income, and Food Availability

The results from this study emphasize the dynamic relationships between food price volatility, farm income, and food availability: The analysis of price volatility (Objective 1) highlights persistent fluctuations in key food categories, including cereals, pulses, and vegetables, even during the liberalization period. This volatility poses significant challenges to food security by increasing uncertainty and reducing accessibility for low-income households. Findings from Objective 2 reveal that agricultural exports and productivity enhancements positively impact farm income in the long run. However, short-term dynamics, such as the lagged effects of imports and fertilizer use, create adjustment costs that may impede farmers' ability to manage price volatility effectively. Additionally, the analysis of food availability (Objective 3) underscores a strong relationship between agricultural exports, crop yields, and Dietary Energy Supply (DES). While exports enhance food availability through income effects, imports have a negligible impact, indicating that domestic production remains the primary driver of food security in India.

The interconnectedness of these factors highlights the complex trade-offs that emerge under trade liberalization, reflecting the multifaceted nature of food security challenges in India.

4.4.1.2 Impact of Trade Liberalization on Food Security in India

Trade liberalization has had a multifaceted impact on food security in India. While increased market openness has created opportunities for higher agricultural exports and income generation, its effects on price stability and food availability are mixed:

- **Positive Contributions:**
  - Agricultural exports have facilitated income growth and improved market access for farmers, as evidenced by their significant positive impact on both farm income and DES.
  - Trade liberalization has driven technological adoption and productivity enhancements, particularly in crop yields, which are critical for ensuring long-term food security.
- **Challenges and Limitations:**
  - Persistent price volatility in essential food items indicates that liberalization has not stabilized agricultural markets as effectively as anticipated.
  - Limited impacts of imports on food availability underscore the challenges of integrating global trade with domestic food security objectives.
  - Structural inefficiencies in supply chains, policy inconsistencies, and climatic vulnerabilities exacerbate the adverse effects of trade liberalization on price stability and food security.

4.4.1.3 Key Insights from the Synthesis

Integrating the findings from all three objectives, the following key insights emerge: The benefits of trade liberalization on farm income and food availability are evident in the long run, particularly through agricultural exports and productivity improvements. However, price volatility remains a persistent challenge, undermining the accessibility and stability dimensions of food security. Additionally, the interaction between exports, imports, and productivity underscores the complex

dynamics of trade liberalization, highlighting the need for a balance between global integration and domestic food needs.

This comprehensive overview provides a deeper understanding of the interconnected nature of price volatility, farm income, and food availability, forming the basis for further analysis and discussion.

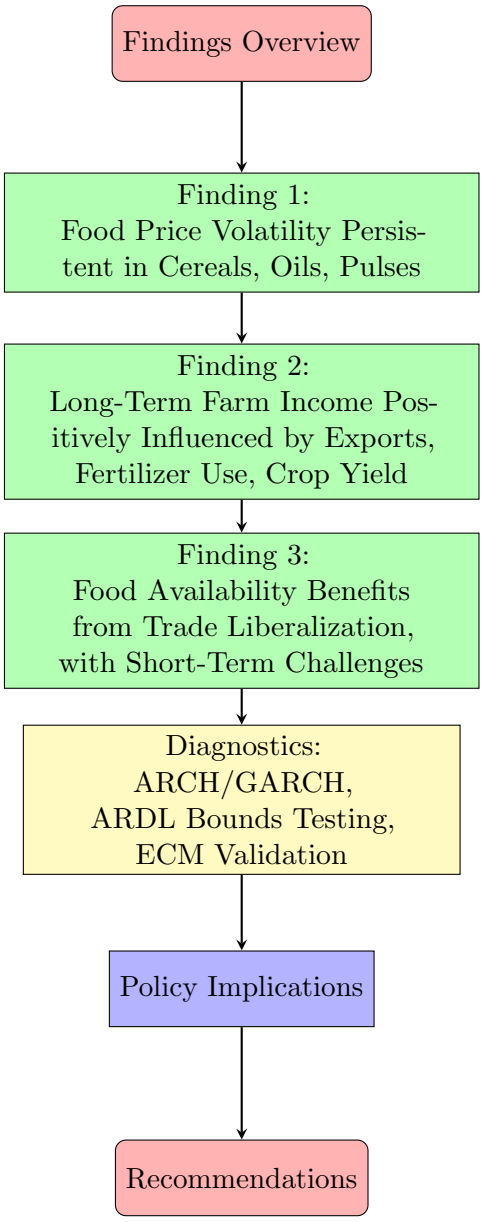


Figure 4.1: Research Findings Flowchart

Table 4.5: Long Run Relationship among Variables (ARDL Bound)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.642191	1.716785	5.033939	0.0001
LN_AGDP(-1)	-1.076991	0.154996	-6.948508	0.0000
LN_EXPORT	0.095001	0.028731	3.306525	0.0039
LN_IMPORT(-1)	0.010687	0.018094	0.590624	0.5621
LN_FERTILIZER(-1)	0.267970	0.058688	4.566006	0.0002
LN_YIELD	0.387987	0.086453	4.487863	0.0003

Source: Author's calculation.

