Exploring the Economic Impact of Changing Climate Conditions and Trade Policies on Agricultural Trade: A CGE Analysis

By Eddy Bekkers and Lee Ann Jackson

Agricultural trade will play a significant role in the future contribution of the agriculture sector to local and global economic outcomes, including economic growth, rural employment, and food prices. Trade outcomes will be affected by changes in production that result from productivity effects associated with climate change. In addition, government intervention in markets may also have significant effects, both on production incentives for farmers and, ultimately, on the competitive conditions in international markets. This paper explores the ways in which changing global agricultural productivity and policy patterns affect economic outcomes.

In the face of expected increased temperature stresses, variable water availability, limits to arable land and continued population growth, debates about how to ensure global food supply will meet future demand are intensifying. In the future, changing climate conditions may alter the relative productivity of regional agricultural production and, as a result, affect the trading patterns. Trade can play an important role in enabling products to move to areas of shortage. At the same

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time, the trading system is also affected by direct and indirect policy interventions. Policy decisions related to public support for agriculture and trade policies will influence outcomes by affecting the decisions of farmers, consumers, and traders and by altering the relative competitiveness of products on the marketplace.

Complex global models are increasingly being used to understand how economic and agricultural systems interact. Purely biophysical models are likely to underestimate the shifting between crops that occurs due to farmers' responses to changes in land and crop prices. However, models that ignore biophysical relationships and focus mainly on economic responses may overestimate the importance of price changes (Baldos and Hertel 2013). The challenge is to develop models that capture the essential relationships of both natural systems and economic systems while incorporating links between the two. Some authors examine these relationships by focusing on the natural resource endowments of countries or regions (see for example, Anderson and Strutt 2014).

Economic models are being extended to incorporate different types of land so that they reflect land use choices, particularly the conversion of forest into agricultural land (Gouel and Laborde 2018; FAO 2017). The heterogeneity of land within countries—and its influence on the way climate change affects land use—has also received a lot of attention (see for example, Ahammad and others 2015; Nelson and others 2013). The analysis in this paper is based on a largely economic model that includes differentiated land uses, allowing some aspects of the biophysical constraints to be reflected in the results. In particular, the model allows for limited possibilities to transform forest land into agricultural land and crop land into grazing land (and vice versa), with the total supply of land highly inelastic. This extension of the model is essential to evaluate the effects of climate change on the global distribution of agricultural production.

This paper focuses on the specific question of how trading relationships and climate change effects interact to determine trade patterns over time. Time lags associated with the effect of policy decisions are also important in terms of how agricultural and economic systems adjust to changing environmental and economic conditions. Some policy decisions, such as investments in research and development, will have longer-term effects on agricultural productivity and resulting comparative advantages. Other decisions, such as the imposition of tariffs, will have immediate economic effects and may also have lingering effects once tariffs are removed. Long-term scenario studies of agriculture have become increasingly important to understanding the trade-offs inherent in policy decisions and the current and future effects that result from these changes.

In this paper, we explore the potential effect of climate-change-related productivity growth and trade costs on global economic outcomes, including exports and imports, import dependency, and export market concentration. Using simulations from a dynamic computable general equilibrium (CGE) model, we first examine the outcomes of a baseline projection of the global economy until 2040 without additional policy shocks. Then, under two scenarios, we examine how the baseline results would change as a result of shocks to the productivity growth of agricultural crops due to climate change and as a result of increases in global trade costs.

This modeling exercise is useful in several ways. First, results from this general equilibrium model reflect systemic interactions and capture the indirect, as well as direct, outcomes of policy choices. Second, because the model is computable, the scenario results provide additional insight into the size and direction of changes over time. Third, dynamic CGE modeling allows analysts to look at the expected effects of climate change and trade policies on future trading patterns.

Section I describes the model of the global economy that we use for our simulations and the underlying data. Section II outlines the baseline projections and the experiments that we implement to highlight how trade policy enables or inhibits products to move within the global trading system and how these affect different parts of the economy. Section III discusses the results of our simulations.

I. Economic Model and Baseline Data

We conduct our analysis with the WTO Global Trade Model (GTM), a recursive dynamic CGE model based on version 7 of the Global Trade Analysis Project (GTAP) model. The model features multiple sectors, multiple factors of production, intermediate linkages, multiple types of demand (private demand, government demand, investment demand, and intermediate demand by firms), nonhomothetic preferences for private households, a host of taxes, and a global transport sector. Each region has a representative agent collecting factor income and tax revenues and spending them under utility maximization on private consumption, government consumption, and savings. Firms display profit-maximizing behavior, choosing the optimal mix of factor inputs and intermediate inputs. Savings are allocated to investment in different regions. A more detailed description of the model can be found in Aguiar and others (forthcoming).

