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Empirical effects of short-term export bans: The case of rice sectors in India, Thailand and Vietnam

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ABSTRACT

India's recent ban on non-basmati rice exports aims to lower domestic rice prices, which have increased by more than 30% since October 2022. However, this move might lead to a decline in rice export numbers, potentially increasing global prices, and worsening food insecurity. This study examines the immediate effects of India's recent ban on rice exports on top rice-producing economies and countries with a share of imported rice from India exceeding 60%. Four policy scenarios were designed, with scenarios 1 and 2 varying the export ban on rice and scenarios 3 and 4 focusing on the reduction in rice crop productivity due to El Niño. The macroeconomic ramifications of these scenarios include a decline in real GDP. Real consumption expenditure is expected to decline in all economies. Sectoral effects show that rice is the most negatively affected crop in Vietnam and India, as farmers redirect resources to other crops.

I. Introduction

On July 20, 2023, the government of India imposed an immediate ban on the export of non-basmati white (NBW)[1] rice to mitigate surging domestic rice prices. This policy decision had significant ripple effects on global rice markets, with prices in major exporting nations such as Thailand and Vietnam increasing by approximately 20% (Thukral, 2023). The ban further exacerbated global food price inflation, with rice prices rising by 15%-20% since September 2022 (Valera et al., 2024; Commodity Markets, 2023). This measure followed a period of relative price stability earlier in the year, despite soaring costs of other cereals driven by the Russia-Ukraine war.

India stands as the world's largest exporter of rice over the past 15 years, supplying nearly 40% of global rice exports by 2022 (USDA, 2023; Ding, 2024). Given this dominant role, India's decision to restrict rice exports carries

profound implications for global food security and trade flows. The recent ban builds upon earlier export restrictions; in 2022, India had already prohibited broken rice exports and introduced a 20% tariff on NBW exports (Economic Times, 2023). These successive interventions may exacerbate global supply shortages, contribute to heightened food insecurity, and yield negative net welfare effects worldwide (Fathelrahman et al., 2024).

India restricted trade at a time concurring with rising concerns over climate-induced disruptions in agricultural production. The rapid onset of El Niño, characterized by anomalous warming of the Eastern Pacific's sea surface, coupled with a positive forecast of Indian Ocean Dipole, poses a substantial threat to rice cultivation in South and Southeast Asia. Historically, El Niño events have led to elevated temperatures and diminished rainfall, adversely affecting rice yields in key producing regions (Chen et al., 2008; Parvati et al., 2024). Additionally, erratic monsoon patterns and declining cumulative rainfall have already begun to impact Southeast Asian rice production (Hariadi et al., 2024). While current agricultural forecasts still predict yields to be normal, presuming typical patterns of weather, a delayed or weakened monsoon could lead to production shortfalls and intensified import demand at a time when India is restricting supply.

Rice is considered a staple food for massive numbers of people, particularly in Asia and Africa, where it constitutes a significant share of daily caloric intake (Supriya et al., 2017; Dwivedi et al., 2017). In many Asian nations, including Indonesia, Bangladesh, Myanmar, the Philippine

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Bhutan, Thailand, Cambodia, Nepal, and Sri Lanka, rice contributes between 40% and 67% of daily calorie consumption (International Food Policy Research Institute, 2023). Similarly, over three billion Indians rely on rice for 35%-60% of their daily energy intake (Emran et al., 2020). Many of these nations, including China, Sri Lanka, Bangladesh, Bhutan, and Nepal are heavily dependent on imports of rice from India, making them particularly vulnerable to market disruptions (Glauber and Swinnen, 2023). India's role as the leading rice supplier to numerous African and Asian markets underscores the potential for widespread economic and food security challenges stemming from the export ban.

India is a dominant exporter of rice (second-largest), particularly of basmati rice, which enjoys high global demand (Kanwar and Nag, 2019; Muthayya et al., 2014). Over half of the imports of rice for 42 countries comes from India, with several African nations sourcing over 80% of their rice from Indian suppliers by 2022. This heavy reliance on Indian exports means that alternative suppliers—such as Vietnam, Thailand, and Pakistan—would struggle to compensate for the supply gap, further exacerbating price volatility.

India's latest export ban is consistent with its historical trade policies. The export restrictions tracker of the International Food Policy Research Institute (IFPRI) indicates that India frequently enacts trade controls when global food prices surge. During the food crises of 2007–08 and 2010–11, India temporarily halted exports of NBW rice to restore stability in domestic markets. More recently, in response to inflationary pressures and increased global demand following the war between Russia and Ukraine in February 2022, India introduced an export ban on wheat, a 5% cap on exports of broken rice, and a 20% export tax on unmilled and husked rice.

This study examines the short-term macroeconomic, sectoral, and trade effects resulting from India's recent export ban on rice, with a particular focus on major producing nations (India, Vietnam, and Thailand) and highly import-dependent countries (e.g., Algeria, Ethiopia, Angola, Bangladesh, Liberia, Qatar, Sri Lanka, Bhutan, Central African Republic, Saudi Arabia, Iran, Kuwait, Nepal, Oman, Sierra Leone, Somalia, and Sudan). By employing a "bottom-up" seven-region Computable General Equilibrium (CGE) model, leveraging the Global Trade Analysis Project (GTAP) framework and its Version 9 database (with 2011 as the reference year), this paper contributes to the ongoing policy debate by quantifying the trade and welfare effects of India's policy intervention.

The paper is structured as follows. Section 2 provides an overview of recent developments in global rice supply. Section 3 outlines the core features and database of the GTAP model employed in this analysis. Section 4 details the simulation scenarios used to assess the impacts of India's export ban. Section 5 presents and interprets the simulation results. Section 6 offers implications for policymakers and venues for future research. The paper concludes in Section 7.

2. Theorical Background: Tightened Global Rice Supplies and the Likely Impacts of the Ban

In 2008, there was a sharp rise in the prices of many commodities around the world, including rice, which saw a particularly large increase. Movements in the price of rice abroad, which increased from USD 400 (January 2008) per ton to roughly USD 1000 (May 2008) per ton caused great concern in both import and export countries (Kompas et al., 2010). To maintain rice's low domestic prices and the safety of the domestic food supply, some rice exporters, including India, imposed an export ban on rice. For instance, India drastically reduced its exports in 2007, and Bangladesh witnessed a spike in rice prices (Dorosh and Rashid, 2013).

To ensure domestic food security, traders anticipated similar supply curbs from other exporters (such as Vietnam and Thailand), which left importers scrambling to secure shipments. In addition, the practice of the Vietnamese government monitoring and regulating rice exports was significantly put to the test in 2008. Given the sharp rise in international rice prices (e.g., from USD 400 in January 2008 to approximately USD 600 in March, then to USD 1000 in May), followed by an overall high inflation rate for food prices in the domestic economy (14.5 percent in the first three months of 2008 compared to 18.9 percent in 2007), the Government of Vietnam made it illegal to sign new export agreements beginning March 25th through the end of May 2008 (Kompas et al., 2010). Studies such as Mottaleb and Durand-Morat (2024), Deuss (2017), Estrades et al. (2015), Gilbert (2011), Wright (2011), Gilbert and Morgan (2010), Timmer (2008), have argued that the spike in rice prices during the 2007–2008 food crisis was caused by restrictions on export by a few of the main nations that export rice rather than low stocks or crop failure.

In 2023, particularly on July 20, India halted exporting its biggest category of rice, cutting the world's largest exporter's shipments by about half and raising concerns about further food price inflation worldwide (Jadhav et al., 2023). A day after India announced its ban, Vietnam, the third-largest rice exporter in the world, called on the nation's food association to guarantee adequate domestic rice supplies. On July 27, the same year—due to supply concerns brought on by India's restrictions on export— the price of rice exports from Vietnam and Thailand increased to its highest level in more than ten years. After four days, particularly on August the 1st, the second and third largest exporters of rice, Thailand, and Vietnam, respectively, began renegotiating prices on sales contracts for approximately 500,000 metric tons scheduled for shipment in August. As a result, the rice price index of the United Nations Food Agency rose by 2.8% in July (compared to June same year) to its highest level in nearly 12 years (Thukral, 2023). Accordingly, the effects of India's ban on the economies of the top exporting countries —and those whose imports from India exceed 60%— will depend on several factors.

The first consideration is the severity of the export ban. Due to this ban, major rice exporting nations like Thailand and Vietnam experienced higher demand and prices, which could have resulted in inflation in their home markets (Fathelrahman et al., 2024). India's rice exports fell by more than 80% as a result of the ban, impacting global supply chains and escalating competition among the surviving exporters (Li and Xiang, 2023).

Additionally, global wheat prices initially rose in response to India's 2022 ban on wheat exports; however, prices decreased as it became clear that India would keep up its humanitarian wheat sales to its neighbors and abide by its existing letters of credit for wheat purchases. India's wheat exports in 2022 reached record levels, but by the end of the year, the volume had decreased significantly. If India keeps allowing non-basmati rice exports to its neighbors or if the ban proves to be only temporary, the market effects might be negligible. A "hard" ban, however, might have a large impact on countries that currently depend on Indian imports. For instance, significant welfare losses, estimated at

USD 1.7 billion worldwide, were suffered by countries like Indonesia and several African countries that imported more than 60% of their rice from India (Fathelrahman et al., 2024). Also, rising rice prices for importing nations have exacerbated inflation and food insecurity, especially in regions like the Middle East and Sub-Saharan Africa (Valera et al., 2024).

