Impact of the COVID-19 pandemic on global value chain and implications for the Belt and Road Initiative

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Abstract: China's Belt and Road Initiative (BRI) has the merit of contributing to regional economic development in tandem with infrastructure investment along economic and transport corridors. However, the issue of its sustainability has been raised due to enormous capital requirements and low profitability. Moreover, the outbreak of the COVID-19 has caused incomparable economic damage and supply chain disruptions worldwide in the form of entry bans, quarantines, trade blockades, and global protectionism, which are barriers to international trade and work against the development of the global value chain (GVC). This paper aims to quantitatively estimate the impact of COVID-19 on GVC adjustment by region and industry and derives policy implications based on the decomposition of value added (VA) and vertical specialisation (VS) trade. It is estimated that the GVC will shrink by 4.8%–20.2% in terms of VS trade depending on various scenarios.

Keywords: COVID-19; Belt and Road Initiative; BRI; global value chain; GVC; adjustment; quarantine and blockade; resilience; vertical specialisation trade.

Reference to this paper should be made as follows: Cheong, I., Yoo, J.H., Hong, K. and Lee, P.T-W. (2022) 'Impact of the COVID-19 pandemic on global value chain and implications for the belt and road initiative', *Int. J. Shipping and Transport Logistics*, Vol. 14, No. 4, pp.371–394.

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This paper is a revised and expanded version of a paper entitled 'Global trade order after the Covid-19: WTO or new one' presented at the Belt and Road Initiative (BRI) Conference 2020, Chartered Institute of Logistics and Transportation, Colombo, Sri Lanka, 11 December 2020.

1 Introduction

China's belt and road initiative (BRI), reminiscent of the Silk Road, is a massive infrastructure project launched by President Xi Jinping to expand China's investment and trade ties (Bird et al., 2019; Garcia-Herrero and Xu, 2019; Yu, 2017). The project, according to the Chinese government, aims to prompt regional integration between China and other Asian, African, and European countries, through enhancing infrastructure and institutional connections. China's investment can contribute to the economic

development of countries marginalised by globalisation. However, it is also arguable that problems such as investment profitability (World Bank, 2018), 'debt-trap diplomacy' (Ang, 2019; Hurley et al., 2019), and the lack of transparency (McBride et al., 2020) have been raised. Among these problems, return on investment can improve when the volume of trade and logistics increases. However, the world economy is turning in a very unfavourable direction for trade, worsening the sustainability of the BRI projects in many countries.

The global economy is currently mired in an unprecedented economic crisis. With increasing global protectionism, the US-China hegemonic conflict, and withdrawal of the United Kingdom from the European Union (EU), the global trade environment is in its worst situation since World War II. In addition, highly contagious COVID-19 has spread worldwide and caused the World Health Organisation (WHO) to declare COVID-19 a pandemic on March 11 2020. Since then, the infectious disease crisis is still on the rise. As of November 9 2020, more than 50 million people have been infected and 1.25 million died. On top of the already deteriorating global trade environment, the COVID-19 pandemic has made adjustment of the global value chain (GVC) inevitable. The virus badly affects the progress of the BRI project (Diplomat 2020; Deutsche Welle 2020; OBOR Europe 2020; Akon and Rahman 2020).

Most countries have been responding to COVID-19 by restricting people's and freight movements by air. As a result, production facilities in the global supply chains have been shut down, resulting in demand and supply systems being damaged on a global scale. Although their impact will vary from industry to industry, international economic organisations such as the OECD and IMF are projecting that COVID-19 will substantially disturb the GVC (OECD, 2020; World Trade Organisation, 2020a; World Bank, 2020b; IMF, 2020a, 2020b; UNCTAD, 2020; UNIDO, 2020). As existing studies have suggested, COVID-19 would cause considerable losses in GDP worldwide. In this sense, international organisations have suggested that active international cooperation through coordinated disease control and economic stimulus actions would conspicuously reduce economic losses and distortion of the GVC (UN, 2020; World Bank, 2020a; World Trade Organisation, 2020a; Yoo et al., 2020).

While development of the GVC mainly occurred via increased production efficiency in recent decades, COVID-19 has caused a shift in focus to the level of resilience of the GVC. Damage to the value chain caused by natural disasters, such as the Great East Japan Earthquake in 2011, is typically limited to the regions and countries affected. However, as is obvious now, highly infectious diseases such as COVID-19 cause incomparable damage to every country in the world. Entry bans, quarantines, and air transport and trade blockades are serious barriers to international trade as well as domestic economic activity.

In addition, the WTO and OECD have emphasised the importance of adjusting the GVC, which is the basis of global trade. However, research on quantitatively analysing the effect of COVID-19 on GVC is scanty. For GVC analysis, it is necessary to calculate the value added (VA) in existing trade statistics and decompose VA into domestic and foreign VA. This paper applies VA decomposition methodologies (Koopman et al., 2014; Antimiani et al. (2018) and the concept of the vertical specialisation (VS) trade (Hummels et al., 2001) to estimate the impact of COVID-19 on international trade and GVC. As the GVC pursues efficiency and resilience by nature simultaneously, this paper draws valuable implications for corporate investment decisions as well as industrial and trade policies post-COVID-19 on GVC adjustment by region and industry. Therefore, the

paper could find its originality in the context of quantitative assessment of the COVID-19 shocks and the impact of recovery measures on GVC.

2 Literature review

The public health pandemic has had negative effects on the global economy higher than the estimation. The mechanism of how the COVID-19 public health crisis expanded to become an economic crisis within such a short time involves the GVC, which is a core part of modern global trade. In global business, international competitive forces have encouraged foreign direct investment (FDI), which utilises cheap production in foreign countries. As a result, global production has become internationally fragmented. Due to the recent public health crisis, many countries around the world have closed their doors to travel and stopped production, ultimately affecting the GVC. Moreover, strict restrictions on movement of the labour force, especially international mobility, have taken a heavy toll on the industry such as airlines, travel, and tourism, thereby affecting the GVC. This section is concerned with the literature review of the impact of public health diseases including COVID-19 on GVC.