The GTM is calibrated to the current GTAP database, which has 141 regions and 57 sectors, and contains additional features such as endogenous capital accumulation and isoelastic factor supply of land and natural resources. The baseline projections of this model will include changes in geographical patterns of net exports and patterns of growth in different crops. All parameters other than those related to the supply functions of land and natural resources are set at standard values provided by the GTAP 109.2 database.

For the sake of computational efficiency—and to focus the analytical results—we use an aggregation of the GTAP data that focuses on 26 sectors, 15 regions, and five factors of production (see Table 1). The sectoral aggregation includes the sectors of interest related to agricultural trade as well as a disaggregation of certain commodity crops.

Changes in agricultural production over time can result from shifts in land use or improvements in yields. As the climate shifts and the location of production changes, agricultural productivity may face new limitations. To account for this, the model incorporates a nested structure for land allocation that allows for shifts in land use for forest, crop, and livestock production. In this structure, agricultural land can be expanded by reducing the amount of forest land. We extend the model with a nested structure for the allocation of land across sectors, following Hertel and others (2008). In particular, the model allocates the total amount of land across forest or across agricultural sectors according to an elasticity of transformation function. Agricultural land, in turn, can be allocated across crops or across livestock. And crop land, in turn, can be allocated across different crops with an elasticity of transformation function, whereas grassland is a homogeneous good used in the different livestock sectors. We follow Hertel and others (2008) and set the elasticities of transformation between forest and agriculture, crops and livestock, and different types of crops at 0.25, 0.5, and 1, respectively.

Table 1
Overview of Regions and Sectors

Regions	Sectors
Other developed countries	Crops
Other Asian countries	Paddy rice
Japan	Wheat
China	Cereal grains nec
India	Vegetables, fruit, nuts
ASEAN	Oil seeds
Canada	Sugar cane, sugar beet
North America	Plant-based fibers
Mexico	Crops nec
Brazil	Livestock
Latin America and Caribbean	Cattle, sheep, goats, horses
European Union 28	Animal products nec
Middle East and North Africa	Raw milk
Sub-Saharan Africa	Wool, silk-worm cocoons
Rest of world	Resource extraction
	Forestry
	Fishing
	Coal
	Processed food
	Meat: cattle, sheep, goats, horses
	Meat products nec
	Vegetable oils and fats
	Dairy products
	Processed rice
	Sugar
	Food products nec
	Beverages and tobacco products
	Other
	Textiles
	Other manufactures
	Services

Unlike Hertel and others (2008), we do not model different agri-ecological zones within each region.

As usual with CGE projections, there are a few necessary qualifications to keep in mind. First, CGE models allow researchers to conduct thought experiments about what the world would be like if certain changes occurred. The results should not be interpreted as unconditional predictions, since they cannot control for many unknown factors that could change. Moreover, the results are sensitive to assumptions about base parameters and underlying model structure.

Second, while the model described here aggregates sectors to allow for a more detailed examination of crops within the agriculture sector, the aggregation does not include biofuels as a subsector for analysis. New biofuel mandates and subsidies could have effects on international food prices, and these effects could increase depending on mandates in the United States and the European Union. Changes to the fossil fuel economy, including the potential expansion of alternatives to fossil fuels, could lead to the removal of biofuel mandates. Including biofuel in the model's structure would likely lead to different results for products like sugar and corn. However, the inclusion of biofuels would require modeling the interaction between fuel and food markets in more detail and is out of the scope of this exercise. Furthermore, other work shows that the effect of biofuel targets on food prices is limited (Delzeit and others 2018).

Third, this model does not include tariff quotas explicitly in its analysis of constraints on trade. In this model, the changes in tariffs are used to capture market access barriers. Given the prevalence of tariff quotas in the agriculture sector, the exclusion of these policy measures could mean that our simulations underestimate the potential effects of the trade policy and climate shocks on trade outcomes.

Fourth, assumptions about agricultural productivity growth play an important role in the results generated through model simulations. As noted previously, the underlying parameters for agricultural productivity growth in the model follow average productivity growth; this has implications for the results, particularly those related to price trends.

II. Design of Dynamic Projections

Before exploring the effect of rising trade costs and climate change on global agricultural trade, we first construct a baseline scenario for the world economy. We start the simulations in 2014 based on the latest release of GTAP, GTAP 10.2. Following standard approaches, we construct a baseline using projections on growth in GDP per capita, population, the labor force, and skills to discipline our trajectory of the world economy until 2040. The growth in population, the labor force, and skills are imposed on the projections, and GDP per capita growth is targeted by endogenizing noncapital-augmenting productivity growth, while allowing for endogenous capital accumulation based on recursive dynamics. GDP per capita growth is based on the Organisation for Economic Co-operation and Development (OECD) Shared Socioeconomic Pathways projections, SSP2 (Dellink and others 2017). Population and labor force growth come from the United Nations population projections, medium variant for 2015 (UN Department of Economic and Social Affairs 2015). Changes in the number of skilled and unskilled workers are inferred from projections on education levels by the International Institute for Applied Systems Analysis (IIASA) (KC and Lutz 2017). The changes in the share of tertiary-educated individuals are used as a proxy for changes in the share of skilled workers.

