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Supply-side Impact of Trade Liberalization and Disruption

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Abstract

Intracontinental trade intensity and concentration are observed worldwide. It has been suggested that supply chain resilience to unexpected shocks be strengthened by enhancing international diversification of input sources. The major objective of this paper is to try to investigate the impact of trade liberalization and disruption on trade and supply chains by means of simulation studies using a computable general equilibrium (CGE) model of global trade, with the introduction of a few trade indicators. World import deviation from the expected least distorted state of trade would be reduced by trade liberalization but expanded by trade disruption, though to a small extent. That said, those impacts on import concentrations and deviations would be mixed at the regional levels. Regional tariff removals would create more import deviations, depending on the economy. The impact of trade disruption on import deviations would vary by economy. It is advised that supply chain resilience be considered by economy and by sector. Meanwhile, the development of analytical methodologies for study of the impact of policy measures on supply chains would be seen as issues for further study.

Key words: Asia-Pacific, supply chain, Trans-Pacific Partnership (TPP), Regional Comprehensive Economic Partnership (RCEP), US tariff hikes, trade sanctions on Russia, mining price increases, computable general equilibrium (CGE) model
JEL classification: C68, F13, F14, F15, F17

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I. Introduction

The COVID-19 pandemic that emerged in 2019 has raised issues regarding the resilience of global supply chains. Bottlenecks of key inputs for production, including medicals as well as semiconductors and energy (resulting from pandemic lockdowns of factories), serve as a reminder of the vulnerability of economies dependent on limited and concentrated suppliers of resources. Citizens were requested to stay home, and transportation prices rose sharply. Shocks at the sector level affected the economy at the macro level. In the meantime, international partners have introduced sanctions (including financial and trade restrictions) on Russia since its military invasion of Ukraine starting in February 2022. Moreover, oil prices soared, peaking in June 2022, and commodity prices have been volatile after the COVID-19 recession.

International trade and investment liberalization and facilitation have been expected to generate efficient resource allocations among regions, contributing to supply chain resilience. Those efforts were attempted through implementation of regional trade agreements (RTAs) including free trade agreements (FTAs) and economic partnership agreements (EPAs) and through a multilateral free trade system under the World Trade Organization (WTO). In the Asia-Pacific, the Trans-Pacific Partnership (TPP) and the Regional Comprehensive Economic Partnership (RCEP) have served as two major pathways toward the Free Trade Area of the Asia-Pacific (FTAAP) under the Asia-Pacific Economic Cooperation (APEC). On the other hand, a few movements toward protectionism have been seen, including the hiking of import tariffs on steel and aluminum in 2018 in the United States (US), and tariff hikes by the US on imports from China starting in 2018, with corresponding hikes of tariffs on imports by China from the US. Those trade policies would have an adverse impact on trade, economy and supply chains.

Global value chain (GVC), defined by the World Bank as "the series of stages in the production of a product or service for sale to consumers" (WB, 2020), is distinct from global supply chain including intermediate inputs rather than just value added. The International Monetary Fund (IMF) studied "global trade and value chains during the pandemic" and argued that "supply chain resilience to shocks is better built by increasing diversification away from domestic sourcing of inputs and greater substitutability in input sourcing (IMF, 2022)." Substantial home bias is found in the sources of intermediate inputs, which suggests room for international diversification of domestic inputs. It is also

estimated that GDP losses due to supply shocks would be reduced by almost half under greater diversification and by about four-fifths under greater substitutability.

The Council of Economic Advisors characterizes supply chain resilience as the "ability (of supply chains) to recover quickly from unexpected events" (CEA, 2022). Four key policy tools for enhancing supply chain resilience have been identified by the Organisation for Economic Co-operation and Development (OECD).[1] The first tool is risk management: anticipating risks, obtaining an accurate diagnosis of the problems and identifying the appropriate policy responses. The second is domestic policy for minimizing exposure to shocks through infrastructure investment; digital trade; sound procurement; and regulatory flexibility, with the aim of enhancing productivity and competitiveness. Third is coordination and coherence between public and private sector trust building, including firm-level risk management, public-private action plans, stress testing of supply chains, and strategic governance at the national level. Fourth, at the international level, is keeping markets open under predictability and transparency through international agreements, trade facilitation and regulatory cooperation. It is argued that these tools would strengthen the resilience of supply chains "without undermining the benefits of open and rules-based international trade" and that trade policies need to provide solutions "without resorting to beggar-thy-neighbour measures."

The major objective of this paper is to try to investigate the impact of trade liberalization and disruption on trade and supply chains. A computable general equilibrium (CGE) model of global trade is used in the quantitative studies of those impacts. The absolute magnitudes of the estimated impacts of those shocks would depend on the scenarios studied and the designed model framework selected. It is much more useful to compare the relative significance of impact across different scenarios. The state of supply and value chains has been studied by developing Multi-Region Input-Output (MRIO) tables and other databases. Meanwhile, policy measures to make those chains resilient have been proposed. That said, the analytical methodologies for studying the impact of those policy measures on supply and value chains appear to be still under development. This paper proposes to contribute to those efforts by means of CGE model simulations with a few trade indicators introduced, for the assessment of those impacts.

The remainder of this paper is organized as follows. Chapter II will describe the states of trade and supply chains by region, introducing a couple of import indicators. Chapter III presents a framework of modeling studies, the structure of the CGE model used and the policy scenarios studied here. The estimated results will be discussed in

[1] https://www.oecd.org/trade/resilient-supply-chains/

Chapter IV's examination of trade and economy; and on trade and supply chains. Chapter V will provide a brief summary and concluding remarks.

II. Trade and Supply Chains

1) Import structure

World trade has increased over the last few decades, with occasional breaks alongside population and domestic production. The shares of selected major economies in the world are summarized in Table 1.[2] China and India[3] were the largest two economies in terms of population in 2017 according to the GTAP 11 Data Base. The US is the largest economy in terms of GDP, followed by China and the 27 member states of the European Union (EU) as a whole. On the other hand, the EU nations hold the largest ratio in terms of imports and exports. The ratio of imports over GDP varies by region, and

Table 1 Structure of the world economy

		Population		GDP		Imports		Import ratio
		(mil.)	(%)	(mil.)	(%)	(mil.)	(%)	(%)
World		7,514		81,394		21,082		25.9
Australia	AUS	25	(0.3)	1,327	(1.6)	296	(1.4)	22.3
China	CHN	1,386	(18.5)	12,310	(15.1)	2,162	(10.3)	17.6
Japan	JPN	127	(1.7)	4,931	(6.1)	859	(4.1)	17.4
Korea	KOR	51	(0.7)	1,624	(2.0)	562	(2.7)	34.6
ASEAN	SEA	648	(8.6)	2,801	(3.4)	1,418	(6.7)	50.6
India	IND	1,339	(17.8)	2,651	(3.3)	520	(2.5)	19.6
US	USA	325	(4.3)	19,480	(23.9)	2,850	(13.5)	14.6
Canada	CAN	37	(0.5)	1,649	(2.0)	519	(2.5)	31.5
Mexico	MEX	125	(1.7)	1,159	(1.4)	439	(2.1)	37.9
Russia	RUS	144	(1.9)	1,574	(1.9)	286	(1.4)	18.1
EU	EUM	448	(6.0)	14,813	(18.2)	6,027	(28.6)	40.7
UK	GBR	66	(0.9)	2,699	(3.3)	899.8	(4.3)	33.3
GCC	GCC	56	(0.7)	1,472	(1.8)	564	(2.7)	38.3
TPP		824	(11.0)	30,138	(37.0)	5,940	(28.2)	19.7
RCEP		3,581	(47.7)	25,851	(31.8)	5,865	(27.8)	22.7
APEC		2,877	(38.3)	48,379	(59.4)	10,033	(47.6)	20.7

Source: Based on GTAP 11b Data Base, 2017, GTAP.

