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The COVID-19 Pandemic, Air Transport Perturbation, and Sector Impacts in ASEAN Plus Five: A Multiregional Input–Output Inoperability Analysis

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Abstract: *This study simulates the sector impacts of demand-side perturbations on air transport sectors due to the COVID-19 pandemic, focusing on ASEAN members plus Australia, China, Japan, the Republic of Korea, and New Zealand. This study involves (i) the generation of a multiregional input–output table from the latest Global Trade Analysis Project data, (ii) a network analysis to determine the importance of the air transport industry in each country, (iii) multiplier and linkages analyses, (iv) determinations of sector impacts from demand-side perturbations on air transport sectors due to the COVID-19 pandemic, and (v) simulation of the effect of fiscal and monetary measures to mitigate the pandemic's impact. This study demonstrates that the aviation industry is a key sector in domestic and regional economic activities, and the reduction in air transport consumer demand due to the pandemic is estimated to cause gross domestic product (GDP) reductions from 0.4% to 2.1%. Government intervention, through fiscal and monetary policies, has, however, mitigated severe impact, moderating GDP and value-added losses. Thus, a viable policy prescription for the aviation industry is of utmost importance.*

Keywords: Air Transport; COVID-19; Inoperability; multiregional input–output; Sector impact.

JEL Classification: D57; L93; R41

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1. Introduction

Fear of infection, travel restrictions, and border closings due to the COVID-19 pandemic have severely impacted the aviation industry. The World Trade Organization reported that total flights per day, as recorded by the OpenSky Network, fell about 80% in early January 2020 to April 2020, gradually rebounding only up to 57% until August 2020 (WTO, 2020). The International Air Transport Association financial outlook predicted that total global air passenger numbers are expected to fall by 54.7% in 2020 compared to those in 2019 (IATA, 2020a). Total global revenue in the air transport industry in 2020 is half that of 2019, $419 billion from $838 billion (IATA, 2020b). Most regions, including North America and Europe, have suffered from more than a 30% decline in earnings before interest and taxes, and the Asia-Pacific region has negative impact of –18% (Statista, 2020).

In its 2018 report, the Air Transport Action Group stated that the direct, indirect or induced, and tourism-related contribution of the aviation industry to world gross domestic product (GDP) was $2.7 trillion, providing 65.5 million jobs (ATAG, 2018). Iacus et al. (2020) projected that disruption in air transport could cause a global GDP reduction ranging from 0.02% to 1.67% and a loss of 25 million – 30 million jobs. Similarly, Nižetić (2020) found that the pandemic has reduced approximately 96% of airport activities in selected European Union regions.

Individual members of the Association of Southeast Asian Nations (ASEAN) have taken early measures to minimise the economic downturn due to then COVID-19 pandemic by initiating economic recovery support of $318.2 billion, equivalent to 10.1% of members' combined GDPs, to maintain ASEAN competitiveness and connectivity (Zulkhibri and Sinay, 2020). Initiatives include new tax incentives, job protection schemes, and direct and indirect financial assistance for severely affected enterprises or individuals. Some ASEAN members are also introducing policy rate cuts and revisions on reserve requirements to help stabilise the market and ensure adequate liquidity and smooth economic activities.

The negative shock of the COVID-19 pandemic on the air transport industry will inevitably impact other economic sectors due to the interconnected nature of business activities. In a pandemic framework, Anderson and May (1991) adopted the microbiological model on the contagious spread of viruses to measure a ‘pandemic coefficient’, or the transmission mechanism coefficient during financial crises. However, incomplete or asymmetric information of the COVID-19 pandemic has intensified the transmission of the shock. The contagion is thus exaggerated as in a state of panic, so the economic agents have behaved differently than normal expectations (Peckham, 2013; Cheung, Tam, and Szeto, 2009).

The need to mitigate the COVID-19 pandemic's impact on the aviation industry forms the premise of this study. It simulates the potential sector impacts of demand-side perturbation on the air transport sector due to the pandemic, focusing on ASEAN members Plus Five (i.e. Australia, China, Japan, the Republic of Korea, and New Zealand).

2. Literature Review

Although much research has examined the adverse effects of various circumstances on the air transport industry (e.g. Kim and Gu, 2004; Kaplansli and Levy, 2010; Noronha and Singal, 2004), few studies have reflected on the impact of a pandemic on the overall links between the aviation industry and other economic sectors. Today, however, the ongoing damage brought about by the COVID-19 pandemic is motivating many to study its impact on the aviation industry – and in turn, on all economic activities – to create a more in-depth understanding of countermeasures planning (He, Niu, Sun, and Li, 2020; Karim, Islam, and Talukder, 2020; Kerr, 2020). As a key industry and one highly impacted by the pandemic, studying the impact of the aviation industry on the global economy has been a commanding task (Gössling, Scott, and Hall, 2020; Akyildirim et al., 2020; Czerny, Fu, Lei, and Oum, 2020; Pearce, 2020).

Due to the pandemic, around 90% of the global population has been subject to travel restrictions either locally or internationally, resulting in a massive drop in air transport demand as well as significant financial losses for aviation industries worldwide (Connor, 2020). As for the ASEAN region, air transport restrictions have also led to mass cancellation of tourism bookings, harming tourism-related businesses and employees (ASEAN, 2020). Direct disruptions in air transport have also interrupted trade activities amongst ASEAN members as well as between

ASEAN members and their trading partners. Restrictions imposed by China – ASEAN’s largest external trade partner – have significantly affected trade revenues, considering that around 17.1% of ASEAN total trade came from China in 2018 (OECD, 2020a).

As air transport plays a major role in other sector activities, the fact that it has been struggling amid the pandemic indicates that other sectors may have been affected as well (OECD, 2020b). For example, other industries dependent on air transport have faced difficulties acquiring necessary inputs for their production activities (Baker, 2020). The tourism industry also has faced challenges, as global travel restrictions are inhibiting transport via air and sea (Gössling, Scott, and Hall, 2020). Both studies mentioned, however, only examined a particular sector's behaviour towards the impacts of pandemic-related shocks on the transport sector, omitting the effects of such shocks on the other economic sectors. Therefore, it is timely to examine the impacts of the pandemic on various economic sectors for ASEAN Plus Five.

Findings could result in uncovering useful countermeasures that will help alleviate the economic downturn due to the pandemic. Methodologically, most past studies employed the Inoperability Input–Output Model (IIOM) to obtain the effects of transport disruptions on the economy (e.g. Santos and Haimes, 2004; Anderson, Santos, and Haimes, 2007; Akhtar and Santos, 2013; El Meligi et al., 2019). The IIOM is superior to other techniques as it captures the economic losses of all other sectors of the economy resulting from the aviation sector's failure (Haimes and Jiang, 2001). Thus, this method is highly practicable to estimate the economic losses in the other economic sectors caused by the current disruptions in the aviation sector.

3. Methodology

This study has five steps. First, a multiregional input–output (MRIO) table is generated for ASEAN members (i.e. Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic [Lao PDR], Malaysia, Philippines, Singapore, Thailand, and Viet Nam) plus Australia, China, Japan, the Republic of Korea, and New Zealand from the latest Global Trade Analysis Project (GTAP) data, version 10. Second, a network analysis is performed to determine the importance of the air transport industry in each country using the MRIO table. Third, the air transport sector's backwards and forward linkages are studied, as well as the output and value-added multipliers using the MRIO table. Fourth, the impact of air transport demand reduction due to the COVID-19 pandemic is simulated to investigate the regional and sector impacts using the IIOM. Fifth, the impact of specific policies are analysed on mitigating the current pandemic's impact.

3.1. Multiregional Input–Output Table

The first step in the MRIO analysis is to utilise an existing MRIO table or to create a new one. As an up-to-date MRIO table with most ASEAN and Asia-Pacific countries is unavailable, this study created a new MRIO table from the latest GTAP database. GTAP databases are constructed by the Center for Global Trade Analysis at Purdue University, and they combine data from several sources. In addition, GTAP uses country-level input–output tables, which are submitted by GTAP members following a well-developed protocol (Huff, McDougall, Walmsley, 2000). However, the GTAP database does not provide an MRIO table, which has led several researchers to construct MRIO tables independently.

Peters, Andrew, and Lennox (2011) described the methodology for converting the GTAP data into an MRIO table. The starting point is the balanced GTAP database, which provides the domestic input–output tables to be placed on the block-diagonal of the MRIO table. The block off-diagonals are based on the import input–output tables distributed using trade shares. This procedure gives a balanced MRIO table, the matrix form of which can be written as follows:

$$Z_{MRIO} = \begin{matrix} Z_1^d + \hat{s}_{11} Z_1^i & \hat{s}_{12} Z_2^i & \cdots & \hat{s}_{1m} Z_m^i \\ \hat{s}_{21} Z_1^i & Z_2^d + \hat{s}_{22} Z_2^i & \cdots & \hat{s}_{2m} Z_m^i \\ \vdots & \vdots & \ddots & \vdots \\ \hat{s}_{m1} Z_1^i & \hat{s}_{m2} Z_2^i & \cdots & Z_m^d + \hat{s}_{mm} Z_m^i \end{matrix} \quad (1)$$

where:
Z_r^d = domestic input–output tables ($VDFM$ in GTAP),
Z_r^i = import input–output table ($VIFM$ in GTAP), and
$\hat{s}_{rs}$ = trade shares ($VXMD_{irs}/VIM_{is}$ in GTAP).

For an MRIO table to be constructed by distributing import tables using trade shares, there is enough information to specify row and column sums in each off-diagonal block. Thus, the MRIO table is not unique, and it is assumed that proportionality between trade shares or input–output table coefficients specifies the distribution in the absence of better information. Others have also used trade shares in producing an MRIO table from GTAP data as well (e.g. Trefler and Zhu, 2010; Bems, Johnson, and Yi, 2011; Johnson and Noguera, 2012). This study aggregates all other countries as rest of the world.

3.2. Network Analysis

Based on the MRIO table, a network analysis is then used to examine the sector importance of the air transport industry in each country and within ASEAN and the Asia-Pacific region. A complex system is a large network of relatively simple components with no central control, in which emergent complex behaviour is exhibited (Mitchell, 2006). According to Reichardt (2008), the first step in understanding complex systems is the decomposition of these systems into their parts. Hence, network analysis utilisation allows one to represent complex systems in terms of their parts and interactions/linkages amongst these parts (Scott, 2000). In this context, policymakers have become interested in network analysis as these tools are applied to most real-world networks (OECD, 2009).

Economic networks using input–output data can be summarised into models as interconnected networks *R = (N, M)* where *R* is the network, *N* is the number of nodes, and *M* is the number of links. Nodes represent 65 economic sectors in the

MRIO table, and links represent the relationships between each sector. Link direction can also be called input–output flows. The goal of this visualisation is to obtain a full picture of the entire network (Lovrić et al., 2018; Said and Fang, 2019), with a focus on key sectors that play economic activity roles.

One of the extents analysed to obtain information about the topological properties of a network is connectivity. Connectivity is measured by node degree (depending on network type) on node level; a higher node degree implies a stronger impact over the network (Howell, 2012). At the network level, connectivity is measured by density, which is a ratio of the actual count of links to the possible maximum count of links. Density is used to measure how many links are in a network compared to the maximum number of links between nodes. Density is also used to measure tightness or compactness amongst all nodes in the network. The greater the density value, the more integrated the relationships between sectors within the network. The definition of network density can be seen through the following equations (Kitamura and Managi, 2017):

$$Density = m/n(n-1) \tag{2}$$

where:

n = the number of nodes, and

m = the number of actual links or connections within the network.

