Beyond the Farm Gate: A CGE Analysis of India's Agriculture-Industry-Trade Linkages

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Abstract

This study applies a Computable General Equilibrium (CGE) model to examine the macro-economic effects of agri-food policy intervention strategies in India, specifically with respect to crop diversification, agro-processing, and exports. Three different simulation analyses are carried out for the country: (i) productivity-driven crop diversification with export focus, (ii) promotion of exports of processed foods through increased productivity in processing and decreased trade costs, and (iii) a combined policy approach with upstream, downstream policies, and fiscal expansion with no effects on prices and employment. Simulation outcome indicates that there exist varying degrees of effects, and these include: crop diversification with positive effects of +0.8%, +0.6%, and +1.5% in real GDP, household consumption, and agricultural exports, respectively, with minimal spillovers outside the agricultural sector. Agro-processing for exports has further strengthened the effects and outcomes, with positive effects of +2.1%, +1.7%, and +5.2% in industry, services, and exports of processed foods, respectively. The combined policies provide balanced and largest effects of +2.6%, +6.8%, and +2.0% in real GDP, total exports, and household consumption, with expansion in the agriculture, industry, and services sectors, without affecting prices and employment opportunities. The analysis provides quantitative support for India's policy related schemes like millet missions, PM Kisan SAMPADA Yojana and agri-export clusters, offering policy-relevant insights for agrarian economies seeking sustainable and export-led growth.

Introduction

Agricultural systems around the world have become more susceptible to the increasing volatility associated with climate change, which has caused an increase in the number of extreme weather events, including droughts, floods, and extreme temperatures. As a result, agriculture experiences negative distortions in supply, leading to disruptions in production, and increased variability in agricultural product prices; this is especially true in poorer countries where agriculture continues to be an important source of employment and income (Costinot, Donaldson, & Smith, 2016; Sheng et al., 2025). Under these types of conditions, countries that continue to rely on a relatively small number of staple crops expose themselves to very large potential welfare losses; consequently, there is a need for structural changes in agri-food systems and a diversification of agri-food systems - both economically and structurally - for improved resilience of agricultural sectors. The concept of structural transformation, through the identification and realization of comparative advantages, productivity improvements and the movement of resources between sectors, results in long-term economic growth for those sectors (Helpman, Melitz, & Yeaple, 2004). According to traditional trade and structural change theories, reallocating resources from low-productivity agriculture into sectors with a higher-productivity sector, including manufacturing and services, will help increase welfare, particularly where there is an expansion of backward and forward linkages in value chains (Melitz, 2003; Burstein, Eichenbaum, & Rebelo, 2005). Therefore, when considering agriculture, it is essential not only to transfer resources from agricultural activities, but also to establish linkages and synergies between agriculture and its processing and trading systems, thereby providing agriculture the opportunity to benefit from economies of scale and differentiated product markets.

An example of this integration is agro-processing. The addition of value to primary agricultural products creates additional tradability for the product, creates opportunities for structural transformation and creates additional opportunities for export. Being part of a global Agrifood value chain provides access to foreign markets, diversification of product options and a greater variety in dietary intake; all three of which have empirical evidence of being linked to improved food security and nutrition outcomes (OECD-FAO, 2025). These benefits will not occur without trade-related policy interventions that provide a balance among food security; sustainable environmental practices; and industrial competitiveness (OECD, 2025).

India is an example of the connectedness of these trends where the nation's agriculture accounts for about 16% of GDP, which has been driven by values and behind/value-added sectors (horticulture, aquaculture and livestock) growing increasingly rapidly. This is evident by the growth of aquaculture at 8.7% (CAGR) and livestock at 8% between 2000-2018, indicating a shift towards more diversified/value-added agricultural production. The production of food grains from 1970-2019 has also increased dramatically from 108.4 million metric tons to 353.96 million tons through 137.29 million hectares. Major states contributing to this are Uttar Pradesh, Madhya Pradesh and Punjab, which produce significant amounts of food grain in India. The increase in production has improved the amount of food grains available to people, increasing per capita food grain consumption from 171.1 kg/year in 1970-71 to 207.6 kg/year in 2023-24. Additionally, the growth of infrastructure related to storage and logistics has contributed to this growth of the food grain market. Cold storage capacity in India is currently at 39,710,000 tons and total storage capacity has increased from 46,155,000 tons in 2022 to 79,799,000 tons in 2024.Economic geography and trade cost theory suggest that such investments reduce effective trade frictions and post-harvest losses, enabling agricultural surplus to be effectively transformed into processed, tradable goods and strengthening backward and forward linkages in the value chain (Melitz, 2003; OECD, 2025).