[2] Those shares, for the member economies of TPP including the US; for RCEP including India; and for FTAAP are also shown here for later reference to the impact of trade liberalization scenarios by modeling studies.

[3] India's population would have exceeded that of China in 2023 according to data from the United Nations Population Fund (UNFPA).

is generally lower in larger economies including the US, China and Japan, but is notably higher in the EU as well as the Association of Southeast Asian Nations (ASEAN) countries.

Regional trade relationships could be stylized by trade intensity index (TII). Import intensity index (MII_{rs}) could be used to look at the relative significance of imports of economy r from source economy s with respect to their importance among world imports, as defined in the following equation, which is calculated as the ratio of the share of imports in economy r from source s (M_{rs}) in total imports in r (M_{rt}) over the share of world imports from s (M_{ws}) in world total imports (M_{wt}).

$$MII_{rs} = \frac{M_{rs}}{M_{rt}} \Big/ \frac{M_{ws}}{M_{wt}}$$

If the above index is more (less) than one, it is indicated that bilateral imports of r from s are larger (smaller) than expected in light of the relative importance of s in world as the source economies of imports.

The heavy connectivity of trade among intracontinental economies is suggested by the standard import intensity index, with some variation, as is shown in Table 2. That trade includes remarkably intensive imports between Australia and New Zealand as well as among the former Soviet Union (FSU) countries including Russia (not shown in Table 2) alongside imports among Asian economies including China, Japan, Korea and the ASEAN countries; among American economies including the US, Canada, Mexico (and central and south America, which are not shown in Table 2); and among European

Table 2 Import intensity

(Index)

	AUS	CHN	JPN	KOR	SEA	IND	USA	CAN	MEX	RUS	EUM	GBR	GCC
AUS	0.0	1.8	1.6	1.7	2.1	1.3	1.3	0.5	0.4	0.1	0.5	1.2	0.4
CHN	3.3	0.0	2.5	3.3	1.9	0.5	0.8	0.6	0.3	1.1	0.5	0.4	1.2
JPN	3.8	1.9	0.0	1.1	2.1	0.5	1.4	0.6	0.3	0.8	0.4	0.5	2.6
KOR	2.7	1.9	2.8	0.0	1.5	0.7	1.2	0.4	0.4	1.2	0.3	0.5	2.8
SEA	1.5	1.9	2.0	2.2	2.9	1.3	0.9	0.2	0.1	0.3	0.3	0.4	1.4
IND	2.2	1.4	0.5	1.1	1.5	0.0	0.9	0.5	0.4	0.7	0.3	0.5	4.1
USA	0.4	1.5	1.3	0.9	0.9	1.5	0.0	5.1	5.7	0.4	0.6	1.3	0.5
CAN	0.3	0.6	0.5	0.4	0.3	0.4	6.0	0.0	1.0	0.1	0.3	0.6	0.1
MEX	0.0	0.8	0.7	0.8	0.4	0.6	6.0	0.6	0.0	0.1	0.3	0.2	0.1
RUS	0.0	1.5	0.6	0.8	0.5	0.6	0.3	0.1	0.0	0.0	1.4	0.8	0.1
EUM	0.2	0.5	0.3	0.3	0.4	0.5	0.6	0.2	0.2	1.4	1.9	1.6	0.3
GBR	0.6	0.6	0.5	0.3	0.5	1.1	1.1	0.8	0.1	0.6	1.8	0.0	0.4
GCC	0.8	1.1	0.9	0.8	0.8	3.8	1.0	0.3	0.1	0.4	0.7	1.6	3.3
World	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Note: Abbreviations are shown in Table 1.

Source: Author's calculations based on GTAP 11b Data Base, 2017, GTAP.

economies including the EU member states and the United Kingdom (UK).

2) Concentration and deviation of imports

GVCs have expanded: WB (2020) finds that "all countries participate in GVCs but in different ways." Two types of GVC trade are discussed there: "*Backward GVC participation*, in which a country's exports embody value added previously imported from abroad; *Forward GVC participation*, in which a country's exports are not fully absorbed in the importing country and instead are embodied in the importing country's exports to third countries." It is also found that developed economies "participate in complex GVCs" whereas developing economies "produce commodities for further processing in other countries." Global input-output tables describing those developments (including those in the Trade in Value Added (TiVA) database, OECD) are available.

The stylized features of regional trade structure have been revealed at the sector level by the comparative advantage/disadvantage of economies. Two more indicators are prepared and introduced in this paper for consideration of the impact of trade shocks to regional supply chains based on trade data by both region and sector, as detailed below. Benchmark data for world trade is estimated here when tariffs are fully eliminated and world trade structure is expected to be the least distorted, rather than using observed trade data as it is, which would be distorted to some extent by existing tariffs and others.

Import concentration: The ratio of concentrated regional imports greater than world average imports (MC_{rs}). It is defined as the sum of common world trade weight averages of the ratios of the shares of imports in economy r from source s in sector i (M_{irs}) in total imports in economy r (M_{trt}) over the shares of world imports from source s in sector i (M_{iws}) in total world imports (M_{twt}), in the case where those exceed the shares of world imports from source s in sector i in total world imports.

$$MC_{rs} = \sum_i \frac{M_{irs}}{M_{trt}} \Big/ \frac{M_{iws}}{M_{twt}} * \frac{M_{iws}}{M_{twt}}, \text{ where } \frac{M_{irs}}{M_{trt}} > \frac{M_{iws}}{M_{twt}}$$

In effect import concentration corresponds to and is calculated as the sectoral sum of the shares of imports in economy r from source s in sector i in total imports in economy r, in the case where those shares of imports exceed the shares of world imports from source s in sector i in total world imports.

$$MC_{rs} = \sum_i \frac{M_{irs}}{M_{trt}}, \text{ where } \frac{M_{irs}}{M_{trt}} > \frac{M_{iws}}{M_{twt}}$$

The sum of import concentrations shown above (MC_{rs}), by source economy s (MC_r) will be used to represent import concentration in economy r later.

Import deviation: The degree of deviation in regional imports from world average imports (MD_{rs}). It is calculated as the sectoral sum of the common world trade weight average of the absolute discrepancies of the shares of imports in economy r from source s in sector i (M_{irs}) in total imports in economy r (M_{trt}) from the shares of world imports from source s in sector i (M_{iws}), in total world imports (M_{twt}):

$$MD_{rs} = \sum_i \left| \frac{M_{irs}}{M_{trt}} - \frac{M_{iws}}{M_{twt}} \right| * \frac{M_{iws}}{M_{twt}}$$

It may be noted that a single economy does not import from its own economy, and therefore it is considered here that those imports deviate from world average. The source economy sum (MD_r) of the above import concentration (MD_{rs}) will also be used to represent import deviation in economy r.

Calculated import concentrations in per cent and import deviations in per myriad are shown in Table 3-A and 3-B[4] respectively. The ratios of import concentration appear to exaggerate import intensities, as seen in Table 2. Import concentrations highlight intensive imports within North America, Europe and East Asia. It is not surprising that those ratios exceed 50%, which simply means that there were more imports from concentrated economies. That said, those import concentrations are in a smaller range than those in the import deviations below, from 63.4% in the Gulf Cooperation Council

Table 3-A Import concentration

(%)