2.1 Economic effects of public health crises

Various reports have studied the relationship between public health crises and economic growth (e.g., Pritchett and Summers, 1996; Bloom et al., 1998; Bhargava and et al., 2001; Cuddington and Hancock, 1994; Robalino et al., 2002a, 2002b; World Health Organisation, 2001; Haacker, 2004). Diseases such as acquired immunodeficiency syndrome (HIV) can lower household income due to increased healthcare costs, leading to decreased labour productivity and ultimately an increase in government expenditures for prevention and treatment (Haacker, 2004). Highly lethal diseases such as HIV tend to be serious in specific regions, and international organisations have created campaigns to reduce the spread of HIV in vulnerable regions like Africa through prevention and education. According to Omran (1971), artificial diseases, which are modern diseases, including cerebral apoplexy, cancer, and chronic diseases, have earned great investments from numerous multinational pharmaceutical companies, as medicines for such diseases had commercial advantages. However, no international cooperative system has been established that can respond to sporadic contagious diseases. Thus, responses to COVID-19 have varied by country, and those nations who have failed to viably respond to it have implemented border closures and national lockdowns. This has caused a direct impact on international trade and intensified the GVC crisis.

Barrett (1998) previously warned that the global spread of a contagious disease could bring about severe public health crises in developed countries, as seen today. As a measure to cope with it, the WHO launched ‘Global Health Security: Epidemic Alert and Response’ in 2001, and since 2005, it has been operated as an alert system going by the name of global outbreak alert and response network (GORAN). Nevertheless, this system has been managed poorly and has made no contribution to improving the current pandemic. A number of studies that have considered COVID-19 a temporary epidemic estimated that economic losses would not be great in early 2020 (OECD 2020; UN, 2020;

World Bank, 2020a; McKinsey, 2020; Maliszewska et al., 2020). Most of these studies even had estimated positive GDP growth rates, although the growth rates were even lowered than the estimation[1]. However, the IMF (2020a, 2020b), McKibbin and Fernando (2020), and Orlik et al. (2020) estimated the world economy to experience minus growth. Especially, the IMF predicted severe economic shock to the global economy, anticipating the global economic growth rate to be –3.1% in its April report (IMF, 2020a) and even lower (–4.9%) in June (IMF, 2020b). It now seems clear in hindsight that the spread of COVID-19 would bring about immense worldwide economic losses. Moreover, active intervention and disease control through international solidarity are commonly being emphasised in many reports.

2.2 COVID-19 and GVC

As a strong driver that brings about productivity and economic growth, GVCs encourage countries' participation in expanding international trade (World Bank, 2019). Lee et al. (2018), who studied industries that affect the expansion of GVCs, suggested that countries participating in GVCs have well-developed innovation systems, which suggests the importance of the efficiency of business service sectors. On the other hand, research by Olczyk and Kordalska (2017) demonstrated that higher labour workmanship leads to increased GVC participation. However, whether or not an increase in domestic VA is conducive to actual economic growth was investigated by Kummritz (2016)[2]. The change in national interests according to the stage of GVC participation has become a research topic of several papers, emphasising the importance of high VA production activities in the GVC smile curve (Hagemejer and Ghodsi, 2017; Degain et al., 2017; Wang et al., 2018).

However, since the outbreak of COVID-19, GVCs have gained fresh attention as a channel for spreading the virus. Until now, GVCs have actually become paralysed and are affecting national economies in a detrimental fashion (IOM 2020). Airliners and logistics industries, which used to be the biggest beneficiaries of globalisation, are now the most adversely affected industries and have become a cause of the spread of COVID-19 internationally. Prior to the outbreak of COVID-19, logistics industries maintained their core competitiveness based on rapid shipping in light of increased individual demand stemming from enormous increases in e-commerce. Therefore, demand for air logistics has also sharply increased (Alkaabi and Debbage, 2011; Kupfer et al., 2017; Lange, 2019). Now, global logistics networks with large-scale investments have suffered enormous losses due to COVID-19. COVID-19 will alter the business paradigm of the world's logistics industry from speed and efficiency to safety and stability, and as a result, logistics costs will rise (World Economic Forum, 2020; Heiko and Darkow, 2013). This will reduce the performance and competitiveness of the logistics industry in the post-COVID-19 era, which will act as another factor in GVC adjustment.

UNCTAD (2020) analyses that the GVC is being enforced to make a drastic change in the level of a 'perfect storm' due to COVID-19. In fact, this storm is not caused by the spread of virus alone. UNCTAD (2020) views that the pressure for change has been aggrandised by the addition of pressure, which COVID-19 has brought, to the mega-trend that existed 'pre-COVID-19'[3]. The COVID-19 will push the world to follow this mega-trend. Although many international organisations such as the WTO pointed out the

impact of COVID-19 on GVC, no quantitative assessment has been made. If COVID-19 increases trade barriers, whether or not the GVC is sustainable becomes a problem. This paper estimates quantitatively the effects of COVID-19 on GVC adjustment by region and industry, including each country's countermeasures and level of international solidarity.

3 Methodology and simulation scenarios

This paper estimates the impact of the COVID-19 pandemic on global trade and GVC. Although the theory of GVC has been developed, there are practical limitations to its quantitative analysis due to the lack of a proper analytical model and data. To cope with this, this paper applies a multinational computational general equilibrium (CGE) model to estimate the impact of COVID-19 on GVC, extending a conventional CGE model to calculate the sources of VA. This paper also uses the concept of vertical specialisation (VS) trade developed by Hummels et al. (2001) to assess the impact of the COVID-19 on GVC. Since it is difficult to determine what the impact of COVID-19 is, this paper sets up several scenarios and conducts a series of simulations.

3.1 Methodology

The GVC analysis requires the decomposition of VA trade data by source, which is different from existing international trade statistics. Economists have performed studies to calculate VA from trade statistics. As a representative empirical methodology of GVCs, Wang et al. (2013) and Koopman et al. (2014) have provided a theoretical foundation to decompose trade into several type of VAs by source. Quast and Kummritz (2015) offer R packages that analyse GVCs using decomposition methodology.

Although it is challenging to estimate the effects of COVID-19 on macroeconomic indicators and imports/exports, projecting the pandemic's effects on GVCs requires an additional technique. The former technique of estimation is feasible based on conventional CGE models such as the GTAP developed by Hertel and Tsigas (1997). However, the latter technique necessitates VA decomposition analysis, as reported by Wang et al. (2013), on top of the GTAP model. GVCs are defined by movement between the country where VA occurs and the destination (Koopman et al., 2014, p.459). At each stage of the production process, VA is continuously added, and the total VA equals the cost that the producing country pays to production factors. VA decomposition methodology was incorporated into the GTAP by Antimiani and Fusacchia (2018). Their model is called the GTAP-VA model, which this paper uses to estimate the impact of COVID-19, which is badly disrupting global value chains, with a set of simulation scenarios.