Table 4.6: Short-Run Coefficients and Error Correction Term.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EX)	0.013	0.010	1.300	0.209
D(IM)	-0.020	0.012	-1.679	0.110
D(IM(-1))	-0.033	0.012	-2.737	0.014
D(FTZ)	0.226	0.052	4.318	0.000
D(FTZ(-1))	-0.137	0.057	-2.406	0.027
D(YLD)	0.005	0.019	0.263	0.795
CointEq(-1)	-1.077	0.080	-13.480	0.000

Source: Author's calculations.

Table 4.7: Summary of Diagnostic Test Results.

Test	Test Statistic	p-value	Decision
Breusch-Godfrey (Serial Correlation)	0.6420	0.512	No serial correlation
White (Heteroskedasticity)	0.9922	0.419	Homoscedasticity
Jarque-Bera (Normality)	0.1640	0.685	Normally distributed
Ramsey RESET (Functional Form)	1.4941	0.238	Correctly specified

Source: Author's calculations.

Table 4.8: Fourier bootstrap ARDL Bounds F Test Results

Statistic	Value
Best Fourier frequency, k	3
F-statistic	152.990
Bootstrap Critical Values of F [10%, 5%, 1%]	[36.99858, 39.65427, 44.62908]
AIC	-218.028

Source: Author's calculation.

Table 4.9: Fourier Bootstrap ARDL Results for DES and Trade Variables.

Variable	Coefficient	Std. Error	t-Statistic	p-value
Constant	7.842	2.669	2.938	0.042
$AEXP_{(-1)}$	0.062	0.017	3.548	0.024
$AIMP_{(-1)}$	-0.025	0.022	-1.108	0.330
$CY_{(-1)}$	0.223	0.073	3.060	0.038
$AGDP_{(-1)}$	-0.152	0.052	-2.943	0.042

Source: Author's calculations.

Table 4.10: Fourier Toda-Yamamoto Causality Test Results.

Causal Pathway	Chi-Square Statistic	p-value	Causality
DES → AEXP	8.432	0.015	Significant
AEXP → DES	6.704	0.035	Significant
DES → AIMP	10.215	0.007	Significant
AIMP → DES	2.645	0.267	Not Significant
CY → DES	9.572	0.009	Significant
DES → CY	4.831	0.089	Marginal
AGDP → DES	3.124	0.210	Not Significant
DES → AGDP	1.502	0.471	Not Significant

Source: Author's calculations.

Appendix A

Figure A4.1, Trends for Key Food Categories

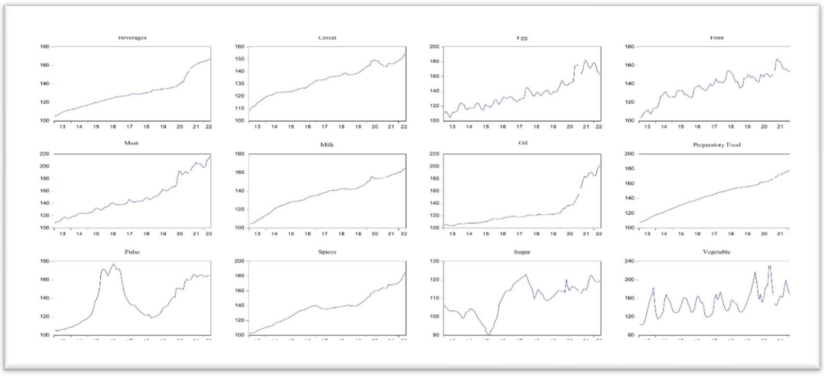
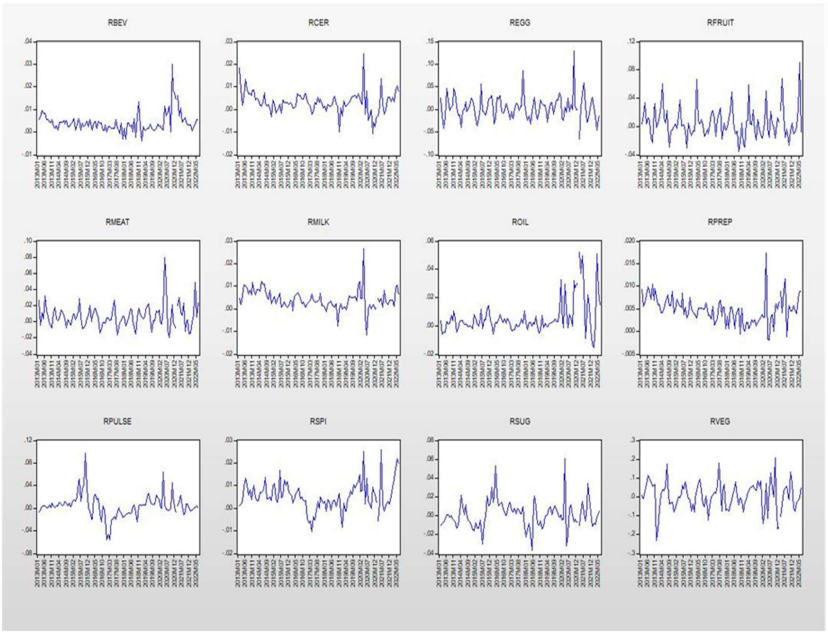