Traditionally, a major thrust in Indian agricultural policy has traditionally been for staple commodities like rice and wheat through minimum support prices and procurement. Even though this policy regime has enabled food security, it led to a scenario where production became localized and put a strain on natural resources. Recently, there has been a policy thrust towards Right Shift into coarse cereals, pulses, oilseeds, and horticultural commodities, keenly aligning with comparative advantage in a climate variable scenario and enabling structural fetching. Structural adjustment in agriculture has led to enhancement in total factor productivity, aligning with relative geographical and temporal comparative advantages and appropriate adoption and transformation (Frontier Research on China's Agricultural Structural Adjustments, 2025). Digital and techno-environment enhancement further enhances productivity and fetches structural fetching in agri-food systems. Simultaneously, simultaneously, side-by-side policies enabled India to take a sharp leap towards processed foods, leveraging a vehicle for industrial growth and execution for export expansion and employment diversification. This is perfectly dovetailed to enable a sharp spurt in agricultural exports, with export values increasing to US$ 35.1 billion during 2023–24 from US$ 23.7 billion in 2019–20. The trade theory of heterogeneous firms and global value chains suggest that through enhanced integration, countries will have the opportunity to benefit from both specialization and diversified exports, contingent on the productivity levels of firms as well as scale economies (Helpman et al., 2004; Melitz, 2003). Although India has invested heavily in diversifying their economy, storage capacity and agro-processing infrastructure, and developing a trade partnership, little to no work has been done on the aggregate economic impact of these investments on the country. Diversifying crops changes how resources are used; the increase in demand for primary goods through agro-processing increases demand for inputs; and increased trade partnerships will change relative prices and welfare levels among various groups and industries within the country. Using a partial equilibrium framework to analyze the entire economy is too limited to reflect the cumulative interrelationships and economic impacts of multiple intervention strategies, such as food security, climate resiliency and industrial transformation, on both the macroeconomic level and households.

Recent studies clearly illustrate the necessity to analyze the interdependencies and tradeoffs associated with these interventions through the use of economy-wide models.

In this context, Computable General Equilibrium (CGE) models offer a suitable analytical framework, as they simultaneously account for intersectoral linkages, factor mobility, household behaviour, and trade flows within a consistent macroeconomic structure. This study contributes to the literature by employing a CGE approach to investigate the trade-agriculture-industry nexus in India, with particular emphasis on how rising agricultural output, expanded storage infrastructure, and processing-led export promotion interact to shape food security, structural transformation, and economic growth under ongoing climate and market pressures.

Literature Review

2.1 Trade and Agriculture (Agricultural trade liberalization, Price transmission and Welfare effects)

The relationship between international trade and agriculture has long been central to debates on food security, rural livelihoods and economic development. Early scholarship emphasized how agricultural trade influences resource allocation, price formation and environmental outcomes, particularly in economies where agriculture plays a dominant role (Koo & Kennedy, 2005). Trade liberalization in agriculture has been viewed both as a mechanism for enhancing efficiency and export competitiveness and as a source of vulnerability due to exposure to global price volatility and uneven distributional impacts.