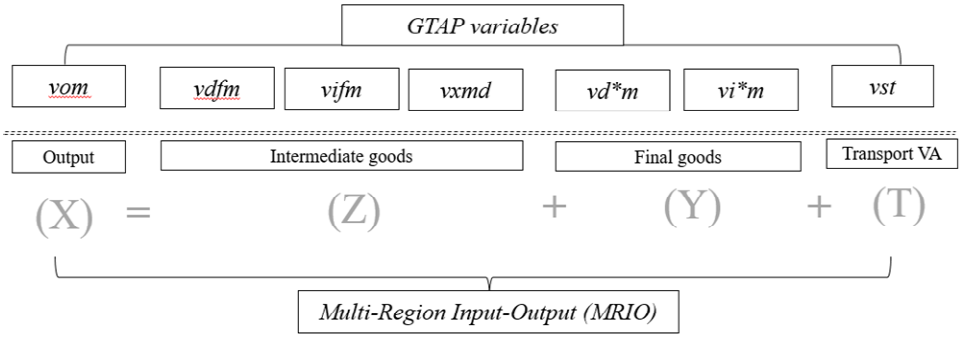
The GTAP database can be widely used for input-output table statistics-based research (McDonald and Thierfelder, 2004; Rutherford, 2005; Aguiar et al., 2019). Peter et al. (2011) meticulously explains how to modify the GTAP database into a generalised IOT form. In detail, the number of exports in the GTAP database (labelled as 'VXMD') is based on the market price of the exporting region, whereas the number of imports

('VIMS') is based on the market price of the importing region. In this sense, exports of VXMD do not match up with the imports of VIMS. The GTAP database considers these differences as margins, net exports, and import taxes according to international trade. The GTAP database systematically identifies these differences by balancing data internationally. This can be expressed in a linearised equation (variables are percentage changes) as follows.

$$vims_i^{rs} = vxmd_i^{rs} + \sum_k vtw_{ki}^{rs} + tfrv_i^{rs} + \left(adrv_i^{rs} + mfrv_i^{rs} + purv_i^{rs} + vrrv_i^{rs} + xtrv_i^{rs}\right) \quad (1)$$

Imports (*vims*) and exports (*vxmd*), other trade margin (*vtwr*), net exports (*tfrv*), and taxes related to imports (*adrv*, *mfrv*, *purv*, vrrv, *xtrv*) are stipulated as the sum. Moreover, as in Figure 1, Peter et al. (2011) calculates the total production (*vom*) as the sum of domestic production (*vdfm*), trade of intermediate goods (*vifm* or *vxmd*), final goods (*vdm*, *vim*), and value added (*vst*).

Figure 1 Structure of IOT linked with trade



Source: revision based on Peter et al. (2011, p.138)

Figure 1 is expressed as an equation as follows: value of output (VOM)[4] vector can be expressed as the sum of intermediate goods Z matrix and final goods FIN for matrix manipulation.

$$VOM_j^r = \sum_i \sum_s Z_{ji}^{rs} + \sum_s FIN_j^{rs} \quad (2)$$

The intermediate goods Z matrix of the above equation is the product of the A matrix and VOM, and equation (2) can be expressed as follows.

$$VOM_j^r = \sum_i \sum_s A_{ji}^{rs} VOM_j^s + \sum_s FIN_j^{rs} \quad (3)$$

When the vector equation is expressed in matrix form, it can be transformed as follows by applying the Leontief inverse matrix toward VOM[5].

$$\begin{bmatrix} VOM^1 \\ VOM^1 \\ \vdots \\ VOM^C \end{bmatrix} = \begin{bmatrix} A^{11} & A^{12} \cdots A^{11} \\ A^{21} & A^{22} \cdots A^{2C} \\ \vdots & \vdots \ddots \vdots \\ A^{C1} & A^{C2} \ldots A^{CC} \end{bmatrix} \begin{bmatrix} VOM^1 \\ VOM^1 \\ \vdots \\ VOM^C \end{bmatrix} + \begin{bmatrix} FIN^{11} & FIN^{12} \cdots FIN^{11} \\ FIN^{21} & FIN^{22} \cdots FIN^{2C} \\ \vdots & \vdots \ddots \vdots \\ FIN^{C1} & FIN^{C2} \ldots FIN^{CC} \end{bmatrix}$$

$$\begin{bmatrix} VOM^1 \\ VOM^1 \\ \vdots \\ VOM^C \end{bmatrix} = \begin{bmatrix} 1-A^{11} & -A^{12} \cdots & -A^{11} \\ -A^{21} & 1-A^{22} \cdots & -A^{2C} \\ \vdots & \vdots \ddots & \vdots \\ -A^{C1} & A^{C2} & \ldots 1-A^{CC} \end{bmatrix}^{-1} \begin{bmatrix} FIN^{11} & FIN^{12} \cdots FIN^{11} \\ FIN^{21} & FIN^{22} \cdots FIN^{2C} \\ \vdots & \vdots \ddots \vdots \\ FIN^{C1} & FIN^{C2} \ldots FIN^{CC} \end{bmatrix} \quad (4)$$

$$= \begin{bmatrix} L^{11} & L^{12} \cdots L^{11} \\ L^{21} & L^{22} \cdots L^{2C} \\ \vdots & \vdots \ddots \vdots \\ L^{C1} & L^{C2} \ldots L^{CC} \end{bmatrix} \begin{bmatrix} FIN^{11} & FIN^{12} \cdots FIN^{11} \\ FIN^{21} & FIN^{22} \cdots FIN^{2C} \\ \vdots & \vdots \ddots \vdots \\ FIN^{C1} & FIN^{C2} \ldots FIN^{CC} \end{bmatrix}$$

Equation (4), deduced by matrix manipulation, means the necessary set of production input for unit consumption. Antimiani and Fusacchia (2018) codified equations (1–4), and some of these are given in Table 1. VL in Table 1 is a VA multiplier, and total VA exports (TVA) is obtained by multiplying VL by total exports (VXE). Using the domestic Leontief matrix vector BC, component matrix vector (DC) and domestic VA exports (DC_DVA) are calculated, and by excluding this from TVA, domestic VA exports (DVA) is finally calculated. Foreign VA exports (FVA) can be calculated using comparable methods using the Leontief matrix vectors across countries – not within countries.

If relevant information is provided, it is relatively easy to consider GVC changes of a specific company or industry, but it is not easy to quantitatively estimate the impact of a specific shock stimulus on the GVC. Accordingly, economists have devised the concept of VS to measure GVC (Hummels et al. 2001). VS refers to a country's imported goods for the production of export goods. This is based on international fragmentation of production and sourcing of foreign intermediate goods. In order to calculate VS, it is necessary to use the Antimiani and Fusacchia (2018) method in the GTAP-VA model to determine from which country's industry the VA came. The GTAP-VA model used in this paper allows exports to be classified as DVA or FVA exports.