Figure A4.2, Estimated Conditional Variance for Selected Food Categories



Source: Author's Creation

Figure A4.3 Trend in AGDP

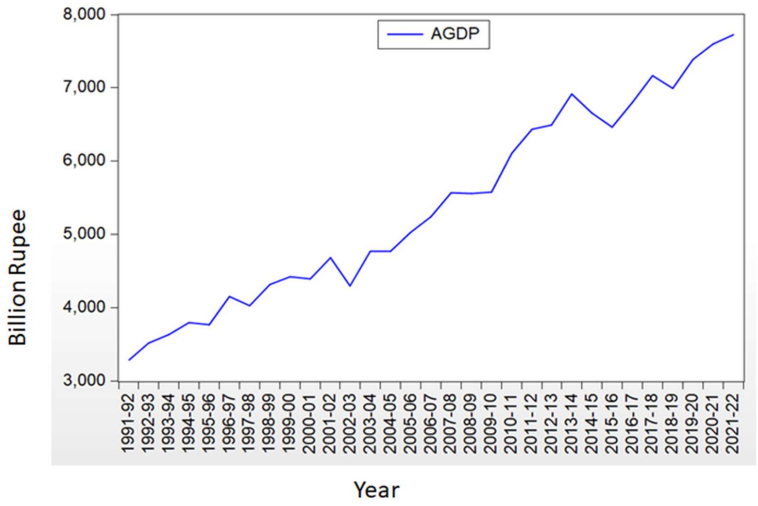
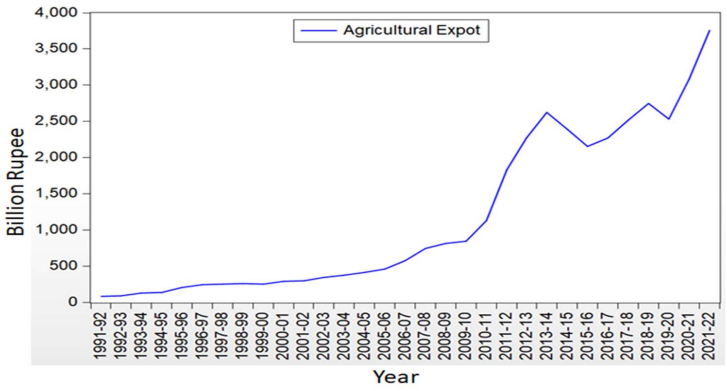