In network terminology, the primary structure refers to two subdivisions in which the core structure consists of a set of nodes that are interconnected and are the focal point of the whole network (Prell, 2016). The core structure forms an integrated block and shares the same network with other nodes in the network. A periphery structure refers to an isolated class of nodes and is associated with the rest of the network mainly through its relationship to the core structure. Among the structures, the core structure is seen as more likely to benefit, largely in the form of economic growth (Clark, 2010; Prell, 2016).

3.3. Input–Output Analysis

The MRIO analysis is an extended version of the existing input–output model based on the conceptual framework proposed by Leontief (1951). The analytical base for the input–output model is the input–output table, which shows the use of inputs and applications of outputs in each sector. The input–output analysis is a research methodology used to establish the importance and sector linkages of transport sectors (Kwak, Yoo, and Chang, 2005). The basic input–output model is:

$$x = Ax + f \qquad (3)$$

where:

x = the total output vector;

A = the technical coefficients vector that denotes interaction amongst the production sectors; and

f = the final demand vector, including private consumption, government consumption, gross fixed capital formation, change in inventories, and exports.

Solving for x, the total production delivered to final demand is obtained by:

$$x = (I - A)^{-1} f \qquad (4)$$

where:

I = the identity matrix, and

$(I - A)^{-1}$ = the Leontief Inverse Matrix, which represents the total production that every sector must generate to satisfy final demand. In other words, the coefficients are the amount by which sector *i* must change its production level to satisfy an increase of one unit in the final demand from sector *j*. Thus, each element of the Leontief Inverse Matrix contains the direct and indirect requirements of an industry to meet its final demand.

Based on the Leontief Inverse Matrix, the multiplier measures the impact on the growth of the whole economy when final demand components change. Multipliers measure, directly and indirectly, the interdependence between one sector and the rest of the economy involved in purchasing and selling amongst sectors. Value-added multipliers measure the estimated amount of value added generated in the whole economy. Value-added multipliers for sector j are defined as the total value added in all sectors of the economy that is necessary for all sectors to produce one unit of product j for final use. In other words, it indicates how the effect of one unit changes in the final demand of a specific sector. The formula to calculate the value-added multiplier (v) is:

$$v = \hat{h}(I - A)^{-1}f \qquad (5)$$

where:

h = the vector of value-added coefficients,

I = the identity matrix, and

A = the matrix of input coefficients for domestic production.

The value-added coefficients are derived by dividing the amount of value-added v of the jth sector by total input to that sector x_j. In matrix notation, h equals $v\hat{x}^{-1}$. Each element of the value-added coefficient indicates the value added per unit of output produced for each sector. Employment multipliers measure the estimated amount of jobs created in the whole economy from additional final demand. The employment multiplier for a sector j is defined as the total employment generated in all sectors of the economy that is necessary for all sectors to produce one unit of product j for final use. The formula to calculate employment multiplier (u) is:

$$u = \hat{w}(I - A)^{-1}f \qquad (6)$$

where:

w = the vector of employment coefficients,

I = the identity matrix; and

A = the matrix of input coefficients for domestic production.

The employment coefficients are derived by dividing the number of jobs w of the jth sector by total input to sector x_j. In matrix notation, w equals $u\hat{x}^{-1}$. Each element of the employment coefficient indicates employment per unit of output produced for each sector.

Next, this study calculates the backwards and forward linkages to analyse sector importance. Backwards and forward linkages measure the level of dependencies between intermediate input purchases and intermediate input sales for a given sector. The backwards linkage effect is represented as the power of dispersion, while the forward linkage effect is expressed as the sensitivity of dispersion (Chiu and Lin, 2012). The mathematical calculation of the backwards linkage effect (B_i^f) and forward linkage effect (F_j^b) is:

$$B_i^f = \frac{\sum_{j=1}^{n} b_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}} \tag{7}$$

$$F_j^b = \frac{\sum_{i=1}^{n} g_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} g_{ij}} \tag{8}$$

where:

b_{ij} = the Leontief Inverse Matrix,

g_{ij} = the Ghosh Inverse Matrix, and

n = the number of sectors.

A comparison of the values of the backwards and forward linkages for each sector in an economy provides a mechanism for identifying the key sectors in that country and for grouping sectors into spatial clusters (Miller and Blair, 2009). Focusing on sector *i*, the backwards linkage effect means that the production activities of sector *i* may induce greater use of other sectors as input for sector *i* production. The forward linkage effect indicates that sector *i* production may be used as an input for other sectors in their own production. Forward and backwards linkage effects are then useful in assessing the impact of the sector *i* on the national economy as a whole (Kwak, Yoo, and Chang, 2005).

After analysing the sector linkages, this study investigates the impacts of demand shocks on the air transport sector due to the pandemic on regional sector performances for the ASEAN and Asia-Pacific region. Although the impacts of demand reduction can be simulated from the standard input–output model, this does not consider the inoperability of other sectors and is therefore susceptible to bias. Thus, Haimes and Jiang (2001) proposed an alternate version of the model known as the IIOM to address the interconnected systems.

3.4. Inoperability Input–Output Model

The IIOM can calculate inoperability, or the degree of inability of a system to perform its intended functions (Haimes et al., 2005). Inoperability can be caused by internal or external factors that disrupt the delivery of a system's intended output (Jung, Santos, and Haimes, 2009). Santos and Haimes (2004) expanded the IIOM to measure output losses due to terrorism activities and other disruptive events to economic systems or sectors. The formulation of the IIOM based on Santos and Haimes (2004) is:

$$q = A^{*}q + f^{*} \qquad (9)$$

where:

q = inoperability vectors,

A^{*} = the interdependency matrix, and

f^{*} = a demand-side perturbation vector.

Vector q is expressed in terms of normalised economic loss, and the elements of q represent the ratio of unrealised production with respect to the business-as-usual (BAU) production level for the respective industry. Matrix A^{*} indicates the degree of coupling of the industry sectors and the elements of A^{*} in a particular row able to provide information on additional inoperability that is being contributed by a column industry to the row industry. Vector f^{*} is expressed in terms of normalised degraded final demand.

Inoperability q is the resulting normalised economic loss that can be potentially realised after an industry sector experiences a prolonged demand-side perturbation of f^* (e.g. pandemic-induced demand reduction). The A^* matrix represents the magnitude of interdependencies of the industry sectors. The elements of the interdependency matrix provide the basis for calculating the inoperability of the industry sectors. Logically, the impact of a demand perturbation to an industry sector of interest depends on its dependence on a primarily perturbed sector. The formula to calculate the interdependency matrix is:

$$A^* = [\mathrm{diag}(\hat{x})]^{-1}[A][\mathrm{diag}(\hat{x})] \qquad (10)$$

where:
$\hat{x}$ = the vector for total BAU output,
$\mathrm{diag}(\hat{x})$ = the diagonal matrix form of $\hat{x}$,
$[\mathrm{diag}(\hat{x})]^{-1}$ = the inverse of $\mathrm{diag}(\hat{x})$, and
A = the technical coefficient matrix.

Next, the demand-side perturbation vector (f^*) is calculated, a decrease in the final demand, normalised according to the BAU production $\hat{x}$:

$$f^* = [\mathrm{diag}(\hat{x})]^{-1}\left[\hat{f} - \tilde{f}\right] \qquad (11)$$

where:
$\hat{f}$ = BAU production, and
$\tilde{f}$ = reduced final demand.

The *i*th element in f^* represents the demand-side perturbation of the *i*th sector. This scalar element is denoted by f_i^*. Once A^* and f^* have been obtained, this study proceeds to calculate the inoperability vectors (q) as follows:

$$q = [I - A^*]^{-1} f^* \qquad (12)$$

where:
q = the percentage of sector inoperability due to demand shocks, and
I = the identity matrix.

Next, this study calculates the economic loss caused by sector inoperability:

$$\delta x = [\mathrm{diag}(q)][x] \tag{13}$$

where:
$\mathrm{diag}(q)$ = a diagonal matrix form of q.

The *i*th element of the economic loss vector is the product of the inoperability of sector *i* and its corresponding BAU production.

The single-region IIOM is unable to provide a detailed analysis of the sector interdependencies between countries. Past researchers found that a multiregional model provides better feedback compared to a single region (Lahr and Dietzenbacher, 2001). In addition, Haimes et al. (2005) showed that multiregional decomposition enables a more focused – and thus more accurate – analysis of the interdependencies for regions of interest. Since the air transport industry is generally linked between countries, it is more appropriate to consider a multiregional analysis.

This study also conducts an ex-ante analysis on the impacts of the COVID-19 pandemic on the economy. Although it is inevitable that the current pandemic will affect all other economic sectors, targeted simulation scenarios in this study can zoom in on the impacts of the pandemic on the air transport sector and its spill-over across the economy. It shows the important role played by the air transport industry in driving national economic growth and its vulnerabilities by using information from the IATA (2020a) study positing that the pandemic could cause passenger demand reduction in the Asia-Pacific region by specific percentages. From the reduction rate, this study simulates demand-side perturbations in air transport industries and assumes no changes in all other industries.

3.5. Policy Shocks

Policymakers have taken actions to mitigate the socio-economic impacts of the pandemic. To analyse the impact of these actions, this study simulates the policy shocks in the MRIO models (post-COVID-19). Based on IATA (2020c), various tax relief measures are addressing air transport industries, including direct tax, indirect tax, employment tax, and withholding tax. This study looks at the direct tax and indirect tax. Direct tax measures address income tax discounts in a focus country, while indirect tax measures address discounts in the value-added tax or the goods and services tax.

The latest tax relief measures have qualitative and quantitative data, and thus this study made several adjustments in the simulation scenario. The data cover most countries in the world and were updated on 27 October 2020. In addition, this study considers the impact of monetary policies enacted by policymakers in terms of lower interest rates, such as the reduction of the overnight policy rate for Malaysia. Information on each country's monetary policy measures was obtained from the International Monetary Fund (2021).

This study simulates the impact of policy measures by assuming an increase in the final demand by certain percentages (after considering the elasticities). Table 1 shows the types of policy measures simulated in the current study. Detailed policy measures and the simulation scenario are included in Appendix 2 and Appendix 3.

Table 1: Fiscal and Monetary Measures Simulated in Current Study

Country	Direct Tax	Indirect Tax	Interest Rate
Brunei Darussalam	✓		
Cambodia			
Indonesia	✓		✓
Lao People’s Democratic Republic	✓		✓
Malaysia	✓		✓
Philippines			✓
Singapore	✓	✓	

Thailand		✓	✓
Viet Nam			✓
Australia	✓	✓	✓
China	✓	✓	✓
Japan	✓	✓	
Korea	✓	✓	✓
New Zealand	✓	✓	

Sources: IATA (2020c) and IMF (2021).

4. Findings

4.1. Generating the Multiregional Input–Output Table

In the first part of this study, the MRIO table was generated from the latest GTAP data that used the base year 2014. Although the base year is not the same as the current year, the input–output analysis uses the base year data to explain the technological development (i.e. technical coefficients) in producing output in the economy. The base year 2014 serves as the base economic structure, where the economic structure is assumed to not have any drastic changes within 5 years. The GTAP data contain 141 countries/regions and 65 sectors.

Table 2 shows the selected countries involved in obtaining the MRIO table, which comprises 9 ASEAN countries (except Myanmar), 5 Asia-Pacific countries, and the rest of the world. The selected focus countries are also known as the Regional Comprehensive Economic Partnership countries.

Table 2: Countries in the Multiregional Input–Output Table

No.	ISO3	Country
1	AUS	Australia
2	CHN	China
3	JPN	Japan
4	KOR	Korea
5	NZL	New Zealand
6	BRN	Brunei Darussalam
7	IDN	Indonesia
8	KHM	Cambodia
9	LAO	Lao People's Democratic Republic
10	MYS	Malaysia
11	PHL	Philippines
12	SGP	Singapore
13	THA	Thailand
14	VNM	Viet Nam
15	ROW	Rest of world

Source: Authors.