Table 1 Examples of additional GEMPACK codes[1]

VL (i, j, r, s) = sum {k, TRAD_COMM, sum [t, REG, VSHDNL (i, k, r, t) * B1 (k, j, t, s)]};
TVA (i, j, t, s, r) = VL (i, j, t, s) * VXE (j, s, r);
BC (i, j, s, r) = IF [s EQ r, B1(i, j, s, r)] + IF (s NE r, 0);
DC (i , j, s) = sum [r, REG, BC (i, j, s, r)] – B2 (i, j, s);
DC_DVA (i, j, s, r) = sum {k, TRAD_COMM, sum [t, REG, VSHDNL (i, k, r, t) * DC (k, j, s)]} * VXE (j, s, r);
DVA (i, j, t, s, r) = IF [t EQ s, TVA (i, j, t, s, r) - DC_DVA (i, j, s, r)];

Notes: [1]These equations are written with the software of GEMPACK, TABLO language, which are documented at the Centre of Policy Studies (2020). The GEMPACK is widely used for CGE modelling along with the GAMS.

3.2 Scenarios

COVID-19 has situated itself at the core of global trade, and global protectionism continues to remain strong. Although there has been backlash against integration of the world economy under the WTO system, and in recent years there has been increased the USA protectionism and US-China economic conflict, the COVID-19 pandemic is becoming a robust watershed moment in the acceleration of de-globalisation. From the perspective of international trade, COVID-19 leads to the expansion of protectionism (imposing tariffs), restrictions of labour force movement, and other impediments[6], ultimately increasing production costs. In this sense, as GVCs fragment production processes to other countries based on national competitiveness, COVID-19 has caused the re-localisation of GVCs to domestic or nearby regions via the actions of reshoring or nearshoring. This means the strengthening of the domestic value chain or regional value chain. Moreover, de-globalisation due to the COVID-19 pandemic adjusts GVCs and restrains production process based on cheap labour.

In order to cope with the health risks due to disease exposure, GVCs that have been expanding based on efficiency should be adjusted by either shortening value chains or seeking domestic production for certain types of items, such as essential drugs. Moreover, as the domestic reorganisation of production facilities intensifies by pledging support to policies that induce reshoring, the adjustment of GVCs is being increasingly facilitated. However, reshoring could negatively affect consumer benefits since low productivity due to the weakened production of domestic manufacturers or insufficient capital or labour force leads to an increase in the unit cost of production. Although adjustment of GVCs that simultaneously consider efficiency and safety is necessary, competitive reshoring should be avoided. In particular, the major purpose of the reshoring policies of the United States, EU, Japan, and other developed countries was originally to encourage multinational corporations to leave China. However, as these policies were altered to foster the domestic redevelopment of manufacturing industries after COVID-19, the already-weak global economic ecosystem has become weakened. Especially, for developing countries that used to be in charge of a certain portion of production processes in GVCs, the situation has become inevitably more deleterious now that multinational corporations have exited due to COVID-19. Global-scale aggravation of barriers to resource allocation combined with huge economic losses in developing countries has cast an inevitable burden on the post-COVID-19 global economy.

Therefore, international discussion and cooperation to alleviate the negative effects of COVID-19 are necessary. In addition to strengthening international development cooperation, each country should enhance their efforts to stop the spread of COVID-19. In the future, countries should abrogate or eliminate any protectionist measures they have introduced during the pandemic and halt competitive reshoring policies. To reduce the increase in logistics costs caused by COVID-19, resource allocation and financial support should be accompanied simultaneously by efficient operation of international logistics. Although international organisations, including the WTO, WHO, and others, strongly insist that importation and exportation of essential supplies such as medical goods should emphasise global solidarity, their suggestion for international discussion and cooperation is not largely supported, as more countries have taken on a protectionist and nationalistic rhetoric. For example, the United States, which is suffering the most harm from COVID-19, has overtly claimed China as being responsible for the pandemic in addition to its original trade conflict with China.

Considering the uncertainty about the post-COVID-19 global economy, although the vaccine is under supply in developed countries, this paper elucidates how COVID-19 would affect the GVC under several scenarios. First, it estimates the negative effects that each country's post-pandemic measures will have on the GVC and then assess the effects of international cooperation measures to stimulate the economy and reduce the losses caused by the virus pandemic. Under these scenarios, the GTAP database version 10 was employed, and countries were aggregated into seven categories while sectors were categorised into 10. East Asia was divided into four (ASEAN, China, Japan, and South Korea), and the rest were divided into the United States, the EU, and ROW (rest of the world).

Table 2 Aggregation scheme for country and sector[1]

	Country (7)	*Sector (10)*
Grouping	ASEAN, China, Japan, South Korea, USA, EU, ROW*	Agriculture, light industry, heavy industry, textile-apparel, chemicals, pharmaceuticals, metal, machinery, automobiles, high-tech

Notes: * ROW means the rest of the world.
[1]Aggregation schemes for each sector and country are given in Appendix tables (A3 and A4).

The effects of COVID-19 are multifaceted and countries' responses varied. Thus, it would be challenging to deal with all of these factors in this paper. The effects of COVID-19 are classified into dearth of supplies and decreased demand: Movement restrictions such as self-isolation, lockdowns, and etc.; bankruptcy of corporations and reduction in productivity caused by a lack of liquidity; reduction in household income; global protectionism and others. By estimating the impact of COVID-19, this paper estimates the effects of international cooperation for trade expansion, such as tariff reductions and more, as well as each country's measures to stimulate the economy by referring to previous research on the effects of diseases on the global economy. Arndt and Wobst (2002) conducted an analysis of reduction of labour productivity (*afe*) using HIV/AIDS as their scenario for a global pandemic. ILO (2020), using a scenario involving reduction in net income (*y*) of households, as well as ADB (2020) and PwC (2020), utilising reduction in logistics efficiency (*ams*), reduction in labour productivity (*afe*), effects of government's financial policies (*to*, *tp*), and more, attempted estimation using CGE models. Table 3 presents the negative impacts of COVID-19 and countermeasures[7].

