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Climate Change on Agriculture in 2050: A CGE Approach

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Contents

I. Introduction

- Agriculture plays a very critical role in terms of global food security and provides livelihood to over 30 percent of the world population.

According to the International Labor Organization (ILO) (2014), agriculture employs:

- 31.3 % of the world's labor force in 2013 (a decline of 29.7 % since 1991),
- 39.3% of the labor force of South-East Asia and the Pacific,
- 3.6% of the developed economies and the European Union

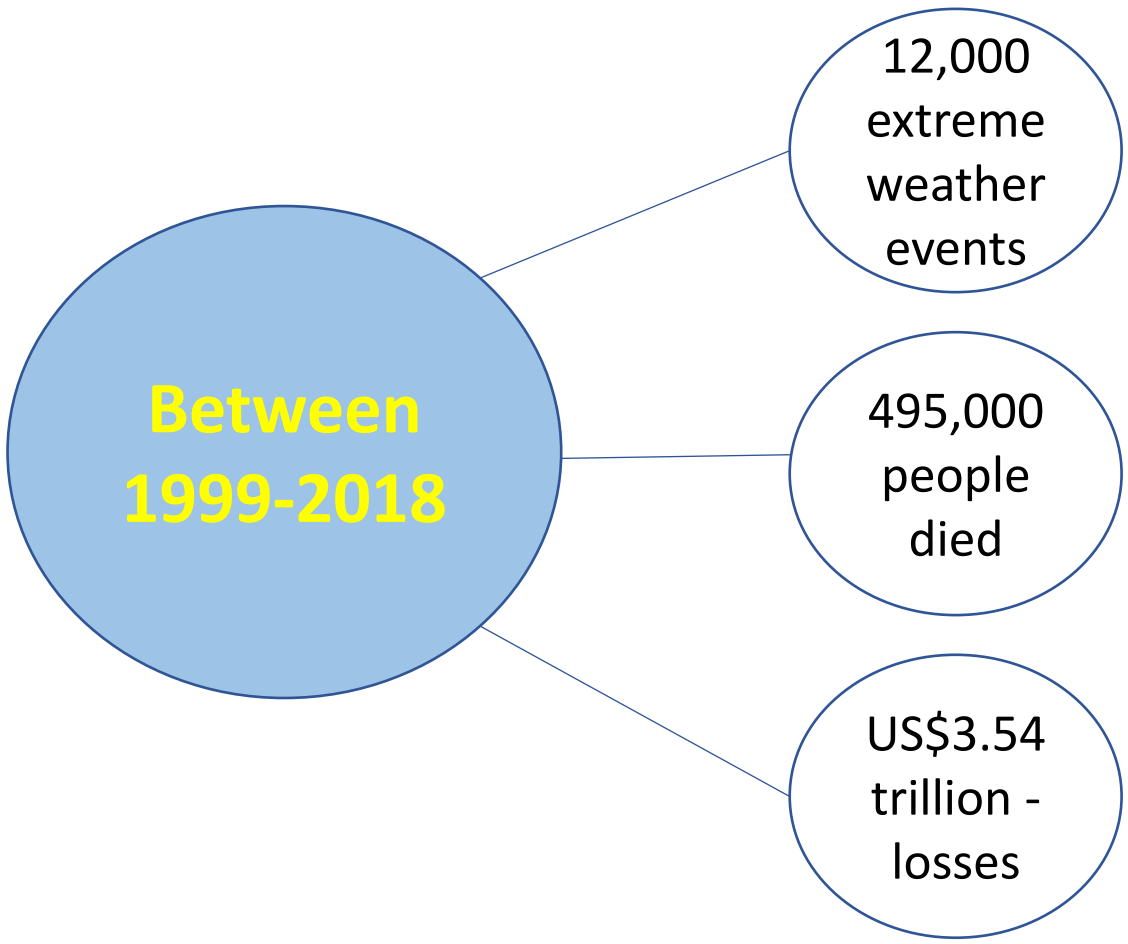
I. Introduction

- The world population will reach 10.08 billion by the year 2050 (UN, 2017).

- Given the expected increase in population together with improved purchasing power by private households, the question then arises whether agricultural production can meet world food demand by the year 2050 (United Nations, 2015; Bruinsma, 2011; and Foure, et al., 2012).

Global Climate Risk Index Report 2020

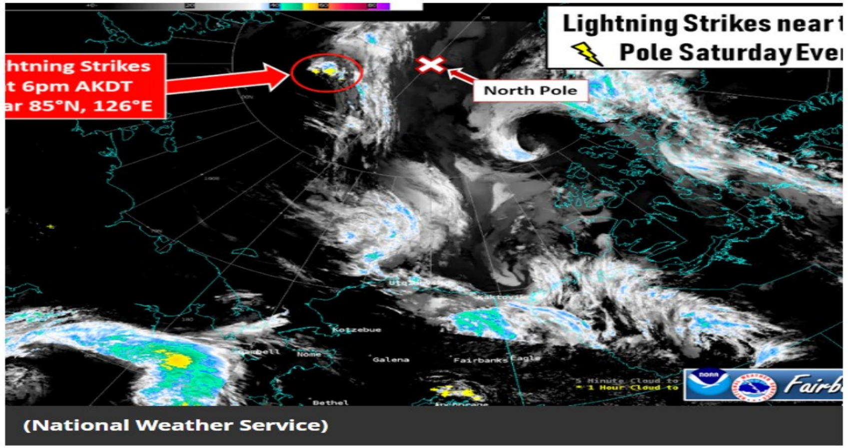
<Fig.1> Global Climate Risk Index 1999-2018