Besides these standard features of projections in dynamic CGE models, we model three additional dynamics. First, we allow for changes in the preference parameters as countries grow richer, so that income elasticities change over time with a country's level of income per capita. The income elasticities for consumption are particularly important, because they allow the model to capture the effect of rising incomes on agriculture consumption. Private consumption is modeled according to a constant difference elasticity (CDE) utility function, which displays little change over time in income elasticities as countries grow richer. We regress the parameter determining income elasticities on GDP per capita and impose the predicted changes on the model. As a result, income elasticities for agricultural goods fall as countries grow richer, whereas income elasticities for services rise.

Second, the model allows for differential productivity growth across sectors, based on empirical estimates employing both EU KLEMS and OECD-STAN total factor productivity data. The estimates imply higher productivity growth in manufacturing than in services. The estimates also predict higher-than-average productivity growth in agriculture, which is in line with the literature on structural change (Herrendorf, Rogerson, and Valentinyi 2013). However, the CGE literature tends to estimate productivity separately for the agricultural sectors (Ludena and others 2007; Fontagné, Fouré, and Ramos 2012), which implies a lower productivity growth in agriculture than in other sectors, especially in countries with high GDP growth. Higher than average productivity growth would imply falling real agricultural prices, whereas separate (lower than average) productivity estimates for the agricultural sectors would imply strongly rising prices. To take a middle ground between the two approaches, we assume that productivity growth in the agricultural sector follows average productivity growth.

Third, the domestic saving rates are targeted to the projections of the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) model Macroeconometrics of the Global Economy (MaGE) (Fontagne and others 2012). In this model, saving rates are determined by demographic development in a life-cycle framework. Saving rates stay virtually constant in the basic model, with savings a Cobb-Douglas share of national expenditures. Targeting the saving rates to the projections from a macroeconomic model makes the model more realistic and also helps the model to get closer to a steady state with converging rates of return, given that the base year (2014) saving rates are too large for a steady state with constant rates of return, especially in countries such as China. Further details on the three extensions are in Bekkers and others (2018).

We examine the effect of two separate shocks, rising trade costs as a result of trade tensions and climate-induced productivity change, on geographical patterns of net exports (including import dependency and export concentration) and on patterns of growth for different agriculture crops. First, we explore the effect of a global increase in tariffs—based on the estimates of Nicita, Olarreaga, and Silva (2018)—on the size of noncooperative tariffs. We work with a scenario in which the tariffs rise by half the level predicted by Nicita, Olarreaga, and Silva (2018). Second, we examine the effect of climate change on crop productivity using the predicted changes in yield per hectare of the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) from the International Food Policy and Research Institute (IFPRI). These projections have also been employed in the comparison of different agricultural economic models in the Agricultural Model Intercomparison and Improvement Project (AgMIP) (Von Lampe and others 2014).

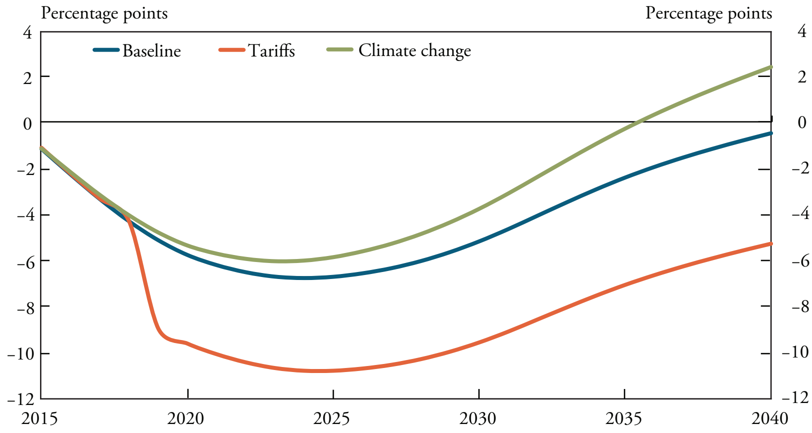
III. Results and Discussion

We project the GTM baseline for the world economy to provide a core baseline, assuming there are no climate-change-related productivity effects and no changes in trade-related policies. As mentioned previously, the baseline assumes that GDP per capita growth, population, labor force, and skills grow at exogenously set rates. Our core calibration results for the development of real crop prices are moderately higher than projections obtained by Anderson and Strutt (2014), who find that real international prices increased from 2007 to 2030 by about 2 percent. This can be attributed to differences in assumptions about productivity growth, as they assume that productivity growth is higher in the primary sectors than in manufacturing and services, whereas we assume that productivity growth in agriculture is smaller than in manufacturing (as discussed previously).