Table 3 Summary of simulation scenarios

Scenario	*Negative effects*			*Countermeasures*		
	Supply side	*Demand side*		*Cooperation*	*Economic stimulus*	
	Productivity (afe)	*Logistics efficiency (ams)*	*Household demand (y)*	*Tariff reduction (tm)*	*Production tax (to)*	*Income tax (tp)*
S1	–1%	–3%	–5%	–3%	–5%	
S2	–3%	–5%	–7.5%	–5%	–7.5%	
S3	–5%	–10%	–10%	–10%	–10%	

The paper also analyses the negative effects of COVID-19 in terms of supply and demand and then estimates impact based on international cooperation and measures to stimulate

the economy. Based on prior research and the duration of COVID-19, this paper sets up three scenarios. Scenario 1 assumes a situation of relatively weak COVID-19 damage, whereas Scenario 3 is a situation of robust damage. Scenario 2 is the basic scenario and is the one with the highest feasibility. These scenarios are contingent on the situation or prospects of COVID-19. The rates of changes for each scenario in terms of productivity (*afe*), logistics efficiency (*ams*), household supply (y), tariff reduction (*tm*), commodity tax (*to*), and income tax (*tp*), which are used in the simulation model, are given in Table 3.

4 Simulation results and discussions

The current economic crisis caused by COVID-19 has taken a severe toll on the GVC. Since GVCs take a long time to form networks, it may be challenging to analyse structural changes within a short period of time. Therefore, most existing studies have not attempted to qualitatively discuss the effects of COVID-19 on modification of the GVC based on past experience and have not provided an economic prognosis under various scenarios. Many reports such as OECD (2020) have mentioned the possibility that COVID-19 would bring about fundamental changes in GVCs, yet it is difficult to find any empirical analysis. Thus, to fill it up, this paper estimates the effects caused by COVID-19 on major regions and industrial sectors and suggests how international cooperation and countries' intervention measures would aid in the recuperation of the GVC.

4.1 Damage caused by COVID-19 on regional exports and GVCs

According to the simulation results, global exports would be reduced by a minimum of 4.01% (Scenario 1) and 16.85% (Scenario 3) due to COVID-19. The results under Scenario 2 will be between Scenario 1 and Scenario 3. Further, although the total export reductions by country are similar to global averages, there exist differences to a greater or lesser degree. While Japan and the US would exhibit smaller declines than average, ASEAN, China, South Korea, and EU would experience bigger shocks than average. Thus, the effects of COVID-19 on exports from developing countries in Asia and EU would be higher than those on exports from Japan and the US.

Table 4 Impacts on total exports and VS exports by country/region

Country/region	*Total exports*			*Vertical specialisation (VS) exports*		
	S1	*S2*	*S3*	*S1*	*S2*	*S3*
ASEAN	–4.53%	–8.89%	–18.18%	–5.01%	–9.93%	–21.17%
China	–6.03%	–10.47%	–19.07%	–6.95%	–12.37%	–23.41%
Japan	–0.72%	–3.26%	–9.41%	–2.31%	–5.98%	–14.18%
Korea	–4.60%	–8.84%	–17.57%	–5.06%	–9.62%	–18.98%
US	–3.09%	–8.99%	–16.19%	–4.36%	–10.90%	–20.16%
EU	–4.66%	–9.48%	–19.24%	–4.57%	–9.15%	–20.21%
ROW	–3.64%	–8.04%	–16.74%	–3.78%	–8.93%	–19.62%
World av.	–4.01%	–8.42%	–16.85%	–4.80%	–9.90%	–20.21%

In assessing the impact of COVID-19 on the GVC, this paper uses VS trade, which is an index of the GVC developed by Hummels et al. (2001), as described in Section 3.1. For VS trade, there would be greater negative effects than on total exports. The degree of decline in world average VS trade due to COVID-19 is expected to be a minimum of 4.8% (Scenario 1) and maximum of 20.21% (Scenario 3). The degree of decline in VS trade would be the largest in China, and it has been shown that ASEAN, and the EU follow thereafter. The degree of decline in VS trade for the Japan would be the lowest among all three scenarios, and those for US and South Korea are predicted to be relatively smaller than other regions. In sum, the global GVC would be reduced, but since the degree of decline for China would be the largest, their industrial ecosystem is expected to be the most vulnerable to the COVID-19 pandemic.

Table 5 Impacts on exports and VS exports by sector

Sector	*Total exports*			*Vertical specialisation (VS) exports*		
	S1	*S2*	*S3*	*S1*	*S2*	*S3*
Agriculture	–6.0%	–9.7%	–16.2%	–6.7%	–10.8%	–18.5%
Light industry	–5.6%	– 10.7%	– 20.9%	–6.5%	–12.0%	–23.4%
Heavy industry	–4.5%	–8.9%	–16.9%	–5.0%	–9.5%	–17.8%
Textile-apparel	–6.5%	–10.2%	–17.2%	–7.8%	–12.6%	–22.0%
Chemical	–4.3%	–8.1%	–14.1%	–6.2%	–11.3%	–20.3%
Pharmaceutical	–5.4%	–9.8%	–16.6%	–5.3%	–9.5%	–16.3%
Metal	–3.6%	–8.1%	–17.1%	–4.5%	–9.5%	–19.9%
Machinery	–1.1%	–6.0%	–17.2%	–2.5%	–8.1%	–21.1%
Automobiles	–2.2%	–6.9%	–16.2%	–2.9%	–8.3%	–18.9%
High–tech	–2.4%	–7.1%	–17.1%	–3.6%	–8.9%	–20.9%

Table 6 Impacts on vertical specialisation (VS) exports by country's sector (scenario 3)

Sector	*ASEAN*	*China*	*Japan*	*Korea*	*USA*	*EU*	*ROW**
Agriculture	–2.20%	–2.41%	–3.14%	–5.86%	–2.24%	–3.10%	–2.21%
Light industry	–10.53%	–3.41%	–9.76%	–10.24%	–4.13%	–5.10%	–2.80%
Heavy industry	–10.59%	–7.64%	–10.78%	–16.11%	–6.07%	–10.74%	–2.77%
Textile-Apparel	–2.06%	–3.38%	–1.52%	–6.86%	–1.17%	–3.14%	–2.63%
Chemical	–12.49%	–6.51%	–2.30%	–8.01%	–3.60%	–3.61%	–7.58%
Pharmaceutical	–5.11%	–4.34%	–2.58%	–7.57%	–3.94%	–5.10%	–3.37%
Metal	–7.68%	–5.02%	–2.21%	–5.23%	–2.75%	–3.00%	–8.02%
Machinery	–4.87%	–3.79%	–2.35%	–3.22%	–3.95%	–4.78%	–7.75%
Automobiles	–1.28%	–7.22%	–4.53%	–2.74%	–1.98%	–3.33%	–1.91%
High–tech	–5.70%	–5.31%	–3.28%	–6.75%	–2.75%	–3.64%	–4.29%

Note: ROW means the rest of the world.