<Table 1>Global Climate Risk Index 2018

CRI Rank	Country	CRI Score
43	Ausralia	49.5
135	Brunei	125.0
9	Canada	21.8
87	Chile	81.2
33	China	45.2
5	India	18.2
1	Japan	5.5
81	Korea	76.5
97	Malaysia	84.8
26	Mexico	37.7
46	New Zealand	53.2
110	Peru	94.0
135	Singapore	125.0
12	United States	23.8
16	Vietnam	26.2

Current Climatic Conditions



Some 36,000 buildings were damaged and vast areas of farmland affected. Rice and fruit were the worst hit just ahead of their harvest for Chuseok. More than 500 farm animals died.

Aerial photos of flood effects in Moyale, Marsabit County on 20th October 2019 (Photo credits: KRCS RPAS team)

Floods in Northern Kenya, Usually receives minimal rain (October, 2019)

Source:

Objectives of this Study

- To investigate the global economic impact of climate change on agriculture in 2050 .

- Focus:

  - The role of economic agents adaptation response to climate change, the potential regional and sector-specific impacts.

  - hanges in production quantities and market prices etc.

Area of Focus

This study focuses on the Asia-pacific region

- CPTPP Comprehensive and Progressive Agreement for Trans-Pacific Partnership. 11 Member countries(Australia, Brunei , Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, Vietnam)
- RCEP Korea and China as - Regional Comprehensive Economic Partnership

  -15 members -10 ASEAN members and 5 FTA members (Korea and China)
- USA Formerly a member of the Trans-Pacific Partnership (TPP) together with the 11 CPTPP member countries
- India Initiated the establishment of RCEP but later withdrew due to fear that the

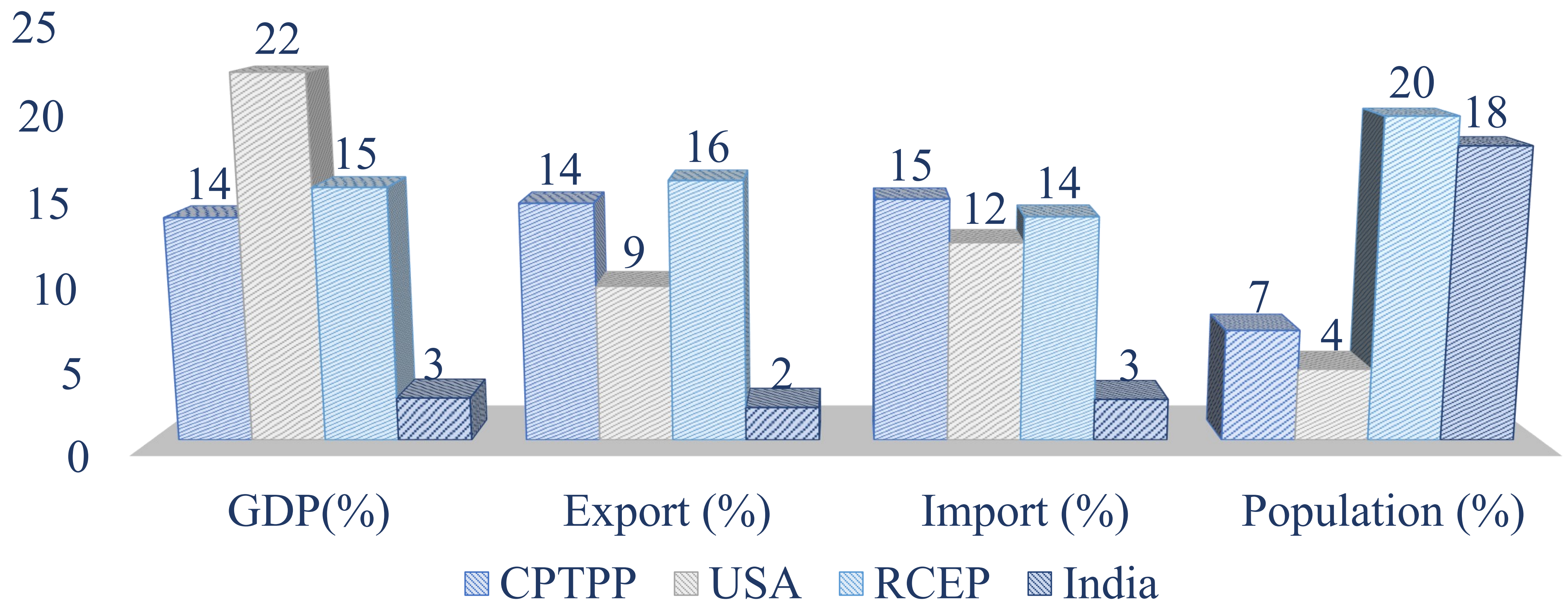
  signed deal would harm domestic producers.