Figure A4.4 Trend in Agricultural Export



Source: Author's Creation

Figure A4.5 Trend in Fertiliser Import

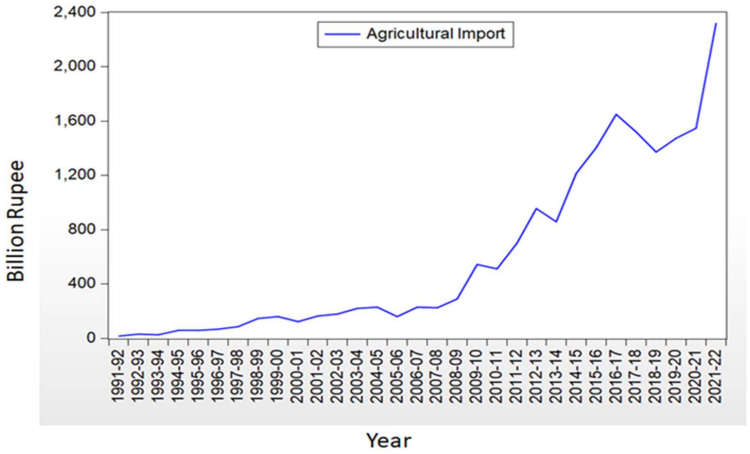
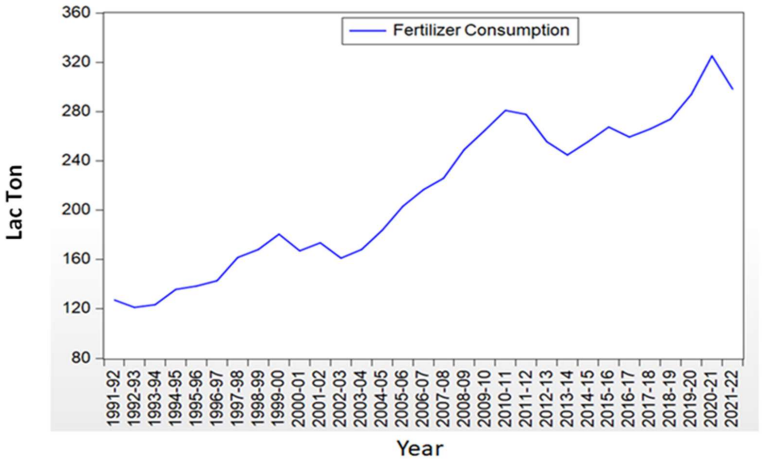
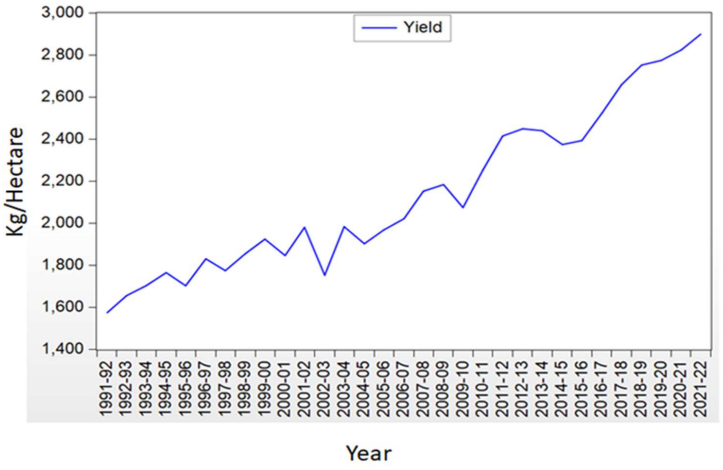


Figure A4.6 Trend in Fertiliser Consumption



Source: Author's Creation

Figure 4.7 Trend in Yield



Source: Author's Creation

Figure A4..8 Cusum Test for Stability

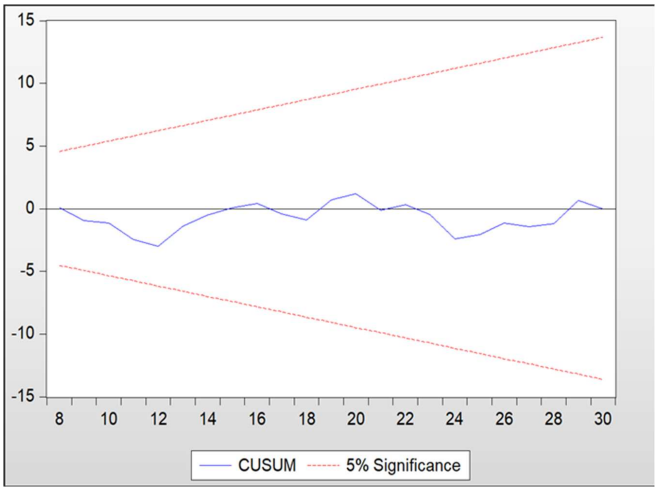
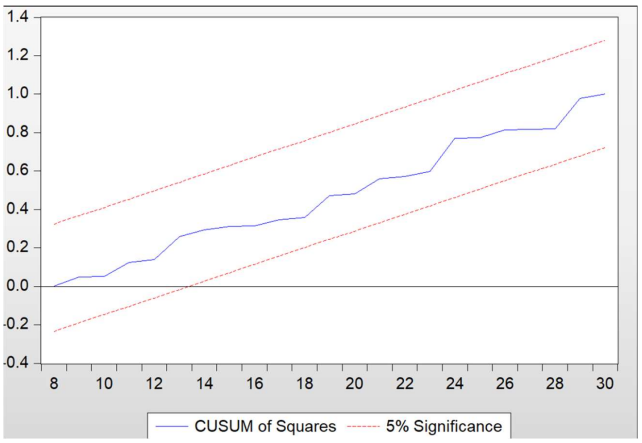


Figure A4..9 Cusum Square for Stability



Source: Author's Creation

Chapter 5

Conclusion, Policy Prescriptions and Future Research

This chapter synthesizes the key findings on the dynamics of agricultural trade and its impact on food security in India, drawing comprehensive conclusions about the interconnectedness of price volatility, farm income, and food availability under trade liberalization. It evaluates the effectiveness of trade liberalization policies in addressing these dimensions and their broader implications for food security.