Table 3 shows the list of sectors and codes[1] used in constructing the MRIO table. This study maintains the existing sector aggregation based on the latest GTAP data to obtain a more detailed and comprehensive analysis. In this study, the focus sector is the air transport sector (54), which uses the code 'atp'.

Based on the GTAP sector breakdown, this study finds that the air transport sector has the most detailed sector data without aggregating the sectors. Hence, this study maintains the existing sector aggregation to ensure no aggregation bias issues.

[1] Detailed sector breakdown can be obtained from CGTA (2021a).

Table 3: Sectors in the Multiregional Input–Output Table

No.	Code	Sector
1	pdr	Paddy rice
2	wht	Wheat
3	gro	Cereal grains nec
4	v_f	Vegetables, fruit, nuts
5	osd	Oil seeds
6	c_b	Sugar cane, sugar beets
7	pfb	Plant-based fibres
8	ocr	Crops nec
9	ctl	Bovine cattle, sheep and goats, horses
10	oap	Animal products nec
11	rmk	Raw milk
12	wol	Wool, silkworm cocoons
13	frs	Forestry
14	fsh	Fishing
15	coa	Coal
16	oil	Oil
17	gas	Gas
18	oxt	Other extraction
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
27	tex	Textiles
28	wap	Wearing apparel
29	lea	Leather products

No.	Code	Sector
30	lum	Wood products
31	ppp	Paper products, publishing
32	p_c	Petroleum, coal products
33	chm	Chemical products
34	bph	Basic pharmaceutical products
35	rpp	Rubber and plastic products
36	nmm	Mineral products nec
37	i_s	Ferrous metals
38	nfm	Metals nec
39	fmp	Metal products
40	ele	Computer, electronic, and optical products
41	eeq	Electrical equipment
42	ome	Machinery and equipment nec
43	mvh	Motor vehicles and parts
44	otn	Transport equipment nec
45	omf	Manufactures nec
46	ely	Electricity
47	gdt	Gas manufacture, distribution
48	wtr	Water
49	cns	Construction
50	trd	Trade
51	afs	Accommodation, food, and service activities
52	otp	Transport nec
53	wtp	Water transport
54	**atp**	**Air transport**
55	whs	Warehousing and support activities
56	cmn	Communication
57	ofi	Financial services nec
58	ins	Insurance
59	rsa	Real estate activities

No.	Code	Sector
60	obs	Business services nec
61	ros	Recreational and other services
62	osg	Public Administration and defence
63	edu	Education
64	hht	Human health and social work activities
65	dwe	Dwellings

nec = not elsewhere classified.
Source: CGTA (2021b).

Once the focus country and sector aggregation were determined, this study developed the MRIO table. Using General Equilibrium Modelling Package (GEMPACK) software to view and extract data from the GTAP database, the MRIO table is produced using MATLAB and Microsoft Excel (Table 4).

Table 4: Structure of the Multiregional Input–Output Table

Base Year: 2014	Country	AUS	AUS	AUS	AUS	CHN	CHN	CHN	CHN	…	…	ROW	ROW	ROW	ROW	AUS	CHN	…	ROW	Margin	Total Output
Country	Sector	S1	S2	…	S65	S1	S2	…	S65	…	…	S1	S2	…	S65	FD	FD	…	FD		
AUS	S1																				
AUS	S2																				
AUS	⋮																				
AUS	S65																				
CHN	S1																				
CHN	S2																				
CHN	⋮							Z													
CHN	S65																				
⋮	⋮																				
ROW	S1																				
ROW	S2																				
ROW	⋮																				
ROW	S65																				
Total Inter-mediate Input																					
Value Added																					
Tax																					
Subsidy																					
Margin																					
Total Input																					

Notes:

1. S1 to S65 represent the sector number.
2. The Z area represents the transaction matrix with dimensions 975 x 975.

Source: Authors.

4.2 Network Analysis

In the second part, this study utilises network analysis to trace the position and role of the air transport sector. The main purpose is to investigate the importance of the air transport sector in the domestic economy for each country and the regions. To achieve this goal, it uses the MRIO table. For convenience, the MRIO table is aggregated into 10 main sectors and focuses on 14 countries. This study performs a descriptive analysis and several tests such as density, distance, eigen, and core/periphery to obtain more detailed information. It then analyses and compares the structural patterns to see the differences between each country's economic structure.

Table 5 shows the descriptive analysis results for 15 input–output networks that consist of 14 countries and a single aggregated country covering 10 main sectors. Based on Table 5, the total edges for the domestic input–output network equal 100 for the 10 nodes/sectors involved, which consist of 65 economic sectors found in the input–output table that were aggregated into 10 main sectors for each country. The total edges for the entire network of input–outputs are 19,570 for 140 nodes. For this study, the edges represent the value of input or output flow from one sector to another sector. Here, the maximum score value of the edges is 1,376,320, located in the domestic network for China.

In addition, Table 5 shows that all countries' networks have a density value equal to 1. In the network analysis, density is used to measure the strength of the relationship amongst all sectors found in the input–output network. The greater the value of density, the more integrated the existing relationships between the sectors within the network. According to Hou, Liu, Wang, and Wu (2018), density values can represent the level of network effectiveness. The greater its value, the closer the relationship between all nodes. Based on the density analysis results, it can be concluded that all networks developed a perfect level of integration with each other.

The average path length value averages 1 for all networks. The low average length of the path reflects the level of strong contact with each other. In the event of any shock to a sector of the economy, it will have an immediate impact on the sector involved as input or output. Moreover, each node can have an indirect relationship with another node if there is a mediator between them (Hou, Liu, Wang, and Wu, 2018). The mediators act as ‘bridges’ in the trade network, as goods from abroad are transmitted to a particular country first and then moved out to other countries. In this study, the value of 1 indicates that each node has a direct relationship to another node without the need for a mediator.

Furthermore, according to May (1972), a complex system can be categorised as a stable system if the eigenvalue is less than 1. Based on the results, all networks developed are stable because the eigenvalue is located between the minimum value of 0.579 in the Singapore domestic network and the maximum value of 0.974 in the Korean domestic network. All networks have eigenvalues from 0 to 1, which indicates that this network is stable.

After establishing the network condition, this study visualises the network for the focus economies. The purpose of network visualisation is to obtain an overview of the network (Lovrić et al., 2018).

Table 5: Descriptive Analysis Results

Country	Edges	Clustering Coefficient	Minimum	Maximum	Density	Average Path Length	Eigenvalue
AUS	100	8,454	0.215	56,715	1.000	1.000	0.588
CHN	100	18,766	7.810	1,376,320	1.000	1.000	0.965
JPN	100	11,261	0.307	200,771	1.000	1.000	0.945
KOR	100	7,544	0.197	99,786	1.000	1.000	0.974
NZL	100	1,419	0.065	14,944	1.000	1.000	0.586
BRN	100	50	0.000	934	1.000	1.000	0.621
IDN	100	4,650	0.125	88,284	1.000	1.000	0.852
KHM	100	100	0.000	3,534	1.000	1.000	0.788
LAO	100	69	0.000	3,888	1.000	1.000	0.715
MYS	100	2,852	0.000	45,944	1.000	1.000	0.910
PHL	100	1,412	0.067	22,635	1.000	1.000	0.826
SGP	100	1,510	0.000	12,481	1.000	1.000	0.579
THA	100	2,802	0.000	34,140	1.000	1.000	0.910
VNM	100	965	0.013	20,499	1.000	1.000	0.900
ALL	19,570	372	0.000	1,376,320	0.894	1.106	0.965

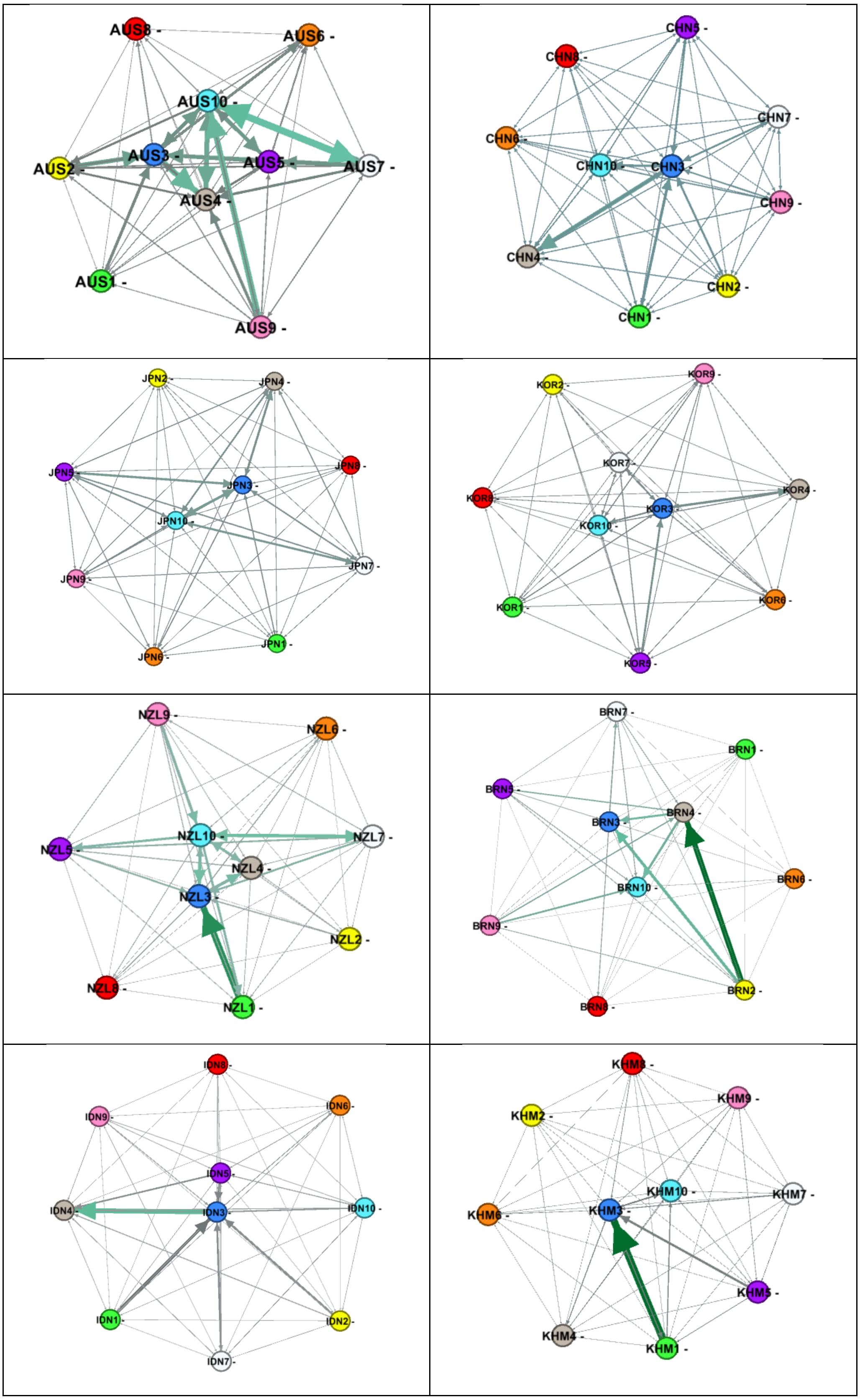
Source: Authors' calculations.