Rice is traded on the international markets much less frequently than other grains. Approximately 11% of the world's total production of rice is exported, compared to other commodities (e.g., maize: 16%, wheat: 27%, and soybeans: 42%) (Glauber and Swinnen, 2023). Therefore, a ban that impacted 40% of global rice exports would strain other suppliers and recently depleted rice stocks but would be required to cushion price impacts. Hence, to understand the likely impacts on the economies of the largest exporters of rice and the heavily dependent countries on rice imports from India, we need to design a set of policies where the ban varies, and this is why we will vary the percentages of the Indian ban on rice exports (policy scenarios 1 and 2).

The second consideration is whether the summer monsoon season will be reduced, which would lead to a decrease in rice production in India and other South and Southeast Asian nations due to a strengthening El Nio and a positive Indian Ocean Dipole. Normal rice yields would continue to ease India's pressure to sustain an export ban to meet domestic demand. Nevertheless, poor rice crops in India and other major exporters, such as Thailand and Vietnam, would drastically cut down on the quantity of rice available on the global market, bolstering the argument for the export ban. Accordingly, a reduction in the productivity of rice crops due to a strengthening of El Niño will likely amplify the impacts of the ban; hence, two scenarios will be designed to account for this factor (policy scenarios 3 and 4).

The third consideration is the likelihood that India's actions will influence other major rice exporters. A negative consequence of the food price spikes in 2007 and 2008 was that other rice exporters followed suit after the major exporters-imposed bans. The restrictions were imposed by several countries such as Vietnam (June 2007), India (October 2007), and Pakistan and Thailand (May 2008). These four countries collectively held over 70% of the market. Between October 2007 and April 2008, the benchmark price of Thai rice almost tripled. The world market will probably react strongly if other nations impose their export restrictions and follow the ban imposed by India on non-basmati rice. Bangladesh, which is India's top rice trading partner and has the highest calorie dependence on rice consumption, closely monitors the trade policies of its neighbors. Additional rice export restrictions would affect other South Asian neighbors, some countries in the Middle East, and Africa, and export duties on broken and other non-basmati rice would worsen the situation. Hence, the possible behavior of other major rice exporters in placing a ban will likely have an effect, therefore, we will consider the fact that Thailand and Vietnam might follow India and restrict their exports in all of the previous scenarios (policy scenarios 1, 2, 3 & 4).

3. Outlines of the Model and Database

For comparative static analysis, we used the GTAP model in this study, which is a class of CGE models. Hertel (1997) describes the theoretical framework of GTAP providing an overview of the model. All marketplaces were perfectly competitive in the GTAP model. All markets have an equilibrium between supply and demand, meaning that the price a producer receives is equal to its marginal cost. By imposing taxes and granting subsidies on goods and essential elements, the regional government can create a barrier between the prices paid by consumers and the prices received by producers. On commodity trading platforms, buyers make a distinction between imported and domestically produced goods. The ability to distinguish imports based on the origin of their products is permitted. Each tradable good can now be traded in both directions, across regional boundaries. The primary production factors and intermediate inputs were the two input categories. The model assumes that inputs within each sector in each region are mixed in a way that minimizes the overall cost at a specific output level. A three-level nested production technology limits the ability of sectors to choose their inputs. At the first level, the intermediate input and primary factor bundles are used in fixed proportions following the Leontief function. At the second level, intermediate input bundles are organized as combinations of domestic and imported bundles with the same input-output name. Similarly, groups of primary factors are created by combining labor, capital, and land. The aggregator function has a Constant Elasticity of Substitution (CES) form in both scenarios. Imported bundles were created as CES composites of imported products with the same name from each region at the third level.

Each region has a single representative household. Aggregate household spending is calculated as a fixed percentage of total regional income, which comprises national savings, government spending, and household consumption. The household purchases bundles of goods to maximize utility while remaining within its budget. The bundles are CES aggregations of imports from each region, with import bundles being CES combinations of domestic goods. The portion of total government spending that each region receives is fixed. A Cobb-Douglas distribution is used to distribute government spending among different commodities. The same nesting approach is used to allocate total household spending on each good between versions that are domestically produced and those that are imported.

Investments in each region are financed through a global savings pool. A specific percentage of each region's income was added to the savings pool. There are two methods of allocating savings to each region in standard GTAP. The first approach involves distributing a predetermined portion of the pool. The second method is to divide funds based on the standard relative rates of return. The GTAP model (database version 9) captures global economic activity across 140 regions and 57 industries. For the sake of analysis, these were combined into seven regions and seven sectors (see Appendix, Table A1).

4. Simulation Design

Table 1 shows the average import tariffs levied on rice between the importing and exporting blocks (for example, MENA levies approximately 15.25% on rice imported from India) estimated using the GTAP database version 9. Starting with South Asia as an importing block, Indian rice (5.68 %) has the highest import tariff on rice, followed by Vietnam (5%) and Thailand (4.99%). For the MENA block, the highest import tariffs on rice were reported for Thai rice (23.41%), followed by India (15.25%), and Vietnam (4.18%). Finally, for SSA, import

tariffs are almost the same for Vietnamese and Thai rice (7.3%) while the tariffs on Indian rice are the least standing at 3.31%.

Table 1: % ad valorem rate (Import Taxes) levied on rice by source

		Importing Blocks / Rice							
		Row	Thailand	Vietnam	South Asia	India	MENA	SSA	Total
Exporting Blocks / Rice	Row	19.65	15.93	9.88	3.41	13.99	9.65	5.73	78.24
	Thailand	15.91	0	5	4.99	0.44	23.41	7.35	57.1
	Vietnam	19	30	0	5	0	4.18	7.3	65.47
	South Asia	1.52	0	0	0	0	0	0.31	1.82
	India	4.57	29.14	19.29	5.68	0	15.25	3.31	77.24
	MENA	2.35	0.38	0.76	2.37	8.21	41.78	2.15	57.99
	SSA	8.86	2.93	7.8	0.82	10.49	0.67	5.66	37.22
	Total	71.86	78.37	42.72	22.27	33.12	94.94	31.8	375.1

*Blocks: Row: Rest of the World; South Asia: Bangladesh, Bhutan, Nepal, Sri Lanka; MENA: Algeria, Iran, Kuwait, Oman, Qatar, Saudi Arabia; SSA: Angola, Central African Republic, Ethiopia, Liberia, Sierra Leone, Somalia, Sudan. **Source: GTAP database version 9. *** Year: 2011.

This study uses computable general equilibrium (CGE) to examine the effects of the Indian export ban. The general equilibrium model is a macroeconomic model that integrates micro- and macro-economics. The fundamentals of economic theory (microeconomics), in which the behavior of economic agents is specifically and thoroughly explained in the form of behavioral equations, form the foundation of the CGE structural model. The interactions between various agents within a country/region and between countries/regions can be described using the CGE. The Global Trade Analysis Project (GTAP) model, developed by Purdue University in 1993, is one of the growing CGE models. The input-output tables and national accounting data utilized for constructing the GTAP model indicate consistent interdependence of markets (Hosny, 2013; Hosoe et al., 2010). In this study, 140 regions and 57 sectors were aggregated using the GTAP version 9 database from the initial equilibrium values of the input-output tables for 2011. This study performs further aggregation based on the necessary and relevant regions and sectors to assess the macroeconomic, sectoral, and effects of trade patterns led by the actual ban on rice exports from India to the major importing countries as well as a potential ban from Vietnam and Thailand. For aggregation based on region, we use aggregated data from the major exporting countries of rice, India, Vietnam, and Thailand, as well as the main Indian rice-importing countries of (1) Algeria, Iran, Kuwait, Oman, Qatar, and Saudi Arabia aggregated as "MENA"; (2) Angola, Ethiopia, Central African Republic, Somalia, Sierra Leone, Sudan, and Liberia aggregated as sub-Saharan Africa "SSA"; (3) Bangladesh, Bhutan, Nepal, and Sri Lanka aggregated as "South Asia." For aggregation based on sector, Paddy rice (PDR) and Processed rice (PCR) were both aggregated into one sector "rice," hence, for the sake of analysis, the following 7 sectors were formed as (1) Rice; (2) Wheat; (3) Grains and Crops; (4) Meat and Livestock; (5) Other crops; (6) Processed Food; and (7) Other Services. The simulation scenarios examined in this study are listed in Table 2.

In scenario 1, we swap the endogenous variable "qxs (i,r,s)" labeled as "export sales of commodity i from region r to region s" with the exogenous variable "txs (i,r,s)" labeled as "Destination-specific change in subsidy on exports i from region r to region s". We then shock the newly transformed "qxs (i,r,s)"—which became exogenous— by reducing it by 100% to represent the ban on Indian rice exports. Accordingly, txs (i,r,s) adjusts, owing to its endogeneity, to reduce "qxs (i,r,s)" by 100%. We follow the same methodology in Vietnam and Thailand, except that "qxs (i,r,s)" is shocked to be reduced by 75% in both countries. In Scenario 2, we follow the same methodology as in Scenario 1 except that "qxs (i,r,s)" is reduced by 75%, 50%, and 50% for India, Vietnam, and Thailand, respectively. In scenario 3, we swap the endogenous variable "qxs (i,r,s)" with the exogenous variable "ams (i,r,s)" labeled as "Import i from region r augmenting technological change in region s". We then shock the newly transformed "qxs (i,r,s)"—which became exogenous— by reducing it by 100% to represent the deterioration of productivity due to the weather effect, which is assumed to reduce the exports of Indian rice. Accordingly, "ams (i,r,s)" is adjusted, owing to its endogeneity, to reduce "qxs (i,r,s)" by 100%. We follow the same methodology in Vietnam and Thailand except that "qxs (i,r,s)" is shocked to be reduced by 75% in both countries. In scenario 4, we follow the same methodology as in scenario 3, except that "qxs (i,r,s)" is reduced by 75%, 50%, and 50% for India, Vietnam, and Thailand, respectively.