<Table 2> Regional Comparison

Region	GDP (US$ billion)	Export (US$ billion)	Import (US$ billion)	Population (million)
CPTPP	10,642	2,993	3,200	491
USA	17,348	1,961	2,636	319
RCEP	12,054	3,273	2,971	1,422
India	2,042	418	549	1,295

Source: GTAP DB Version 10 (August, 2019)

<Fig.2> Regional Share in the World



Source: GTAP DB Version 10 (August, 2019)

II. Literature Review (Summary)

- Available literature confirm that climate change is already happening with the increase in surface air temperature, and increase in GHG emissions not only from industrial production but also from agriculture, forestry and other land use (AFOLU) human operations (IPCC, 2018, and 2019; Eckstein D. et al. (2020). These studies provide a range of projections for future changes in the earth’s climate by using biological laws to simulate the interaction between the atmosphere, oceans, land surface, snow ice, and permafrost, and their response to rising levels of GHGs.

- Numerous studies evaluate the impact of climatic changes on biological processes including, crop yields (Arangon et al. 2018; Birthal et al. 2014; Ray et al., 2019).

- Other studies apply data on the projected crop yields under-different climatic conditions to quantify the economic impacts of climate change (Zeshan and Ko, 2017; Bandra and Cai, 2014).

II. Literature Review

- There are numerous studies are analyzing the economic impact of climate change through projected crop yield under different climatic conditions within the Asia-pacific region. However, most of these studies have used old data and apply different sectoral and regional aggregation.

- Furthermore, this study applies the most current GTAP database (GTAP version 10, whose base year is 2014).

III. The CGE Model

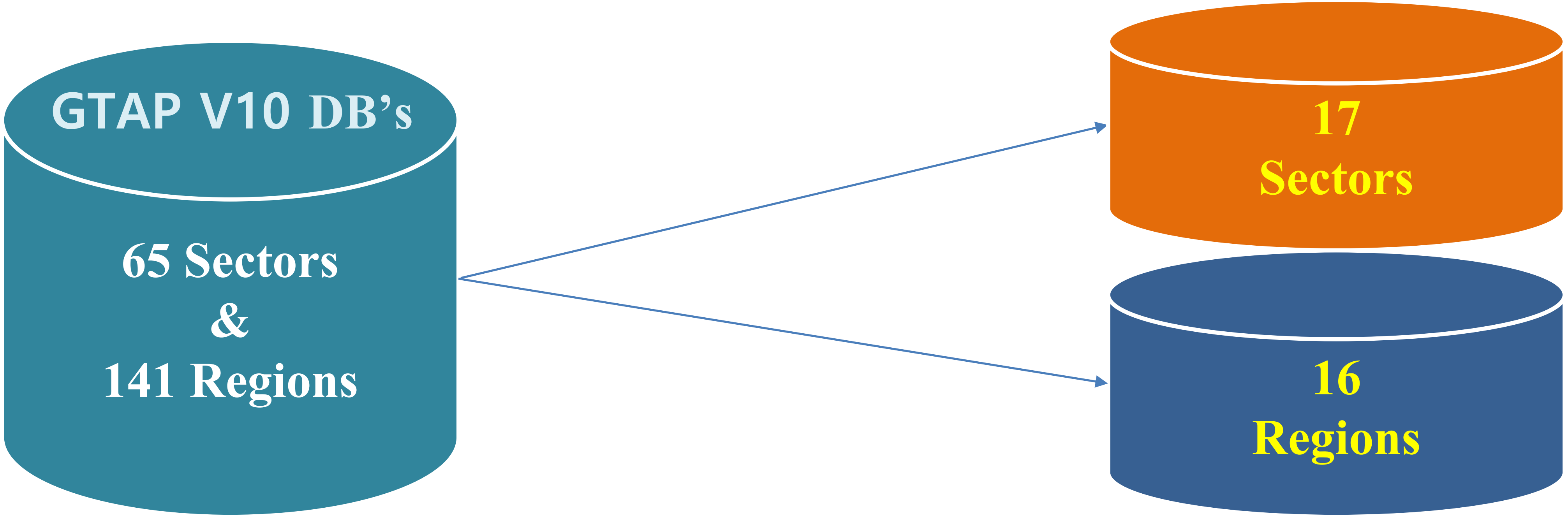
- A Computable General Equilibrium (CGE) Model constitutes a system of non-linear simultaneous equations that define the constrained optimizing behavior of economic agents such as savers, investors, producers, exporters, importers, consumers, the government, et.c.

- We employ the multi-sector multi-region computable general equilibrium (CGE) approach based on the standard GTAP model.

IV. Data and Simulation Procedures

The GTAP version 10 database (whose base year is 2014) released in August 2019, contains data on 141 regions in 65 sectors.

<Fig.3> Data Aggregation



Simulation Procedure

- We develop a baseline experiment and define two counterfactual Experiments.

Simulation Procedure -

- First, we solve for Economy-wide productivity that is necessary to achieve the projected growth in real GDP given the projected growth in factor supplies, and population, by swapping qgdp with aoreg.

- To account for reduced price sensitivity due to the expected increase in private household income, we reduce INCPAR (income parameter) by 50%.

Baseline Scenario in 2050

- We describe all the global economies in 2050 relative to 2014 without climate change.