	AUS	CHN	JPN	KOR	SEA	IND	USA	CAN	MEX	RUS	EUM	GBR	GCC	Total
AUS	0.0	20.0	5.2	5.1	13.4	1.7	10.7	0.7	0.0	0.0	0.0	3.7	0.4	68.6
CHN	5.0	0.0	10.1	10.7	12.0	0.2	3.5	0.6	0.0	1.7	0.3	0.2	3.8	71.2
JPN	5.7	22.5	0.0	3.0	13.8	0.0	13.5	0.7	0.2	1.3	0.0	0.0	8.1	74.2
KOR	4.1	18.2	11.0	0.0	8.7	0.3	10.3	0.0	0.5	1.6	0.0	0.3	8.7	71.1
SEA	1.9	22.3	8.2	7.0	20.0	2.3	6.4	0.0	0.0	0.0	0.0	0.0	3.9	78.5
IND	3.5	12.9	0.0	2.2	8.5	0.0	6.2	0.2	0.5	0.4	0.9	0.4	13.2	72.5
USA	0.3	14.3	4.2	0.9	3.1	2.4	0.0	11.6	12.3	0.4	0.3	4.2	0.4	65.3
CAN	0.0	0.0	0.0	0.5	0.2	0.0	63.9	0.0	1.4	0.0	0.0	0.4	0.0	68.6
MEX	0.0	3.9	1.6	1.0	0.5	0.4	63.7	0.3	0.0	0.0	0.0	0.0	0.0	73.0
RUS	0.0	13.2	1.5	1.9	1.8	0.1	0.0	0.0	0.0	0.0	37.8	0.4	0.3	76.8
EUM	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.4	56.8	5.7	0.0	73.2
GBR	0.7	1.1	0.7	0.2	0.9	1.3	8.1	1.5	0.0	0.7	52.9	0.0	0.0	77.4
GCC	0.9	6.4	2.6	2.2	3.3	7.4	5.9	0.0	0.0	0.3	6.1	5.0	10.8	63.4
World	0.6	0.9	0.5	1.2	4.2	0.0	8.8	1.6	1.4	0.7	29.2	3.1	1.7	59.6

Note: Abbreviations are shown in Table 1.

Source: Author's calculations based on GTAP Data Base 11, 2017, GTAP.

[4] The figures for ASEAN as import sources are calculated as the simple sum of those figures for the individual ASEAN countries as import sources, to be consistent with regional aggregation in the model simulations discussed later. Those figures are larger if calculated for the aggregated ASEAN countries as import sources.

Table 3-B Import deviation

(‰)

	AUS	CHN	JPN	KOR	SEA	IND	USA	CAN	MEX	RUS	EUM	GBR	GCC	Total
AUS	0.7	15.5	2.6	2.9	1.8	0.4	8.1	0.4	0.4	0.9	39.2	1.1	2.3	81.5
CHN	2.0	24.3	4.0	7.5	2.0	0.4	5.4	0.3	0.4	0.5	54.1	1.5	1.4	114.2
JPN	3.2	20.8	2.9	1.2	1.4	0.3	7.1	0.3	0.5	0.2	60.4	0.6	8.6	111.9
KOR	1.8	19.2	5.2	2.2	1.1	0.2	2.9	0.3	0.6	0.6	64.6	1.1	9.5	115.2
SEA	0.4	16.6	2.2	3.1	2.5	0.2	3.6	0.4	0.6	0.7	69.9	1.2	2.0	108.6
IND	1.1	14.0	1.5	1.0	1.1	0.7	4.3	0.2	0.6	0.4	64.0	1.2	12.3	120.5
USA	0.6	11.7	1.7	1.0	0.6	0.4	14.1	2.3	3.2	0.7	35.9	1.2	1.7	79.0
CAN	0.6	11.8	1.4	1.9	1.1	0.4	59.6	0.5	0.2	0.9	65.4	0.6	3.0	152.8
MEX	0.7	7.7	1.0	0.9	0.8	0.5	57.7	0.2	0.6	0.9	63.9	1.8	3.2	146.9
RUS	0.7	10.0	1.9	1.6	0.9	0.3	8.9	0.5	0.6	1.0	59.8	0.3	3.1	97.1
EUM	0.6	13.9	2.0	1.7	0.9	0.3	3.8	0.4	0.5	0.8	96.3	1.6	2.1	127.6
GBR	0.6	10.2	1.8	1.8	0.9	0.4	10.3	0.5	0.6	0.7	91.2	2.2	2.1	128.4
GCC	0.6	4.2	2.2	1.6	0.9	1.1	3.8	0.4	0.6	0.8	36.0	0.9	3.4	62.5
World	0.0	2.2	0.1	0.1	0.1	0.1	0.6	0.0	0.0	0.0	5.5	0.1	0.0	9.3

Note: Abbreviations are shown in Table 1.
Source: Author's calculations based on GTAP Data Base 11, 2017, GTAP.

(GCC) countries to 76.8% in Russia.

Degree of import deviation ranges between 62.8‰ in the GCC countries and 155.5‰ in Canada followed by Mexico (148.7‰): those nations import significantly more from the US. Import deviation is elevated the most by the largest imports from the EU, but in two ways. Imports in the EU as well as the UK and Russia are much greater than the world average. On the other hand, imports in other economies are much less than world average. Another major contributor to measured import deviation is China, whose goods and services are imported more by Australia, Asia, the US and Russia but less by Canada, Mexico and the UK. That said, import deviation in the world as a whole, under current measurement without any trade shocks, is indicated to be much smaller, at around 9.3‰, than import deviations in individual economies, which offset each other at the aggregated level but not necessarily in terms of the average. Possible trade distortions due to current tariff levels would be limited in world trade.

III. Framework of model simulations

1) Structure of CGE model

In this paper, the impact of trade shocks is estimated using the Global Trade Analysis Project (GTAP) 11b Data Base released in December 2023, which is the second bug-fixed version of the GTAP 11 Data Base (Aguiar, Chepeliev, Corong and van der

Mensbrugghe, 2022); and the standard GTAP model, version 7 (Corong, Hertel, McDougall, Tsigas and van der Mensbrugghe, 2017), which is solved by the General Equilibrium Modelling PACKage (GRMPACK) software (Horridge, Jerie, Mustakinov and Schiffman, 2018). Global trade and economic data are provided for a few reference years up to 2017 in GTAP 11b Data Base. That data for 2017 (which is immediately before the following policy scenarios take place) is aggregated, without updating to the recent reference year, from 65 to 15 sectors and from 141 economies and 19 aggregated regions to 32 economies for model simulations, as is shown in Annex Tables A and B. In consideration of trade liberalization scenarios in this study, the APEC member economies[5] are disaggregated, except for Papua New Guinea (for which data is not available in the GTAP database) as well as the ASEAN countries.[6] On the other hand, the OECD and GCC member countries as well as the FSU countries are distinguished from other countries, in consideration of trade disruption scenarios.

The standard GTAP model is a multi-region, multi-sector CGE model linking economies through international trade, and introducing imperfect substitutes of commodities among economies through the Armington assumption (Armington, 1969). In the model used in this paper, trade balance is not fixed, and international capital movement is endogenously determined, with the expected rates of return on capital equalized among economies.

Moreover, a few dynamic effects are incorporated into the standard framework of fixed production endowments with perfect competition and constant return to scale. First, capital stock is endogenous, linking changes in investment to capital stock employing the methodology used in Francois, McDonald and Nordström (1996). Second, labor supply is also endogenous, linking changes in real wages to labor supply following the methodology used by the Cabinet Secretariat (CS, 2015) and by the US International Trade Commission (USITC, 2016).[7] Third, productivity improvement of economy at the region-wide level is introduced, linking trade openness to output technology following the methodology used in CS (2015).

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[5] Australia; Brunei; Canada; Chile; China; Chinese Taipei; Hong Kong, China; Indonesia; Japan; Korea; Malaysia; Mexico; New Zealand; Singapore; Papua New Guinea; Peru; Philippines; Russia; Thailand; the US; Viet Nam.

[6] Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Singapore, Philippines, Thailand, Viet Nam. The data for Myanmar is not individually available in the GTAP database: it is proxied by the composite region of Myanmar and Timor-Leste.

[7] The elasticity of labor supply with respect to real wages is set as 0.8 following CS (2015), which is around two times those used in USITC (2016).

2) Policy scenarios

The economic impact of the eight scenarios below will be estimated by a CGE model in this study. The first set of four scenarios consists of trade liberalization scenarios; the second set of four scenarios consists of trade disruption scenarios. A brief description of the states of those scenarios and the assumptions for their model simulations follows.