A significant strand of literature focuses on the case for freer trade in agriculture and its potential welfare gains. Parikh et al. (2013) argue that agricultural trade liberalization can improve global food availability and efficiency by aligning production with comparative advantage, especially when combined with technological progress and investment in productivity-enhancing infrastructure. However, they caution that adjustment costs can be substantial for smallholders and net food-importing regions, underscoring the importance of complementary domestic policies. This perspective aligns with broader structural transformation theories, where trade acts as a catalyst for reallocating resources toward more productive activities while reshaping agricultural production systems. More recent studies have advanced empirical methods to examine agricultural trade patterns and policy regimes. Kim and Steinbach (2023), using a structural gravity framework combined with machine learning techniques, provide new insights into preferential trading arrangements in agriculture. Their findings suggest that agricultural trade remains highly sensitive to policy preferences and institutional arrangements, often deviating from predictions of frictionless trade models. This reinforces the argument that agriculture is distinct from other tradable sectors due to persistent policy interventions, non-tariff barriers, and food security concerns. Another emerging strand of literature emphasizes the interaction between trade, agriculture, and nutrition outcomes. Alta et al. (2023) highlight how trade and agricultural policies can unintentionally create barriers to healthier diets by influencing relative prices, availability, and consumption patterns of food. Similarly, Johnson et al. (2023) demonstrate that trade policy decisions, when aligned with nutrition and food security objectives, can strengthen dietary diversity and resilience, particularly in developing countries. These studies expand the traditional trade–welfare framework by incorporating health and nutrition dimensions into agricultural trade analysis. The role of foreign direct investment (FDI) in agriculture has also gained attention in recent research. Badu-Prah et al. (2023) show that trade openness and FDI inflows can positively influence agricultural output and productivity in developing countries by facilitating technology transfer, capital formation, and access to global value chains. However, the benefits are contingent on institutional quality and the capacity of domestic agriculture to integrate with industrial and processing sectors. This highlights the importance of backward and forward linkages between agriculture, industry, and trade.

Climate change and environmental sustainability have increasingly shaped contemporary discussions on agricultural trade. Anderson (2022) argues that trade-related food policies have become more complex in a context of heightened climate variability and geopolitical uncertainty. Export restrictions, stockholding and trade distortions, while often implemented to stabilize domestic markets, can exacerbate global price volatility and undermine collective food security. Raihan et al. (2024) further extend this analysis by examining the interlinkages between agriculture, international trade, renewable energy use and environmental sustainability in India, finding that trade-driven growth can have mixed environmental effects unless accompanied by green energy transitions and sustainable agricultural practices. India-specific studies provide important insights into the trade–agriculture nexus in a large agrarian economy. Sharma (2025) documents the evolving agricultural trade regime in India, highlighting challenges arising from multilateral trade stalemates, increasing use of non-tariff measures, and tensions between domestic policy objectives and international trade commitments. Complementing this, Tantri (2023) emphasizes the role of trade facilitation and regulatory reforms in enhancing India's agricultural export performance, particularly for select high-value commodities. Charishma and Singh (2024) empirically analyze agriculture's contribution to India's export basket, noting a gradual shift from primary commodities to processed and value-added products.

2.2 Crop Diversification and Structural Change (Diversification as risk management, Climate resilience and Income stabilization)

Crop diversification has long been recognised as a critical mechanism linking agricultural transformation with broader processes of structural change and economic development. From a structuralist and evolutionary economics perspective, diversification reflects the reallocation of resources from low-productivity activities to higher-value and more knowledge-intensive ones, thereby enhancing productivity, resilience, and income growth (Saviotti et al., 2020). In agriculture, diversification away from traditional staples towards high-value crops, livestock, and agro-processing-oriented crops is viewed as a key pathway through which the sector integrates with industry and trade, reinforcing economy-wide structural transformation.

Theoretical contributions emphasise that diversification is both an outcome and a driver of structural change. Saviotti et al. (2020) argue that diversification expands the economic opportunity set by increasing variety in production and consumption, enabling economies to better adapt to demand shifts and technological change. Applied to agriculture, this implies a transition from subsistence-oriented monocropping to commercially oriented, diversified systems that are more responsive to domestic and global markets. Such transitions are particularly relevant in developing economies, where agriculture remains a major employer but faces declining relative productivity.

Empirical literature highlights multiple dimensions of crop diversification, including intercropping, crop rotation, mixed farming systems, and shifts towards high-value crops. Hufnagel et al. (2020), in a comprehensive review, demonstrate that crop diversification improves agro-ecological sustainability, reduces production risk, and stabilises farm incomes, while also generating positive spillovers for resource use efficiency. These findings support the argument that diversification contributes not only to micro-level resilience but also to macro-level structural stability, an aspect often incorporated in economy-wide modelling frameworks such as CGE models.

In the Indian context, crop diversification has been closely linked to regional patterns of agricultural growth and structural change. Early studies by Joshi et al. (2006) highlight the role of diversification towards fruits, vegetables, and livestock products in accelerating agricultural growth and enhancing farmers' income, particularly in states with better market access and infrastructure. Subsequent regional analyses confirm substantial inter-state variation in diversification patterns, reflecting differences in agro-climatic conditions, policy incentives, and access to markets (Nagpure et al., 2017; Pandey & Kumari, 2021).