- We do this by supplying our model with values of the five macroeconomic variables, which include; real GDP, Population, Skilled labor, Unskilled labor, physical capital stock, and arable land.

Baseline Scenarios

<Table 3> Projected Macroeconomic Variables

Region	Code	GDP (qgdp)	Population (qo)	Skilled labor (qo)	Unskilled labor (qo)	Capital stock (qo)	Arable land (qo)
Australia	AUS	127.04	37.05	44.73	6.6	109.65	3.36
Brunei	BRN	62.63	27.92	58.79	-5.4	42.05	2.02
Canada	CAN	116.69	24.27	43.88	13.4	91.58	4.48
Chile	CHL	121.39	13.66	42.95	37.7	73.6	3.36
Japan	JPN	64.7	-14.3	-0.94	-11.2	46.48	-0.44
Malaysia	MYS	190.22	35.96	70	35	217.31	2.02
Mexico	MEX	190.32	33.23	32	36.27	152.56	3.36
New Zealand	NZL	116.27	21.63	54.71	8.51	132.23	-0.44
Peru	PER	177.21	34.33	28.29	37.7	258.64	3.36
Singapore	SGP	80.45	17.98	12.2	3.35	53.4	2.02
Vietnam	VNM	185.77	22.42	68.84	40.4	242.43	2.18
United States	USA	87.11	20.65	62.96	11.1	61.6	-0.91
Korea, Rep.	KOR	177.2	-1.49	20.8	6.6	192.71	0.7
China	CHN	284.5	-1.03	11.05	-6.49	264	3.36
India	IND	325.72	25.27	57.33	37.6	281.95	2.02
Rest of the World	ROW	183.56	36.1	49.8	35.99	233.4	3.36

Source: SSP2, UN Population, Bruinsma (2011), Four'e et al (2012)

- Projected real GDP is from SSP2 while Population is drawn from UN World Population Prospects (2017), Skilled and Unskilled labor and Physical Capital growth are from Foure et al. (2012), while, Arable land projections are taken from Bruinsma, (2011).

Policy Scenarios

- We develop two counterfactual scenarios describing all the economies in 2050 with climate change under RCP 2.6 and RCP 8.5 projected crop yield scenarios.

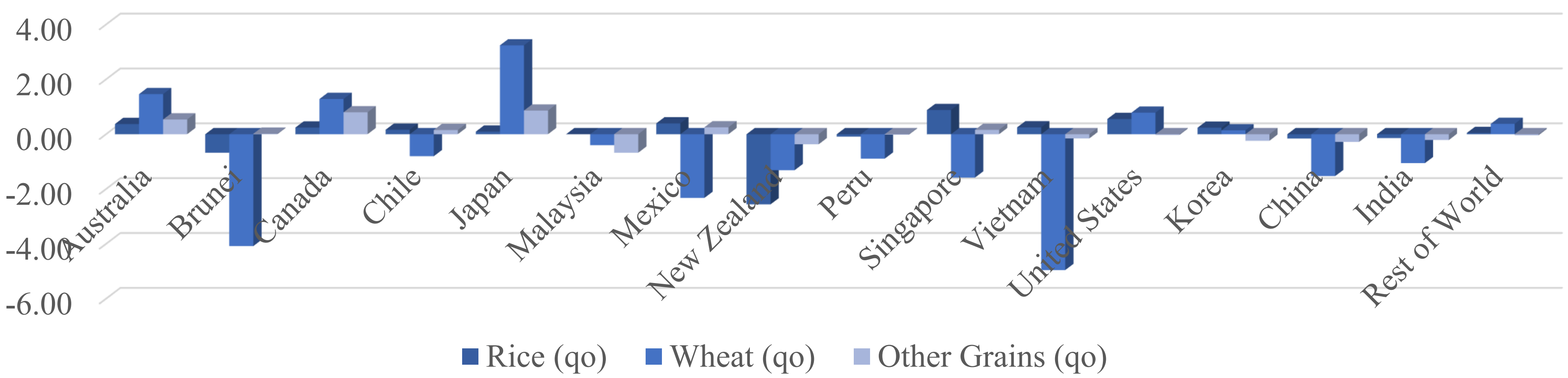
- Crop yield changes are simulated in the GTAP model as a shift to the total factor productivity of the crop sectors.