Table 5 shows the estimated impact of COVID-19 on total exports and VS trade and considerable differences by sector. In particular, light industry, high-tech, machinery, and automobiles, which have the most developed GVCs, are expected to suffer the largest effects on their exports and VS trade. The total volume of exports for light industry could be reduced by a maximum of 20.9%, and 23.4% of total VS trade may disappear. The paper predicts that 16.2% of exports and 18.9% of VS trade in the automobile industry could be eliminated.

Table 6 shows the estimated impact of COVID-19 on the GVC by country and by industry. Of the 10 industries analysed, it was estimated that China would be hit the hardest in automobiles industries and ASEAN would also hit the most in light and chemical industries. On the other hand, the US appears to be the most resilient, at least in two industries (textile-apparel, and high-tech). While metal and machinery would be the most negatively affected among the ROW industries, the impact on chemical and textile-apparel is estimated to be lower than in other regions.

4.2 Impacts of global cooperation and economic stimulus

The effects of countermeasures against COVID-19 are presented in Table 7. COVID-19 had been expected to have an enormous impact on trade and subsequently reduce the GVC by over 20% in Section 4.1. However, if global cooperation is possible, any losses affecting the GVC may be offset by 3.8% (Scenario 1) –9.0% (Scenario 3). Much higher GVC expansion will be made possible when and if countries adopt an economic stimulus approach. If global cooperation and economic stimulus are promoted simultaneously, a kind of synergistic effect can be expected, as the effect of simultaneously promoting global cooperation and economic stimulus is greater than the sum of the independent effects of global cooperation and economic stimulus. Based on the results of Scenario 3, the world average GVC growth rate is expected to be greater than the GVC reduction rate (Table 4). However, ASEAN and China are unlikely to recover from the effects of COVID-19. The biggest winners of global cooperation and economic stimulus are expected to be the US.

As COVID-19 is taking a huge toll on GVCs, countries are preparing various countermeasures to stimulate their economies. As the simulation results show, if countries do not take sufficient measures to stimulate their economies, deterioration of the GVC is unavoidable. The effects of countermeasures under Scenario 3 are given in Table 8, which suggests that the positive effects of countermeasures do not match the damage caused to the GVC by COVID-19. It is expected that the US will be able to restore the GVC the most in metal, machinery, and high-tech industries. In particular, South Korea is estimated to be able to restore the most in three industries (metal, machinery and automobiles), whereas the EU will be able to recover in heavy industry. In the case of China, except heavy industry, the net recovery effects to their GVC across all industries are expected to be limited. Taken together, the impact of COVID-19 on the GVC varies widely among countries, but most countries will be greatly affected, and even if countermeasures are triggered, it is unlikely to make up for GVC losses.

Table 7 Impacts of cooperation and economic stimulus on VS exports by country/region

	Global cooperation			*Fiscal policy*			*Cooperation and fiscal policy*		
	S1	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*
ASEAN	4.5%	4.5%	10.9%	6.21%	9.11%	11.00%	11.06%	14.07%	23.37%
China	3.7%	3.7%	9.2%	5.89%	8.76%	10.97%	9.87%	12.83%	21.29%
Japan	2.6%	2.6%	7.0%	6.46%	9.90%	13.34%	9.08%	12.63%	20.63%
Korea	3.4%	3.4%	8.3%	6.80%	9.95%	12.02%	10.54%	13.82%	21.86%
USA	5.5%	3.2%	6.9%	18.30%	25.67%	28.76%	22.74%	30.26%	40.56%
EU	3.9%	3.8%	9.0%	8.92%	12.98%	15.50%	13.24%	17.40%	26.73%
ROW*	3.8%	3.7%	9.1%	9.46%	14.10%	17.75%	13.54%	18.30%	28.53%
World average	3.8%	3.7%	9.0%	8.51%	12.43%	15.07%	12.64%	16.68%	25.87%

Note: ROW means the rest of the world.

Table 8 Recovery effects of global cooperation and economic stimulus on VA trade (Scenario 3)

	ASEAN	*China*	*Japan*	*Korea*	*USA*	*EU*	*ROW**
Agriculture	12.43%	15.29%	7.11%	14.66%	23.25%	18.89%	15.11%
Light industry	18.02%	22.05%	11.30%	18.79%	61.50%	25.65%	30.00%
Heavy industry	21.87%	106.82%	69.39%	17.82%	35.82%	50.50%	21.77%
Textile apparel	20.72%	11.77%	29.12%	15.55%	60.08%	21.54%	13.17%
Chemical	15.37%	22.90%	17.05%	24.04%	26.97%	32.36%	14.11%
Pharmaceutical	5.77%	11.73%	9.81%	17.53%	23.62%	17.61%	17.20%
Metal	19.97%	17.14%	16.97%	24.98%	72.03%	40.31%	22.29%
Machinery	33.08%	26.21%	27.16%	33.15%	77.35%	38.83%	56.62%
Automobiles	25.43%	15.72%	22.90%	20.69%	54.80%	35.22%	44.64%
High-tech	34.21%	26.95%	21.98%	16.69%	73.39%	34.68%	44.88%

Note: ROW means the rest of the world.

5 Conclusions and policy implications

The simulation results of this paper show that COVID-19 alone will hamper much of international trade and the GVC and that its impact may be even greater than that of protectionist policies. Atlantic Council (2020), a group of experts in international relations, predicted the post-COVID-19 world order in three ways. Scenario 1 refers to the world's largest economies, such as the US, China, and the EU, fighting each other even in the post-COVID-19. Scenario 2 assumes China's global leadership. That is, China promotes the BRI projects in the spirit of the ancient 'peaceful' Silk Road, and China gains international support for the Chinese-style economic system. Scenario 3 is the exact opposite of Scenario 1. It is called the 'New Renaissance', which is similar to the G20 cooperation. After the global financial crisis, the G20 countries have promoted extensive international cooperation to revive the global economy. The findings in this paper show that the results of Scenario 1, where the losses are worsening by competition, and the results of Scenario 3, where international cooperation can overcome the losses. If Scenario 3 and Scenario 2 are promoted at the same time, the world economy devastated by the COVID-19 will be able to recover rapidly.