Chart 1 illustrates the projected cumulative percentage change in average crop prices in the baseline scenario and in the two experiments. The chart shows that average crop prices fall moderately in the baseline by 0.5 percent over 25 years. The results from the two experiments show the same trend in prices, but the size of the effect differs. A hypothetical increase in global tariffs would reduce prices temporarily, but lead to a permanently lower price level, as the higher tariffs imposed in the experiment in 2019 would lead global demand for crops to fall. Climate change leads to higher global crop prices due to reductions in land-augmenting crop productivity. Globally, the effect from climate-change-induced productivity changes is modest, with crop prices increasing by 2.5 percent—about 3 percent more than in the baseline. The trend in real food prices over time, first declining and then rising, can be explained by the fact that land as a fixed production factor becomes an increasing constraint over time on the expansion of agricultural production.

Additional charts in the appendix show the effect of the two experiments, higher tariffs and climate change, on the prices of crops, livestock, and processed food in different regions. The appendix charts make clear that the average picture—rising food prices as a result of climate change and falling prices as a result of higher tariffs—holds in most countries. A notable exception is the United States, where rising tariffs lead to higher producer prices of crops, livestock, and processed food.

Chart 1
Percentage Change in Global Crop Prices under Different Scenarios



Global export shares of different commodities will also be affected by changes in GDP, population, the labor force, and sectoral productivity. Table 2 highlights results for U.S. global export shares by commodity. In the baseline, the U.S. global market share in agricultural commodities exports (excluding intraregional trade), both crops and livestock, remains relatively stable. This compares favorably to the decline in global market share in manufacturing and services exports over the baseline period. U.S. global export shares of wheat decrease more than other commodities in the baseline due to the increased export share in other regions such as Canada and the rest of the world (Russia and non-EU Eastern Europe).

The hypothetical increase in global tariffs would moderately reduce the United States' market share in global agricultural commodities, though the reduction is much smaller than in manufacturing goods. Wheat, fruits and vegetables, livestock, and processed food are among the agriculture commodities that experience larger decreases in U.S. global export shares due to increased trade costs. China, ASEAN, and India pick up market share in these products.

Additional results on changes in market shares in all regions and all scenarios are displayed in appendix Charts A-3–A-6. Chart A-3 shows that the United States loses market share for crops but restores its share partially in the climate-change scenario. Chart A-4 shows that

Table 2
Share of U.S. Exports in Global Exports for Different Commodities

	Initial (percent)	Baseline (percent)	Trade costs (percent)	Climate change (percent)
Sectors	2015	2040	2040	2040
Agriculture	20.50	19.12	18.39	19.67
Crops	21.40	19.87	19.20	20.49
Wheat	19.36	15.14	14.40	16.04
Other grains	35.16	32.72	31.77	32.72
Vegetables and fruits	15.29	13.40	12.89	13.72
Oil seeds	34.12	31.68	29.10	32.71
Plant fibers	26.05	21.42	20.02	22.16
Livestock	12.92	13.30	12.24	13.21
Processed food	12.62	10.98	8.46	11.05
Manufactures	12.08	9.54	6.76	9.49
Services	14.39	12.74	10.74	12.68

the United States loses market share in processed food under the trade-cost scenario, whereas India gains market share. Chart A-6 makes clear that there is a relatively large change in the U.S. market share in manufacturing goods from 2015 to 2040, which is even more pronounced under the trade-cost scenario. The changes seem an order of magnitude larger than the changes for agricultural goods and processed food.

Results from the climate-change scenario indicate that productivity changes have a moderate effect on U.S. market shares in global exports, though the U.S. share of crops picks up somewhat from about 20 percent to 20.5 percent. This slight pickup reflects the fact that climate change has more beneficial effects on crop productivity in more moderate climate zones. U.S. export shares in this scenario decrease slightly compared with the baseline results for livestock, reflecting the growth of livestock production in regions with available grazing land. Regions losing export market share are India, Other Asia, and Latin America (only slightly).

Another way to analyze the trade effects of these different scenarios is to examine the change in export market concentration. The Herfindahl-Hirschman index (HHI) is a common measure of market concentration used to determine market competitiveness. The index can take values ranging from 0 to 1, with increases in the HHI generally indicating a decrease in competition and an increase in market power.

Table 3 displays HHIs for the 15 exporting regions (excluding intra-regional trade). For agricultural products, the index ranges from 0.099 for processed foods to 0.23 for oil seeds in the 2040 baseline. For manufacturing and services, the baseline indexes are 0.134 and 0.126, respectively. The baseline results show that despite the reallocation of market shares, export market concentration for agricultural commodities is not expected to change much over time. As a comparison, export concentration in the manufacturing sectors is expected to rise from 0.128 to 0.134, which can be explained by the continuing increase in China's market share. A hypothetical increase in tariffs would lead to a moderate fall in the HHI for most agricultural products, implying that exports would become less concentrated.