Trade liberalization

TPP:	tariff removals among the TPP economies including the US
RCEP:	tariff removals among the RCEP economies including India
FTAAP:	tariff removals among the APEC economies
World:	tariff removals worldwide

Trade disruption

US-MTL:	25% hikes in US tariffs on the imports of metals
US-CHN:	15% hikes in US and Chinese bilateral tariffs
RUS:	blocks of OECD goods imports from and exports to Russia
MNG:	20% increase in mining prices

TPP was negotiated by 12 economies[8]; the concluded Agreement was signed in February 2016. That said, the US withdrew from TPP in January 2017 and the Comprehensive and Progressive Agreement for Trans-Pacific (CPTPP) entered into force among the remaining 11 economies in December 2018. RCEP was negotiated by 16 economies,[9] but India eventually withdrew; RCEP entered into force among 15 economies in January 2022. Meanwhile, the APEC economies adopted the Bogor Goal of free and open trade and investment in the Asia-Pacific by 2020, which has been succeeded by the Putrajaya Vision 2040.

Average tariff rates on total aggregated goods are shown in Table 4[10] by region for imports from the APEC economies and the world. The average tariff rate for the APEC economies is 2.18%, which is slightly lower than the world average (2.34%). That said, average tariff rate varies among the APEC economies. It is already zero in Hong Kong, China; and Singapore, but higher than the world average including in Russia (4.86%) and

[8] Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, the US, Viet Nam.

[9] ASEAN 10 countries, Australia, China, India, Japan, Korea, New Zealand.

[10] These tariff rates are based on data for 2017, right before above major EPAs were implemented. It may be noted that those tariffs include tariff reductions according to FTAs/EPAs entered into force before 2017 but not yet fully implemented to some extent during their phase periods of a few decades.

Table 4 Average tariff rates

(%)

	From APEC	From World		From APEC	From World
Australia	0.91	1.77	New Zealand	0.97	1.38
China	3.15	3.71	Hong Kong, China	0.00	0.00
Japan	2.23	2.07	Korea	2.63	2.38
Chinese Taipei	2.02	2.08	Brunei	0.07	0.11
Indonesia	1.40	1.89	Malaysia	1.13	1.64
Philippines	1.40	1.78	Singapore	0.00	0.01
Thailand	2.33	3.33	Viet Nam	2.06	2.64
Cambodia	3.68	4.17	Laos	1.09	1.29
Myanmar	1.69	1.81	India	5.79	5.79
US	1.51	1.54	Canada	0.85	0.87
Mexico	0.86	1.04	Chile	0.21	0.32
Peru	0.78	0.72	Russia	5.67	4.86
EU	2.43	0.64	UK	2.83	1.01
TPP members	1.50	1.39	RCEP members	3.00	2.55
APEC economies	1.90	2.18	World	2.81	2.34

Source: Author's calculations based on GTAP 11b Data Base, 2017, GTAP.

China (3.71%). Tariff rates on imports from the APEC economies are lower than those from the world in Australia, New Zealand, China and the ASEAN countries, but higher in Russia. On the other hand, average tariff rate in the TPP member economies (1.39%) is lower than that in the APEC economies as well as the world, but average tariff rate in the RCEP economies, including India (5.79%), is higher than that in the APEC economies as well as the world. The above variability would reflect differences in the geographical progress of RTAs, especially those that have been more intracontinental than intercontinental, as indicated previously by trade intensity and concentration.

The impact of trade liberalization will be estimated here assuming full removal of tariffs in the TPP, RCEP, FTAAP economies and the world. The purpose of the studies in this paper is to compare the economic impact under common broad assumptions. There is a need for studies of actual impact of TPP/CPTPP[11] and RCEP based on the provisions of those agreements, including partial tariff reductions allowing exemptions from full tariff removals. It may also be noted that the above TPP scenario, but not CPTPP, includes tariff removals by the US as well as India in the RCEP scenario. Another purpose of this study is to compare the potential impact of trade liberalization from a border perspective.

[11] The actual impact of TPP based on the Agreement was studied by the TPP governments: on the US economy in USITC (2016); on the Japanese economy in CS (2015); and on other economies elsewhere. The TPP impact on 12 member economies is available in Kawasaki (2017), which uses the most accurate tariff reduction data provided by the International Trade Centre (ITC).

The US Department of Commerce (USDOC) investigated the effects of imports of steel and aluminum on national security under section 232 of the Trade Expansion Act of 1962, as amended in January 2018. The Secretary of Commerce recommended a few alternatives to the US president to "enable an 80% capacity utilization rate at 2017 demand"; these included an additional 24% global tariff on all steel imports, in expectation of a 37% reduction of steel imports (USDOC, 2018a) and of a 7.7% reduction on unwrought and the other aluminum imports, having the same impact as the 86.7% quota (USDOC, 2018b) respectively. The US president issued a presidential proclamation in March 2018, imposing a 25% additional tariff on US steel imports and a 10% additional tariff on aluminum imports.

The economic impact of US import tariff hikes on steel and aluminum would be larger for economies from which the US imports those products more than from other economies. Imports by major economies of US steel and aluminum in 2017 are shown in Table 5. It is indicated that the source economies of those US imports are concentrated in a limited numbers of economies. More than half of US steel is imported from five economies, led by Canada, followed by Brazil, Korea, Mexico and Russia. US imports of aluminum are predominantly from Canada, which has a 43.0% share of US world imports. In this paper it is assumed (as a simple mechanical scenario) that a 25% tariff will be

Table 5 Major US imports of steels and aluminum (2017)

(thousand metric tons, %)

	Steel				Aluminum		
1	Canada	5,800	(16.1)	1	Canada	2,974	(43.0)
2	Brazil	4,679	(13.0)	2	Russia	751	(10.9)
3	Korea	3,654	(10.2)	3	UAE	683	(9.9)
4	Mexico	3,249	(9.0)	4	China	657	(9.5)
5	Russia	3,124	(8.7)	5	Bahrain	256	(3.7)
6	Turkey	2,249	(6.3)	6	Argentina	218	(3.2)
7	Japan	1,781	(5.0)	7	South Africa	170	(2.5)
8	Germany	1,371	(3.8)	8	India	158	(2.3)
9	Chinese Taipei	1,252	(3.5)	9	Qatar	124	(1.8)
10	India	854	(2.4)	10	Venezuela	98	(1.4)
11	China	784	(2.2)	11	Indonesia	78	(1.1)
12	Viet Nam	728	(2.0)	12	Mexico	68	(1.0)
13	Netherlands	590	(1.6)	13	Germany	59	(0.8)
14	Italy	515	(1.4)	14	Saudi Arabia	49	(0.7)
15	Thailand	417	(1.2)	15	Brazil	40	(0.6)
	Above 15	31,047	(86.4)		Above 15	6,384	(92.3)
	World	35,927	(100.0)		World	6,917	(100.0)

Notes: Figures are annualized based on source data (US Census Bureau) from January to October 2017.
Source: Based on USDOC (2018a) and USDOC (2018b).

added to US imports of all metals and metal products from all countries.

On the other hand, the US Trade Representative (USTR) investigated China's acts, policies and practices related to technology transfer, intellectual property and innovation under section 301 of the Trade Act of 1974, and provided the findings in March 2018 (USTR, 2018). The US started to increase tariffs on imports from China on the day after the release of above report, which was followed by the corresponding hikes in tariffs on imports from the US by China shortly after that. Tariffs were increased to the greatest extent in September 2018, resulting in US tariffed imports from China totaling 470 billion US dollars (USD) in 2019, accounting for almost all trade (486 billion USD) and China's tariffed imports from the US of 79 billion USD, a share of around 64% for all products (124 billion USD) according to Bekker and Schroter (2020). Meanwhile, it is also indicated that the US average tariff rate on imports from China was hiked to 16.0% in January 2020 from 2.6% in January 2018, a 13.4% point increase; and that in the same period China's average tariff rate from the US was also hiked, from 6.2% to 16.4% (an increase of 10.2% points). It is assumed here in this paper that the bilateral tariff rate between the US and China will be hiked by 15% on all traded goods in a uniform manner, again as a simple mechanical scenario.