Recent evidence further strengthens this linkage. Gupta and Kannan (2024), using state-level panel data, show that crop diversification has a statistically significant and positive association with agricultural growth in India, particularly in states undergoing faster structural transformation. Their findings suggest that diversification complements industrial and service sector growth by releasing surplus labour and stimulating demand for downstream processing and logistics services. Similarly, Deogharia (2020) observes that diversification improves growth performance across major crops by enabling more efficient allocation of land and inputs, thereby supporting long-term structural change in Indian agriculture.

The interaction between agricultural diversification and industrial growth has also been emphasised in broader development literature. Krishna (2001) notes that diversification in primary sectors creates demand linkages with industry through input use, processing, and marketing, reinforcing cumulative growth processes. In this sense, crop diversification serves as a critical conduit through which agriculture integrates with industry and trade, a relationship that is central to economy-wide analytical frameworks.

2.3 Agro-Processing and Value Chains (Forward linkages, Industrial policy and Export competitiveness)

Agro-processing plays a central role at the intersection of agriculture and industry by converting primary agricultural outputs into value-added products and linking farmers to domestic and global markets. From the perspective of structural transformation, the expansion of agro-processing marks a critical step in the transition from a predominantly agrarian economy toward a more industrialised and trade-oriented growth path (Johnston & Mellor, 1961; Timmer, 1988; Wilkinson & Rocha, 2008). Early theoretical and empirical work emphasises agro-processing as a key channel through which productivity gains in agriculture are transmitted to industrial growth, employment generation, and export diversification (Chengappa, 2004; Wilkinson & Rocha, 2008). Global evidence shows that the growth of agro-processing has been driven by rising urban demand, changing food consumption patterns, technological progress, and deeper integration into global value chains. The sector strengthens backward linkages by increasing demand for agricultural raw materials, inputs, and logistics, while also reinforcing forward linkages through processing, packaging, marketing, and trade. These interconnected relationships generate multiplier effects across the economy an essential mechanism captured within general equilibrium frameworks analysing agriculture-industry interactions. Value chain approaches offer further insight into these dynamics. Studies by Paremoer (2018) and Dube et al. (2018) demonstrate how agro-processing facilitates regional and national value chain integration by coordinating production, processing, and distribution among multiple actors. These findings align with new structural economics, which highlights agro-industrial upgrading as a pathway for exploiting latent comparative advantage and fostering industrial deepening. Singh et al. (2025) show that investments in agro-processing and effective value chain governance enhance price realisation for farmers, reduce post-harvest losses, and support sustainable intensification. Similarly, Attahiru (2025) underscores the role of agro-processing in reshaping rural development routes by connecting agriculture with industrial policy, digital finance and improved market access. Despite being one of the world's largest producers of agricultural commodities, India's share of processed output remains relatively low, pointing to substantial untapped potential (Kachru, 2010; Bathla & Kannan, 2021). Bathla and Jha (2020) further showed that India's integration into global value chains remains concentrated in low value-added segments, with limited participation in higher stages of processing, branding and industrialisation which weakens the transmission of agricultural growth to industrial expansion and export competitiveness. Satyasai and Singh (2021) highlight the uneven regional distribution of food processing industries and entrust the role of farmer producer organisations (FPOs) in strengthening farm and industry linkages. Venkatesh (2021) and Dhiman and Sharma (2023) note that small-scale and informal agro-based industries contribute significantly to rural employment but faces persistent constraints related to technology adoption, access to finance and market integration. From a theoretical standpoint, agro-processing embodies Hirschman's linkage effects and Kaldorian cumulative causation, whereby industrial expansion stimulates agricultural demand and productivity, reinforcing a virtuous cycle of growth. While existing studies provide valuable sectoral and value-chain-level insights, most rely on partial equilibrium or descriptive approaches. As a result, the economy-wide implications of agro-processing expansion such as effects on labour markets, household welfare, land use and trade balances remain inadequately explored. This study addresses this gap by employing a Computable General Equilibrium (CGE) model to jointly analyse agriculture, industry and trade by which it offers new insights into resource reallocation, inter-sectoral linkages, welfare outcomes and pathways for agri-led industrial and export-oriented growth.