Table 4 shows the share of exports to different destinations (as a share of total U.S. exports) in the model's baseline results. For agricultural commodities, the share of exports to Chinese and African markets are expected to rise, whereas the share of exports to European and Japanese markets are expected to fall.

Regional differences in GDP growth and agricultural productivity mean that trade among countries will differ substantially in 2040. Asian developing economies will account for larger shares of U.S. exports of many agricultural commodities. For example, Table 4 illustrates the importance of the Chinese market for oil seeds from the United States. The simulations also indicate the large and increasing importance of China as a destination for U.S. livestock. Absent policy changes, the share of livestock exports to China is expected to rise further. According to the baseline projections, ASEAN economies will be increasingly important markets for U.S. wheat and plant fibers. Specifically, the share of wheat exports to ASEAN countries are expected to increase from around 17 percent in 2015 to around 22 percent in 2040, while the share of plant fiber exports are expected to increase from around 21 percent in 2015 to around 26 percent in 2040.

Table 5 shows results for the baseline simulations on changes to import dependency (the share of imports in total demand) from 2015 to 2040 for different sectors and commodities. The regions with the lowest import dependency on agriculture include India (expected to

Table 3
Herfindahl-Hirschman Index of Regional Export Shares for Different Commodities

	Initial	Baseline	Trade costs	Climate change
Sectors	2015	2040	2040	2040
Agriculture	0.101	0.099	0.097	0.101
Crops	0.106	0.104	0.101	0.105
Wheat	0.177	0.163	0.155	0.173
Other grains	0.197	0.184	0.181	0.185
Vegetables and fruits	0.108	0.107	0.107	0.108
Oil seeds	0.238	0.230	0.227	0.229
Plant fibers	0.148	0.158	0.160	0.150
Livestock	0.122	0.132	0.134	0.133
Processed food	0.107	0.099	0.099	0.099
Manufactures	0.128	0.134	0.142	0.133
Services	0.149	0.126	0.112	0.126

fall slightly from 2.45 in 2015 to 2.10 in 2040) and Latin America (expected to fall from 8.21 in 2015 to 7.82 in 2040). In contrast, the regions with the highest import dependency on agriculture include the EU (expected to decrease from 31.59 in 2015 to 30.32 in 2040) and Canada (expected to decrease from 33.19 to 29.79 in 2040). Import dependency in the United States is not expected to change substantially for the different commodities examined here. Import dependency is expected to be stable for most other countries as well, though Canada is expected to see a slight reduction in import dependency, and Other Asia is expected to see a slight increase.

Chart 2 displays the cumulative effect of the two experiments, an increase in trade costs and changes in crop productivity due to climate change, on welfare. The table makes clear that most countries lose considerably with rising tariffs (up to almost 5 percent for Mexico and Other Asia). The small improvement for the United States is due to the standard terms of trade effects: imposing higher tariffs reduces world demand for goods imported by the United States, thus improving the terms of trade. The effect of climate-change-related changes in crop productivity on welfare is more moderate, with the most affected regions being India and Other Asia. However, these small effects should

Table 4
Share of Destination Markets in U.S. Exports for Various Commodities

Sector	Year	Other Asia (percent)	Japan (percent)	China (percent)	India (percent)	ASEAN (percent)	Canada (percent)	Mexico (percent)	LAC (percent)	EU (percent)	MENA (percent)	SSA (percent)
Agriculture	2015	9.26	8.32	28.32	1.25	7.37	8.00	10.43	7.48	8.83	6.65	1.60
	2040	10.66	4.90	36.57	1.12	8.38	5.37	9.22	6.58	5.55	7.32	2.22
Crops	2015	8.88	8.75	27.86	1.32	7.55	7.67	10.43	7.77	8.67	6.99	1.69
	2040	10.66	4.90	36.57	1.12	8.38	5.37	9.22	6.58	5.55	7.32	2.22
Wheat	2015	9.88	11.24	2.29	0.00	17.47	0.24	10.97	17.97	2.85	5.63	12.22
	2040	12.37	6.97	1.67	0.00	22.16	0.20	9.17	15.37	1.59	5.53	17.68
Other grains	2015	12.15	21.51	12.25	0.00	1.23	3.04	18.54	18.97	2.58	8.52	0.78
	2040	14.65	15.12	14.12	0.00	1.35	2.66	17.76	20.04	2.17	10.60	1.08
Vegetables and fruits	2015	11.27	5.64	2.98	5.24	5.68	26.69	8.08	3.43	19.77	6.93	0.61
	2040	16.62	3.88	4.32	5.79	6.48	21.06	9.52	2.92	14.94	9.56	0.93
Oil seeds	2015	4.75	3.86	60.34	0.00	7.17	1.66	7.73	1.40	8.16	3.98	0.02
	2040	3.97	1.76	70.77	0.00	6.55	1.08	5.97	1.04	4.40	3.72	0.02
Plant fibers	2015	11.69	1.26	25.19	2.03	21.41	0.06	9.20	7.05	0.96	20.59	0.02
	2040	11.57	0.55	22.56	2.01	26.12	0.04	7.49	6.54	0.56	22.11	0.03
Livestock	2015	14.50	2.28	34.78	0.27	4.83	12.62	10.46	3.48	10.99	1.92	0.36
	2040	15.77	1.28	42.50	0.18	5.75	9.14	9.07	2.98	7.47	2.11	0.52