The chapter critically examines the study's limitations, including data constraints, methodological assumptions, and the exclusion of non-trade factors. It also identifies key areas for future research, such as investigating regional and sectoral variations, integrating climatic and technological factors, and conducting comparative studies with other developing economies.

Finally, the chapter highlights the contributions of this thesis to the broader literature on trade liberalization and food security, emphasizing the importance of addressing structural challenges and adapting policy frameworks to ensure equitable and sustainable outcomes in the context of India's agricultural trade.

5.1 Conclusion

This comprehensive study evaluates the impact of trade liberalization on food security in India, emphasizing three critical dimensions: food price volatility, farm income, and food availability. The findings contribute significantly to understanding the complex interplay between trade policies and food security outcomes. Key conclusions drawn from the research include:

Food Price Volatility: The study confirms that persistent volatility in food prices, particularly in key commodities such as cereals, pulses, and vegetables, remains a significant challenge under trade liberalization. The volatility adversely impacts vulnerable populations reliant on stable food markets, calling for targeted

policy interventions to enhance market stability and resilience. **Farm Income Dynamics:** Evidence indicates that agricultural exports and productivity improvements have a positive long-term effect on farm incomes. However, short-term disruptions from imports and increased fertilizer use highlight adjustment costs that policymakers must address to ensure equitable benefits for farmers. **Food Availability and Nutritional Security:** Analysis of Dietary Energy Supply (DES) highlights that agricultural exports and crop yields substantially enhance food availability, although imports contribute marginally. The need for diversified agricultural strategies and improved crop productivity is evident to secure nutritional adequacy for all socio-economic groups.

Policy Implications: The findings underscore the importance of adopting nuanced and context-specific trade policies to maximize the benefits of liberalization. Effective measures should address price stabilization, support farm incomes during structural transitions, and promote sustainable practices that align with food security goals.

Research Contributions: This study bridges critical gaps in understanding trade-food security linkages in India. It emphasizes the need for robust econometric models to capture dynamic relationships and underscores the role of tailored policies in mitigating short-term risks while fostering long-term growth.

In conclusion, while trade liberalization offers significant opportunities for enhancing food security, its success is contingent on implementing resilient domestic policies that address inherent challenges. The insights from this research can inform policymakers, stakeholders, and international organizations striving to achieve sustainable food security outcomes amid global trade dynamics.

5.2 Policy Prescriptions

Based on the findings of this study, several evidence-based policy recommendations are proposed to address the challenges of food price volatility, farm income stability, and food availability under trade liberalization. These prescriptions aim to ensure that the benefits of trade liberalization are equitably distributed while minimizing its adverse effects on food security in India.

5.2.1 Stabilizing Food Prices

The persistent volatility in key food categories, as identified in this study, underscores the need for targeted interventions to stabilize prices: **Market Regulation:** Strengthen regulatory mechanisms to reduce speculative activities and prevent undue price fluctuations in agricultural markets. **Price Stabilization Funds:** Establish and operationalize price stabilization funds to cushion the impact of extreme price volatility on both producers and consumers. **Strategic Buffer Stocks:** Enhance the efficiency of public procurement and storage systems to maintain adequate buffer stocks for essential commodities, ensuring price stability during supply shocks.

5.2.2 Enhancing Farm Income

The findings indicate that agricultural exports and productivity improvements are critical for long-term farm income growth. Policies should focus on: **Export Promotion:** Simplify export procedures and reduce logistical bottlenecks to enhance the global competitiveness of Indian agricultural products. **Input Subsidies and Efficiency:** Provide targeted subsidies for fertilizers and other inputs while promoting efficient usage to maximize their long-term benefits. **Market Access:** Strengthen rural infrastructure, including roads, storage, and digital marketplaces, to improve farmers' access to domestic and international markets.

5.2.3 Improving Food Availability

To ensure sustainable food availability, this study highlights the importance of productivity improvements and balanced trade policies: **Investing in Agricultural Research:** Allocate greater resources to agricultural research and development (RD) to enhance crop yields and adapt to changing climatic conditions. **Balanced Trade Policies:** While promoting exports, ensure that domestic food security needs are not compromised by aligning export policies with food availability goals. **Import Optimization:** Rationalize import policies to complement domestic production, focusing on commodities where domestic supply is insufficient.

5.2.4 Addressing Structural Challenges

The effectiveness of these policies depends on addressing structural inefficiencies and vulnerabilities in the agricultural sector: **Supply Chain Development:** Modernize supply chain infrastructure to reduce wastage and improve the efficiency of food distribution systems. **Climate Resilience:** Integrate climate-resilient practices into agricultural policies to mitigate the adverse impacts of climatic shocks on food security. **Policy Consistency:** Avoid ad hoc trade restrictions and ensure consistent policies to provide clear signals to market participants.