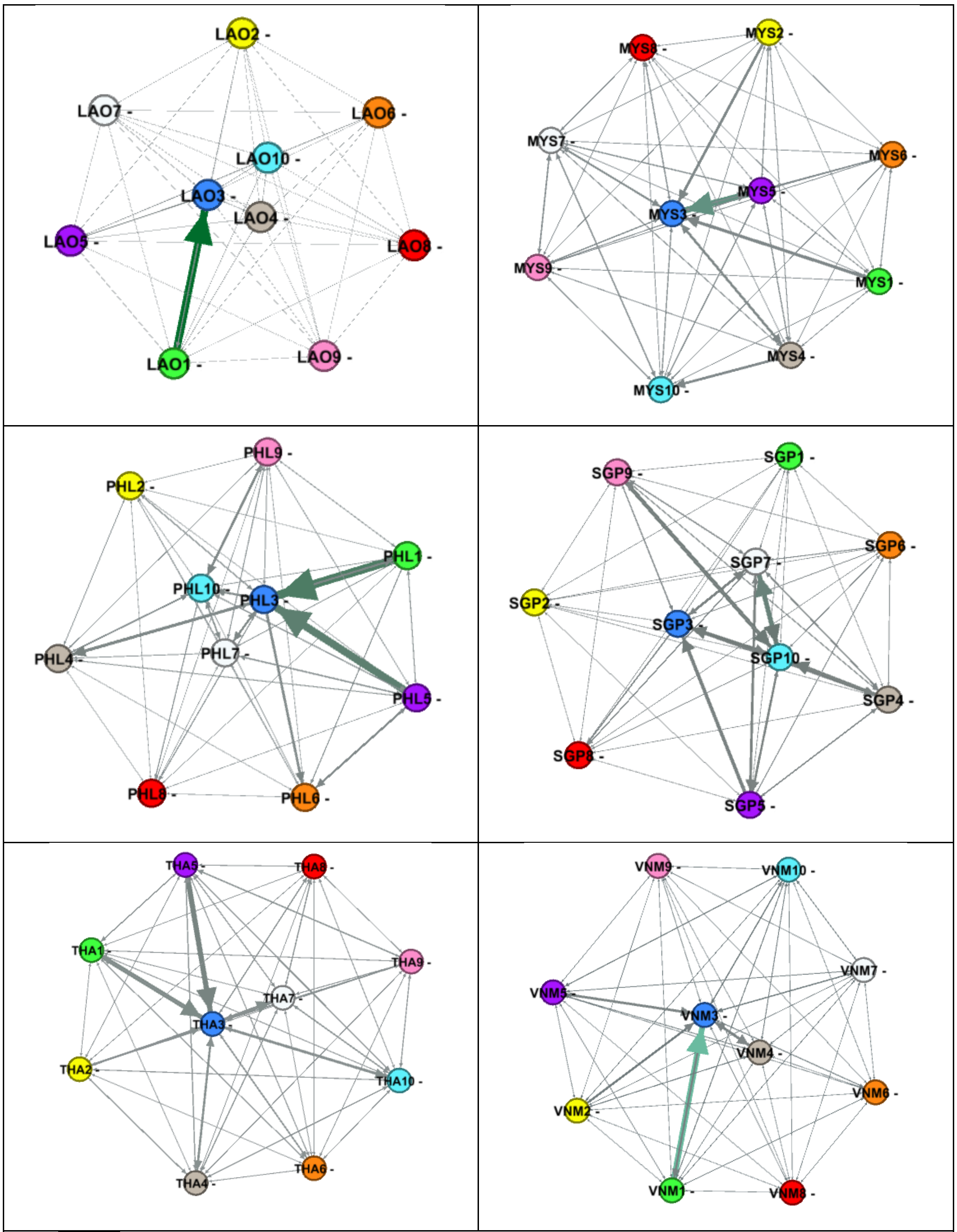
Figure 1 shows the network of economic structures for each country. In this study, links (i.e. edges) indicate the actual relationship or actual value of the amount of inputs and outputs flowing from one sector to another. The direction of the edges is also the direction of input–output flow. The thickness of the edges indicates the number of input or output transactions that occurred. The thicker the size of the edges, the greater the value of the transaction.

For example, the AUS3 node represents the manufacturing sector found in the Australian economic structure. The AUS3 node is one of the thickest inbound links towards the red AUS8 node, the node for the air transport sector in Australia. However, the thickness of the edges between the AUS3 node (i.e. manufacturing sector) towards the AUS8 node (i.e. air transport sector) is not as thick as the direction of the AUS3 node-link towards AUS4 (i.e. construction and utility sector) or AUS10 (i.e. other services sector).

In addition, the node size for this study indicates the total number of inputs contained for each sector. The larger the node size, the higher the input volume and vice versa.

Figure 1: Economic Structure for the Focus Countries, 2014





(green)	Agriculture, Forestry, and Fishing
(yellow)	Mining and Quarrying
(blue)	Manufacturing
(grey)	Construction and Utilities
(purple)	Trade
(orange)	Accommodations, Food, and Service Activities
(white)	Other Transport, Storage, Information and Communications Services
(red)	Air Transport
(pink)	Finance and Insurance Services
(cyan)	Other Services

Source: Authors' calculations.

Table 6: Results for Core Structures in the Network

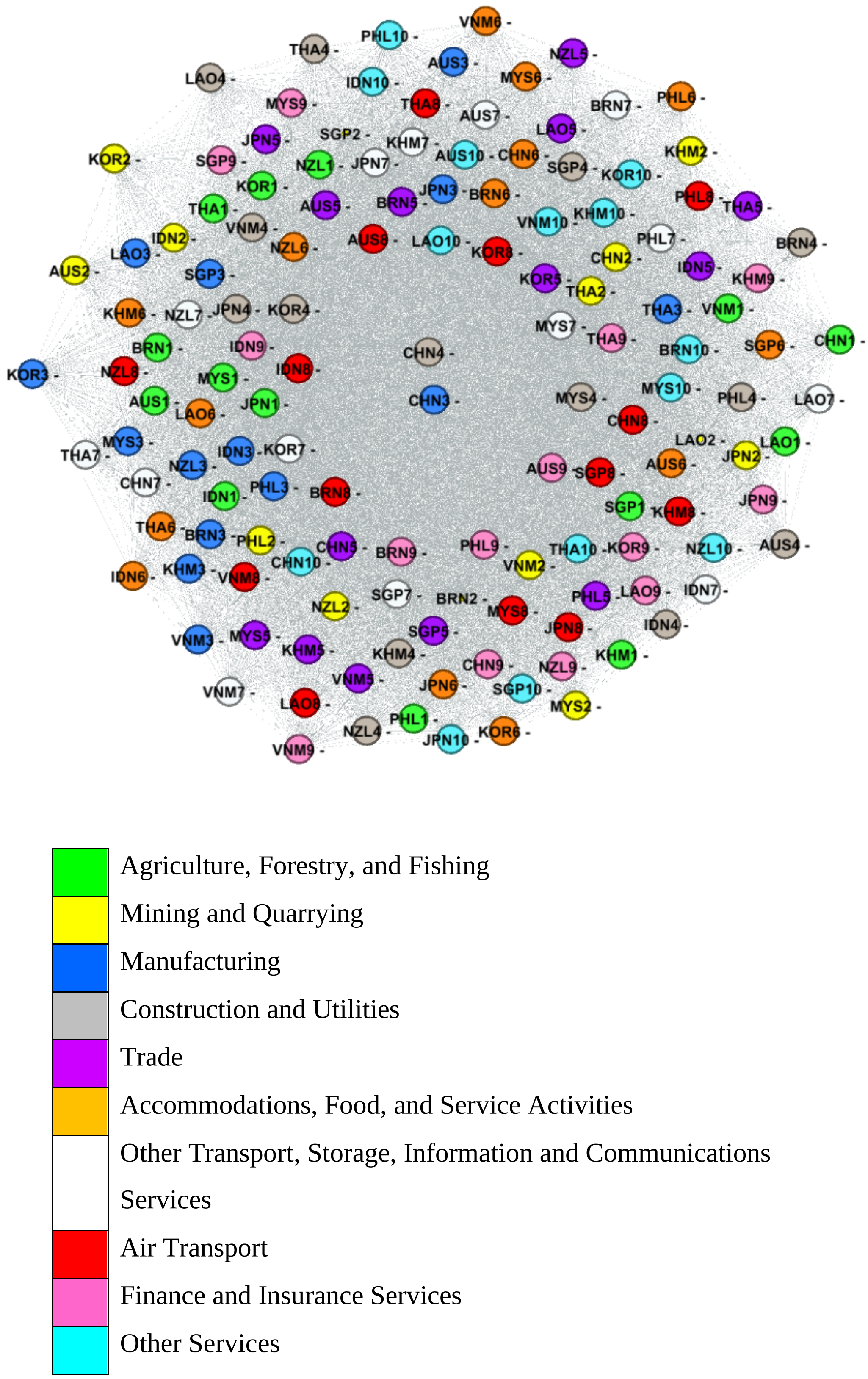
Country	Sector
AUS	Manufacturing (3), construction and utilities (4), trade (5), other services (10)
CHN	Manufacturing (3), other services (10)
JPN	Manufacturing (3), other services (10)
KOR	Manufacturing (3); other transport, storage, information, and communications services (7); other services (10)
NZL	Manufacturing (3), construction and utilities (4), other services (10)
BRN	Manufacturing (3), construction and utilities (4), other services (10)
IDN	Manufacturing (3), trade (5)
KHM	Manufacturing (3), other services (10)
LAO	Manufacturing (3), construction and utilities (4), other services (10)
MYS	Manufacturing (3), trade (5)
PHL	Manufacturing (3); other transport, storage, information, and communications services (7); other services (10)
SGP	Manufacturing (3); other transport, storage, information, and communications services (7); other services (10)
THA	Manufacturing (3); other transport, storage, information, and communications services (7)
VNM	Manufacturing (3), construction and utilities (4)
ALL AGGR.	Manufacturing (3), construction and utilities (4)

Source: Authors' calculations.

Table 6 shows the results of the main class membership (i.e. core) of the input–output network for the 15 types of networks. The position of the nodes depicted in Figure 1 indicates that the nodes located in the central part of the network are core nodes or core sectors, while the nodes at the edge of the network surrounding the core nodes are periphery nodes. According to Csermely, London, Wu, and Uzzi (2013), if the core/periphery structure theory holds, then the network structure can be separated into a core structure and periphery structure. When the core structures are highly integrated nodes and periphery structures are fully connected to the core nodes, there are no links between any two nodes in the periphery. The core structure in the network analysis is a node with many links and a high degree of integration to other nodes in the same network. Meanwhile, nodes categorised in the side or periphery structure group are composed of a set of nodes with a smaller link between the periphery structured nodes.

Based on Table 6 and Figure 1, for the domestic input–output network or the economic structure of the countries studied, the manufacturing sector is the core node. In addition, for most countries studied, other nodes (i.e. the construction and utilities sector; other transport, storage, information, and communications services; and other services) are also core nodes. In Figure 2, for the visual of the entire input–output network that combines 14 countries, node CHN3 (i.e. manufacturing) and CHN4 (i.e. construction and utilities) are the core nodes in the network.

Figure 2: ASEAN and Asia-Pacific Region Input–Output Network, 2015



Source: Authors' calculations.

Based on the results of the core/periphery analysis, it can be concluded that the air transport sector is a periphery sector in the economic structures of the countries studied. Although the air transport sector is seen as a periphery sector, which is seen as less important than core sectors, the changes that have taken place in this sector will, to some extent, have implications for the continued achievement of economic performance for a country as a whole. This is because, through the density test and average path length test, the value of both is 1, which means that each sector in this network integrates perfectly and has a direct relationship without the need for another node as a mediator. Therefore, any change or shock by any sector will have direct implications for other sectors in the economy.