5. Simulation Results

This section reports the results from the simulations implemented in the GTAP for the four scenarios presented earlier. The results highlight the macroeconomic, sectoral, and trade pattern effects.

5.1. The macroeconomic effects

Tables 3 and 4 present the results of the macroeconomic effects of the four scenarios. First, most regions are expected to decrease their real GDP in all four scenarios. India, Thailand, and Vietnam experienced the highest decrease in Scenario 3, at -1.35%, -1.11%, and -2.37%, respectively. This finding indicates that the decrease in productivity due to a strengthening El Nio and a positive Indian Ocean Dipole will have the greatest effect on the economies of India, Vietnam, and Thailand. Governments' policies in India, Vietnam, and Thailand should concentrate

on implementing climate adaptation strategies because of the major impacts El Niño and the Indian Ocean Dipole have on these countries' econom in terms of a decline in productivity. Additionally, these governments should invest in R&D for drought-resistant crop varieties taking into acco the process of upgrading irrigation infrastructure and offering incentives for climate-resilient crops.

Table 2: The four-scenarios examined

Scenario	India	Thailand	Vietnam
1st	Will reduce its exports by 100% due to a "ban on exports"	Will reduce its exports by 75% due to the spillover of the Indian "ban on exports"	Will reduce its exports by 75% to the spillover of the Indian "ban on exports"
2nd	Will reduce its exports by 75% due to a "ban on exports" and the remaining 25% is to facilitate food security in some countries.	Will reduce its exports by 50% due to the spillover of the Indian "ban on exports"	Will reduce its exports by 50% to the spillover of the Indian "ban on exports"
3rd	Will reduce its exports by 100% due to "El Niño" which means that the deterioration of productivity due to the "weather effect" has brought down the exports	Will reduce its exports by 75% due to the spillover of "El Niño"	Will reduce its exports by 75% to the spillover of "El Niño"
4th	Will reduce its exports by 75% due to "El Niño" which means that the deterioration of productivity due to the "weather effect" has brought down the exports and the remaining 25% is to facilitate food security in some countries	Will reduce its exports by 50% due to the spillover of "El Niño"	Will reduce its exports by 50% to the spillover of "El Niño"

Simulation results

Meanwhile, there is little change (negative effect) in real GDP for any region in all four scenarios except the MENA region, where their economies will slightly increase in scenarios 3 and 4. Generally, the decrease in real GDP in Scenarios 3 and 4 is slightly greater than that in the other scenarios.

Secondly, scenarios 1 & 2 affect exports in India, Vietnam, and Thailand positively in all commodities except rice compared to the rest of the regions as India, Vietnam, and Thailand experience expansion in their exports in all sectors —except rice— ranging from 1% to 4.7% for India where the highest expansion is reported for wheat and the least expansion is reported for the sector of services "Other services." Likewise, Thailand experienced the highest expansion in wheat production, ranging from 35.24% in Scenario 2 to 52.06% in Scenario 1. For Vietnam, the country experiences the highest expansion in the sector of "Meat and Livestock" ranging from 12% in scenario 2 to 18.02% in scenario 1 while the least expansion in its exports is reported for the sector of services. The expansion in exports of all commodities, except rice, is seen as a logical step in compensating for the lost values from depressed exports of rice and provides further evidence that wheat is considered the second most important commodity strategically for both India and Thailand following rice. As wheat and livestock experienced a growth in exports in response to the ban on rice exports, policymakers in India, Thailand, and Vietnam should encourage the growth of alternative export markets. This shift can be facilitated by supply chain improvements, trade agreements, and export incentives. To secure demand for non-rice commodities, bilateral agreements with major importers and regional trade agreements may be necessary.

Percentage changes in Terms of Trade (ToT) indicate that the export earnings from each unit of each exported commodity in all scenarios for India, Thailand, and Vietnam have more import-purchasing power for its imports. The highest improvement in ToT is observed in Scenario 3, where the improvements are 0.35%, 0.46%, and 0.37% for Thailand, Vietnam, and India, respectively. Third, the changes in the trade balance indicate that each of India, Thailand, and Vietnam's current account positions deteriorate in all scenarios except a positive change for India in scenario 2 (USD 5.3 mio) and for Vietnam in scenarios 3 and 4, where its reports were USD 450 million and USD 277 million, respectively. The trade balance for Vietnam is positive, with a broader surplus in scenario 3 than in scenario 2, which indicates the capabilities of Vietnam in controlling its productivity and exports during natural disasters and climate change, unlike India and Thailand. To protect themselves from changes in agricultural prices, India and Thailand should establish funds for stabilization or position themselves into futures contracts. To preserve export competitiveness without escalating inflation, central banks in impacted economies should keep an eye on changes in exchange rates and take appropriate action. Additionally, as their trade balances worsen, Thailand and India could design counteractive measures to boost domestic production of essential imports and lessen their dependency on foreign markets.

As for the importing regions, the trade balance for the MENA and SSA regions is positive in Scenarios 1 and 2. In this study, the net welfare gains from implementing the four scenarios were measured by equivalent variation (EV) and real consumption expenditure (RCE). The EV calculates how much income would need to be transferred into or taken out of an economy both before and after the occurrence of shocks (the scenarios) and after the policy has been altered (Brown et al., 2005; Siriwardana, 2006, 2006b). Table 3 shows that there is an obvious contrast regarding the effect on the EV resulting from the different scenarios. In scenarios 1 and 2, both India and Vietnam seem to encounter favorable EVs, which indicates an improvement in economic welfare due to trade creation resulting from the ban on rice exports. However, both countries

seem to experience a massive deterioration in their economic welfare in scenarios 3 and 4, which indicates how detrimental the effect on productivity —led by strengthening El Nio and a positive Indian Ocean Dipole— is on the economies of India and Vietnam. The authorities in Vietnam and India —in response to a fall in real consumption expenditures—should support low-income households by enacting price stabilization policies, food subsidies, or direct cash transfers. Additionally, in response to the economic downturn, monetary policy should cut interest rates moderately to increase domestic investment and consumption.

Table 3: The macroeconomic effects of the four scenarios

	Real GDP (%)	ToT* (%)	TB** (US$ million)	EV*** (US$ million)	RCE**** (%)
Scenario 1					
ROW	-0.0036	-0.0041	668.5422	-3042.5867	-0.0052
Thailand	-0.1929	0.2604	-615.0076	-1.7275	-0.0006
Vietnam	-0.1788	0.2973	-26.5879	12.7559	0.0109
South Asia	-0.0057	-0.1102	-63.7775	-74.2777	-0.0556
India	-0.0176	0.2215	-22.5310	350.7697	0.0201
MENA	0.0116	-0.1823	50.5827	-622.7437	-0.0368
SSA	-0.0125	-0.0820	8.7802	-136.4927	-0.0443
Scenario 2					
ROW	-0.0024	-0.0028	429.3673	-2006.9163	-0.0034
Thailand	-0.0653	0.1725	-409.4985	214.8594	0.0720
Vietnam	-0.0554	0.2001	-30.6890	98.2006	0.0838
South Asia	-0.0037	-0.0728	-42.9859	-49.0118	-0.0367
India	-0.0021	0.1600	5.3237	455.3016	0.0261
MENA	0.0088	-0.1305	42.6705	-435.4513	-0.0258
SSA	-0.0082	-0.0550	5.8129	-90.8712	-0.0295
Scenario 3					
ROW	-0.0046	-0.0091	-4.1352	-4660.6836	-0.0079
Thailand	-1.1150	0.3588	-197.2352	-2943.2268	-0.9864
Vietnam	-2.3761	0.4673	449.7957	-2836.6479	-2.4201
South Asia	-0.0089	-0.1697	-52.1480	-111.8468	-0.0837
India	-1.3515	0.3752	-109.7462	-24126.0273	-1.3829
MENA	0.0093	-0.1730	-93.7356	-634.5436	-0.0375
SSA	-0.0152	-0.0932	7.2094	-159.2657	-0.0516
Scenario 4					
ROW	-0.0030	-0.0062	28.2737	-3130.3027	-0.0053
Thailand	-0.7116	0.2429	-134.7308	-1841.9122	-0.6173
Vietnam	-1.4854	0.3119	277.3639	-1752.7739	-1.4954
South Asia	-0.0059	-0.1130	-35.5652	-74.5195	-0.0558
India	-0.8767	0.2582	-83.1383	-15596.4570	-0.8940
MENA	0.0067	-0.1177	-57.0022	-422.9336	-0.0250
SSA	-0.0099	-0.0620	4.8014	-105.2830	-0.0341

Note: All projections are percentage deviations from the base period except for the trade balance and the equivalent variation (EV) which are in US$ million. *Terms of Trade; **Trade Balance; ***Equivalent Variation; ****Real Consumption Expenditure.
Source: Model simulation.