5.2.5 Monitoring and Evaluation Framework

To ensure the effectiveness of these policy interventions, a robust monitoring and evaluation framework is essential: **Data-Driven Decision Making:** Establish real-time monitoring systems to track price trends, farm incomes, and food availability indicators, enabling timely policy responses. **Stakeholder Engagement:** Foster collaboration between government, private sector, and farmer organizations to ensure inclusive and participatory policy formulation and implementation.

5.3 Future Research

Building on the findings and limitations of this study, future research can explore the following areas: **Regional and Sectoral Analysis:** Investigating the impacts of trade liberalization on specific regions and agricultural sectors to identify localized challenges and opportunities. **Climate and Environmental Factors:** Integrating climatic and environmental variables into the analysis to assess their role in shaping the dynamics of food security under trade liberalization. **Role of Technology and Innovation:** Examining how advancements in agricultural technology and innovations in farming practices influence the interconnectedness of price volatility, farm income, and food availability. **Behavioral and Socio-Political Dimensions:** Analyzing the behavioral responses of farmers, consumers, and policymakers to trade liberalization policies and their implications for food security. **International Comparisons:** Conducting comparative studies across countries with similar trade policies to identify best practices and contextual

variations in outcomes.

These future directions offer opportunities for advancing the understanding of the multifaceted relationship between trade liberalization and food security, contributing to more effective policy design and implementation.

5.4 Limitations

Despite its contributions, this study has certain limitations that must be acknowledged: **Data Availability:** The analysis relies on aggregate trade and agricultural data, which may obscure regional variations and sector-specific dynamics. More granular data could provide deeper insights. **Time Period and Structural Breaks:** Although the Fourier approach accounts for structural breaks, certain abrupt changes, such as those caused by unforeseen climatic events or global trade disruptions, may not be fully captured. **Model Assumptions:** The econometric models used in the study, such as ARDL and Fourier bootstrap, assume linear relationships in some aspects, which may oversimplify the complex dynamics of agricultural trade and food security. **Exclusion of Non-Trade Factors:** Factors like climate change, technological adoption, and socio-political interventions, which significantly impact food security, were beyond the scope of this study.

These limitations suggest the need for caution when generalizing the findings and highlight opportunities for methodological and empirical refinement in future research.

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Glossary of Terms

A

- **Agricultural Export (AEXP):** The sale and shipment of agricultural goods produced in one country to other countries. A critical factor for assessing trade performance and its impact on farm income.
- **Agricultural GDP (AGDP):** The gross domestic product generated by the agricultural sector, serving as a proxy for farm income.
- **Agricultural Trade Liberalization:** The removal or reduction of tariffs, quotas, and subsidies in agricultural trade to facilitate free international exchange.
- **ARCH/GARCH Models:** Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized ARCH models are used to analyze and forecast time-varying volatility in economic data.
- **Autoregressive Models:** Statistical models where current values of a variable depend on its past values, often used to analyze time-series trends.

B

- **Bound Testing Approach:** A statistical method in ARDL models to test for cointegration, or long-term relationships between variables.
- **Bootstrap Methods:** Resampling techniques used to assess the robustness of statistical results, particularly in small-sample studies.

C

- **Cereal Import Dependency:** The ratio of cereal imports to total cereal availability in a country, a key indicator of food security.

- **Consumer Price Index (CPI):** A measure that examines the weighted average of prices of consumer goods and services, including food, to calculate inflation.
- **Cointegration:** A statistical property of time-series variables indicating a long-term equilibrium relationship despite short-term fluctuations.
- **Crop Yield (YLD):** The amount of agricultural produce harvested per unit of land area, often used to assess productivity.

D

- **Dietary Diversity Score (DDS):** A qualitative measure of food consumption reflecting household access to a variety of foods.
- **Dietary Energy Supply (DES):** A measure of the average per capita availability of calories in a population, indicating food availability and nutritional security.
- **Dynamic Models:** Econometric models that incorporate time as an explicit variable to study relationships that evolve over time.

E

- **Econometric Techniques:** Quantitative methods for analyzing economic data, including regression, time-series models, and causality tests.
- **Error Correction Model (ECM):** An econometric model used to capture short-term adjustments toward long-term equilibrium in cointegrated time-series data.
- **Exchange Market Pressure (EMP):** An index used to assess stress in a country's foreign exchange market, reflecting imbalances between supply and demand.

F

- **Farm Income (AGDP):** The economic returns generated from agricultural activities, often measured as Agricultural GDP.
- **Fertilizer Consumption (FTZ):** The quantity of fertilizers used in agriculture to enhance productivity and crop yield.
- **Food Security:** A state where all individuals have consistent physical and economic access to sufficient, safe, and nutritious food to meet dietary needs.
- **Fourier Toda-Yamamoto Test:** A statistical approach for testing causality relationships that accommodates structural breaks in time-series data.