In addition, by comparing and observing the inflow of edges to the air transport sector for Figure 1, the manufacturing sector is the largest contributor to the input–output flow to the air transport sector. This can give the impression that if there is any change in production for the air transport sector (i.e. expansion or contraction), the manufacturing sector is a sector that will have the greatest impact compared to other sectors.

Indeed, the study finds that all sectors in the economic structure are integrated with each other. This means that any change or shock by any sector will have direct implications for other sectors in the economy. Secondly, based on the results of membership of the core and periphery structures, as a whole, it can be concluded that the manufacturing sector is the core sector for all economic structures for the countries studied. The construction and utilities; other transport, storage, information, and communications services; and other services sectors are also amongst the core sectors in most countries. In addition, based on the network analysis, the air transport sector is the periphery structure for all economic structures.

Finally, through observation of the edges, the analysis finds that the manufacturing sector is impacted if there is any change in production of the air transport sector. The network analysis occurred before the study is extended to obtain an overview of the economic structure. By looking at the economic structure based on the analysis of input–output networks, it does provide clear information on the position and role of the air transport sector as a whole.

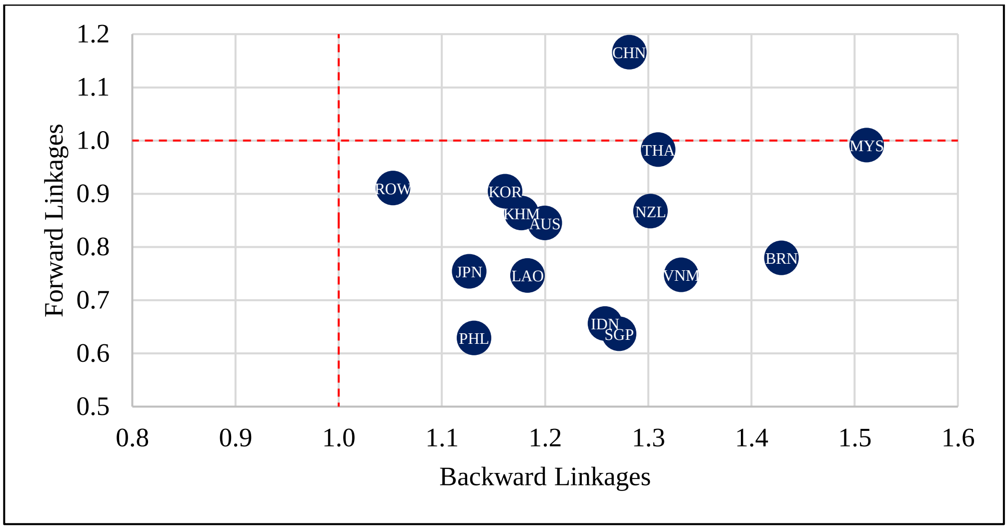
4.3 Linkages and Multiplier Analysis

In this section, this study analyses sector linkages and multiplier effects for the air transport sector to help understand the importance of the aviation industry in driving domestic and regional economies. The study uses the GTAP-MRIO data in an input–output analysis. Linkage analysis is a tool used in measuring the importance of a sector that produces goods and services for the economy. It examines the interdependence of supply and demand within the sectors. The tools most used in interdependence analysis are backwards and forward linkages, which measure the level of dependencies between intermediate input purchases and intermediate input sales for a given sector. This study disaggregates the linkages into the domestic economy and regional economy to understand the respective roles.

The backwards linkages are used to indicate the interdependence of a particular sector with other sectors involved in the purchasing of inputs. Since the backwards linkage involves input from various sectors, the interrelationships amongst suppliers in sectors are shown. The forward linkage is used to indicate the interdependence of a particular sector with other sectors that involve in selling of output. Hence, it defines the relationship amongst the producers of output in the sectors.

Figure 3 shows the backwards and forward linkages for the air transport sector in the regional economy. It can be seen that the value of backwards linkages for all countries is more than 1, denoting that the air transport sector has high linkages with the source sectors in the region (i.e. sectors used as input for the air transport sector). Meanwhile, all countries, except China, have values of less than 1 for forwarding linkages. This means that air transport sectors in China have a larger role in the regional economy compared to all other countries. China's role as a primary and intermediate input supplier is a contributing factor.

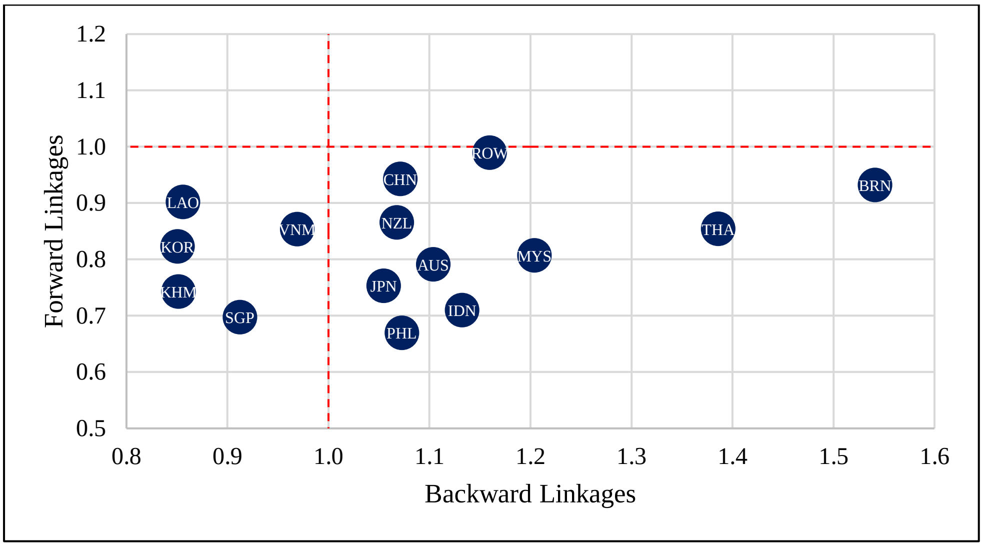
Figure 3: Backwards and Forward Linkages for the Air Transport Sector in the Regional Economy



Source: Authors' calculations.

Figure 4 shows the linkages in the domestic economy. This is based on the idea that some sectors may be crucial for regional economic development compared to the domestic economy and vice versa. In terms of the backward linkages, some countries (i.e. Cambodia, Korea, Lao PDR, Singapore, and Viet Nam) have a value of less than 1. This shows that the air transport sectors in these countries have stronger backwards linkages in the regional economy compared to the domestic economy. For the domestic economy, all countries have forward linkages of less than 1. This means that even for China, the air transport sector has fewer linkages to sectors that use inputs in the domestic economy, compared to the regional economy.

Figure 4: Backwards and Forward Linkages for the Air Transport Sectors in the Domestic Economy



Source: Authors' calculations.

Table 7: Output Multiplier Effects for Air Transport Sector in the Domestic Economy

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
1	pdr	0.000	0.001	0.000	0.000	0.000	0.000	0.006	0.002	0.000	0.000	0.000	0.000	0.001	0.000
2	wht	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	gro	0.000	0.003	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	v_f	0.001	0.011	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.005	0.000
5	osd	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000
6	c_b	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	pfb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	ocr	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.001	0.000
9	ctl	0.001	0.002	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
10	oap	0.000	0.002	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.001	0.000	0.000	0.001	0.000
11	rmk	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	wol	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	frs	0.001	0.002	0.000	0.000	0.001	0.000	0.001	0.001	0.002	0.001	0.000	0.000	0.001	0.001
14	fsh	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.004	0.000	0.000	0.001	0.000	0.001	0.000
15	coa	0.008	0.034	0.000	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.001
16	oil	0.078	0.070	0.000	0.001	0.061	0.177	0.121	0.000	0.010	0.199	0.012	0.000	0.050	0.090

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
17	gas	0.008	0.000	0.000	0.000	0.006	0.399	0.014	0.000	0.000	0.034	0.000	0.000	0.007	0.001
18	oxt	0.008	0.009	0.001	0.000	0.001	0.003	0.002	0.000	0.000	0.001	0.000	0.000	0.001	0.001
19	cmt	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000
20	omt	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.001	0.000
21	vol	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0.000
22	mil	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
23	pcr	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000
24	sgr	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
25	ofd	0.002	0.007	0.000	0.001	0.001	0.000	0.010	0.004	0.000	0.001	0.003	0.000	0.004	0.001
26	b_t	0.001	0.011	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.005	0.000
27	tex	0.001	0.014	0.001	0.000	0.002	0.000	0.008	0.000	0.000	0.000	0.002	0.000	0.004	0.000
28	wap	0.000	0.008	0.001	0.002	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.000	0.002	0.001
29	lea	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000
30	lum	0.002	0.004	0.001	0.001	0.004	0.000	0.001	0.001	0.000	0.002	0.001	0.000	0.003	0.000
31	ppp	0.010	0.015	0.014	0.002	0.010	0.000	0.009	0.003	0.000	0.009	0.005	0.001	0.011	0.002
32	p_c	0.240	0.367	0.227	0.422	0.300	0.693	0.269	0.002	0.069	0.366	0.198	0.100	0.324	0.100
33	chm	0.005	0.037	0.009	0.008	0.004	0.000	0.035	0.000	0.000	0.007	0.004	0.001	0.016	0.003

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
34	bph	0.001	0.001	0.000	0.001	0.000	0.000	0.009	0.000	0.000	0.001	0.002	0.000	0.001	0.000
35	rpp	0.006	0.022	0.010	0.004	0.004	0.000	0.036	0.001	0.000	0.009	0.007	0.001	0.019	0.004
36	nmm	0.003	0.011	0.003	0.001	0.004	0.000	0.001	0.001	0.000	0.005	0.003	0.000	0.002	0.005
37	i_s	0.009	0.043	0.032	0.007	0.002	0.001	0.001	0.001	0.000	0.003	0.001	0.000	0.008	0.000
38	nfm	0.006	0.024	0.004	0.002	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001
39	fmp	0.008	0.017	0.005	0.007	0.007	0.000	0.005	0.001	0.000	0.004	0.001	0.001	0.003	0.000
40	ele	0.004	0.024	0.005	0.004	0.002	0.000	0.001	0.002	0.000	0.004	0.002	0.001	0.008	0.001
41	eeq	0.001	0.023	0.004	0.004	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.008	0.000
42	ome	0.002	0.043	0.007	0.008	0.002	0.000	0.004	0.001	0.000	0.003	0.002	0.001	0.010	0.000
43	mvh	0.002	0.018	0.037	0.002	0.001	0.000	0.005	0.040	0.000	0.002	0.000	0.000	0.060	0.001
44	otn	0.084	0.108	0.089	0.009	0.001	0.000	0.036	0.007	0.001	0.000	0.002	0.042	0.022	0.042
45	omf	0.001	0.005	0.003	0.003	0.002	0.000	0.001	0.001	0.002	0.002	0.004	0.000	0.005	0.004
46	ely	0.012	0.030	0.026	0.010	0.012	0.073	0.005	0.003	0.002	0.008	0.015	0.003	0.024	0.006
47	gdt	0.002	0.000	0.000	0.000	0.003	0.058	0.004	0.000	0.009	0.006	0.001	0.000	0.003	0.001
48	wtr	0.004	0.006	0.007	0.001	0.002	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003
49	cns	0.020	0.007	0.009	0.002	0.021	0.000	0.004	0.000	0.001	0.031	0.000	0.002	0.002	0.000
50	trd	0.057	0.060	0.033	0.017	0.049	0.008	0.073	0.013	0.013	0.060	0.044	0.014	0.053	0.013