As for Indian rice-importing countries, based on the projection, it seems that all the scenarios lead to negative EVs, indicating a trade diversion effect. The scale is larger when productivity is affected by weather conditions (scenarios 3 and 4) than when only a ban is placed (scenarios 1 and 2). All economies are projected to have a decreasing trend in real consumption expenditure, with consumers —in India— generally worse off in scenarios 3 and 4 (-1.4% and -0.89%, respectively) and better off in scenarios 1 and 2 (0.02% and 0.03%, respectively). In addition, the real consumption expenditure in Vietnam is projected to improve in scenarios 1 and 2 (0.01% and 0.08%, respectively) and deteriorate —massively compared to other economies— in scenarios 3 and 4 (-2.42% and -1.49% respectively).

In the long run, one of the feasible structural adjustments is to introduce policies that foster crop rotation, soil conservation, and precision farming which can enhance productivity resilience. In addition, governments should design policies that would help economies anticipate and mitigate the impact of future climatic disruptions by strengthening meteorological and disaster response systems.

Table 4: Changes in exports volume by country and commodity in %

	RoW	Thailand	Vietnam	South Asia	India	MENA	SSA
Scenario 1							
Rice	36.8898	-74.9448	-74.9797	34.9720	-99.9199	51.5255	30.4824
Wheat	0.1134	52.0669	6.0133	-2.8719	4.7510	-1.2475	0.5374
Grains & Crops	-0.2917	18.5869	11.0038	-1.9228	2.1209	-0.4596	-0.2255
Other Crops	-0.5276	28.3240	9.8934	-4.2482	3.5196	-1.3057	-0.1573
Meat & Livestock	-0.3560	24.3017	18.0269	-4.2049	2.9789	-1.6100	0.1219
Other Services	-0.0345	0.8156	1.3909	-0.8324	0.7363	-0.0320	-0.0543
Processed Food	-0.1273	4.5480	4.2263	-0.9868	1.3464	-2.4089	-0.0977
Scenario 2							
Rice	24.0909	-49.9595	-49.9856	22.8434	-74.9275	33.7460	19.7598
Wheat	0.0785	35.2404	4.1142	-1.9082	3.3726	-0.9365	0.3579
Grains & Crops	-0.2042	12.8630	7.3896	-1.3052	1.5370	-0.3535	-0.1691
Other Crops	-0.3644	19.4422	6.6507	-2.8801	2.5470	-0.9645	-0.1222
Meat & Livestock	-0.2451	16.6668	12.0289	-2.8163	2.2152	-1.1696	0.0823
Other Services	-0.0225	0.4976	0.8779	-0.5537	0.5263	-0.0233	-0.0352
Processed Food	-0.0864	3.1400	2.8267	-0.6550	0.9831	-1.6993	-0.0688
Scenario 3							
Rice	36.3391	-75.0000	-75.0000	37.4693	-100.0000	49.0987	34.5867
Wheat	0.0470	24.9876	-7.6391	-3.4004	-5.0591	-0.6477	0.6823
Grains & Crops	-0.0267	9.8267	3.2430	-1.4333	-2.6324	0.0868	0.2750
Other Crops	0.2681	13.9190	2.2354	-1.7374	-9.8936	0.2719	0.9579
Meat & Livestock	0.0628	-0.0777	-1.7257	-4.0923	-6.6752	-0.7013	0.8123
Other Services	-0.0650	1.2315	2.1602	-0.8877	0.4232	-0.0413	-0.0941
Processed Food	0.0778	0.7635	-5.1651	-0.9857	-4.2070	-1.7289	0.1386
Scenario 4							
Rice	23.5775	-50.0000	-50.0000	24.2034	-75.0000	31.5127	22.3852
Wheat	0.0341	15.8499	-4.5831	-2.2801	-3.0332	-0.4516	0.4589
Grains & Crops	-0.0194	6.3032	2.1945	-0.9865	-1.5627	0.0463	0.1784
Other Crops	0.1630	8.9139	1.5604	-1.2506	-6.2015	0.1382	0.6220
Meat & Livestock	0.0322	0.3806	-0.7046	-2.7679	-4.1068	-0.4994	0.5273
Other Services	-0.0428	0.7728	1.3548	-0.5963	0.3157	-0.0282	-0.0615
Processed Food	0.0458	0.5550	-3.0771	-0.6643	-2.6349	-1.1679	0.0879

Note: All projections are percentage deviations from the base period. Source: Model simulation.

5.2 Sectoral effects

One of the major outcomes of trade restrictions, such as export bans, is that resources, such as labor, capital, and land, are reallocated. For instance, restrictions on trade may cause economies to shift toward increased capital intensity in production to compensate for labor resource shortages. Although consumption levels will be lower than in the baseline scenario, this adjustment may increase GDP (Lymar et al., 2024). This, in turn, leads to some degree of structural adjustment in the factor markets. Multilateral trade liberalization would generally benefit the world because resources are reallocated to each nation's sectors where there is a comparative advantage (Brown et al. 2006).

The sectoral effects resulting from the imposed scenarios are reported in Tables 5, 6, and 7(a, b,c & d). Table 5 outlines the output effects by sector in all regions considered in this study, which are presented as a percentage change in output volumes relative to the initial output levels under the four scenarios. Rice is expected to decrease massively in India, Vietnam, and Thailand in all scenarios, particularly, in scenarios 1&2, rice in India and Vietnam will suffer the most as farmers will shift resources into other sectors where the most benefited sectors from the reduction of rice outputs are wheat, grains and crops and other crops. For Thailand, rice outputs will suffer the most in scenarios 1 and 3, and, as in the case of India and Vietnam, outputs of wheat, grains, crops, and other crops will flourish the most. Imposing an export ban on rice in India, Vietnam, and Thailand will lead to an increase in rice output in other regions, particularly in the MENA region, where rice output will increase by 24.15%, 17.28%, 20.12%, and 13.72% in scenarios 1, 2, 3, and 4, respectively. One of the main reasons for this disparity is that, by imposing tariffs (i.e., export bans), Sectoral structures are adjusted by economies based on their comparative advantage (Siriwardana and Yang, 2008). Generally, Table 5 indicates that in the wheat and grain sectors, the economies of India, Vietnam, and Thailand have greater structural adjustments. As restrictions on export are leading to shifts in resources (land, labor, and capital), it is advised that governments in India, Vietnam, and Thailand should encourage farmers and businesses to switch to high-value and climate-resilient crops. A seamless transition can be designed with the help of policies such as wheat, grain, and other crop subsidies. Also, initiatives by the governments to reskill should be the main focus of labor market policies to smoothen out workers' transition from industries that are in decline (such as rice farming) to those that are growing (such as wheat and processed foods). Governments should also seek to design vocational training programs to improve workforce flexibility.

Table 6 shows the estimated changes in the trade balance by sector for all regions under the four scenarios. In India, “Processed food” shows the largest improvement in trade balance followed by “Grains and Crops” then “Other Crops” in scenarios 1 & 2, however, in scenarios 3 & 4, all sectors —except “Other Services”— deteriorate which shows how climate change harms these sectors. In Vietnam, also “Processed food” shows the largest improvement in the trade balance, however, the improvement of the trade balance for “Other Crops” is larger than “Grains and Crops” in scenarios 1 and 2. Surprisingly, in scenarios 3 and 4, all sectors —except “Processed Food”— improve, which shows the different nature of the Vietnamese economy compared to the Indian economy when exposed to the effects of El Niño and the positive Indian Ocean Dipole. In Thailand, “Processed food” shows the largest improvement in the trade balance, followed by “Grains and Crops” than “Other Crops” in scenarios 1 and 2. In general, all sectors show an improvement in Thailand except “Wheat,” which resembles to a great extent the behavior of the Vietnamese economy under the four different scenarios considered. In response to these improvements in Processed food across India, Vietnam, and Thailand, their Governments should support investment in this industry to boost value addition and global competitiveness, as processed foods, grains, and other crops exhibit positive trade balance effects. Some of the strategies that can be implemented to enhance trade balances in key sectors and to promote better access to international markets are to ensure that growing industries take advantage of new demand opportunities, trade agreements, and logistics infrastructure. To maintain a competitive relative price for exports, central banks may need to modify their exchange rate policies, particularly when production shifts across sectors are involved.

Tables 7 (a, b, c, d) report the estimated changes for India, Vietnam, and Thailand in demand for the key primary factors of land, labor (including unskilled and skilled labor), and capital by the mapped sectors under various scenarios. The directions of change are similar to the trade balance and output by sector in Tables 5 and 6, respectively. Therefore, these results further suggest a potential need for the reallocation of primary factors among sectors. In the case of India, all sectors—except rice— slightly increase the demand for the use of all primary factors (scenarios 1 and 2); however, Meat and Livestock decrease the use of labor and capital (scenarios 1 and 2), indicating that this sector suffers from low productivity and a higher cost of capital. The importance of rice comes into play in scenarios 3 and 4, where the demand for all primary factors increases significantly, while it decreases for all the remaining sectors except for Meat and Livestock, where the demand for labor and capital improves slightly along with this surge in demand for rice. Generally, all sectors, except rice, increase demand for the use of all primary factors in Vietnam and Thailand (scenarios 1 and 2 for Vietnam and all scenarios for Thailand); however, the increase is reported to be very high compared to that in India, which outlines the importance of these sectors in the economies of Vietnam and Thailand and the high mobility of the primary factors in these two countries compared to the low mobility reported in India. However, there are some exceptions. For instance, in Vietnam, the demand for the use of all factors decreases in the case of wheat, grains, and meat in scenarios 3 and 4, indicating that the use of land, labor, and capital appears to experience negative adjustments in these sectors. This indicates that the labor force is expected to move from declining sectors to growing sectors in other crops and services.