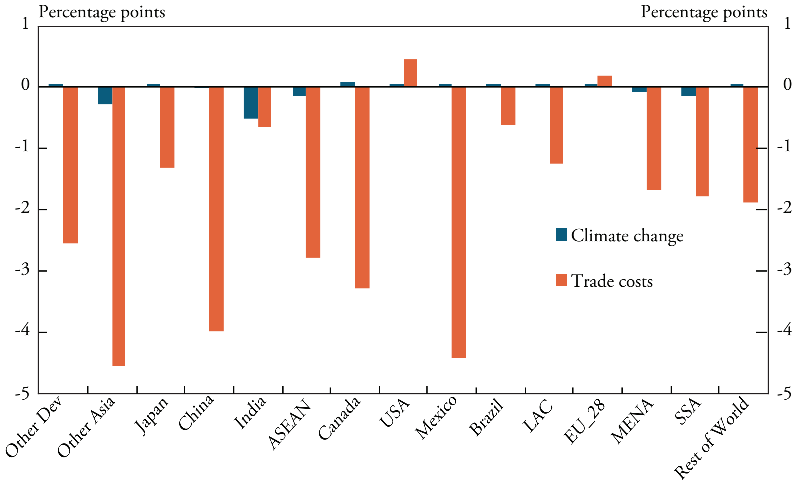
Table 5

Import Dependency: The Share of Imports in Demand

Sector	Year	Other Asia (percent)	Japan (percent)	China (percent)	India (percent)	ASEAN (percent)	Canada (percent)	USA (percent)	LAC (percent)	EU (percent)	MENA (percent)	SSA (percent)
Agriculture	2015	20.21	22.41	6.95	2.45	13.60	33.19	13.00	8.21	31.59	19.95	3.23
	2040	22.05	23.41	7.44	2.10	14.90	29.79	12.48	7.82	30.32	21.29	3.74
Crops	2015	24.37	27.32	9.04	3.13	15.46	50.34	20.18	11.82	45.51	23.75	3.41
	2040	28.23	29.25	10.36	2.74	17.47	46.71	19.72	11.73	45.40	26.13	4.06
Wheat	2015	26.39	87.18	1.97	0.04	98.94	84.66	15.93	46.10	30.07	36.14	72.15
	2040	42.99	88.76	1.08	0.02	98.94	82.63	18.78	43.49	30.73	39.71	69.09
Other grains	2015	84.39	95.84	6.33	0.15	30.55	15.79	2.65	25.91	28.46	37.02	1.48
	2040	83.56	95.97	4.71	0.15	27.92	15.04	2.61	26.09	28.77	38.99	1.54
Vegetables and fruits	2015	20.19	13.19	2.26	6.50	15.50	81.31	39.78	7.64	60.27	13.32	1.67
	2040	24.17	13.99	2.54	6.10	16.20	80.88	42.12	7.31	60.22	15.00	1.92
Oil seeds	2015	54.46	93.60	57.28	0.91	15.43	15.93	15.95	5.58	58.08	39.92	1.05
	2040	60.84	93.72	58.28	0.81	14.84	15.26	16.88	5.14	58.33	44.09	1.25

Chart 2

Change in Real Income (Welfare) in Response to Both Climate Change and Trade Cost Shocks



be interpreted with care for three reasons. First, climate change will have other economic effects on welfare—for example, on revenues in tourism areas, on labor productivity as a result of higher temperatures, and on production in coastal areas. Second, the effect of climate change is expected to accelerate in later years, with most climate change studies employing time horizons up to 2100. Third, the calculated effect represents the average welfare effects in a country (on a representative agent). However, producers in specific sectors that depend heavily on crops, such as farmers, may be affected more severely.

IV. Conclusions

The simulations described in this paper provide insights into the potential effects of climate change and trade policies on future trading patterns and agricultural prices. Results from the baseline projections show crop prices falling moderately to the year 2040. The simulations indicate that climate change and the resulting productivity effects on agriculture lead to rising crop prices, on average. In contrast, policy changes that disrupt trade, modeled as increases in trade costs, lead to lower crop prices on average than those in the baseline due to reduced global demand for crops.