The 65 countries participating in the BRI projects are shown in Table 9. Most countries except Singapore and United Arab Emirates have poor logistics infrastructure with raw materials and simple products, their trade will shrink even more than in other regions. If COVID-19 pandemic is prolonged and global trade environments worsens, their GVC and VC will be shrunken. The findings in this paper show that the GVC shock is more than expected and that it will be difficult for China to recover the funds invested in BRI projects, even though the vaccine is supplied.

This paper shows an estimation that COVID-19 can significantly weaken the GVC, and global exports may decrease by 20.2% and that one fifth of the current production network of the automotive industry could disappear. The results in the paper show that the ASEAN and China could be hit the hardest by the COVID-19, while the Japan and US could relatively be less suffered. While the COVID-19 could disrupt the GVC, the

cooperation and economic stimulus would mitigate the crisis of the world economy from the COVID-19 shocks, only if the countermeasures are large enough. In other words, global cooperation and stimulus measures implemented by each country could play an important role in offsetting the collapse of the GVC. Moreover, it is difficult to expect the world's largest economies of the US and China to reach an agreement for economic recovery, since the US is insisting on China's responsibility for COVID-19.

Table 9 Regional classification of BRI participating countries

Southeast Asia	Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Vietnam
Central Asia and Mongolia	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Mongolia
Middle East	Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Palestine, Syria, United Arab Emirates, Yemen
South Asia	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka
Eastern Europe and CIS region	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Turkey, Ukraine

Source: Fung Business Intelligence Centre (2016)

With COVID-19, economies in all countries are suffering, and BRI is no exception. Due to COVID-19, 40% of BRI projects are delayed and another 20% are financially serious (OBOR Europe 2020). It is a financially difficult situation because all countries in the world have suffered serious damage from COVID-19 and have spent a lot of emergency economy funds. Moreover, as the pandemic is not being caught, China should promote quarantine support from BRI countries as a top priority. BRI should be transformed into a 'Healthy Silk Road'.

Also, due to the risk of COVID-19, digitisation is the basis for quarantine and economic activities. China, overcoming the pandemic, should support the digitalisation of the BRI countries. Since there are many cases of suspicion of Chinese support, support should be made purely in terms of foreign development aid, and support guidelines should be clarified so as not to cause another dispute. That is, China needs continue to support infrastructure construction in marginalised regions to improve connectivity between markets. This is because it is necessary to secure a strong supply chain for the implementation of the 'double cycle' economic policy announced by President Xi Jinping in 2020 and recovery of the Chinese economy.

Finally, authors would like to mention the limitations of this paper. Because it is difficult to accurately determine the damage of COVID-19, this paper set up three scenarios. In addition, since vaccines have begun to be supplied, the worst situation can be avoided, and the final paper has set a set of scenarios by reducing the degree of damage of the coronavirus compared to the first draft of this paper. These scenarios may be controversial, but the authors tried to establish the best scenarios based on the prospects of several international economic organisations such as the International Monetary Fund (IMF).

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Notes

1 OECD (2020) anticipated the world GDP to be reduced by 1.5% and world trade by about 4% in 2020, whereas the UN (2020) estimated that the global economic growth rate could fall from 2.5% to 1.2% due to COVID-19. Likewise, the World Bank (2020a) lowered its economic growth rate for East Asian developing countries from the present 5.8% to 2.1%, and McKinsey (2020) estimated the global GDP growth rate to be 1.5%, 2.4% for the United States, and 0.4% for China. McKibbin and Fernando (2020) estimated minus GDP growth rates in most countries, including the US, EU, and China. However, these institutions and researchers significantly lowered their outlooks in mid-2020.

2 Unlike other researchers, Kummritz (2016) claimed that the expansion of GVCs boost the economy by increasing domestic value added and productivities of all countries.

3 The mega-trend suggested by UNCTAD is revolution (4th industrial revolution), economic nationalism (global protectionism), and importance of sustainable development.

4 Numerical values of output in GTAP database version 10 are given in Appendix (Table A1).

5 Leontief inverse matrices are given for China and ASEAN in Appendix (Table A2) for readers' reference. Those for other regions can be provided upon request.

6 G20 countries implemented 154 new trade measures from mid-October 2019 to mid-May 2020, of which 95 facilitate trade and 59 restrict trade (WTO, 2020b).

7 A similar methodology was used in Yoo et al (2020). However, in this paper, the scope of the shock was more comprehensively designed by adding countermeasures as shown in Table 3, considering recent development of the COVID-19 vaccine.

Appendix

Regional output by sector (VOM) is given in Table A1. The table is taken from the GTAP database version 10.

Table A1 Numerical value of output (VOM, million $)

	ASEAN	*China*	*Japan*	*South Korea*	*US*	*EU*	*ROW*
Agriculture	1,597	2,874	417	160	1,406	2,017	3,984
Light Industry	539	1,530	354	159	1,423	1,565	1,803
Heavy Industry	559	725	14	8	501	257	649
Textile-apparel	346	1,382	41	54	311	449	515
Chemical	792	1,876	478	314	1,297	1,490	1,799
Pharmaceutical	60	179	67	15	189	379	408
Metal	659	3,530	638	333	1,030	1,662	1,948
Machinery	220	1,277	331	130	702	956	1,035
Automobile	304	1,115	516	206	1,043	1,355	1,633
High-tech	575	2,322	438	353	1,014	1,159	1,323

Leontief inverse matrix is calculated with the GTAP-VA program. This is needed for equation (4). Here only two matrices for ASEAN and China are provided because of space limitation. Additional data can be provided upon request.

Table A2 Leontief inverse matrix (China, ASEAN)