In light of these results, governments should focus on businesses moving between industries where credit facilities and low-interest loans could be accessed more easily to ensure that financial limitations don't prevent them from making the necessary adjustments. Additionally, to ensure that the reactions to restrictions on export are sound, the governments of Vietnam, Thailand, and India should keep buffer stocks of rice to stabilize domestic supply and prices. With this strategy, serious market disruptions and worries about food security may be avoided. Additionally, to ensure an efficient resource allocation, regulations on land use should be modified to allow for a more seamless transition of land from expanding sectors (such as wheat and other crops) to declining ones (i.e., rice). It will be crucial for governments to consider investment in Climate-Resilient Farming by promoting climate-smart agricultural protocols such as precision farming, drought-resistant crops, and enhanced irrigation systems since some industries—such as rice, meat, and grains—are particularly vulnerable to climate change.

Table 5: Estimated change (%) in output by sector under four scenarios

	RoW	Thailand	Vietnam	South Asia	India	MENA	SSA
Scenario 1							
Rice	4.7272	-38.5973	-19.0734	2.5825	-6.7577	24.1511	15.7893
Wheat	-0.0001	7.9900	5.2433	-0.8205	0.1900	-0.5502	0.0854
Grains & Crops	-0.1094	6.4001	5.5934	-0.5015	0.2759	-0.1849	-0.0549
Other Crops	-0.1858	12.3395	9.4546	-0.5041	0.2997	-0.8474	0.0034
Meat & Livestock	-0.0879	7.3487	2.3379	0.0309	-0.0155	-0.3249	-0.0430
Other Services	-0.0107	0.5217	0.6361	-0.1744	0.1532	-0.0338	-0.0374
Processed Food	-0.0562	3.2134	2.2262	-0.3509	0.2306	-0.7561	-0.0563
Scenario 2							
Rice	3.1491	-25.9553	-12.7608	1.7233	-5.0708	17.2880	10.5124
Wheat	0.0007	5.5937	3.5928	-0.5476	0.1440	-0.3971	0.0570
Grains & Crops	-0.0754	4.4558	3.7868	-0.3391	0.2070	-0.1359	-0.0380
Other Crops	-0.1289	8.5264	6.3572	-0.3400	0.2238	-0.6173	-0.0047
Meat & Livestock	-0.0596	5.0761	1.6183	0.0205	-0.0066	-0.2303	-0.0294
Other Services	-0.0070	0.3564	0.4289	-0.1158	0.1148	-0.0242	-0.0246
Processed Food	-0.0378	2.2329	1.5220	-0.2339	0.1758	-0.5324	-0.0384
Scenario 3							
Rice	4.8500	-30.2472	-14.2145	2.6183	-2.0027	20.1236	15.5445
Wheat	-0.0019	4.3271	-7.0241	-0.7936	-1.3383	-0.3752	0.1068
Grains & Crops	-0.0298	2.7317	-0.0843	-0.3580	-1.2358	-0.0761	-0.0144
Other Crops	0.1431	5.8121	1.9469	-0.2483	-1.5290	0.0923	0.4497
Meat & Livestock	-0.0276	-0.2956	-1.7332	0.0406	-0.5341	-0.1613	0.0289
Other Services	-0.0161	0.2947	0.2226	-0.1965	-0.5126	-0.0320	-0.0510
Processed Food	-0.0093	0.2822	-3.6389	-0.2694	-1.6771	-0.5663	0.0030
Scenario 4							
Rice	3.2528	-19.8193	-9.3801	1.7660	-1.8476	13.7215	10.2817
Wheat	-0.0011	2.7718	-4.2191	-0.5368	-0.8528	-0.2556	0.0732
Grains & Crops	-0.0208	1.7769	0.0519	-0.2469	-0.7816	-0.0539	-0.0099
Other Crops	0.0890	3.7455	1.3753	-0.1757	-0.9693	0.0364	0.2928
Meat & Livestock	-0.0200	-0.0562	-1.0218	0.0269	-0.3432	-0.1114	0.0177
Other Services	-0.0107	0.1878	0.1470	-0.1317	-0.3227	-0.0218	-0.0335
Processed Food	-0.0078	0.2308	-2.1872	-0.1844	-1.0696	-0.3818	0.0007

Note: All projections are percentage deviations from the base period. Source: Model simulation.

Table 6: Estimated change in trade balance by sector under four scenarios (US$ million)

	RoW	Thailand	Vietnam	South Asia	India	MENA	SSA
Scenario 1							
Rice	9353.4990	-3891.9512	-1828.1746	340.3482	-3367.1016	556.8208	73.0729
Wheat	53.6320	-18.2925	-19.2642	-3.4967	5.5305	-20.0170	-3.1192
Grains & Crops	-1033.3962	605.9843	224.0311	-30.7467	181.9346	-27.3980	-3.1043
Other Crops	-534.1328	116.9907	296.2756	-13.8367	118.9046	3.1521	-1.1769
Meat & Livestock	-770.0778	577.9578	90.2722	-6.5793	87.0354	-45.2582	0.7314
Other Services	-5455.6509	1319.2367	916.7328	-329.5666	2748.2981	-155.1859	-54.8928
Processed Food	-945.3318	675.0668	293.5391	-19.8997	202.8674	-261.5311	-2.7310
Scenario 2							
Rice	6212.4248	-2475.9607	-1166.3094	226.6348	-2366.4932	404.6779	48.2296
Wheat	37.4907	-12.6837	-13.1813	-2.3169	3.9163	-14.6561	-2.0666
Grains & Crops	-716.4977	422.9516	150.0135	-20.7255	131.2063	-20.7123	-2.4424
Other Crops	-367.1662	80.7903	199.2717	-9.3580	85.9594	2.0908	-1.0315
Meat & Livestock	-531.4423	397.9062	60.2023	-4.4060	64.7252	-32.7879	0.4063
Other Services	-3559.1807	712.7790	546.7084	-219.5837	1938.9517	-111.9654	-35.2853
Processed Food	-646.2615	464.7189	192.6060	-13.2306	147.0581	-183.9765	-1.9972
Scenario 3							
Rice	9538.9570	-3897.2813	-1885.7949	347.6620	-3398.1777	475.6903	72.3734
Wheat	2.2663	-2.4751	28.3641	-5.3467	-5.3724	-14.6021	-3.4250
Grains & Crops	-332.2770	345.1687	135.5714	-24.8540	-167.3102	-6.9419	7.0357
Other Crops	183.3826	60.9147	75.0769	-5.3253	-328.8157	0.2338	14.6769
Meat & Livestock	195.3793	-0.3229	20.1557	-5.6109	-191.4299	-20.8206	11.5181
Other Services	-10453.2627	3143.5833	2338.8237	-339.5239	4495.9463	-330.8672	-103.0768
Processed Food	861.4181	153.1779	-262.4011	-19.1492	-514.5865	-196.4279	8.1070
Scenario 4							
Rice	6371.2002	-2478.8293	-1199.2939	233.9393	-2405.4961	328.4082	47.5041
Wheat	3.3517	-1.8829	16.9561	-3.5419	-3.1997	-10.0021	-2.2396
Grains & Crops	-224.3427	222.0067	87.5052	-16.9892	-96.2443	-5.2856	4.5901
Other Crops	108.2536	39.0845	52.0462	-3.8559	-205.2807	0.1811	9.5450
Meat & Livestock	108.6338	10.2234	14.2275	-3.8167	-117.4133	-14.8664	7.4326
Other Services	-6862.3291	1966.9910	1459.4807	-228.3946	3063.7446	-223.1955	-67.1799
Processed Food	523.5064	107.6760	-153.5577	-12.9062	-319.2486	-132.2420	5.1491

Note: All projections are percentage deviations from the base period. Source: Model simulation.

Table 7a: Estimated change (%) in demand for key primary factors by sector (Scenario 1)

Sector	Land	Unskilled labor	Skilled labor	Capital
India				
Rice	-4.6596	-7.3902	-7.5023	-7.4765
Wheat	0.3394	0.0893	0.0237	0.0388
Grains & Crops	0.4143	0.1839	0.1182	0.1333
Other Crops	0.4350	0.2101	0.1444	0.1595
Meat & Livestock	0.2936	-0.2192	-0.3474	-0.3179
Other Services	0.8789	0.3556	0.0374	0.1106
Processed Food	0.8377	0.3341	0.0558	0.1198
Vietnam				
Rice	-12.8982	-23.4875	-23.9268	-23.9142
Wheat	6.0250	4.4876	4.1983	4.2066
Grains & Crops	6.3357	4.8776	4.5878	4.5962
Other Crops	9.7596	9.1861	8.8904	8.8989
Meat & Livestock	4.3770	0.5669	0.0119	0.0278
Other Services	7.3543	1.6170	0.2383	0.2778
Processed Food	7.6539	2.9496	1.7356	1.7704
Thailand				
Rice	-25.8034	-45.5031	-45.9211	-45.9199
Wheat	10.0602	5.9636	5.6347	5.6357
Grains & Crops	8.6439	4.2077	3.8815	3.8825
Other Crops	13.9311	10.7783	10.4421	10.4430
Meat & Livestock	12.2154	5.2735	4.6323	4.6341
Other Services	15.1892	1.7491	0.1917	0.1961
Processed Food	15.6562	4.3316	2.9520	2.9559