The model also provides some insights into the potential trade effects for the United States. Baseline projections show the U.S. market share in agricultural trade rising slightly, while the market shares in manufacturing and services trade decrease slightly. The destination of U.S. exports also evolves over the baseline scenario, with developing Asian economies and Sub-Saharan Africa increasing their share of U.S. crop exports in 2040.

Taking into consideration the possibility of productivity changes due to climate change or economic effects due to increased tariffs, the modeling results highlight how outcomes may differ from the baseline. The climate-change scenario suggests that the United States' share in global agricultural exports will moderately increase due to the more moderate climate in the United States. In contrast, the increased-tarriffs scenario shows that for most agricultural commodities, the U.S. share of global exports will fall below those projected in the baseline. Future research will examine the interaction between these two scenarios.

Appendix
Additional Charts and Tables

Chart A-1

Cumulative Percentage Change in Food Prices for Different Regions as a Result of Higher Tariffs

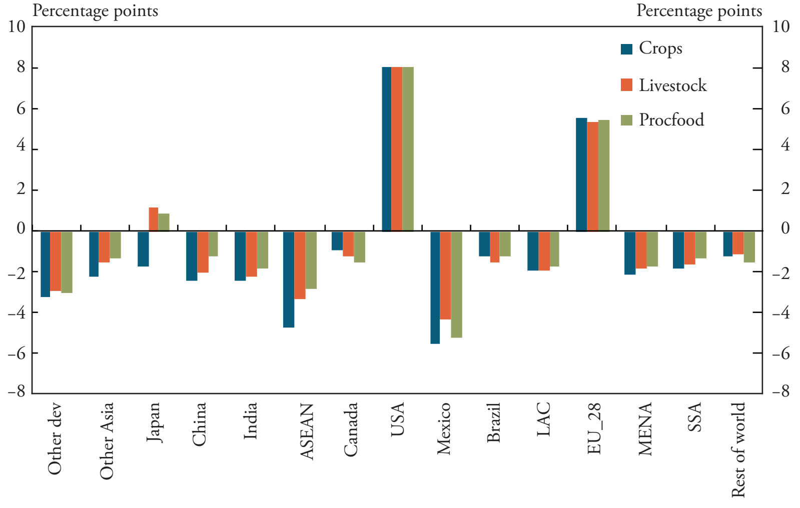


Chart A-2

Cumulative Percentage Change in Food Prices for Different Regions as a Result of Climate Change