	Agri	*Light*	*Heavy*	*Textile*	*Chem*	*Pharm*	*Metal*	*Machinery*	*Automobile*	*High-tech*
					China					
Agriculture	1.72	0.126	0.048	0.328	0.147	0.312	0.058	0.057	0.055	0.053
Light industry	0.058	1.37	0.074	0.079	0.073	0.122	0.094	0.132	0.137	0.138
Heavy industry	0.03	0.103	1.09	0.042	0.204	0.071	0.177	0.076	0.063	0.063
Textile-apparel	0.014	0.126	0.022	1.83	0.024	0.024	0.03	0.035	0.055	0.031
Chemical	0.145	0.348	0.119	0.2	1.67	0.242	0.186	0.13	0.119	0.138
Pharmaceutical	0.006	0.006	0.005	0.006	0.006	1.04	0.006	0.006	0.006	0.005
Metal	0.071	0.23	0.202	0.104	0.139	0.149	1.68	0.582	0.447	0.427
Machinery	0.013	0.043	0.07	0.015	0.03	0.019	0.058	1.25	0.085	0.041
Automobile	0.006	0.01	0.014	0.009	0.009	0.009	0.013	0.039	1.4	0.012
High-tech	0.019	0.067	0.052	0.038	0.031	0.026	0.051	0.194	0.146	1.46
					ASEAN					
	Agri	*Light*	*Heavy*	*Textile*	*Chem*	*Pharm*	*Metal*	*Machinery*	*Automobile*	*High-tech*
Agriculture	1.470	0.024	0.009	0.055	0.027	0.039	0.011	0.016	0.010	0.010
Light industry	0.002	0.009	0.002	1.230	0.001	0.001	0.002	0.002	0.005	0.002
Heavy industry	0.045	0.084	0.026	0.048	1.190	0.058	0.040	0.020	0.021	0.027
Textile-apparel	0.005	0.001	0.001	0.001	0.001	1.020	0.001	0.001	0.001	0.001
Chemical	0.011	0.018	0.008	0.007	0.006	0.005	0.010	0.082	0.055	1.220
Pharmaceutical	0.029	0.057	0.029	0.026	0.020	0.027	1.290	0.137	0.136	0.065
Metal	0.004	0.005	0.007	0.001	0.003	0.001	0.005	1.100	0.012	0.004
Machinery	0.004	0.004	0.004	0.002	0.002	0.002	0.006	0.011	1.140	0.004
Automobile	0.024	0.081	1.080	0.029	0.232	0.033	0.173	0.028	0.029	0.022
High-tech	0.048	1.160	0.015	0.052	0.019	0.045	0.030	0.038	0.050	0.043

Table A3 GTAP Sectoral aggregation and HS (Harmonised System) concordance

No.	*Old code*	*Sector description*	*No*	*Sectoral Aggregation*	*HS Codes (Chapter, Heading, Sub-heading)*
1	pdr	Paddy rice	1	Agriculture	01~24, 350110~350510, 4101~4103, 4301, 5001, 510111~510220, 5201, 530110~5305, 710110~710121
2	wht	Wheat			
3	gro	Cereal grains nec			
4	v_f	Vegetables, fruit, nuts			
5	osd	Oil seeds			
6	c_b	Sugar cane, sugar beet			
7	pfb	Plant-based fibers			
8	ocr	Crops nec			
9	ctl	Bovine cattle, sheep and goats			
10	oap	Animal products nec			
11	rmk	Raw milk			
12	wol	Wool, silk-worm cocoons			
14	fsh	Fishing			
19	cmt	Bovine meat products			
20	omt	Meat products nec			
21	vol	Vegetable oils and fats			
22	mil	Dairy products			
23	pcr	Processed rice			
24	sgr	Sugar			
25	ofd	Food products nec			
26	b_t	Beverages and tobacco products			
13	frs	Forestry	2	HeavyMfg	060410~060499, 1301, 1402~1403, 270111~271121, 271410,
15	coa	Coal			
16	oil	Oil			
17	gas	Gas			
18	oxt	Minerals nec			
27	tex	Textiles	3	TextApparel	41~43, 50~65, 8804, 940430~940490, 9605
28	wap	Wearing apparel			
29	lea	Leather products			

Table A3 GTAP Sectoral aggregation and HS (Harmonised System) concordance (continued)

No.	*Old code*	*Sector description*	*No*	*Sectoral Aggregation*	*HS Codes (Chapter, Heading, Sub-heading)*
30	lum	Wood products	4	LightMfg	0501, 3406~3606, 3704~3706, 3804, 420321, 4206, 4401, 4405~4421, 4501~4504, 4601~4602, 4701~4707, 4801~4823, 4901~4911, 5904~5905, 6309~6310, 6601~6603, 7101~7105, 7113~7118, 844250, 8715, 9023, 9201~9209, 9401~9404, 9501~9508, 9601~9618, 9701~9706
31	ppp	Paper products, publishing			
35	rpp	Rubber and plastic products			
45	omf	Manufactures nec			
32	p_c	Petroleum, coal products	5	Chemical	2704, 2706, 2710~2713
33	chm	Chemical products			
34	bph	Basic pharmaceutical products	6	Pharmaceutical	3003~3004
36	nmm	Mineral products nec	7	Metal	251820, 251830, 252020, 2522~2523, 2618~2620, 2715, 2818, 3801, 3816, 3823~3824, 6801~6815, 6901~6914, 70~83, 8401~8404, 8485~8487, 854620, 854710, 9307, 940591, 9406
37	i_s	Ferrous metals			
38	nfm	Metals nec			
39	fmp	Metal products			
40	ele	Computer, electronic and optic	8	Hightech	8443, 8469~8473, 8517~8523, 8525, 8527~8529, 8532~8534, 8540~8542, 9009
41	eeq	Electrical equipment			
42	ome	Machinery and equipment nec	9	Machinery	690110, 7315, 7321~732290, 840120, 8405~8408, 8410, 8411~8487, 8501~8517, 8523~8524, 8526, 8530~8531, 8535~8539, 8542~8548, 8701, 870410, 8709~8710, 871620, 90~91, 9301~9306, 9402, 9405, 9704
43	mvh	Motor vehicles and parts	10	Transport	8407~8709, 8411~841210, 86, 870120~8708, 8711~8716, 8801~8803, 8805, 89
44	otn	Transport equipment nec			

Table A4 GTAP country aggregation

Region description	*No.*	*Regional aggregation*
Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand, Viet Nam	1	ASEAN
China	2	China
Japan	3	Japan
South Korea	4	Korea
United States of America	5	USA
Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom	6	EU
Australia, New Zealand, Rest of Oceania, Hong Kong, Mongolia, Taiwan, Rest of East Asia, Rest of Southeast Asia, Bangladesh, India, Nepal, Pakistan, Sri Lanka, Rest of South Asia, Canada, Mexico, Rest of North America, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Rest of South America, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Rest of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, Caribbean, Switzerland, Norway, Rest of EFTA, Albania, Belarus, Russian Federation, Ukraine, Rest of Eastern Europe, Rest of Europe, Kazakhstan, Kyrgyzstan, Tajikistan, Rest of Former Soviet Union, Armenia, Azerbaijan, Georgia, Bahrain, Iran Islamic Republic of, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Turkey, United Arab Emirates, Rest of Western Asia, Egypt, Morocco, Tunisia, Rest of North Africa, Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Guinea, Nigeria, Senegal, Togo, Rest of Western Africa, Central Africa, South Central Africa, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Tanzania, Uganda, Zambia, Zimbabwe, Rest of Eastern Africa, Botswana, Namibia, South Africa, Rest of South African Customs, Rest of the World	7	ROW