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
51	afs	0.012	0.015	0.001	0.006	0.012	0.000	0.019	0.003	0.002	0.011	0.011	0.005	0.016	0.003
52	otp	0.031	0.025	0.021	0.005	0.011	0.001	0.011	0.003	0.002	0.024	0.005	0.005	0.023	0.001
53	wtp	0.003	0.003	0.003	0.001	0.001	0.000	0.007	0.003	0.000	0.004	0.001	0.004	0.002	0.000
54	**atp**	**1.003**	**1.004**	**1.004**	**1.001**	**1.006**	**1.000**	**1.002**	**1.001**	**1.000**	**1.017**	**1.001**	**1.003**	**1.026**	**1.001**
55	whs	0.027	0.119	0.122	0.025	0.015	0.004	0.032	0.027	0.002	0.233	0.009	0.109	0.310	0.009
56	cmn	0.050	0.019	0.038	0.010	0.080	0.000	0.025	0.004	0.004	0.042	0.027	0.007	0.032	0.012
57	ofi	0.032	0.088	0.016	0.027	0.038	0.000	0.041	0.004	0.001	0.089	0.038	0.006	0.061	0.002
58	ins	0.008	0.017	0.004	0.004	0.006	0.005	0.011	0.002	0.000	0.003	0.008	0.001	0.004	0.000
59	rsa	0.024	0.011	0.019	0.011	0.034	0.000	0.004	0.002	0.000	0.010	0.014	0.005	0.009	0.003
60	obs	0.200	0.063	0.192	0.017	0.335	0.002	0.044	0.024	0.001	0.042	0.202	0.028	0.065	0.043
61	ros	0.102	0.057	0.089	0.004	0.021	0.000	0.089	0.030	0.041	0.046	0.015	0.018	0.079	0.002
62	osg	0.003	0.002	0.005	0.008	0.002	0.000	0.002	0.000	0.000	0.001	0.000	0.001	0.001	0.001
63	edu	0.003	0.004	0.009	0.000	0.002	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.001
64	hht	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000
65	dwe	0.000	0.014	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Total		2.092	2.498	2.054	1.643	2.077	2.429	1.974	1.208	1.165	2.297	1.650	1.364	2.307	1.366

Notes: Red cells represent the top 10 sectors with the highest multiplier effects.
Source: Authors' calculations.

Next, this study calculates the output and value-added multiplier impacts for each country. Multiplier impacts describe the economy-wide impact of a certain injection or shock on economic indicators, such as value added and output. For example, the output multiplier measures the total output that is potentially generated by each additional $1 of the final demand for a particular industry. Table 6 shows the output multiplier effects of the air transport sector that have been decomposed into specific sectors.

For every unit increase in final demand for the air transport sector in each country, output for each sector will increase by the respective values in Table 7. For example, the output multiplier for the air transport sector in Australia is 2.092, and this is mostly contributed by air transport (1.00), petroleum and coal products (0.34), business services (0.20) and recreational and other services (0.10).

Among the study countries, China (2.50) has the largest output multiplier for the air transport sector, followed by Brunei Darussalam (2.43), Thailand (2.31), and Malaysia (2.30). This value means that for every $1 increase in the final demand for the air transport sector in China, the output for China will increase by $2.50. Meanwhile, the Lao PDR (1.17) and Cambodia (1.21) have the lowest output multipliers for the air transport sector. The varying values of the output multiplier show that the implications and contribution of the air transport sector varies by country. It is essential to note that changes in output do not necessarily mean changes in GDP, as some portion of output is contributed by imported input.

To understand the multiplier effects on domestic GDP, this study calculates the value-added multiplier. The value-added multiplier for the air transport sector is shown in Table 8. The value-added multiplier measures the impact of additional demand of a certain sector (i.e. the air transport sector) on the economy (i.e. the GDP). From Table 8, it can be seen that all countries have a value of less than 1, which means that for each $1 increase in final demand, the value added for that country will increase by less than $1. This is due to the imported input being consumed in the economy. In addition, some countries have higher value-added multipliers compared to other countries. For example, Australia, Brunei Darussalam, and China have the highest value-added multipliers, while Singapore has the lowest. In terms of sector decomposition, the air transport sector in most countries has the highest value-added multiplier effects compared to other sectors, except Brunei Darussalam, Malaysia, New Zealand, Singapore, and Thailand.

Table 8: Value-Added Multiplier Effects for the Air Transport Sector in the Domestic Economy

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
1	pdr	0.000	0.001	0.000	0.000	0.000	0.000	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2	wht	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	gro	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	v_f	0.000	0.008	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.003	0.000
5	osd	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000
6	c_b	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	pfb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	ocr	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.001	0.000
9	ctl	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
10	oap	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000
11	rmk	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	wol	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	frs	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.002	0.001	0.000	0.000	0.000	0.000
14	fsh	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.003	0.000	0.000	0.001	0.000	0.000	0.000
15	coa	0.004	0.018	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.001
16	oil	0.051	0.036	0.000	0.001	0.028	0.162	0.108	0.000	0.000	0.155	0.009	0.000	0.031	0.053

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
17	gas	0.006	0.000	0.000	0.000	0.003	0.340	0.013	0.000	0.000	0.027	0.000	0.000	0.005	0.001
18	oxt	0.005	0.004	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000
19	cmt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	omt	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	vol	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	mil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	pcr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	sgr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	ofd	0.001	0.001	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.001	0.000	0.001	0.000
26	b_t	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
27	tex	0.000	0.002	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.001	0.000
28	wap	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
29	lea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	lum	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000
31	ppp	0.004	0.003	0.004	0.001	0.004	0.000	0.003	0.000	0.000	0.002	0.001	0.000	0.003	0.000
32	p_c	0.015	0.015	0.006	0.012	0.007	0.060	0.024	0.001	0.003	0.015	0.015	0.002	0.021	0.005
33	chm	0.001	0.005	0.001	0.001	0.001	0.000	0.009	0.000	0.000	0.001	0.001	0.000	0.003	0.001

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
34	bph	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.001	0.000	0.001	0.000
35	rpp	0.002	0.005	0.002	0.001	0.002	0.000	0.013	0.000	0.000	0.002	0.002	0.000	0.007	0.001
36	nmm	0.001	0.002	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.002	0.001	0.000	0.001	0.002
37	i_s	0.002	0.007	0.005	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
38	nfm	0.001	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39	fmp	0.003	0.003	0.001	0.002	0.002	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000
40	ele	0.001	0.004	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000
41	eeq	0.000	0.004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
42	ome	0.001	0.008	0.002	0.002	0.001	0.000	0.002	0.000	0.000	0.001	0.000	0.000	0.002	0.000
43	mvh	0.001	0.003	0.006	0.001	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.010	0.000
44	otn	0.030	0.021	0.016	0.002	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.014	0.005	0.012
45	omf	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.001	0.001
46	ely	0.005	0.009	0.004	0.003	0.007	0.006	0.001	0.000	0.000	0.001	0.008	0.001	0.009	0.003
47	gdt	0.001	0.000	0.000	0.000	0.001	0.031	0.002	0.000	0.005	0.003	0.001	0.000	0.001	0.001
48	wtr	0.002	0.003	0.003	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.002	0.001	0.002	0.001
49	cns	0.006	0.002	0.003	0.001	0.006	0.000	0.001	0.000	0.000	0.009	0.000	0.000	0.000	0.000
50	trd	0.030	0.036	0.017	0.008	0.026	0.006	0.048	0.009	0.008	0.028	0.031	0.007	0.041	0.007

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
51	afs	0.005	0.003	0.000	0.002	0.006	0.000	0.006	0.001	0.001	0.002	0.002	0.002	0.006	0.001
52	otp	0.013	0.009	0.007	0.002	0.004	0.000	0.004	0.001	0.001	0.008	0.002	0.002	0.005	0.000
53	wtp	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.000
54	**atp**	**0.207**	**0.206**	**0.190**	**0.236**	**0.120**	**0.018**	**0.120**	**0.200**	**0.251**	**0.070**	**0.203**	**0.055**	**0.089**	**0.123**
55	whs	0.012	0.051	0.058	0.011	0.007	0.003	0.016	0.016	0.002	0.100	0.005	0.062	0.147	0.005
56	cmn	0.017	0.007	0.017	0.004	0.034	0.000	0.016	0.003	0.002	0.019	0.016	0.002	0.017	0.007
57	ofi	0.023	0.051	0.009	0.016	0.022	0.000	0.030	0.002	0.000	0.038	0.025	0.003	0.040	0.002
58	ins	0.004	0.006	0.002	0.002	0.002	0.005	0.008	0.001	0.000	0.001	0.005	0.001	0.003	0.000
59	rsa	0.011	0.006	0.010	0.007	0.019	0.000	0.002	0.001	0.000	0.005	0.007	0.003	0.004	0.002
60	obs	0.094	0.025	0.090	0.009	0.174	0.001	0.017	0.006	0.001	0.022	0.120	0.012	0.025	0.023
61	ros	0.046	0.028	0.041	0.002	0.010	0.000	0.045	0.016	0.006	0.017	0.008	0.009	0.027	0.001
62	osg	0.002	0.001	0.003	0.005	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.001
63	edu	0.002	0.003	0.005	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.001
64	hht	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65	dwe	0.000	0.010	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Total		0.614	0.631	0.511	0.337	0.501	0.637	0.544	0.271	0.284	0.541	0.476	0.179	0.527	0.259

Note: Red cells represent the top 10 sectors with the highest multiplier effects.
Source: Authors' calculations.

4.4. Air Transport Demand Reduction Analysis

This study simulates the potential sector impacts of demand-side perturbations on the air transport sector due to the pandemic by reducing demand for the air transport sector and investigating its sector impact on all other sectors. Table 9 shows the sector inoperability focusing on ASEAN Plus Five, and the red represents highest inoperability in each country. It is clear that the most affected sector is the air transport sector, as the inoperability rates in the air transport sector are higher compared to the simulation rate. This is contributed by the indirect effects due to intradependency (i.e. dependency within itself) and interdependency (i.e. dependency with other sectors) of the air transport sector. For example, a 52.0% final demand reduction on the air transport sector for Thailand due to the pandemic will cause additional demand reduction in the air transport sector due to sector dependency by 1.8%. The sum of the demand reduction is equal to the inoperability rate obtained (i.e. 53.8%). Thailand has the highest inoperability in the air transport sector, followed by Malaysia (52.3%) and Korea (52.2%).

In addition, oil (16), petroleum and coal products (32), and warehousing and support activities (55) are other sectors with the highest inoperability. This can be explained from the high sector linkages and multiplier effects for these sectors. In terms of countries, the Lao PDR, Philippines, and Viet Nam have the highest average inoperability, while Japan and Korea have the lowest average inoperability.

Once the inoperability is obtained, this study then calculates the economic loss from sector inoperability (Table 10). As expected, the air transport sector has the largest economic loss for all countries, except Brunei Darussalam. This is due to higher inoperability in air transport sectors compared to other sectors. However, Brunei Darussalam has more output loss in the oil (16) sector compared to the air transport sector. One possible explanation is Brunei Darussalam has higher oil sector output, as it is a main source of the country’s income. Thus, a slight reduction in the air transport sector can lead to a larger reduction in the output of the oil sector.