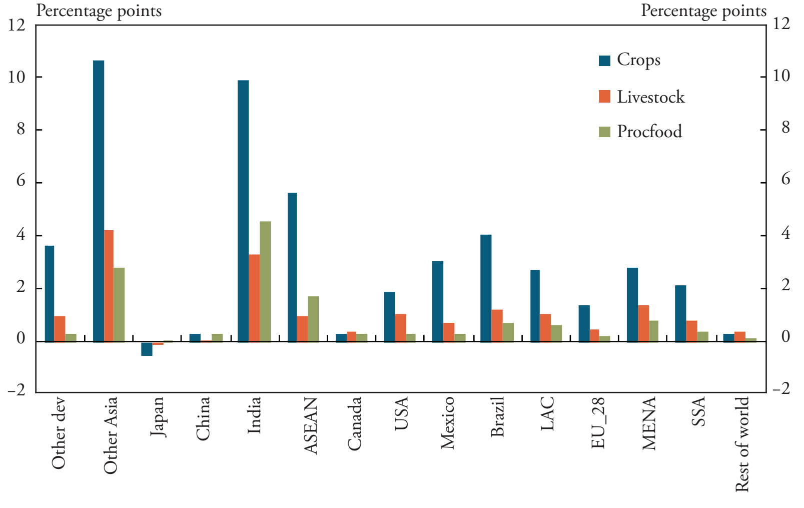


Chart A-3

Market Share of Different Regions for Crops under Different Scenarios

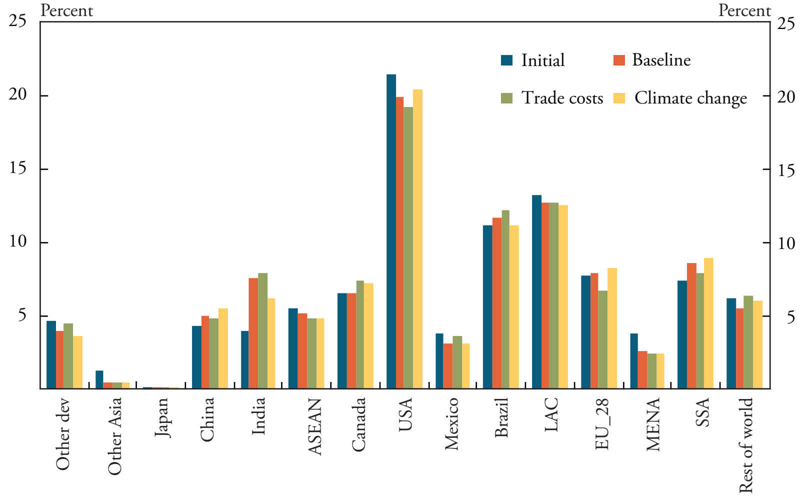


Chart A-4

Market Share of Different Regions for Livestock under Different Scenarios

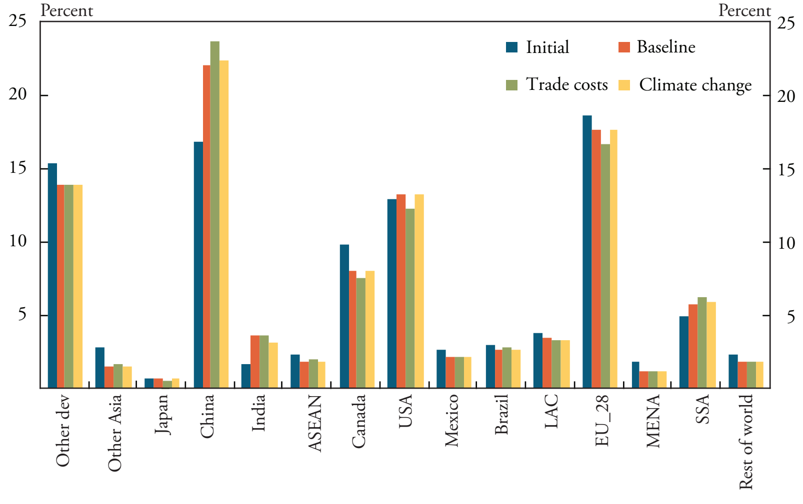


Chart A-5

Market Share of Different Regions for Processed Food under Different Scenarios

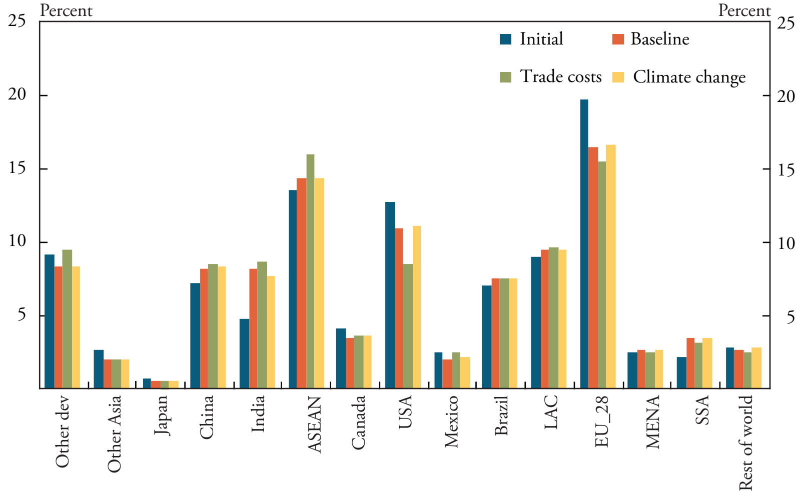
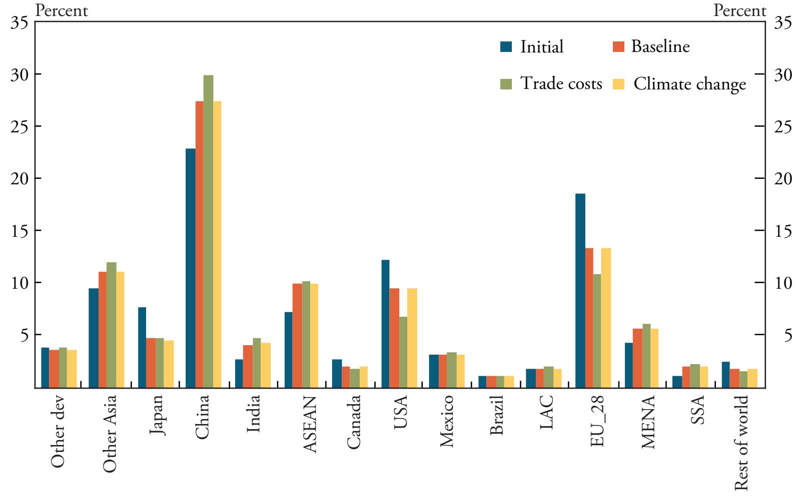


Chart A-6

Market Share of Different Regions for Manufactures under Different Scenarios



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