Table 7b: Estimated change (%) in demand for key primary factors by sector (Scenario 2)

Sector	Land	Unskilled labor	Skilled labor	Capital
India				
Rice	-3.4916	-5.5489	-5.6337	-5.6142
Wheat	0.2555	0.0687	0.0196	0.0309
Grains & Crops	0.3105	0.1381	0.0889	0.1002
Other Crops	0.3251	0.1566	0.1074	0.1187
Meat & Livestock	0.2236	-0.1583	-0.2544	-0.2323
Other Services	0.6578	0.2664	0.0281	0.0828
Processed Food	0.6285	0.2533	0.0449	0.0928
Vietnam				
Rice	-8.5370	-15.8608	-16.1724	-16.1634
Wheat	4.1178	3.0828	2.8885	2.8941
Grains & Crops	4.2899	3.2992	3.1048	3.1104
Other Crops	6.5681	6.1701	5.9730	5.9786
Meat & Livestock	2.9961	0.4141	0.0390	0.0498
Other Services	4.9873	1.0907	0.1601	0.1868
Processed Food	5.1948	2.0090	1.1914	1.2149
Thailand				
Rice	-16.9071	-31.2185	-31.5409	-31.5403
Wheat	7.0172	4.1844	3.9607	3.9612
Grains & Crops	6.0051	2.9227	2.7004	2.7009
Other Crops	9.6234	7.4411	7.2140	7.2145
Meat & Livestock	8.4442	3.6211	3.1848	3.1858
Other Services	10.5168	1.1968	0.1309	0.1331
Processed Food	10.8356	2.9957	2.0551	2.0570

Table 7c: Estimated change (%) in demand for key primary factors by sector (Scenario 3)

Sector	Land	Unskilled labor	Skilled labor	Capital
India				
Rice	17.9034	28.6689	29.0993	29.0045
Wheat	-1.6577	-1.1407	-0.9253	-0.9728
Grains & Crops	-1.5685	-1.0277	-0.8122	-0.8597
Other Crops	-1.8236	-1.3509	-1.1357	-1.1831
Meat & Livestock	-1.2795	-0.0682	0.3555	0.2621
Other Services	-2.5450	-1.1819	-0.1364	-0.3671
Processed Food	-2.8573	-2.0187	-1.1081	-1.3089
Vietnam				
Rice	-0.2049	-0.4567	-0.5085	-0.5051
Wheat	-6.1891	-7.8742	-7.9020	-7.9002
Grains & Crops	-0.0359	-0.1301	-0.1592	-0.1573
Other Crops	1.7620	2.1444	2.1150	2.1170
Meat & Livestock	-1.2974	-2.1295	-2.1858	-2.1821
Other Services	0.3252	0.3299	0.1887	0.1979
Processed Food	-1.5236	-3.5690	-3.6898	-3.6818
Thailand				
Rice	-9.0391	-18.1303	-18.3674	-18.3543
Wheat	5.1974	3.4575	3.3074	3.3157
Grains & Crops	3.7807	1.6827	1.5340	1.5422
Other Crops	6.5153	5.1113	4.9600	4.9684
Meat & Livestock	2.8347	-1.7115	-1.9977	-1.9818
Other Services	6.9854	0.8373	0.1204	0.1599
Processed Food	6.5819	0.7665	0.1397	0.1743

Table 7d: Estimated change (%) in demand for key primary factors by sector (Scenario 4)

Sector	Land	Unskilled labor	Skilled labor	Capital
India				
Rice	11.4129	18.1172	18.3788	18.3212
Wheat	-1.0495	-0.7322	-0.5965	-0.6264
Grains & Crops	-0.9874	-0.6537	-0.5179	-0.5478
Other Crops	-1.1509	-0.8606	-0.7250	-0.7548
Meat & Livestock	-0.8051	-0.0562	0.2103	0.1516
Other Services	-1.5887	-0.7442	-0.0860	-0.2310
Processed Food	-1.7931	-1.2851	-0.7111	-0.8375
Vietnam				
Rice	-0.3476	-0.6954	-0.7354	-0.7331
Wheat	-3.6923	-4.7582	-4.7802	-4.7789
Grains & Crops	0.0926	0.0131	-0.0095	-0.0082
Other Crops	1.2641	1.4948	1.4720	1.4733
Meat & Livestock	-0.7208	-1.2948	-1.3387	-1.3362
Other Services	0.3215	0.2291	0.1196	0.1259
Processed Food	-0.8018	-2.1321	-2.2267	-2.2213
Thailand				
Rice	-5.8039	-11.7929	-11.9515	-11.9432
Wheat	3.3284	2.2122	2.1161	2.1211
Grains & Crops	2.4460	1.1032	1.0076	1.0125
Other Crops	4.1920	3.2987	3.2020	3.2071
Meat & Livestock	1.9227	-0.9571	-1.1423	-1.1327
Other Services	4.4779	0.5380	0.0764	0.1004
Processed Food	4.2451	0.5437	0.1399	0.1609

5.3. Effects on trade patterns

Tables 8 (a, b, c, d) present the changes in export sales in the different sectors used in this study in India, Vietnam, and Thailand. In scenarios 1 and 2, the results indicate that all sectors benefit from imposing export bans on rice. The sectors where exports increased the most in India were wheat (between 4.5% for SSA and 7.8% for Thailand) and meat and livestock (between -3.6% for Thailand and 5.5% for South Asia). For Vietnam, the sectors with the greatest increase in exports were meat and livestock (9.5% for Thailand and 20.7% for South Asia), grains and crops (4.6% for Thailand and 12.5% for MENA and SSA). For Thailand, the surge in wheat exports outperformed other sectors (between 50% for SSA and 56.4% for Vietnam), followed by other crops (between 25.1% for India and 30.5% for Vietnam). In scenarios 3 and 4, the findings suggest that most sectors in India suffer from a decline in their exports (e.g., other crops in the range of -4.3% for South Asia and -8.2% for Thailand); however, this decline seems to be less acute in Vietnam (where exports in some sectors increase slightly) while Thailand appears to preserve an increasing trend of exports in most sectors, especially in the wheat sector (between 14.1% for Vietnam and 17.3% for India).
Since bans on rice exports pushed up exports in other sectors (e.g., wheat, meat, and livestock), the governments of India, Vietnam, and Thailand should actively seek to negotiate new trade agreements and partnerships to stabilize demand for these alternative exports. Engaging in bilateral and multilateral trade negotiations with regions like SSA, MENA, and South Asia could provide long-term stability. Also, Policymakers should consider incentivizing diversification in agricultural outputs whereby supporting farmers to produce a broader range of high-value crops (e.g., wheat, grains, and processed food) that can be competitive in global markets could lead to reducing dependence on rice exports. Farmers and exporters in sectors adversely affected by trade shocks (e.g., Indian crop producers facing export declines) should be provided with direct subsidies, tax incentives, and financial assistance as a part of governments' plans to channel financial support to its most beneficial uses.
Governments should also seek to stabilize Currency Exchange Rates which necessitate the mandate of monetary policy to maintain a competitive exchange rate to advocate export competitiveness, as changes in trade patterns have an impact on terms of trade. Fiscal policy should also align with monetary policy to support affected sectors by allocating budgetary resources for export-oriented sectoral development programs to sustain competitiveness despite trade shocks.

Table 8a: Change in exports sales of commodity i from region r to region s (Scenario 1)

Sector	Row	Thailand	Vietnam	S.Asia	India	MENA	SSA
India							
Rice	-100.0	-40.6	-35.4	-100.0	-0.7	-100.0	-100.0
Wheat	4.5	7.8	6.7	4.3	2.6	4.7	4.5
Grains & Crops	2.3	-4.2	0.0	2.3	1.6	2.4	2.3
Other Crops	3.6	-4.0	3.7	4.6	1.1	2.5	3.7
Meat & Livestock	4.3	-3.6	-1.0	5.5	2.5	4.6	4.2
Other Services	0.8	0.9	0.8	0.9	0.7	0.7	0.7
Processed Food	1.4	1.9	0.5	1.5	1.0	2.1	1.4
Vietnam							
Rice	-75.0	-11.1	-2.7	-75.0	38.4	-75.0	-75.0
Wheat	6.0	9.2	8.0	5.9	3.9	6.0	5.7
Grains & Crops	11.1	4.6	10.5	12.0	11.4	12.5	12.5
Other Crops	10.1	2.1	10.7	10.9	7.0	9.0	10.1
Meat & Livestock	18.2	9.5	13.8	20.7	16.4	19.7	19.2
Other Services	1.4	1.5	1.5	1.3	1.3	1.4	1.4
Processed Food	4.2	4.7	3.6	4.4	3.5	4.9	4.3
Thailand							
Rice	-75.0	27.1	25.9	-75.0	77.3	-75.0	-75.0
Wheat	52.9	57.7	56.4	53.8	51.4	50.3	50.0
Grains & Crops	18.6	16.3	18.2	21.7	20.9	21.1	22.9
Other Crops	28.3	23.6	30.5	31.6	25.1	27.6	28.9
Meat & Livestock	24.3	19.1	20.1	27.4	23.9	27.5	26.5
Other Services	0.8	1.0	0.8	1.0	0.7	0.8	0.8
Processed Food	4.6	5.5	3.6	4.6	3.9	5.3	4.8

Table 8b: Change in exports sales of commodity i from region r to region s (Scenario 2)