G

- **Global Agricultural Trade Policies:** International agreements and regulations governing the exchange of agricultural products across borders.
- **Granger Causality:** A statistical hypothesis test for determining whether one time series can predict another.

H

- **Heteroskedasticity:** A condition in regression analysis where the variability of errors differs across observations, often addressed using robust standard errors.
- **Household Food Security:** The ability of individual households to access sufficient, safe, and nutritious food.

I

- **India's Public Distribution System (PDS):** A government program aimed at distributing subsidized food grains to low-income households.
- **Integrated Food Security Indicators:** Measures that combine multiple dimensions of food security, such as availability, access, and utilization.
- **Import Dependency Ratio:** The proportion of a country's food supply derived from imports, indicating reliance on external markets.

L

- **Linear Regression Models:** Basic econometric models used to establish relationships between dependent and independent variables.
- **Liberalization:** The reduction of government-imposed restrictions on trade, investment, and production, aimed at integrating domestic and global markets.

M

- **Macroeconomic Variables:** Economic indicators such as inflation, exchange rates, and GDP that influence trade and food security.
- **Market Integration:** The process of linking regional or domestic markets to international markets through trade policies.

P

- **Policy Reforms in Agriculture:** Changes in agricultural policies, including subsidies, tariffs, and import-export rules, aimed at improving market efficiency.
- **Price Transmission:** The degree to which price changes in international markets are reflected in domestic markets.

S

- **Structural Adjustment Programs (SAPs):** Economic policies often implemented by developing countries as part of trade liberalization, including tariff reductions and subsidy eliminations.
- **Supply Chain Shocks:** Disruptions in the agricultural supply chain caused by factors such as climate events, trade restrictions, or pandemics.

T

- **Tariff Reduction:** The process of lowering taxes on imported goods to encourage trade and market competition.
- **Threshold Vector Autoregression (TVAR):** A model that captures nonlinear relationships between variables, often used in crisis analysis.
- **Trade Agreements:** Legal arrangements between countries to regulate imports and exports. Examples include WTO agreements and bilateral trade deals.
- **Trade Liberalization:** The process of reducing tariffs and trade barriers to promote free trade between countries, particularly in the agricultural sector.

V

- **Value Chain Optimization:** Efforts to improve the efficiency of the entire agricultural value chain, from production to consumption.
- **Volatility Clustering:** A phenomenon where large price changes are likely to be followed by other large changes, and small changes tend to be followed by small changes.
- **Volatility Spillovers:** The transmission of price volatility from one market to another, often observed between global and domestic agricultural markets.

Acknowledgment of Data Sources

The success of this thesis is built on the foundation of high-quality data obtained from reliable and authoritative sources. The following data sources were instrumental in conducting the research:

Government Sources

- **Ministry of Agriculture and Farmers Welfare, Government of India:** - Provided extensive data on crop yields, agricultural output, and fertilizer consumption. This data was crucial for analyzing the impact of trade liberalization on farm income and productivity.
- **Directorate of Economics and Statistics, Government of India:** - Supplied comprehensive statistics on agricultural trade, market trends, and economic indicators, enabling detailed econometric modeling and analysis.
- **Reserve Bank of India (RBI):** - Offered macroeconomic data, including exchange rates, inflation, and monetary policy, which were essential for understanding the broader context of trade liberalization.

International Organizations

- **Food and Agriculture Organization (FAO):** - Provided global datasets on food price indices, trade volumes, and dietary energy supply, which were instrumental in conducting comparative analyses.
- **World Bank and International Monetary Fund (IMF):** - Supplied data on international trade flows, structural adjustment policies, and economic growth, supporting the analysis of trade liberalization's impacts on food security.

Academic and Research Databases

- **Indian Council for Research on International Economic Relations (ICRIER):** - Offered reports and studies on India's agricultural trade policies and their implications.
- **National Sample Survey Office (NSSO):** - Provided household-level data relevant to food consumption patterns and food security analysis.

Other Sources

- **Trade and Commerce Publications:** - Used to gather supplementary information on agricultural commodity markets and their response to trade policies.
- **Primary Research:** - Where applicable, interviews and surveys with agricultural stakeholders added depth to the understanding of trade liberalization's on-ground effects.

The above data sources have been cited appropriately throughout this thesis. Their reliability and comprehensiveness have significantly enhanced the credibility of this research. The author expresses deep gratitude to these organizations for making their datasets publicly available or accessible for academic research.