3. Methodology

3.1 Model Framework

This study employs a single-country, static Computable General Equilibrium (CGE) model calibrated to a recent Social Accounting Matrix (SAM) for India which captures the interlinkages between agriculture, agro-processing, manufacturing, services, factor markets, institutions and trade that enables economy-wide assessment of stated problems. The CGE framework is grounded in neoclassical general equilibrium theory, where producers maximize profits, households maximize utility and all commodity and factor markets clear simultaneously.

Production in each activity is represented using a nested constant elasticity of substitution (CES) structure, combining primary factors (labour, capital, and land) and intermediate inputs. Output is allocated between domestic and export markets through a Constant Elasticity of Transformation (CET) function, while domestic demand is met through a CES Armington specification that differentiates between imported and domestically produced goods. This structure is particularly suitable for analysing trade policy and export promotion in an open economy such as India.

3.2 Data and Model Implementation

The model is implemented using GAMS IDE version 23.5 (Windows environment) where the SAM is organized into three linked modules: (i) a base model file (defining equations and parameters), (ii) a calibration module (benchmark equilibrium values), and (iii) a simulation module (policy shocks). Model reliability and solvability were verified by ensuring exact replication of the benchmark equilibrium prior to simulations.

The sectoral classification explicitly distinguishes crops (including millets, pulses, oilseeds and other crops), livestock, food processing, manufacturing and services, allowing targeted policy interventions along the agricultural value chain. Labor is disaggregated into eight categories by skill (uneducated, primary, secondary, tertiary) and location (rural and urban), enabling distributional analysis of employment effects.

3.3 Macroeconomic Closure Rules

The choice of macroeconomic closures reflects medium-run conditions in the Indian economy, where capital is mobile (sector) and public finances are policy-driven. The closures adopted are as follows:

- Numeraire: The Consumer Price Index (CPI) is fixed as the numeraire, while the domestic price index adjusts endogenously. This allows real variables to be interpreted in welfare-consistent terms.
- Factor Market Closure:
    - Labor is assumed to be fully employed and mobile across activities, capturing reallocation effects induced by diversification and processing expansion.

- Capital is fully employed and mobile across non-primary activities, while land is activity-specific to crop production.

- Savings–Investment Closure: Investment is savings-driven, with total investment adjusting endogenously to available savings. This reflects India's macroeconomic environment, where private and public savings constrain investment levels.
- Government Account Closure: Government savings are flexible, while direct tax rates are fixed. Government consumption is policy-driven in selected simulations.
- Current Account Closure: Foreign savings are fixed, and the exchange rate is flexible, allowing trade balances to adjust through price signals rather than external borrowing.

These closures ensure that policy shocks operate through real sector adjustments, relative prices, and factor reallocation, rather than through artificial macro imbalances.

3.4 Policy Simulation Design

Three policy scenarios are intended to replicate major Indian government initiatives on crop diversification, agro-processing and export promotion.

Simulation 1 (S1): Crop Diversification with Export Orientation

This scenario represents India's crop diversification policy combined with export spurs. A 15 percent increase in total factor productivity (TFP) is given to diversified crops such as pulses, oilseeds, millets, coarse cereals, cotton and fruits and vegetables capturing major government investment to increase the yield of such crops. Export taxes on these crops are reduced by 10 percent to capture the improved market access and export facilitation.

Conditions: To avoid the crowding-out effect and maintain the neutrality rice is excluded from productivity enhancement.

Simulation 2 (S2): Processed Food Export Promotion

A 15 percent TFP increase is given in food processing activities, representing investments in processing technology, cold chains, storage and logistics. Export taxes on processed food commodities are reduced by 10 percent, and export transaction costs are reduced by 25 percent, capturing improvements in trade and transport infrastructure. This simulation focuses on agro-processing-led export growth.

Simulation 3 (S3): Integrated Agriculture-Industry-Trade Policy Package

The final scenario combines the crop diversification and agro-processing interventions of S1 and S2 with a 10 percent increase in real government consumption. This represents coordinated public investment supporting agriculture, processing, infrastructure and trade. By integrating productivity gains, value addition, trade cost reductions and fiscal support, this simulation captures complementarities across sectors, generating stronger linkages, crowding-in private investment and larger welfare gains. The scenario reflects a realistic, coordinated policy mix rather than isolated interventions.