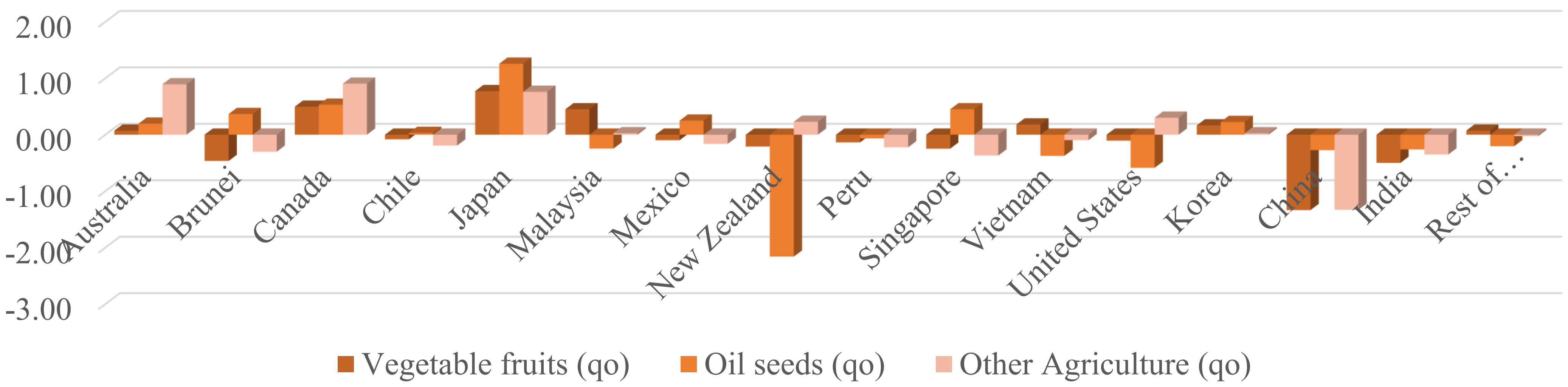
<Table 4> Projected crop yield (in 2050) under RCP 2.6 and RCP 8.5 (%)

Region	Rice		Wheat		Other grain		Oil seeds		Vegetable & fruit		Other Agriculture	
	RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5
Australia	-0.02	-0.19	-0.27	-0.4	-0.12	-0.28	-0.09	-0.28	-0.13	-0.29	-0.15	-0.31
Brunei	-0.27	-0.55	-0.93	-1.81	-0.11	-0.3	0.06	0.01	-0.31	-0.66	-0.32	-0.69
Canada	0	0	0.05	-0.03	0.15	0.05	0.17	0.14	0.09	0.04	0.12	0.05
Chile	-0.19	-0.43	-0.6	-1.18	-0.11	-0.34	0.02	-0.09	-0.22	-0.51	-0.22	-0.53
Japan	0.15	0.16	-0.09	0.09	-0.04	-0.18	0.01	-0.01	0.01	0.02	-0.03	-0.02
Malaysia	-0.04	-0.08	0	0	-0.17	-0.42	0.12	-0.05	-0.02	-0.14	-0.02	-0.15
Mexico	-0.19	-0.43	-0.6	-1.18	-0.11	-0.34	0.02	-0.09	-0.22	-0.51	-0.22	-0.53
New Zealand	-0.02	-0.19	-0.27	-0.4	-0.12	-0.28	-0.09	-0.28	-0.13	-0.29	-0.15	-0.31
Peru	-0.19	-0.43	-0.6	-1.18	-0.11	-0.34	0.02	-0.09	-0.22	-0.51	-0.22	-0.53
Singapore	-0.27	-0.55	-0.93	-1.81	-0.11	-0.3	0.06	0.01	-0.31	-0.66	-0.32	-0.69
Vietnam	-0.09	-0.18	0.03	0.03	-0.22	-0.57	-0.12	-0.26	-0.1	-0.25	-0.1	-0.26
United States	-0.09	-0.27	0.06	0.07	-0.22	-0.63	-0.03	-0.21	-0.07	-0.26	-0.07	-0.26
Korea	-0.01	-0.06	0.23	0.24	-0.35	-0.66	-0.03	-0.07	-0.04	-0.14	-0.05	-0.16
China	-1.34	-2.6	-4.83	-9.39	0.25	0.31	0.31	0.42	-1.4	-2.82	-1.42	-2.87
India	-0.27	-0.55	-0.93	-1.81	-0.11	-0.3	0.06	0.01	-0.31	-0.66	-0.32	-0.69
Rest of World	-0.07	-0.2	0.05	-0.01	-0.13	-0.37	-0.15	-0.37	-0.08	-0.24	-0.08	-0.25