The US merchandise trade deficit in 2017 was largest with China (375 billion USD), a share of close to 50% of the world total (792 billion USD) followed by Mexico (69 billion USD), Japan (69 billion USD) and Germany (64 billion USD), according to "International Trade," US Census Bureau.[12] US exports to and imports from China, and their balance as well, are shown in Table 6. The US imports more than 3.5 times more

Table 6 US merchandise trade with China, by sector

(billion USD, %)

	Exports		Imports		Balance
Agriculture, forestry and fisheries	18.5	(14.1)	1.0	(0.2)	17.5
Mining	5.4	(4.1)	0.4	(0.1)	5.0
Processed foods	4.2	(3.2)	7.4	(1.5)	-3.2
Textiles and apparel	1.7	(1.3)	75.8	(15.6)	-74.2
Other manufacturing	10.4	(7.9)	69.5	(14.3)	-59.0
Chemical products	26.2	(20.0)	46.7	(9.6)	-20.5
Metals	9.2	(7.0)	24.5	(5.0)	-15.3
Motor vehicles	14.1	(10.7)	18.4	(3.8)	-4.3
Other machinery	14.3	(10.9)	90.0	(18.5)	-75.8
Electronic products	27.4	(20.9)	151.7	(31.3)	-124.4
Total	131.2	(100.0)	485.3	(100.0)	-354.1

Source: Author's calculations based on GTAP 11b Data Base, 2017, GTAP.

[12] https://www.census.gov/foreign-trade/index.html

from China than the US exports to China. By sector, the US is a large exporter of agriculture, forestry and fisheries to China but is not a larger importer; this results in a trade surplus in that sector. The US does not export much textiles and apparel and other light manufacturing, but imports considerable values in those sectors, contributing to large trade deficits. Chemical products, metals and motor vehicles have larger shares of US exports than of US imports, but they have trade deficits. Other machinery and electronic products in particular have larger ratios in imports than in exports, and generate larger trade deficits.

Several economies[13] introduced sanction packages including the following measures in response to Russia's military invasion of Ukraine, which began in February 2022, as summarized by the International Working Group on Russian Sanctions (IWGRS, 2022). Russian Central Bank accounts had their access to dollars and euros frozen. Seven Russian banks were disconnected from Society for Worldwide Interbank Financial Telecommunication (SWIFT). The access of Russian companies to capital markets was closed. The WTO members have withdrawn most favored nation (MFN) status from Russia. Exports to Russia of "goods and technologies in the oil refining, aerospace, technologies and dual-use goods, and luxury goods" have been prohibited. Imports from

Table 7 Russia's trade structure

(%)

Sector	Exports	Imports	Region	Exports	Imports
Agri. forestry and fisheries	2.9	3.9	Australia	0.1	0.1
Mining	42.8	1.5	China	11.5	17.5
Processed foods	3.2	6.1	Japan	3.3	2.6
Textiles and apparel	0.3	7.6	Korea	3.2	2.8
Other manufacturing	3.5	4.2	ASEAN	2.2	3.4
Chemical products	20.4	14.2	India	1.6	1.2
Metals	11.8	5.9	US	5.5	3.3
Motor vehicles	0.9	8.2	Canada	0.3	0.3
Other machinery	2.6	17.8	Mexico	0.2	0.1
Electronic products	0.9	6.9	EU	41.0	42.0
Electricity, gas and water	0.4	0.2	UK	2.4	2.7
Construction	0.6	1.6	Other OECD	5.8	5.2
Transportation	2.6	2.5	Other FSU	13.6	11.9
Other private services	6.6	18.4	GCC	1.0	0.5
Public services	0.5	1.1			
Goods	89.3	76.2	OECD	61.9	59.2
Total	100.0	100.0	World	100.0	100.0

Source: Author's calculations based on GTAP 11b Data Base, 2017, GTAP.

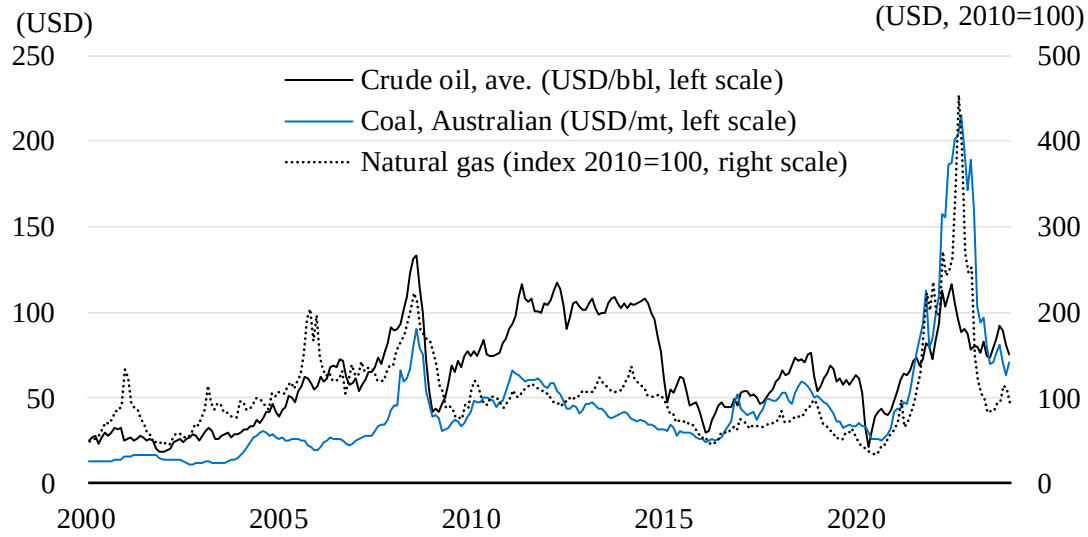
[13] Australia, New Zealand, Japan, Korea, Singapore, the US, Canada, Bahamas, the EU, the UK, Switzerland, Norway, North Macedonia and Georgia as of March 2022.

Russia of oil and gas, as well as seafood, vodka and spirits, and non-industrial diamonds were banned. All flights to Russia were banned. It is assumed in the model simulation in this paper that trade in goods between Russia and the OECD countries[14] will be blocked.

The structures of Russia's exports and imports by sector and by region are shown in Table 7. By sector, Russia's exports are concentrated on mining, chemical products and metals. On the other hand, Russia imports relatively more agriculture and foods, textiles and apparel, motor vehicles and other machinery than other economies. By region, Russia is an intensive trade partner of China, the EU and the FSU countries. The OECD countries share around three fifths of both exports to and imports from Russia.

In the meantime, prices of commodities including oil, coal and gas rose from their bottoms in 2020 due to the COVID-19 recession and peaked in mid-2022 after Russia's military invasion of Ukraine, as is shown in Chart 1. The average oil price in 2022 (97.1 USD per barrel) was higher than that in 2019 (61.4 USD) by around 60% according to World Bank Commodity Price Data.[15] Average coal and gas prices in 2022 were more than four times those in 2019. Major agriculture commodities have also shown similar trends over time. The impact of increases in the price of mining commodities will be estimated separately from that of trade sanctions on Russia, assuming a much more moderate 20% increase due to accuracy constraints of the model solution method.[16]

Chart 1 Trends in mining prices



Source: Based on World Bank Commodity Price Data, WB.