Table 8: Inoperability due to Air Transport Perturbations

(%)

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
1	pdr	0.30	0.07	0.01	0.06	0.35	1.00	0.14	0.16	0.00	0.08	0.01	0.13	0.07	0.02
2	wht	0.11	0.07	0.01	0.07	0.10	0.26	0.10	0.19	0.05	0.10	0.04	0.20	0.12	0.03
3	gro	0.09	0.15	0.02	0.07	0.13	0.37	0.11	0.32	0.03	0.24	0.05	0.49	0.18	0.03
4	v_f	0.12	0.11	0.01	0.04	0.08	0.29	0.07	0.26	0.01	0.07	0.06	0.09	0.24	0.06
5	osd	0.15	0.12	0.02	0.06	0.12	0.19	0.10	0.20	0.03	0.22	0.04	0.17	0.31	0.04
6	c_b	0.13	0.07	0.02	0.03	0.15	0.99	0.03	0.19	0.01	0.18	0.08	0.69	0.20	0.03
7	pfb	0.12	0.14	0.06	0.07	0.11	0.24	0.16	0.11	0.01	0.14	0.17	0.15	0.21	0.11
8	ocr	0.15	0.26	0.10	0.11	0.14	0.78	0.24	0.48	0.09	0.25	0.19	0.18	0.47	0.15
9	ctl	0.12	0.15	0.02	0.06	0.12	1.07	0.13	0.27	0.01	0.31	0.02	0.07	0.31	0.02
10	oap	0.14	0.05	0.02	0.06	0.11	0.63	0.14	0.22	0.00	0.27	0.01	0.05	0.08	0.02
11	rmk	0.12	0.04	0.01	0.03	0.10	1.06	0.04	0.29	0.01	0.04	0.01	0.15	0.18	0.01
12	wol	0.13	0.12	0.05	0.04	0.18	0.15	0.20	0.13	0.08	0.08	0.08	0.09	0.21	0.06
13	frs	0.27	0.15	0.12	0.13	0.26	0.09	0.14	0.25	0.21	0.36	0.06	0.22	0.36	0.19
14	fsh	0.11	0.08	0.02	0.07	0.14	0.10	0.07	0.30	0.00	0.05	0.04	0.13	0.18	0.03
15	coa	1.23	0.82	0.37	0.92	2.26	0.13	1.18	0.64	0.27	0.65	0.58	0.37	0.64	0.37
16	oil	8.27	2.72	1.92	4.93	12.26	6.39	5.01	4.32	4.53	9.86	8.92	8.79	5.98	4.62

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
17	gas	0.85	0.92	0.13	0.26	1.46	1.40	1.34	3.11	1.31	1.98	1.95	1.15	2.28	2.05
18	oxt	0.33	0.20	0.27	0.16	0.34	0.37	0.18	0.26	0.23	0.46	0.21	0.31	0.26	0.30
19	cmt	0.08	0.14	0.01	0.06	0.07	0.01	0.19	0.48	0.00	0.25	0.04	0.01	0.35	0.06
20	omt	0.11	0.05	0.01	0.08	0.13	0.00	0.12	0.43	0.00	0.05	0.01	0.01	0.08	0.04
21	vol	0.11	0.12	0.03	0.13	0.13	0.11	0.07	0.29	0.00	0.18	0.06	0.12	0.32	0.05
22	mil	0.09	0.04	0.01	0.03	0.06	0.05	0.02	0.42	0.03	0.04	0.04	0.08	0.20	0.02
23	pcr	0.29	0.07	0.01	0.05	0.13	0.04	0.06	0.14	0.00	0.03	0.01	0.01	0.07	0.02
24	sgr	0.10	0.14	0.03	0.06	0.10	0.07	0.03	0.20	0.10	0.12	0.08	0.12	0.19	0.02
25	ofd	0.08	0.06	0.01	0.07	0.07	0.04	0.15	0.24	0.00	0.09	0.06	0.12	0.18	0.05
26	b_t	0.12	0.19	0.01	0.08	0.11	0.05	0.06	0.37	0.01	0.10	0.06	0.12	0.41	0.02
27	tex	0.23	0.14	0.17	0.16	0.36	0.25	0.23	0.10	0.04	0.21	0.20	0.17	0.29	0.11
28	wap	0.18	0.11	0.11	0.19	0.06	0.17	0.09	0.07	0.05	0.08	0.13	0.55	0.18	0.07
29	lea	0.29	0.07	0.05	0.17	0.08	0.64	0.12	0.06	0.03	0.27	0.13	0.11	0.22	0.06
30	lum	0.25	0.14	0.17	0.30	0.30	0.11	0.10	0.26	0.19	0.31	0.20	0.16	0.33	0.19
31	ppp	0.46	0.26	0.27	0.26	0.78	0.49	0.51	1.11	0.73	0.92	0.63	0.52	1.16	0.25
32	p_c	8.97	2.77	1.96	4.95	13.37	9.55	5.46	13.26	2.99	11.54	9.32	8.80	5.99	4.34
33	chm	0.41	0.22	0.26	0.30	0.40	0.34	0.49	0.36	0.31	0.41	0.27	0.35	0.49	0.21
34	bph	0.26	0.03	0.02	0.10	0.16	0.03	1.04	1.21	0.07	0.35	0.33	0.17	0.29	0.08

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
35	rpp	0.51	0.25	0.28	0.27	0.45	0.76	0.79	0.55	0.31	0.52	0.60	0.42	0.70	0.34
36	nmm	0.21	0.09	0.15	0.11	0.36	0.17	0.05	0.26	0.03	0.40	0.22	0.13	0.18	0.16
37	i_s	0.60	0.21	0.37	0.33	0.50	0.72	0.15	1.28	0.54	0.44	0.29	0.39	0.65	0.56
38	nfm	0.38	0.23	0.24	0.28	0.45	0.18	0.26	0.46	0.38	0.35	0.28	0.32	0.36	0.27
39	fmp	0.39	0.21	0.18	0.30	0.44	0.21	0.08	0.72	0.30	0.33	0.33	0.36	0.46	0.32
40	ele	0.33	0.21	0.18	0.20	0.35	0.16	0.19	0.35	0.21	0.22	0.21	0.21	0.23	0.22
41	eeq	0.33	0.23	0.19	0.23	0.25	0.30	0.26	0.42	0.30	0.28	0.26	0.25	0.47	0.23
42	ome	0.27	0.22	0.19	0.29	0.22	0.24	0.39	0.37	0.24	0.35	0.24	0.27	0.48	0.25
43	mvh	0.15	0.11	0.28	0.12	0.17	0.11	0.29	3.11	0.18	0.09	0.25	0.19	0.87	0.17
44	otn	6.99	2.04	2.35	1.69	1.46	0.89	1.76	2.48	1.98	1.37	0.98	5.05	2.18	1.20
45	omf	0.13	0.14	0.12	0.28	0.22	0.17	0.17	0.19	0.30	0.26	0.31	0.20	0.26	0.21
46	ely	0.47	0.32	0.27	0.37	0.54	0.91	0.27	0.65	0.40	0.66	0.54	0.71	0.86	0.21
47	gdt	1.10	0.21	0.04	0.12	1.34	1.62	0.42	0.48	0.98	0.67	0.54	0.24	0.74	0.23
48	wtr	0.23	0.18	0.17	0.19	0.18	0.04	0.34	0.33	0.33	0.38	0.27	0.51	0.47	0.27
49	cns	0.09	0.01	0.04	0.02	0.15	0.00	0.02	0.03	0.01	0.50	0.00	0.06	0.04	0.00
50	trd	0.31	0.26	0.11	0.20	0.44	0.27	0.42	0.45	0.23	0.55	0.32	0.68	0.50	0.18
51	afs	0.21	0.31	0.02	0.15	0.33	0.15	0.48	0.65	0.19	0.58	0.25	0.69	0.58	0.12
52	otp	0.37	0.20	0.16	0.17	0.45	0.23	0.36	0.33	0.16	1.40	0.17	0.25	0.66	0.18

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
53	wtp	0.60	0.15	0.09	0.09	0.28	0.20	0.34	0.76	0.26	0.35	0.27	0.23	0.31	0.13
54	**atp**	51.38	50.31	50.32	52.24	50.55	50.33	49.22	45.49	51.28	52.25	47.25	48.43	53.81	45.22
55	whs	1.56	2.17	4.24	2.15	3.50	1.71	3.41	11.53	4.74	22.26	3.32	10.26	21.66	5.44
56	cmn	0.49	0.17	0.17	0.18	0.77	0.02	0.72	0.87	0.31	1.19	0.48	0.39	1.50	0.34
57	ofi	0.31	0.42	0.18	0.46	0.73	0.11	0.88	1.10	0.37	1.90	0.57	0.42	1.97	0.36
58	ins	0.36	0.64	0.09	0.17	0.43	0.52	1.87	1.80	0.45	0.27	0.57	0.40	0.58	0.38
59	rsa	0.51	0.22	0.18	0.22	0.69	0.15	0.49	0.96	0.24	1.07	1.22	0.86	1.31	0.44
60	obs	1.04	0.36	0.55	0.25	1.83	0.08	2.93	3.71	0.26	1.29	4.24	0.70	2.49	1.06
61	ros	1.59	0.60	0.56	0.27	0.91	0.77	1.81	1.76	0.63	4.14	0.73	1.52	2.45	0.72
62	osg	0.09	0.04	0.04	0.10	0.07	0.02	0.09	0.46	0.13	0.12	0.04	0.23	0.10	0.17
63	edu	0.06	0.05	0.09	0.01	0.07	0.03	0.06	0.13	0.07	0.12	0.01	0.15	0.07	0.09
64	hht	0.01	0.01	0.00	0.02	0.01	0.00	0.01	0.02	0.00	0.04	0.00	0.06	0.02	0.01
65	dwe	0.00	0.13	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.06	0.00	0.00	0.01	0.00
Average		1.47	1.47	1.10	1.05	1.16	1.58	1.36	1.33	1.73	1.19	1.92	1.37	1.53	1.85

Notes: Red represent the top 5 sectors with the highest inoperability.
Source: Authors' calculations.

Table 9: Output Loss due to Air Transport Perturbations

($ million)

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
1	pdr	0.8	57.6	2.5	5.6	0.0	0.0	48.2	2.3	0.1	0.6	1.0	0.0	9.1	2.2
2	wht	8.6	32.5	0.0	1.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	gro	2.9	159.2	0.0	0.6	0.3	0.0	6.2	0.3	0.0	0.1	1.0	0.0	1.8	0.4
4	v_f	8.9	558.0	2.1	6.1	2.1	0.0	12.6	1.6	0.1	0.7	3.3	0.1	47.6	3.2
5	osd	4.6	73.2	0.1	0.5	0.0	0.0	19.9	0.3	0.0	33.8	1.0	0.0	2.4	0.5
6	c_b	1.6	46.8	0.1	0.1	0.0	0.0	0.8	0.1	0.0	1.5	1.3	0.0	4.2	0.4
7	pfb	3.1	27.7	0.0	0.3	0.1	0.0	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.5
8	ocr	0.7	83.4	6.2	0.5	0.3	0.0	15.8	2.8	0.2	5.5	1.1	0.5	9.6	6.4
9	ctl	15.6	126.0	0.5	2.8	5.2	0.0	4.5	1.0	0.1	0.4	0.2	0.0	2.8	0.1
10	oap	6.3	123.6	3.5	5.8	0.9	0.1	16.4	2.3	0.0	14.0	1.3	0.0	7.0	1.9
11	rmk	5.1	8.5	0.5	0.5	10.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.6	0.1
12	wol	4.8	8.2	0.1	0.3	1.3	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.4	0.0
13	frs	14.6	108.1	6.6	3.0	8.1	0.0	13.3	1.2	3.3	16.7	2.2	0.0	4.8	5.3
14	fsh	4.2	119.4	2.6	4.4	1.7	0.0	10.8	4.7	0.0	2.2	3.5	0.2	9.0	2.8
15	coa	777.6	1,670.9	0.2	1.8	12.7	0.0	470.8	0.0	0.0	1.3	3.2	0.0	2.8	12.8
16	oil	1,090.4	3,266.0	9.3	18.9	174.2	251.3	1,300.4	0.0	4.2	1,921.6	40.8	7.8	432.2	500.3
17	gas	156.1	20.0	0.0	0.0	14.7	79.7	270.3	0.0	0.0	321.2	0.8	0.0	60.2	2.0
18	oxt	382.4	641.4	22.0	7.9	4.0	1.4	49.1	0.5	1.2	16.0	11.3	1.3	13.9	6.3