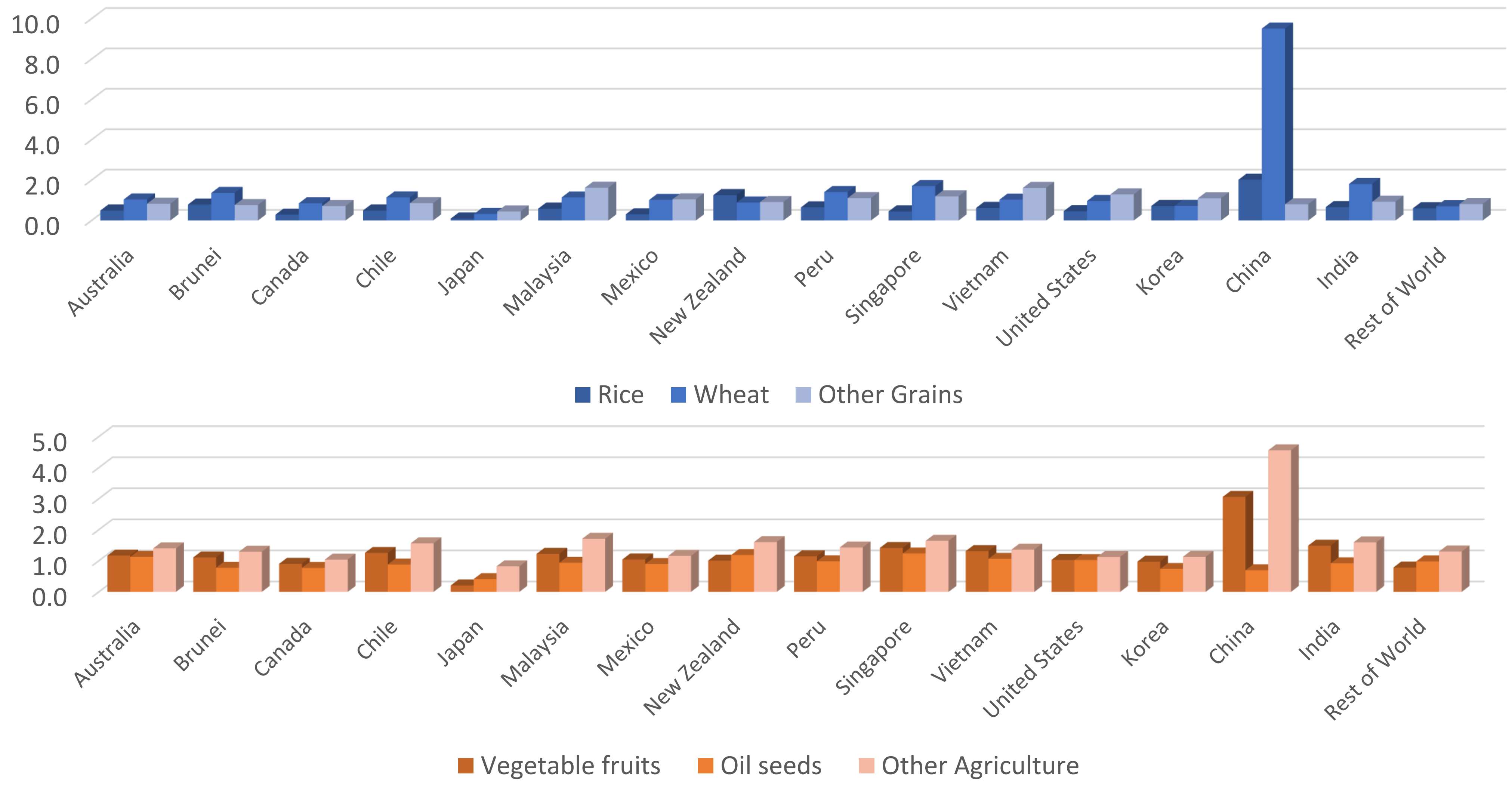
Sources: Adapted from Xie et al (2018)

<Fig. 4> Effect on Agricultural Production in (%)





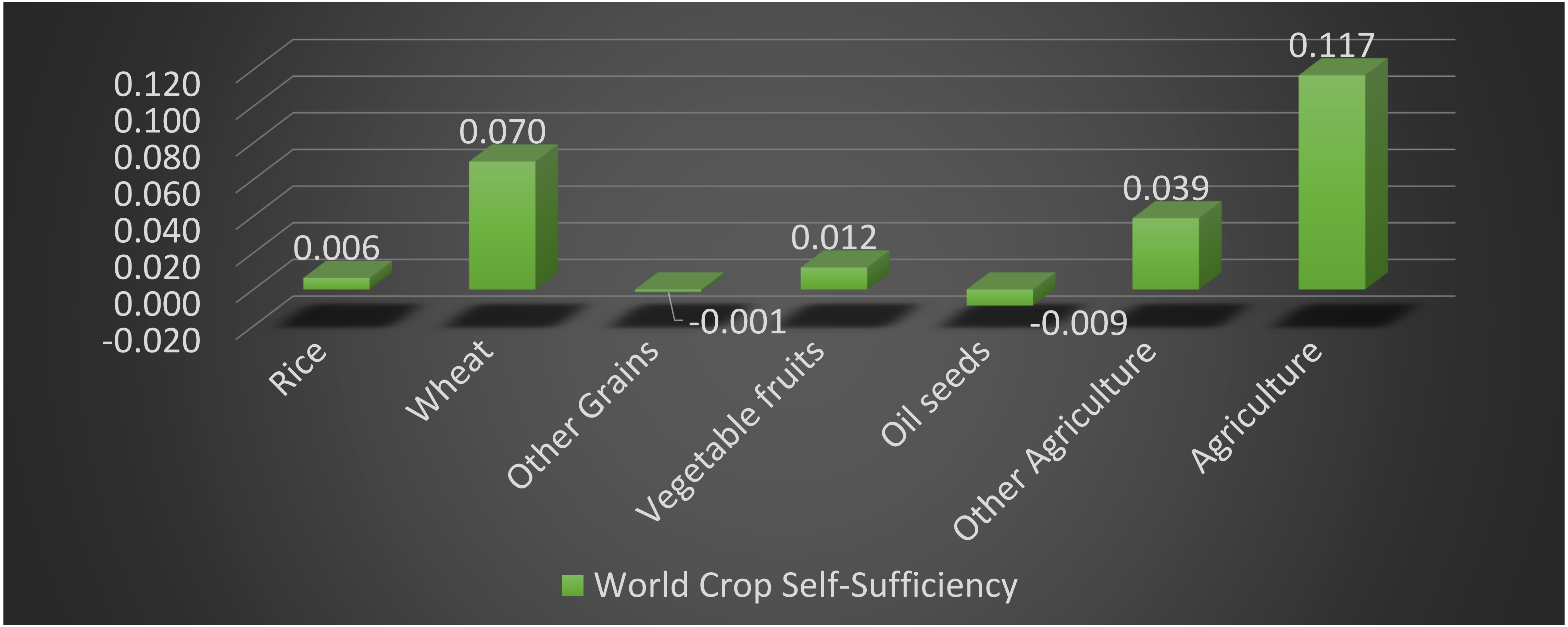
<Fig.5>Effect on Market Prices (%)