[14] These include Bulgaria, Croatia, Cyprus, Malta, and Romania, which are non-OECD member economies but member states of the EU under the regional aggregation in model simulations here.
[15] https://www.worldbank.org/en/research/commodity-markets
[16] The solution method of Gragg with three steps (2, 4, 6) is employed in the model simulations discussed here, except in the case of trade sanctions on Russia, which is solved by Euler with one

IV. Estimated results

1) Impact on trade and economy

The estimated impact of the above trade liberalization and disruption scenarios on import volumes is shown in Table 8. World imports and trade would be boosted by 7.70% under world tariff removals. The impact of TPP tariff removals on world imports (0.19%) would be much smaller (due mainly to lower tariff rates in the TPP economies) compared with that of RCEP tariff removals (1.45%), though import values for the TPP economies and the RCEP economies have nearly the same ratios of world imports. Meanwhile, the impact of FTAAP tariff removals (2.37%) would be larger than that of TPP and RCEP tariff removals. It is indicated that imports would generally increase more under larger tariff removals. On the other hand, world imports are estimated to decrease under all four trade disruption scenarios examined here, the decreases ranging between 0.37% and 1.58% smaller than the estimated increase of world imports under world tariff removals.

The impact of tariff removals by economy is indicated to vary depending on the RTA membership of each economy. Imports of RTA member economies would increase due to trade creation effects among the member economies but those of non-RTA member economies would decrease due to trade diversion effects leading to replacement of their trade with the member economies by trade created among the members. That said,

Table 8 Impact on import volumes

(%)

	TPP	RCEP	FTAAP	World	US-MTL	US-CHN	RUS	MNG
World	0.19	1.45	2.37	7.70	-0.37	-0.65	-1.58	-0.50
Australia	1.17	3.88	3.40	6.19	-0.09	-0.19	-0.64	0.55
China	-0.26	5.49	8.72	18.12	0.02	-7.34	0.33	-2.68
Japan	3.10	8.88	10.77	11.67	0.20	1.09	-1.59	-0.34
Korea	-0.27	8.62	9.23	10.60	0.10	0.98	-1.38	-1.62
ASEAN	1.35	2.69	3.92	7.31	0.27	1.97	-0.78	-1.85
India	-0.32	6.38	-1.21	19.17	0.07	1.10	-0.58	-3.24
US	0.80	-0.04	3.56	5.72	-2.64	-3.98	-1.49	-0.67
Canada	0.66	-0.08	1.66	1.87	-2.71	0.91	-0.41	-1.36
Mexico	0.61	-0.34	3.31	3.37	-2.11	5.94	-2.01	0.05
Russia	-0.21	0.44	4.18	11.99	-0.18	0.20	-38.60	1.80
EU	-0.28	-0.32	-0.92	2.40	0.29	0.58	-1.96	0.39
UK	-0.17	-0.17	-0.48	3.11	-0.01	0.45	-0.96	-0.04
GCC	-0.16	0.34	0.41	10.08	-0.05	0.00	-0.49	2.45

Source: Author's simulations.

step (5).

imports would increase universally in all economies in the world under world tariff removals; those increases would be larger in Asia including China and India, but smaller in North America and Europe, reflecting differences in the tariff levels among economies.

On the other hand, the impact of trade disruption scenarios would be specific to economies. Given US metal tariff hikes by 25%, US imports of metals are estimated to decrease by 42.1%, resulting in a 2.64% decrease in US total imports. Imports would also decrease by similar magnitudes in Canada and Mexico, which are intensive trade partners of the US. The decrease in US imports under bilateral tariff hikes between the US and China (3.98%) would be larger than that above. China's imports are also estimated to decrease more, by 7.34%, though that would not necessarily be the case under US metal tariff hikes. It may be noted that imports and exports of the other economies are estimated to increase rather than decrease due to trade diversion effects, notably in almost all 10 ASEAN countries; Canada; and Mexico, consistent with actual developments seen after 2018.[17]

Meanwhile, under the 100% blocks of goods exports to and imports from Russia by the OECD countries, Russia's imports are estimated to decrease by the singularly high rate of 38.60%. That said, that decrease is smaller than the share of the OECD countries

Table 9 Impact on real GDP

(%)

	TPP	RCEP	FTAAP	World	US-MTL	US-CHN	RUS	MNG
World	0.12	1.10	1.82	5.13	-0.31	-0.90	-1.43	-0.68
Australia	0.74	1.91	1.69	3.02	0.02	-0.01	-0.47	-1.96
China	-0.15	3.30	5.22	10.59	0.03	-4.44	0.18	-1.89
Japan	1.89	5.24	6.38	6.82	0.26	0.71	-1.50	0.60
Korea	-0.21	5.43	5.82	6.41	0.18	0.68	-1.49	-1.02
ASEAN	0.32	1.75	2.70	4.89	0.30	1.27	-0.81	-1.96
India	-0.20	3.61	-0.68	10.79	0.11	0.62	-0.48	-1.89
US	0.37	-0.01	1.84	2.79	-1.55	-2.42	-1.16	-0.36
Canada	0.39	-0.07	0.95	0.94	-1.40	0.53	-0.34	-1.74
Mexico	0.32	-0.15	2.39	2.22	-1.40	4.10	-2.17	0.40
Russia	-0.21	0.10	2.17	5.79	0.07	0.31	-22.33	-2.23
EU	-0.24	-0.18	-0.62	1.56	0.29	0.45	-2.09	0.41
UK	-0.12	-0.08	-0.27	1.85	0.04	0.28	-0.85	-0.04
GCC	-0.21	-0.03	-0.19	6.55	0.19	0.23	-0.88	-1.72

Source: Author's simulations.

[17] US trade deficits with China decreased by 96 billion USD from 2017 to 2023, according to "International Trade," US Census Bureau. On the other hand, the US trade deficit with Mexico increased by 83 billion USD, followed by Viet Nam (66 billion USD) and Canada (52 billion USD), resulting in a world increase of 271 billion USD, from 792 to 1,063 billion USD.

in Russia's import markets, around 60%, due to trade diversion effects of Russia's trade with the OECD countries leading to replacement by trade with non-OECD economies including China, the ASEAN countries and India. On the other hand, the prices of mining industry and commodity, Russia's main exporting sector, are estimated to increase the most in the EU (3.5%), followed by other OECD countries (2.6%) and the UK (1.9%). Moreover, if mining prices were separately hiked by 20%, total imports are estimated to increase in mining export economies including the GCC countries (2.45%), Russia (1.80%) and Australia (0.55%), but to decrease more in mining dependent economies including China (2.68%) and India (3.24%) than mining-efficient economies including Japan (0.34%) and the US (0.67%).

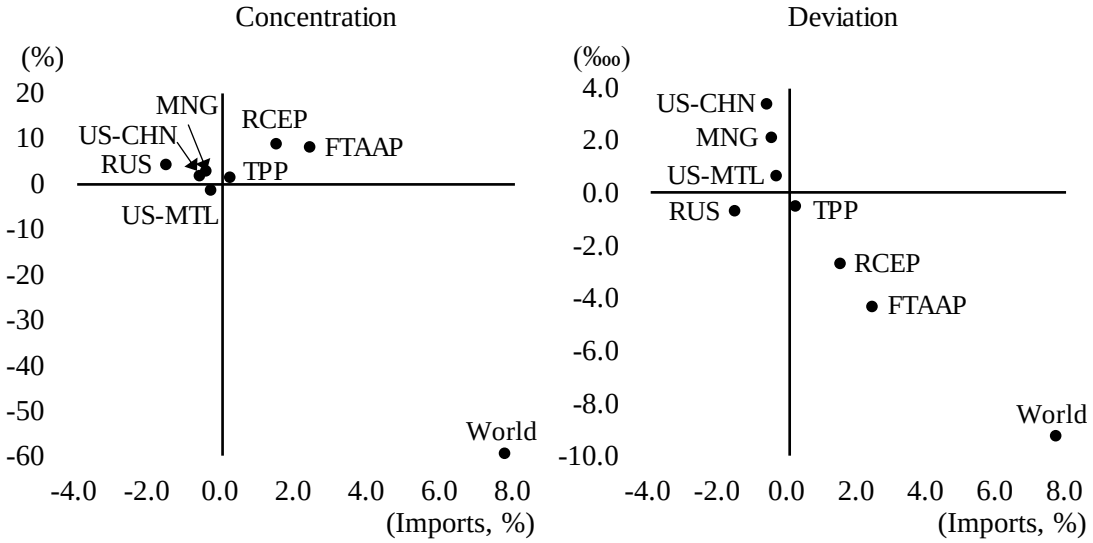
The impact of trade liberalization and disruption on macroeconomy, measured in terms of changes in real GDP, is shown in Table 9. That impact is generally indicated to be in line with the changes in imports discussed above. World real GDP is estimated to increase or decrease in proportion to changes in imports. The member economies of RTAs would primarily benefit from joining RTAs, which suggests that "free rider" gains under trade liberalization would be limited. On the other hand, an economy-specific adverse impact under US metal tariff hikes, bilateral tariff hikes between the US and China, and trade sanctions on Russia is also suggested, as discussed above. That said, the impact of mining price increases would be in the opposite direction. Real GDP is no longer estimated to increase in mining exporters due to higher inflation than in other economies.