Sector	Row	Thailand	Vietnam	S.Asia	India	MENA	SSA
India							
Rice	-75.0	-28.9	-24.1	-75.0	-0.3	-75.0	-75.0
Wheat	3.2	5.5	4.7	3.0	1.8	3.3	3.2
Grains & Crops	1.7	-2.9	0.1	1.6	1.1	1.7	1.6
Other Crops	2.6	-2.7	2.6	3.2	0.9	1.9	2.7
Meat & Livestock	3.1	-2.4	-0.5	3.9	1.9	3.4	3.1
Other Services	0.5	0.6	0.6	0.6	0.5	0.5	0.5
Processed Food	1.0	1.4	0.4	1.1	0.7	1.5	1.0
Vietnam							
Rice	-50.0	-8.3	-1.6	-50.0	24.8	-50.0	-50.0
Wheat	4.1	6.3	5.5	4.0	2.6	4.1	3.9
Grains & Crops	7.5	2.9	7.0	8.0	7.6	8.4	8.4
Other Crops	6.8	1.3	7.1	7.3	4.7	6.0	6.8
Meat & Livestock	12.1	6.2	9.1	13.8	10.9	13.2	12.8
Other Services	0.9	1.0	1.0	0.8	0.8	0.9	0.9
Processed Food	2.8	3.2	2.4	3.0	2.3	3.3	2.9
Thailand							
Rice	-50.0	18.4	18.7	-50.0	50.8	-50.0	-50.0
Wheat	35.8	38.9	38.0	36.3	34.8	34.1	33.9
Grains & Crops	12.8	11.3	12.7	15.0	14.5	14.6	15.8
Other Crops	19.4	16.3	20.9	21.6	17.2	19.0	19.8
Meat & Livestock	16.7	13.1	13.9	18.7	16.4	18.8	18.1
Other Services	0.5	0.6	0.5	0.6	0.4	0.5	0.5
Processed Food	3.1	3.8	2.5	3.2	2.7	3.6	3.3

Table 8c: Change in exports sales of commodity i from region r to region s (Scenario 3)

Sector	Row	Thailand	Vietnam	S.Asia	India	MENA	SSA
India							
Rice	-107.5	-81.1	-84.3	-106.2	-61.4	-89.0	-105.5
Wheat	-5.4	-5.4	-9.1	-4.6	-4.2	-5.0	-5.4
Grains & Crops	-2.6	-6.6	-5.0	-1.3	-2.6	-2.4	-2.7
Other Crops	-10.0	-13.0	-9.2	-7.1	-6.7	-9.3	-10.0
Meat & Livestock	-7.2	-6.2	-5.7	-4.7	-4.7	-6.5	-7.0
Other Services	0.5	0.1	-0.4	0.6	-0.2	0.4	0.4
Processed Food	-4.3	-4.3	-4.4	-3.5	-3.9	-3.7	-4.2
Vietnam							
Rice	-75.0	-24.8	-35.7	-80.3	16.1	-38.5	-73.9
Wheat	-7.6	-7.4	-11.0	-7.1	-6.2	-6.9	-7.1
Grains & Crops	3.3	-0.8	1.3	4.6	3.9	3.5	3.4
Other Crops	2.1	-1.0	3.1	5.2	6.5	2.8	1.9
Meat & Livestock	-1.8	-0.7	-0.5	0.4	1.3	-1.2	-1.8
Other Services	2.2	1.8	1.5	2.0	1.6	2.2	2.2
Processed Food	-5.2	-5.2	-5.7	-4.6	-4.2	-4.6	-5.3
Thailand							
Rice	-77.0	-35.3	-29.1	-73.2	17.3	-40.6	-71.3
Wheat	25.4	26.1	21.9	26.4	27.5	24.2	24.0
Grains & Crops	9.8	7.9	8.4	12.4	11.9	11.0	11.7
Other Crops	13.6	11.9	15.6	17.8	18.2	14.6	13.5
Meat & Livestock	-0.1	0.7	1.3	2.1	3.0	0.5	0.0
Other Services	1.3	1.0	0.4	1.4	0.6	1.2	1.3
Processed Food	0.7	0.8	0.6	1.4	1.5	1.3	0.8

Table 8d: Change in exports sales of commodity i from region r to region s (Scenario 4)

Sector	Row	Thailand	Vietnam	S.Asia	India	MENA	SSA
India							
Rice	-83.7	-59.3	-62.4	-82.1	-43.0	-63.0	-80.2
Wheat	-3.2	-3.2	-5.5	-2.8	-2.6	-3.0	-3.2
Grains & Crops	-1.5	-4.1	-3.0	-0.7	-1.6	-1.4	-1.6
Other Crops	-6.3	-8.2	-5.8	-4.3	-4.2	-5.8	-6.3
Meat & Livestock	-4.4	-4.0	-3.6	-2.8	-2.9	-4.0	-4.3
Other Services	0.3	0.1	-0.2	0.4	-0.1	0.3	0.3
Processed Food	-2.7	-2.7	-2.8	-2.2	-2.5	-2.3	-2.6
Vietnam							
Rice	-50.0	-14.4	-22.4	-55.0	16.9	-20.1	-48.8
Wheat	-4.6	-4.4	-6.6	-4.3	-3.7	-4.1	-4.2
Grains & Crops	2.2	-0.4	1.0	3.0	2.6	2.4	2.3
Other Crops	1.5	-0.6	2.2	3.5	4.2	1.9	1.3
Meat & Livestock	-0.7	-0.2	0.0	0.7	1.1	-0.4	-0.7
Other Services	1.4	1.2	0.9	1.3	1.0	1.4	1.4
Processed Food	-3.1	-3.1	-3.4	-2.7	-2.5	-2.7	-3.1
Thailand							
Rice	-51.7	-21.7	-17.9	-48.7	17.5	-21.6	-46.6
Wheat	16.1	16.6	14.1	16.7	17.3	15.4	15.2
Grains & Crops	6.3	5.1	5.4	7.9	7.5	7.0	7.5
Other Crops	8.7	7.6	10.0	11.4	11.5	9.3	8.7
Meat & Livestock	0.4	0.8	1.2	1.9	2.2	0.8	0.4
Other Services	0.8	0.6	0.3	0.9	0.4	0.8	0.8
Processed Food	0.5	0.6	0.4	1.0	1.0	0.9	0.6

6. Policy and Research Implications

The findings of this study aim to provide considerable implications for policymakers which are of particular importance to macroeconomic stability, trade policy, and long-run economic development. Tariff regime simplification should be considered by policymakers in addition to the refinement of trade facilitation policies since lowering restrictions on trade while ensuring well-balanced market access can counter adverse effects due to trade war and elevate long-run economic stability. The research further outlines the importance of exchange rate management to hedge against external shocks by combining a flexible exchange rate policy with macroprudential measures. The governments of India, Thailand, and Vietnam have the difficult task of counteracting negative trade shocks built on synchronizing their fiscal policies with macroeconomic conditions. This is achieved through employing counter-cyclical fiscal policy measures such as deliberate public investment schemes and changes in tax policies to keep stable domestic demand. Also, central banks should carefully design their monetary policies to anchor inflation expectations while supporting economic growth. Additionally, enhancing macroeconomic stability for these countries requires adopting a data-dependent approach to interest rate management as well as in the case of India's inflation-targeting framework. To achieve resilience, structural economic reforms such as improving labor market flexibility, enhancing productivity through digitalization, and diversification of the export sector, are also needed.

Although this paper presents some important findings, there are areas left open for study. Future research could explore the trade policy effects disaggregated to sectors or regions, producing more detailed policy recommendations. Also, the design of analysis using dynamic CGE modeling can provide a more complete picture of the policy intervention over time, particularly their long-term effects on welfare and growth.

Interestingly, further investigation into how financial markets operate in mitigating trade shocks, (e.g., how investors adjust their portfolios when policy changes) would prove useful in providing additional insights towards stabilizing economic conditions. With the added focus on sustainability, subsequent research could investigate how trade policy impacts Sustainable Development Goals (SDGs), particularly with regard to environmental sustainability, poverty reduction, and inclusive growth.

7. Concluding Remarks

On July 20, India declared that it would limit non-basmati rice exports to lower domestic rice prices, which have increased by over 30% since October 2022. The worldwide rice market has seen price increases of 15–20% since September 2022; the ban is the most recent setback to this trend. India's current action complements its previous, more relaxed export limitations on rice. India put a 20% additional tariff on exports of non-basmati rice in 2022 and outlawed the export of broken rice. However, the most recent prohibition might have caused these numbers to decline, raising the possibility of increased global prices and worsening food insecurity. The objective of this study is to outline the immediate empirical effects of India's recent ban on rice exports on the economies of top rice-producing countries (for example, Thailand, Vietnam, and India) and countries whose share of imported rice from India exceeds 60%. To understand the likely impacts on these economies, we designed four policy scenarios in which scenarios 1 and 2 are concerned with varying the export ban on rice in India, Vietnam, and Thailand; scenarios 3 and 4 are concerned with a reduction in the productivity of rice crops in India, Vietnam, and Thailand due to the strengthening of El Nio. In terms of macroeconomic ramifications, the majority of the regions were expected to experience a decline in real GDP in each of the four scenarios, with India, Thailand, and Vietnam experiencing the greatest decline in Scenario 3. This suggests that the economies of India, Vietnam, and Thailand will be most affected by a decline in productivity brought on by a strengthening El Nio and a positive Indian Ocean Dipole. The percentage changes in Terms of Trade (ToT) show that in all cases, India, Thailand, and Vietnam have more import-purchasing power because of the export earnings from each unit of each exported commodity. Trade balance fluctuations show that under all but one of the scenarios, the current account positions of Vietnam, Thailand, and India decline. However, Vietnam's trade balance is positive and shows a larger surplus in Scenario 3 than in Scenario 2, demonstrating that, in contrast to India and Thailand, Vietnam can control its productivity and exports during times of natural disasters and climate change.