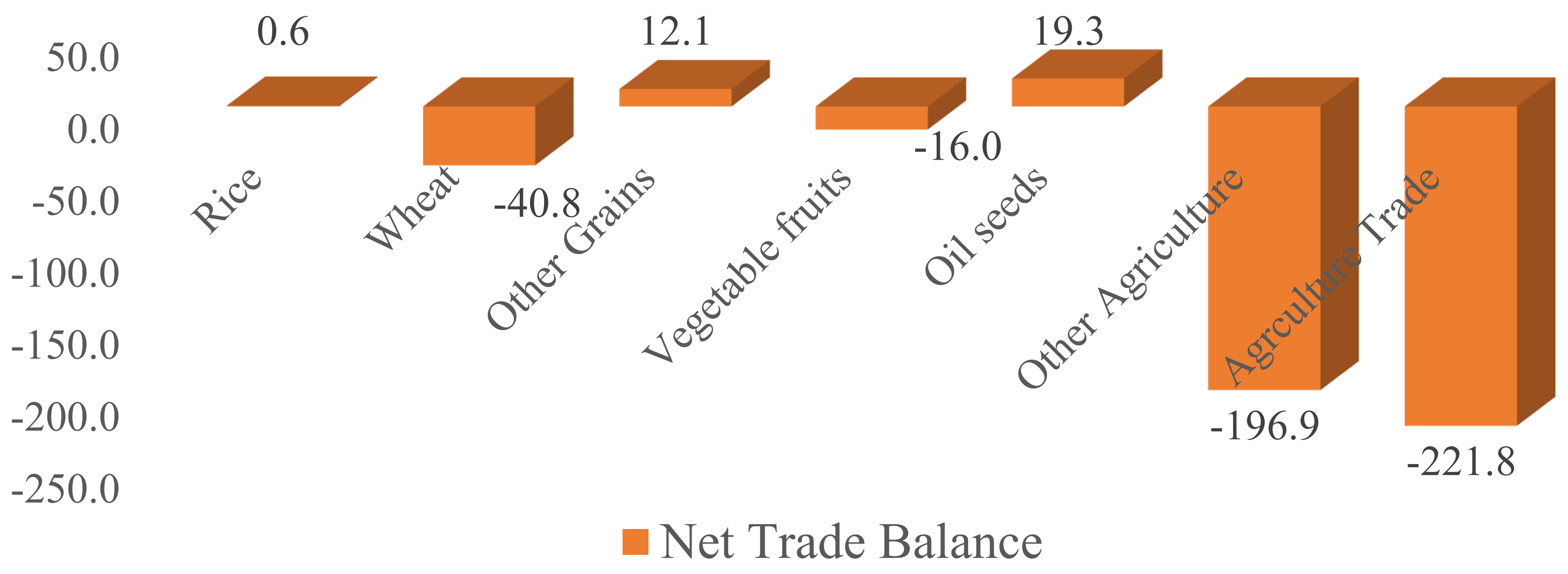
<Table 5> Effect on Private Household Demand in (%)

Region	Effect on Private household Demand					
	Rice	Wheat	Other Grains	Vegetable fruits	Oil seeds	Other Agriculture
Australia	0.09	0.00	0.09	0.03	-0.13	-1.72
Brunei	-0.71	-0.23	-0.09	-0.18	-0.19	-1.08
Canada	0.24	-0.02	0.44	0.17	0.25	-0.74
Chile	-0.03	-0.06	-0.05	-0.38	-0.04	-0.80
Japan	0.03	0.00	0.49	0.32	0.09	-0.49
Malaysia	-0.04	-0.59	-0.56	0.58	0.04	-0.39
Mexico	-0.04	-0.08	0.05	-0.08	-0.06	-0.67
New Zealand	-1.06	-0.01	-0.06	-0.10	-0.02	-1.03
Peru	-0.23	-1.66	-0.13	-0.19	-0.14	-0.44
Singapore	0.00	-1.99	-0.31	-0.30	-0.56	-0.81
Vietnam	-0.18	-4.76	-0.94	-0.05	-0.34	-0.33
United States	0.39	-0.01	-0.27	-0.06	-0.02	-1.00
Korea	0.12	0.07	-0.16	0.10	0.07	-0.55
China	-0.59	-2.03	-0.25	-0.73	0.29	-1.90
India	-0.27	-0.48	-0.27	-0.46	-0.24	-0.51
Rest of World	-0.14	-0.11	-0.18	-0.13	-0.20	-0.50
Global	-2.41	-11.97	-2.20	-1.44	-1.22	-12.96