2) Impact on trade and supply chains

The impact of trade liberalization and disruption on supply chain is considered in this study, looking at changes in import concentration and deviation indicators introduced earlier. Chart 2 shows estimates of those changes in world trade for the eight policy scenarios, compared with changes in world trade volumes.

If tariffs were removed globally, current import concentration covering around 60% of world imports would be eliminated; this would be expected to generate the least distorted states of world imports. That said, it would not reduce trade intensities to the large extent discussed above. Moreover, world import concentration is not necessarily indicated to be reduced in the other trade liberalization and disruption scenarios studied here using current measurements. World imports are estimated to concentrate 8.7% more under RCEP tariff removals and 8.3% more under FTAAP tariff removals. Meanwhile, trade disruptions would result in greater import concentration, except in the case of US metal tariff hikes. World imports are estimated to concentrate 4.2% more under trade sanctions on Russia, though this magnitude is smaller than that under the removal of

Chart 2 Changes in supply chain: World trade



Source: Author's simulations.

RCEP and FTAAP tariffs discussed above.

On the other hand, estimated changes in world import deviation indicate an expected impact on supply chains, though of a tiny magnitude. Trade liberalization would reduce world import deviations. That impact would be larger in proportion to impact on imports in the four tariff removal scenarios examined here. Import deviation is estimated to decrease by 0.5 per myriad (‰) under TPP, by 2.7‰ under RCEP, by 4.3‰ under FTAAP and by 9.3‰ under removal of world tariffs. Meanwhile, trade disruption would expand import deviation, which in turn is estimated to increase except in the case of trade sanctions on Russia. The coefficients with respect to changes in import volume would be larger than those under trade liberalization here.

That said, the impact of trade liberalization and disruption on import concentration and deviation would be mixed at the regional level, as is shown in Table 10-A and 10-B.

Imports are estimated to concentrate more in a few economies, including the US and Russia, under world tariff removals. The impact of tariff removals under TPP, RCEP and FTAAP would not necessarily be common across the member economies. Imports are estimated to concentrate less in the RTA member economies in the cases of Australia under TPP; the ASEAN countries under RCEP; and Australia, the ASEAN countries, Mexico and Russia under FTAAP tariff removals, but to concentrate more in the other member economies, given that the creation of trade among the RTA members is greater than that with the non-RTA member economies.

Table 10-A Impact of trade liberalization on supply chain

	Import concentration (%)				Import deviation (‰)			
	TPP	RCEP	FTAAP	World	TPP	RCEP	FTAAP	World
World	1.49	8.73	8.32	-59.63	-0.51	-2.67	-4.31	-9.27
Australia	-0.15	0.66	-0.58	-2.08	2.44	2.34	2.89	-8.13
China	-0.43	1.68	1.88	0.27	0.05	7.03	7.56	-7.36
Japan	1.11	0.97	1.81	-0.01	1.16	2.81	4.04	0.18
Korea	-0.05	3.41	1.11	-0.78	0.01	6.66	6.37	7.74
ASEAN	0.60	-1.85	-1.60	-3.77	0.44	2.56	2.27	-3.98
India	0.00	0.02	0.17	-2.76	0.07	9.68	0.99	-2.52
US	0.20	1.49	2.99	2.11	0.25	0.32	6.05	2.69
Canada	1.34	-0.02	1.17	-0.03	0.52	-0.29	-3.02	-4.42
Mexico	0.23	-0.08	-0.67	-1.63	0.23	-0.22	-3.39	-3.46
Russia	-0.07	-0.41	-3.63	4.29	0.03	0.00	-3.25	-0.39
EU	0.01	-0.01	-0.01	-0.25	-0.01	-0.05	-0.06	-11.04
UK	0.01	-0.03	-0.04	0.40	0.00	0.07	0.14	-10.49
GCC	0.00	-0.40	-0.52	2.01	-0.03	-0.42	-0.71	0.53

Source: Author's simulations.

Meanwhile, in a few economies including Korea and the US. import deviations are not necessarily estimated to decrease under world tariff removals. Moreover, they are estimated to increase in the vast majority of cases under TPP, RCEP and FTAAP tariff removals, except in Canada, Mexico and Russia under FTAAP. Estimates suggest that tariff removals under RTAs would generate more import deviations from the least distorted structure of world imports in those cases. Regional trade liberalization efforts would be considered as steps toward achieving the ultimate goal of global trade liberalization, but not necessarily the most efficient resource allocations in the world.

On the other hand, if the US hiked metal tariffs, imports would concentrate more and import deviations would expand in the US, but import deviation would be reduced in Canada and Mexico, whose intensive trade with the US would be weakened. The US and China would be affected by their bilateral tariff hikes in different ways. Imports are estimated to concentrate less in the US but more in China and import deviation is estimated to decrease in the US but increase in China. This would reflect the asymmetric structure of imports between the US and China, as seen in Table 2. The US imports more from China than the world average; this would be reduced. Conversely, China imports less than the world average from the US; that would be expanded. It would be advised that the US imports from China would be decreased, but China's imports from the US would be increased from the perspective of reducing regional import concentration and deviation.

Meanwhile, the impact of trade sanctions on Russia would result primarily in greater import concentration and deviation in Russia. That said, import deviations are

Table 10-B Impact of trade disruption on supply chain

	Import concentration (%)				Import deviation (‰)			
	US-MTL	US-CHN	RUS	MNG	US-MTL	US-CHN	RUS	MNG
World	-1.20	1.91	4.17	2.75	0.69	3.40	-0.67	2.11
Australia	-0.60	-0.73	-0.41	-0.64	-0.44	1.35	0.24	-0.94
China	0.46	3.48	0.16	-1.19	0.01	2.55	-0.18	1.90
Japan	0.23	1.10	0.46	0.46	-0.41	1.06	1.74	0.77
Korea	-1.70	-1.60	0.54	-3.59	0.00	0.94	2.25	2.33
ASEAN	0.00	-2.22	-0.38	-2.39	-0.19	1.60	-0.77	-0.12
India	0.39	0.24	0.58	-1.22	-0.07	0.84	-1.24	3.68
US	2.67	-4.27	1.61	0.56	0.49	-8.53	-0.33	-1.43
Canada	0.33	0.34	0.07	-0.16	-2.58	-2.35	-0.03	-1.02
Mexico	-0.38	-0.14	0.06	0.02	-2.82	-1.00	-0.04	-1.08
Russia	0.12	-0.58	11.64	2.30	0.39	-0.22	66.20	2.86
EU	0.14	-0.14	0.54	0.59	0.67	-0.53	2.87	0.91
UK	0.06	-0.16	0.05	-0.39	0.59	-0.66	1.55	0.40
GCC	-0.06	-0.13	-0.38	-1.04	-0.13	-0.18	0.06	-1.54

Source: Author's simulations.

estimated to expand more in the EU member states and Korea (who are intensive importers from Russia) than in the other OECD countries, who are blocking exports to and imports from Russia. The impact of mining price increases is estimated to vary among the major exporters. Imports would concentrate more and import deviation would expand in Russia; on the other hand, imports would concentrate less and import deviations would be reduced in Australia and the GCC countries.