Result and Discussion

Table 1. Macroeconomic and Demand-Side Effects of Policy Simulations (%)

Indicator (Real)	**Base**	**S1**	**S2**	**S3**
Absorption	205.99	0.09	0.13	0.23

Private Consumption	122.97	0.09	0.14	0.23
Investment	59.61	0.12	0.18	0.29
Government Consumption	22.06	0.00	0.00	0.10
Exports (real)	37.14	0.11	0.21	0.33
Imports (real)	42.41	0.10	0.19	0.28
GDP at Market Prices	200.72	0.09	0.14	0.24
Household Real Income	137.73	0.09	0.14	0.24

Table 1 presents the real macroeconomic impacts of crop diversification (S1), agro-processing–led export promotion (S2), and the integrated policy package with government support (S3). Under Simulation S1, real absorption increases by 0.09 percent, driven by modest but positive growth in private consumption (0.09 percent) and investment (0.12 percent). This reflects the productivity-led supply expansion mechanism, where higher total factor productivity in diversified crops lowers unit costs, increases output and raises factor incomes. The resulting 0.11 percent rise in real exports indicates improved competitiveness of agricultural commodities, consistent with India's Crop Diversification Programme (PM-RKVY) and millet-promotion initiatives that aim to enhance both sustainability and market access.

Simulation S2 exhibits stronger macroeconomic responses, with absorption rising by 0.13 percent, investment by 0.18 percent and exports by 0.21 percent. The lower trade and transport cost which is expanding the export volume is in line with the new trade and value-chain theory where the reduced trade costs enhance downstream demand for agricultural raw materials while improving export profitability. This outcome mirrors the objectives of PM Kisan SAMPADA Yojana and export facilitation measures under India's agri-food policy framework. S3 exhibit higher gain compared to S1 and S2, where combined productivity shocks and a 10 percent increase in government consumption reinforce private sector responses. Real absorption rises by 0.23 percent, exports by 0.33 percent and GDP at market prices by 0.24 percent. The increase in public expenditure arouses aggregate demand directly while crowding in private investment (0.29 percent) through higher expected returns which is in favour of Keynesian demand-side transmission in a model (CGE setting), where fiscal expansion complements supply-side reforms to generate higher output and incomes. The 0.24 percent rise in household real income accentuates the distributional benefits of coordinated policies of government in agricultural, processing and export promotion.

Overall, the results demonstrate that isolated productivity improvements (S1) produce limited macroeconomic gains, wherein integrated policies like combining diversification, value addition, trade facilitation and public spending (S3) generate stronger and more sustained growth effects. This provides quantitative support for India's current policy approach of aligning agricultural diversification, agro-processing incentives and export promotion within a broader public investment strategy.

Table 2. Sectoral Output and Export Performance (%)

A. Sectoral GDP / Output

Sector	Base Share (%)	S1	S2	S3
Agriculture	18.80	0.08	0.06	0.14
Crops	10.73	0.10	0.04	0.14

Manufacturing	14.64	0.12	0.21	0.33
Food Processing	1.38	0.08	0.14	0.21
Services	54.45	0.09	0.13	0.23

B. Real Export Value

Sector	**Base Share (%)**	**S1**	**S2**	**S3**
Total Exports	100.00	0.11	0.21	0.33
Agriculture	2.09	-0.10	-0.50	-0.61
Manufacturing	52.51	0.13	0.33	0.46
Food Processing	3.74	0.01	0.44	0.45
Services	43.94	0.11	0.10	0.22

In S1, productivity-driven crop diversification increases agricultural and crop output moderately (0.08 and 0.10 percent), although it has limited spillover effects on manufacturing (0.12 percent) and food processing (0.08 percent), implying that productivity in the primary sector alone has not been adequate for promoting overall growth or export performance. In S2, agro-processing and trade facilitation policies change the growth dynamic in favour of non-agricultural sectors, as manufacturing and food processing output increase by 0.21 and 0.14 percent, respectively, representing addition, subtraction, or improved competitiveness under PM Kisan SAMPADA and logistics reforms. In S3, an overall package yields superior results, including increases in manufacturing (0.33 percent), food processing (0.21 percent), services (0.23 percent), and agriculture (0.14 percent), thus asserting effective forward and backward linkages from agro-industry to the overall economy. Export results reflect this shift in structure as well. The total export results show a gradual improvement from 0.11% (S1) to 0.33% (S3) of growth with strong growth of up to 0.46% for manufacturing and 0.45% for food processing. The agri-export growth worsens from -0.61% to -0.10% as a result of increased domestic absorption and improved domestic price incentives. Thus, this result illustrates that for India's diversification strategy to be realized, there is a need for productivity enhancement at the farm level accompanied by agro-processing investments and cost of trade reductions.