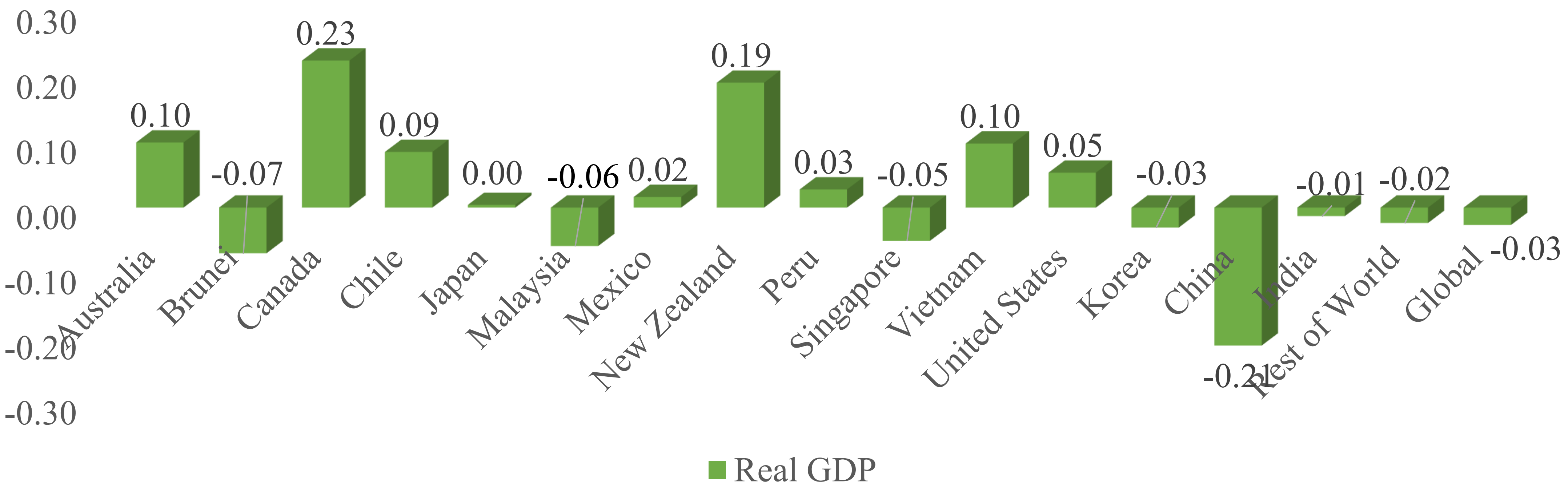
<Fig. 7> Effect on World Crop Self-sufficiency



<Fig.8> Effect on Trade Balance US$ Million



<Fig. 9> Effect on Real GDP in (%)



Real GDP

The Negative effect on real GDP for majority of the regions is due to the decline in investment and exports, and the rise in imports.

<Table 6> Effects on Welfare in US$ Billion

Region	Effect of Climate Change on Welfare in US$ Billion					
	Allocative Efficiency	Endowments	Technical Change	Terms of Trade	Investment Savings	Total Welfare
Australia	0.07	0.06	-0.11	-0.35	0.05	-0.28
Brunei	0.00	0.00	0.00	-0.01	0.00	-0.01
Canada	0.31	0.10	0.05	0.50	0.78	1.85
Chile	0.01	-0.01	-0.09	0.23	-0.02	0.13
Japan	-0.07	0.05	-0.01	0.65	-0.32	0.30
Malaysia	-0.03	-0.16	-0.12	-0.06	0.00	-0.40
Mexico	-0.01	-0.06	-0.24	0.27	-0.09	-0.15
New Zealand	0.05	-0.03	-0.05	0.57	-0.02	0.55
Peru	-0.02	-0.06	-0.19	0.05	-0.01	-0.25
Singapore	-0.01	0.00	-0.02	-0.04	-0.04	-0.12
Vietnam	-0.05	-0.08	-0.18	0.05	-0.01	-0.30
United States	0.26	0.06	-0.94	3.48	0.26	3.30
Korea	-0.04	-0.18	-0.12	-0.01	-0.16	-0.50
China	-7.21	-14.34	-36.39	-10.15	1.97	-65.86
India	-0.31	-1.38	-3.31	1.01	-0.28	-4.64
Rest of World	-4.53	-6.61	-9.06	1.64	-2.61	-23.37
Global EV	-11.57	-22.65	-50.78	-2.17	-0.48	-89.76

Conclusion Remarks

Simulation results show a heterogeneous response to the effect of extreme climate change across regions and sectors.

- Extreme climate change increases the prices of all agricultural commodities in all regions.

- Reallocation of production and consumption of agricultural commodities through international trade reduces the negative effect of extreme climate change, as confirmed by the net trade balance results.

Conclusion Remarks

Adaptation policies should be selective, innovative, facilitative, and optimizing.

- Prioritize - Crops that can help address national food security.
- Innovative - Developing new technologies that can respond to climate change
  Improving storage of agricultural goods to avoid wastage.
- Facilitative - Including creating a conducive environment for reallocation of production and consumption of agricultural commodities across countries.
  - Establishing the necessary infrastructure to support agricultural production.
- Optimization - Involving the localization of adaptation mechanisms.

Thank you all

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