Regarding net welfare gains, as determined by real consumption expenditure (RCE) and equivalent variation (EV), India and Vietnam seem to be experiencing positive EVs, indicating an improvement in economic welfare as a result of the trade creation that occurs when rice exports are banned in scenarios 1 and 2. However, scenarios 3 and 4 appear to show a significant decline in the economic well-being of both countries, highlighting the damaging impact of increased productivity caused by a strengthening El Niño and a positive Indian Ocean Dipole on the economies of Vietnam and India.

For countries that import rice from India, the projection shows that every scenario results in negative EVs, suggesting a trade diversion effect. When weather affects productivity (scenarios 3 and 4), the scale is larger than when a ban is the only measure (scenarios 1 and 2). Real consumption expenditure is expected to decline in all economies, with consumers in India generally doing worse in Scenarios 3 and 4, and better in Scenarios 1 and 2. Additionally, it is predicted that real consumption expenditure in Vietnam will increase in scenarios 1 and 2 and significantly decline in scenarios 3 and 4 relative to other economies.

In terms of sectoral effects, rice will be the most negatively affected in Vietnam and India, as farmers will redirect their resources to other areas such as wheat, grains, and other crops, which will benefit the most from the decrease in rice output. In Scenarios 1 and 3, Thailand's rice outputs will be the most negatively impacted; in contrast, wheat, grains, crops, and other crops will be the most positively impacted, similar to what happens in India and Vietnam. The MENA region will see an increase in rice production if exports from Thailand, Vietnam, and India are prohibited. In scenarios 1 and 2, "Processed food" in India exhibits the greatest improvement in the trade balance, followed by "Grains and Crops" and then "Other Crops". On the other hand, scenarios 3 and 4 demonstrate how climate change negatively affects all sectors except for "Other Services".

Except for rice, all Indian sectors showed a slight increase in demand for the use of all primary factors (scenarios 1 and 2). However, the use of labor and capital in the meat and livestock sector decreases (Scenarios 1 and 2), suggesting that this sector is experiencing low productivity and a higher cost of capital. Overall, all sectors in Vietnam and Thailand (scenarios 1 and 2 for Vietnam and all scenarios for Thailand) increased their demand for the use of all primary factors, except for rice. However, the increase is reported to be very high in comparison to that in India, highlighting the vitality of these sectors in the economies of these two countries, as well as the high mobility of primary factors in these two countries, as opposed to the low mobility reported in India.

Finally, it appears from the Effects on Trade Patterns that in Scenarios 1 and 2, export bans on rice will be advantageous to all industries. Wheat, meat, and livestock were the two industries in India where exports rose the most. Meat and livestock were Vietnam's top export-growth industries, followed by grains and crops. The increase in wheat exports to Thailand pushed all other sectors followed by other crops. The increase in wheat exports for Thailand surpassed that of all other sectors, followed by that of other crops. The results of scenarios 3 and 4 indicate that most Indian industries, including other crops, are experiencing a decline in exports. However, Vietnam appears to be less affected by this decline (with some sectors experiencing a slight increase in exports), while Thailand seems to maintain an increasing trend in exports across most sectors, particularly wheat.

By creating new vulnerabilities in commodity markets, India's decision to ban non-basmati rice exports jeopardizes the already precarious global food security. What transpires and how severe the consequences will depend on several factors, including the state of the atmosphere, specifics of the export ban, and the responses of other rice exporters. Therefore, governments must learn from past price spikes that have long-lasting effects on world hunger, food insecurity, nutrition, and poverty. Therefore, we hope that the findings of this study will be crucial in determining trade policy decisions and discourage governments from enacting export restrictions.

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Data availability
The author confirms that all data generated or analyzed during this study are included in this published article. Furthermore, primary and secondary sources and data supporting the findings of this study were all publicly available at the time of submission.

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Mazen Diwani (**ORCID ID: 0000-0003-4253-314X**) is an Economist with over 14 years of diversified experience in academia, research, and industry across the Middle East, Europe, Central Asia, and China. He holds a Ph.D. in Economics from Sapienza University of Rome (Italy), where his research focused on models for economics and finance. Dr. Diwani's academic expertise spans economic modeling, policy evaluation, and macroeconomic simulations. His research integrates theoretical modeling, empirical analysis, and computational techniques to address complex economic challenges.

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In addition to academia, Dr. Diwani has professional experience as an Operations Consultant with the Food and Agriculture Organization of the United Nations, focusing on macroeconomic analysis and policy evaluation for the Near East and North Africa region. He also has significant industry experience in the banking sector, where he specialized in credit risk analysis and financial policy recommendations. Dr. Diwani is an Advanced Higher Education Fellow (FHEA) and actively participates in international conferences and collaborative research initiatives.

His ongoing research includes exploring the economic effects of crises, such as the Russian-Ukrainian war, and conducting computable general equilibrium (CGE) analyses to evaluate international trade policies and macroeconomic resilience.

Table A1. Aggregation of regions and commodities

Aggregated region	GTAP region	Aggregated sector	GTAP commodity in each sector
Rest of the World (RoW)	All other Regions	*Rice*	Paddy rice; Processed rice
India	India	*Wheat*	Wheat
Vietnam	Vietnam	*Grains and Crops*	Cereal grains nec, Vegetables, fruit, nuts, Oil seeds, Sugar cane, sugar beet, Plant-based fibers
Thailand	Thailand	*Meat and Livestock*	Cattle: cattle, sheep, goats, horses, asses, mules, and hinnies; and semen thereof, Other Animal Products: swine, poultry and other live animals; eggs, in shell (fresh or cooked), natural honey, snails (fresh or preserved) except sea snails; frogs' legs, edible products of animal origin n.e.c., hides, skins and furskins, raw , insect waxes and spermaceti, whether or not refined or coloured, Raw milk, Wool: wool, silk, and other raw animal materials used in textile, Cattle Meat: fresh or chilled meat and edible offal of cattle, sheep, goats, horses, asses, mules, and hinnies. raw fats or grease from any animal or bird, Other Meat: pig meat and offal. preserves and preparations of meat, meat offal or blood, flours, meals and pellets of meat or inedible meat offal; greaves
MENA	Algeria, Iran, Kuwait, Oman, Qatar, and Saudi Arabia		
Sub-Saharan Africa "SSA"	Angola, Ethiopia, Central African Republic, Somalia, Sierra Leone, Sudan, and Liberia		
		Other Services	Forestry: forestry, logging and related service activities, Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing, Coal: mining and agglomeration of hard coal, lignite and peat, Oil: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part), Gas: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part), Other Mining: mining of metal ores, uranium, gems. other mining and quarrying, Textiles: textiles and man-made fibres, Wearing Apparel: Clothing, dressing and dyeing of fur, Leather: tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear, Lumber: wood and products of wood and cork, except furniture; articles of straw and plaiting materials, Paper & Paper Products: includes publishing, printing and reproduction of recorded media, Petroleum & Coke: coke oven products, refined petroleum products, processing of nuclear fuel, Chemical Rubber Products: basic chemicals, other chemical products, rubber and plastics products, Non-Metallic Minerals: cement, plaster, lime, gravel, concrete, Iron & Steel: basic production and casting, Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver,Fabricated Metal Products: Sheet metal products, but not machinery and equipment, Motor Motor vehicles and parts: cars, lorries, trailers and semi-trailers, Other Transport Equipment: Manufacture of other transport equipment, Electronic Equipment: office, accounting and computing machinery, radio, television and communication equipment and apparatus, Other Machinery & Equipment: electrical machinery and apparatus n.e.c., medical, precision and optical instruments, watches and clocks, Other Manufacturing: includes recycling, Electricity: production, collection and distribution, Gas Distribution: distribution of gaseous fuels through mains; steam and hot water supply, Water: collection, purification and distribution, Construction: building houses factories offices and roads, Trade: all retail sales; wholesale trade and commission trade; hotels and restaurants; repairs of motor vehicles and personal and household goods; retail sale of automotive fuel, Other Transport: road, rail ; pipelines, auxiliary transport activities; travel agencies, Water transport, Air transport, Communications: post and telecommunications, Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding, Insurance: includes pension funding, except compulsory social security, Other Business Services: real estate, renting and business activities, Recreation & Other Services: recreational, cultural and sporting activities, other service activities; private households with employed persons (servants), Other Services (Government): public administration and defense; compulsory social security, education, health and social work, sewage and refuse disposal, sanitation and similar activities, activities of membership organizations n.e.c., extra-territorial organizations and bodies, Dwellings: ownership of dwellings (imputed rents of houses occupied by owners)
South Asia	Angola, Ethiopia, Central African Republic, Somalia, Sierra Leone, Sudan, and Liberia		
		Other Crops	live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds, beverage and spice crops, unmanufactured tobacco, cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets, plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes, sugar beet seed and seeds of forage plants, other raw vegetable materials

Source: GTAP database version 9.