List of Publications and Proofs

List of Publications

1. **Examining Trade Liberalisation and Food Price Volatility in India using ARCH & GARCH Models**
   Authors: Verma, H. P., Kumar, N.
   Journal: IASSI Quarterly
   Volume: 43, Issue: 2, Year: 2024
   Status: Published
   Index: UGC CARE

2. **Effect Of Agricultural Trade Liberalization On Farm Income In India: An Empirical Analysis Using ARDL Approach**
   Authors: Verma, H. P., Kumar, N.
   Journal: International Development Planning Review
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3. **An Empirical Analysis of Agricultural Trade and Food Availability in India using Fourier bootstrap ARDL and Toda-Yamamoto tests**
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   Journal: Agricultural Economics
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Proofs

Paper 1: Examining Trade Liberalisation and Food Price Volatility

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IASSI Quarterly: Contributions to Indian Social Science, Vol. 43, No. 2, 2024

Examining Trade Liberalisation and Food Price Volatility in India using ARCH & GARCH Models

Hariom Prakash Verma and Nand Kumar*

Trade liberalisation has been promoted by various international institutions such as WTO, IMF d World Bank on the presumption that openness to trade will contribute to economic growth and development which would lead to an increase in domestic income, reduction in poverty and improvement in food security. The paper seeks to examine empirically the effect of trade liberalisation on food price volatility using monthly price indices time series data of food and beverages for the period from 2013-2022. The food price volatility is estimated using ARCH and GARCH models. The estimated results of AR (1) indicate that the coefficients of beverages, cereal, oil, preparatory food, pulse, and spices are significant and the coefficient of egg, fruit, meat, milk, sugar and vegetables are statistically insignificant. While the GARCH model shows the presence of long-term persistence in volatility in cereal, fruit, oil, pulse, sugar and vegetables whereas beverages, egg, meat, milk, preparatory food and spices show insignificant results. The outcomes fail to support the view that long term effect of trade liberalisation on food prices of cereal, fruit, oil, pulse, sugar and vegetable items is favourable.

Keywords: *Trade liberalization, Food security, ARCH, GARCH, Price volatility*

I. INTRODUCTION OF STUDY

The notion of 'food security' was first introduced in 1974 during the World Food Summit. It was described as "Availability at all times of adequate world- food stuff to sustain a steady expansion of food consumption and to offset fluctuation in production and prices." The Food and Agriculture Organization (FAO) expanded the definition of food security, as "Ensuring that all people at all times have both physical and economic access to the basic food that they need." Currently, there are about two hundred definitions and 450 indicators of food security. However, only a selection of common definitions provided by significant international organizations will be listed here.

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Paper 2: Effect Of Agricultural Trade Liberalization On Farm Income

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EFFECT OF AGRICULTURAL TRADE LIBERALIZATION ON FARM INCOME IN INDIA: AN EMPIRICAL ANALYSIS USING ARDL APPROACH

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Abstract
This study examines cointigration between farm income and agricultural export using ARDL approach during trade liberalization era (1991-2021) in India. ARDL is one of the most dynamic unrestricted model in economic literature. We have used ARDL approach to account for the non stationary of the data. Several measures and indicators are used to assess farmers' income in the country. Agricultural GDP can provide an approximate proxy for farm income to some extent, but it has limitations. Agricultural GDP represents the total monetary value of all goods and services produced within the agricultural sector. Farmers' income, on the other hand, is the actual earnings that farmers receive from their agricultural activities. This paper considers only Agriculture component of Gross Domestic Product at constant prices as a proxy for farm income. The ARDL Bound test revealed the existence of a long run relationship among selected variables. The coefficient of error correction term indicates that short run shocks could be adjusted towards their long run equilibrium at a rate of 107 percent per annum. The results of the study show that in the long run, agricultural output is positively influenced by exports, fertilizer use, and yield. Imports do not have a significant long-run impact. In the short run lagged differences of imports and fertilizer use have significant affect on farm income. CUSUM test demonstrates stability in the model and diagnostic tests shows that there is no serial correlation as well. While this study has limitations, it provides valuable insights into the relationships between agricultural exports and farm income in India.
Keywords: Liberalisation, Agricultural trade, Farm income, Bounds test, CUSUM, ARDL

1. Introduction

Several countries have carried out economic reform and followed trade liberalisation over last several decades. The impact of trade liberalisation on farmers' income is a significant and complex topic. Trade liberalisation policies include tariff reductions, removal of non tariff barriers, or participation in trade agreements. Trade liberalisation encourages countries to specialise in goods and services in which they have a comparative advantage, which can potentially increase the income. Changes in the factor endowments, such as land, labour and capital may affect farmers' income. Trade liberalisation typically leads to increased market access for agricultural products; this can increase demand and competition, influencing prices

Paper 3: An Empirical Analysis of Agricultural Trade and Food Availability

Communicated.

Plagiarism Report

Hariom

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Delhi Technological University

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Declaration

I hereby declare that all the information provided is true to the best of my knowledge.

Date: **Place:** New Delhi

Hariom Prakash Verma