In the meantime, the impact of the return of the US to TPP and of India to RCEP would be a concern. Imports would generally increase more under the wider membership of TPP including the US and resulting from the wider RCEP including India, as discussed in Box. That said, the impact on import concentration and deviation would not necessarily be common between the two EPA expansion scenarios. The structure of trade among the 15 RCEP economies would be balanced in line with India's return, but that among the TPP economies would be unbalanced in line with US return.

V. Summary and concluding remarks

The COVID-19 pandemic has reminded us of the vulnerability of supply chains and has raised issues concerning the resilience of global supply chains, as have supply shocks (and the associated volatility of commodity prices) caused by Russia's military invasion of Ukraine. On the other hand, trade and investment liberalization and facilitation have been expected to contribute to supply chain resilience—but a few movements toward protectionism have emerged. In the meantime, the international

Box: Impact of the return of the US to TPP and of India to RCEP

The US withdrew from TPP; India withdrew from RCEP. The impact of the US return to TPP or joining CPTPP, as well as India's return to RCEP has been of concern. The impact of tariff removals among the TPP economies and the CPTPP economies without the US, and removals among the RCEP economies, and the 15 RCEP economies without India, are compared in the following table.

	Imports (%)		Concentration (%)		Deviation (‰)	
	TPP	CPTPP	TPP	CPTPP	TPP	CPTPP
12 TPP economies	1.39	0.46	0.340	0.217	0.0042	0.0011
11 TPP economies	1.94	0.97	0.474	0.445	0.0057	0.0025
US	0.80	-0.10	0.196	-0.030	0.0025	-0.0003
	Imports (%)		Concentration (%)		Deviation (‰)	
	RCEP	RCEP15	RCEP	RCEP15	RCEP	RCEP15
16 RCEP economies	5.59	4.70	1.955	2.181	0.0820	0.0719
15 RCEP economies	5.51	5.19	2.272	2.518	0.0795	0.0825
India	6.38	-0.31	0.015	0.119	0.0968	0.0074
Source: Author's simulations.						

The impact on imports would be similar across TPP and RCEP scenarios. US imports are estimated to decrease under CPTPP tariff removals without the US joining, but turn to increase with the US joining TPP. The imports of the 11 TPP economies in total are estimated to increase more under TPP than under CPTPP. Meanwhile, India's imports are also estimated to decrease under RCEP15 with India not joining, but to increase with India joining RCEP. The imports of the 15 RCEP economies are also estimated to increase more under RCEP than under RCEP15. Those observations do not contradict general expectations that economic impact would be larger under wider trade liberalization at aggregated levels.

On the other hand, the impact on import concentration and deviation would not necessarily be common between the two scenarios. Import concentration and deviation are estimated to be larger in the US and in the 11 TPP economies on average under TPP than under CPTPP. This implies that supply chains among the TPP economies would be less resilient if the US returned to TPP, which would in turn strengthen unbalanced trade among the TPP economies. On the contrary, import concentration and deviation are estimated to be smaller in the 15 RCEP economies on average under RCEP than under RCEP15, which implies that supply chains would be more resilient if India returned to RCEP, rebalancing the trade of the 15 RCEP economies. That said, the estimated impact of import concentration and deviation in India are mixed in this regard.

diversification of input sources for production has been suggested to make supply chains resilient against unexpected events.

Heavy intracontinental import intensities have been observed by standard trade intensity index worldwide, and in economies including those in Oceania, Asia, America, Europe and the FSU countries. In addition to trade intensity index, two more trade indicators are introduced in this paper: import concentration, the ratio of concentrated regional imports; and import deviation, the degree of deviation in regional imports. The

ratios of import concentration look exaggerated in terms of some features suggested by import intensity; they range between 63.4% and 76.8% by region—not surprisingly exceeding 50%. The degree of import deviation ranges from 62.8‰ to 155.5‰ by region but it is indicated to be much smaller in the world as a whole (9.3‰) than in individual economies, which offset each other at the aggregated level. Possible trade distortion due to current tariff levels would be limited in aggregated world trade.

The impact of each of the four trade liberalization and four disruption scenarios is estimated using a CGE model of global trade incorporating a few dynamic effects: capital accumulation, endogenous labor supply and productivity improvement. Those trade liberalization scenarios involve tariff removals among TPP, RCEP, and FTAAP members and worldwide. Trade disruption scenarios involve US metal tariff hikes, bilateral tariff hikes between the US and China, trade sanctions on Russia, and mining price increases.

World imports are estimated to increase more under larger tariff removals but decrease under trade disruption scenarios. That said, the impact of tariff removals by region is indicated to vary depending on the RTA memberships of economies, which differentiate trade creation and diversion effects among economies. On the other hand, the impact of trade disruption scenarios would be specific to particular economies. US metal tariff hikes would result in decreases of imports not just in the US but also in Canada and Mexico. Bilateral tariff hikes between the US and China would result in import decreases in the US and China but increases in several other economies. Trade sanctions on Russia by the OECD countries would reduce Russia's trade but less so in proportion to the market share of the OECD countries. Mining price increases would differentiate between exporters and importers in terms of impact. All in all, trade diversion effects are suggested to matter here. The impact of trade liberalization and disruption on macroeconomy is generally indicated to be in line with the resulting changes in imports.

If tariffs were fully removed globally, current import concentration covering around 60% of world imports would be eliminated. That said, world import concentration is not necessarily indicated to be reduced in the other trade liberalization and disruption scenarios examined here under their current measurements. On the other hand, estimated changes in world import deviation indicate an expected impact on supply chains, i.e., reductions under trade liberalization and expansions under trade disruptions, though of a tiny magnitude. That said, those impacts would be mixed at the regional level. Tariff removals under RTAs would generate more import deviations depending on economies. Trade disruption would have different impacts on import deviations specific to economies. Meanwhile, the impact of the return of the US to TPP and of India to RCEP would not be

common between the two scenarios. Supply chain resilience is advised to be considered by economy and by sector.

Lastly but not least importantly, the limitations of studies conducted here must be acknowledged. First, the import data, which comes from trade statistics, which do not distinguish between intermediate inputs and values added, is limited. A second issue in this study is the appropriate measurement of import diversification in relation to supply chains rather than introduced import concentration and deviation indicators. Further studies on the impact of policy measures on supply chains would be needed to address issues related to the development of analytical methodologies, including model simulations, alongside the measurement of the performance of supply chains.

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Annex Table A Sectoral aggregation

AFF	Agriculture, forestry and fisheries	MNG	Mining
PFD	Processed foods	TXL	Textiles and apparel
OMF	Other manufacturing	CHM	Chemical products
MTL	Metals	MVH	Motor vehicles
OME	Other machinery	ELE	Electronic products
EGW	Electricity, gas and water	CNS	Construction
T_T	Transportation	OSP	Other private services
OSG	Public services		

Source: Author's compilation based on GTAP 11b Data Base, GTAP.

Annex Table B Regional aggregation

AUS	Australia	NZL	New Zealand
CHN	China	HKG	Hong Kong, China
JPN	Japan	KOR	Korea
TWN	Chinese Taipei	BRN	Brunei
IDN	Indonesia	MYS	Malaysia
PHL	Philippines	SGP	Singapore
THA	Thailand	VNM	Viet Nam
USA	US	CAN	Canada
MEX	Mexico	CHL	Chile
PER	Peru	RUS	Russia
KHM	Cambodia	LAO	Laos
XSE	Myanmar*	IND	India
OAO	Other Asia-Pacific	CSA	Other central and south America
EUM	EU	GBR	UK
OOE	Other OECD	FSU	Other FSU
GCC	GCC	ROW	Rest of the world

Source: Author's compilation based on GTAP 11b Data Base, GTAP.