Table 3. Prices, Factor Markets, and Welfare (%)

Indicator	**Base**	**S1**	**S2**	**S3**
Output Prices (PX – Total)	100.00	0.01	-0.01	-0.01
Export Prices (PE – Total)	100.00	0.01	-0.01	0.00
Composite Prices (PQ – Total)	100.00	0.01	-0.03	-0.02
Labor Supply (QFS – Labor)	64.34	0.08	0.11	0.21
Capital Supply (QFS – Capital)	111.45	0.09	0.08	0.17
Household Real Consumption	109.00	0.10	0.15	0.24

Under S1, prices of outputs and exports rise slightly by 0.01 percent due to increased productivity in diversified crops. Under S2, prices of outputs, exports, and composite decline slightly by -0.01 to -0.03 percent following trade cost reductions, improvements in processing productivity, and competitive pressures that share gains from increased productivity. Under S3, the cumulative policy combines the price-neutral effect with a slight decline of 0.02 percent in composite prices, indicating that gains in productivity and trade services outweigh the expansion of economic demand with increased investment outlays.

Factor market effects are stronger and consistent with the structural transformation theory. Labor supply increases cumulatively from 0.08 percent (S1) to 0.21 percent (S3) with a sequential increase in labour demand for agro-processing, manufacturing, logistics, and services activities. The increase in capital supply can also be noted, especially in S3 (0.17 percent), because of the rising rates of return for investment in processing and other non-agricultural activities, aligning with the infrastructure development initiatives in India and private sector investment opportunities in food processing and export facilities. Consequently, these changes in factor markets get reflected in the welfare gains, with real household consumption rising from 0.10 percent in S1 to 0.24 percent in S3, thereby suggesting that productivity-driven growth, trade facilitation, and government spending positively contribute to real income gains through increased employment opportunities, favourable price effects, and economic activity expansions. Hence, it can be affirmed that findings do substantiate the hypothesis that India's strategies of diversification and export facilitation have contributed largely to welfare measures through factor market redeployment and productivity gains rather than through price increases, thereby ensuring that these strategies remain pro-poor and macro-economically sound.

Analysis of the outcome suggests that the jobs are well-distributed across all skill segments, and the demand is rising steadily from S1 to S3. The ruralUneducated and Prim workers have the highest chance of obtaining jobs, and the names suggest that the percentage rise will be 0.25 percent and 0.23 percent for S3, mainly because of the diversification and export promotion policies that are increasing the demand for labour in the agriculture, food processing, and allied sectors. The overall demand for jobs in the urban area is also rising steadily, and the evident spillover effect is promising for the uneducated and Prim workers, which will rise up to 0.24 percent, mainly because of the rising demand for jobs in the sectors of manufacture, logistics, and services.

Conclusion and Policy Implications

The simulation results indicate that crop diversification policies have only small positive effects on agricultural production, employment, and household welfare, and little effectiveness in promoting exports and structural transformation. The policies based on manufacturing and processing of agricultural products, through productivity and trade cost reductions, have considerable effectiveness in promoting manufacturing and processing production and exports, thus emphasizing the need for value addition and logistics optimization. The overall policy bundle achieves maximum effectiveness, as it increases real GDP, exports, investment and household incomes without affecting prices. The reduction in primary agricultural exports is due to diversion for satisfying domestic demand, rather than losses of competitiveness, since total exports increase. Employment effects are also pro-poor and universal, as employment increases for all skill levels of rural and urban workers. These results provide support for some recent initiatives taken by the government of India, such as PM-RKVY for crop diversification, millet missions, and PM Kisan SAMPADA Yojana and agro-export clusters. These results also indicate that for diversification policies, some follow-through policies involving processing and facilitating trade are also required. The returns to public investment in agro-processing and logistics infrastructure appear to be very high and economy-wide.

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