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
19	cmt	11.8	50.3	1.0	6.9	4.7	0.0	7.7	0.8	0.0	0.1	1.0	0.1	6.7	0.2
20	omt	3.3	108.0	1.7	6.4	1.3	0.0	7.9	2.6	0.0	0.4	1.0	0.1	8.7	0.4
21	vol	2.5	146.5	2.3	3.2	0.2	0.0	24.0	0.3	0.0	60.5	1.5	0.5	9.8	0.5
22	mil	12.0	23.1	2.0	2.0	9.1	0.0	0.9	0.2	0.0	1.0	1.5	0.6	5.0	0.3
23	pcr	3.1	98.0	1.5	3.6	0.0	0.0	12.5	1.8	0.0	0.6	1.4	0.0	10.0	2.2
24	sgr	6.8	26.6	2.0	0.8	0.1	0.0	1.1	0.3	0.0	0.4	1.8	0.1	9.0	0.4
25	ofd	31.4	360.3	14.3	39.7	5.8	0.0	94.7	4.8	0.1	13.0	16.6	6.5	47.0	9.8
26	b_t	21.0	539.4	6.9	10.5	4.6	0.0	8.4	0.6	0.1	3.6	4.4	1.6	42.3	1.7
27	tex	10.8	1,083.4	29.9	35.6	4.6	0.0	83.2	0.9	0.0	9.2	9.1	0.8	39.6	13.7
28	wap	6.7	465.0	21.6	46.6	0.3	0.1	10.5	5.6	0.2	1.6	6.4	2.9	19.9	15.5
29	lea	1.8	139.0	1.8	11.5	0.3	0.0	14.3	1.2	0.0	1.3	1.2	1.3	6.8	11.8
30	lum	31.9	312.1	33.9	22.5	14.3	0.0	18.1	1.3	1.3	23.6	6.3	0.7	24.4	5.7
31	ppp	128.6	867.9	315.4	77.4	29.5	0.2	99.0	1.8	0.1	80.4	18.6	29.9	84.9	13.1
32	p_c	2,674.9	17,146.1	5,006.2	7,630.8	721.5	58.6	2,179.8	0.9	8.5	2,721.6	636.8	3,906.2	2,801.2	204.6
33	chm	81.0	2,810.2	568.5	475.3	20.8	0.7	354.0	0.4	0.3	140.9	22.1	167.6	207.5	23.5
34	bph	15.2	60.3	14.3	15.1	2.0	0.0	67.1	0.1	0.0	6.3	6.0	15.8	10.1	1.1
35	rpp	80.1	1,634.2	402.7	189.3	14.2	0.0	321.8	1.2	0.3	121.7	28.9	27.7	215.3	33.6
36	nmm	40.6	730.4	102.6	44.8	10.8	0.3	12.1	0.6	0.0	50.2	9.1	3.9	23.7	20.3
37	i_s	119.7	2,810.2	1,291.4	526.8	9.2	0.3	18.2	0.8	0.0	48.7	11.8	5.0	87.6	16.2
38	nfm	182.7	1,840.4	246.2	129.6	9.6	0.0	42.6	0.5	2.4	27.4	9.4	7.9	24.6	9.3
39	fmp	116.5	1,248.2	211.5	265.6	20.4	0.2	50.3	0.9	0.1	56.6	7.4	29.3	36.9	8.9

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
40	ele	52.2	3,454.3	525.9	552.6	6.2	0.0	29.9	2.4	0.3	296.2	73.0	145.1	178.4	123.0
41	eeq	18.5	1,633.8	266.2	195.1	4.5	0.0	22.6	1.0	0.1	47.9	25.2	16.6	93.6	17.7
42	ome	41.9	2,864.8	616.6	380.6	9.4	0.1	55.8	0.5	0.1	93.7	32.4	49.4	140.0	12.3
43	mvh	28.7	954.0	1,206.4	203.5	2.1	0.0	57.3	23.0	0.0	23.0	3.9	3.3	458.1	5.6
44	otn	893.7	4,807.5	2,023.8	633.6	7.2	0.2	300.7	12.4	0.2	54.9	33.7	474.0	212.1	101.1
45	omf	16.6	450.8	92.8	148.5	5.2	0.2	24.6	0.8	0.4	29.6	15.5	12.1	59.3	26.7
46	ely	187.2	1,550.0	568.6	237.5	34.8	6.8	42.9	2.3	0.9	74.2	53.4	60.0	175.2	19.7
47	gdt	25.8	14.1	0.7	0.4	7.1	6.0	37.7	0.0	3.8	58.6	2.8	0.0	26.8	2.8
48	wtr	57.9	313.0	156.2	40.1	6.1	0.1	11.5	0.8	0.3	22.7	9.3	47.9	20.8	8.2
49	cns	316.1	326.7	234.4	50.9	59.7	0.0	40.6	0.4	0.1	248.9	1.2	41.0	13.5	1.0
50	trd	713.5	2,865.6	870.8	411.3	124.3	2.6	600.4	10.1	2.2	607.2	180.4	362.8	446.4	41.2
51	afs	180.5	737.4	48.0	131.2	36.6	0.3	159.7	3.4	0.4	107.1	42.5	106.5	138.3	8.5
52	otp	424.1	1,286.9	470.4	123.2	32.1	0.3	122.9	3.6	1.0	182.0	26.3	87.7	178.8	6.1
53	wtp	46.8	172.2	68.8	22.9	4.3	0.2	65.4	2.3	0.1	49.1	6.3	94.0	32.0	2.3
54	**atp**	10,221.7	36,332.0	15,596.2	10,469.5	2,248.5	78.2	7,362.4	525.1	49.4	6,650.7	2,958.7	8,164.4	5,962.3	1,302.2
55	whs	439.5	4,929.6	2,633.3	665.6	79.7	6.3	334.8	35.3	5.7	1,611.5	128.3	1,655.0	2,091.7	43.9
56	cmn	606.2	916.0	735.1	193.2	204.2	0.2	203.0	2.8	0.6	323.7	92.3	146.5	224.4	26.7
57	ofi	444.5	3,804.9	345.7	389.9	103.1	0.4	327.7	2.7	0.1	658.2	125.4	196.9	405.2	10.2
58	ins	97.2	671.9	88.1	75.1	17.2	1.8	85.8	1.3	0.1	30.5	26.0	47.5	31.7	3.7
59	rsa	335.4	586.3	401.2	203.4	107.7	0.7	40.3	2.6	0.0	100.1	51.7	149.6	74.9	9.8
60	obs	2,305.5	2,988.1	3,486.4	406.0	812.2	1.1	347.4	13.6	0.2	348.5	630.8	605.4	469.9	77.6

Sector	Code	AUS	CHN	JPN	KOR	NZL	BRN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
61	ros	1,215.4	2,604.5	1,517.6	155.4	106.6	0.4	731.4	46.0	7.1	418.2	74.5	288.2	634.2	19.8
62	osg	99.4	215.6	143.9	113.9	9.8	0.3	32.6	1.6	0.5	22.1	6.1	49.1	23.0	10.0
63	edu	52.1	223.9	299.0	14.2	6.4	0.2	12.9	0.4	0.2	13.5	1.3	26.1	9.9	4.3
64	hht	15.6	46.8	18.4	24.4	1.7	0.0	4.0	0.1	0.0	8.1	0.8	16.5	4.4	0.8
65	dwe	0.5	598.1	0.8	0.5	0.1	0.0	49.3	0.0	0.0	5.9	0.1	0.0	0.8	0.0
Total		24,907.4	114,978.5	40,749.2	25,447.1	5,155.9	499.7	16,771.5	739.3	97.0	17,790.8	5,476.4	17,064.1	16,435.3	2,822.9

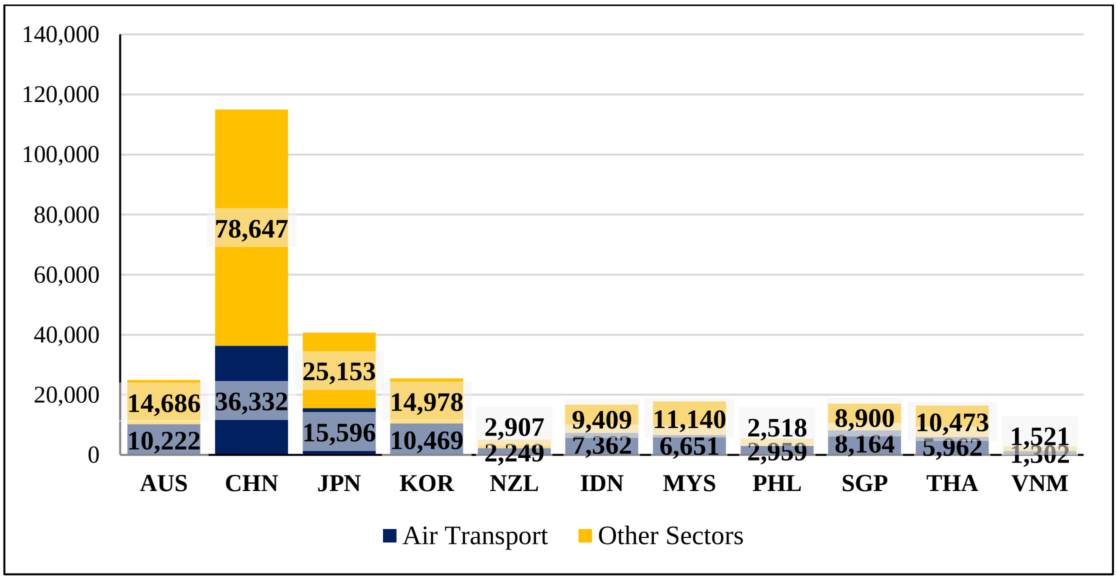
Note: Red represent the top 5 sectors with the output loss in each country.
Source: Authors' calculations.

For most countries, petroleum and coal products (32) have the largest loss in output after the air transport sector, followed by warehousing and support activities (55). This can be caused by a high dependency on the air transport sector and significantly higher output compared to other sectors. However, primary sectors such as information and communications technology services, public administration, defence and social security, education, health and social work, and farming are amongst the sectors with lowest output loss.

In terms of countries, the Lao PDR had the lowest output loss ($97 million), while China recorded the highest output loss – $115 billion – mainly composed of the air transport sector ($36.3 billion), petroleum and coal products ($17.1 billion), warehousing and support activities ($4.9 billion), and transport equipment ($4.8 billion). However, the output loss is not equal to the GDP (i.e. value-added) loss. This is due to imported inputs that do not contribute to country GDP. Thus, Figure 5 shows the value-added loss for the air transport sector and other sectors in the economy.

Figure 5: Value-Added Loss from Air Transport and Other Sectors

($ million)



Source: Authors' calculations.

Figure 5 shows that China has the largest value ($28.9 billion), followed by Japan ($10.2 billion) and Australia ($7.9 billion). The value-added loss for Brunei Darussalam, Cambodia, and Lao PDR have been excluded from Figure 5 due to relatively small values that could not be seen clearly. Although these countries have a smaller value-added loss, it is important to note that this is due to their smaller GDPs.

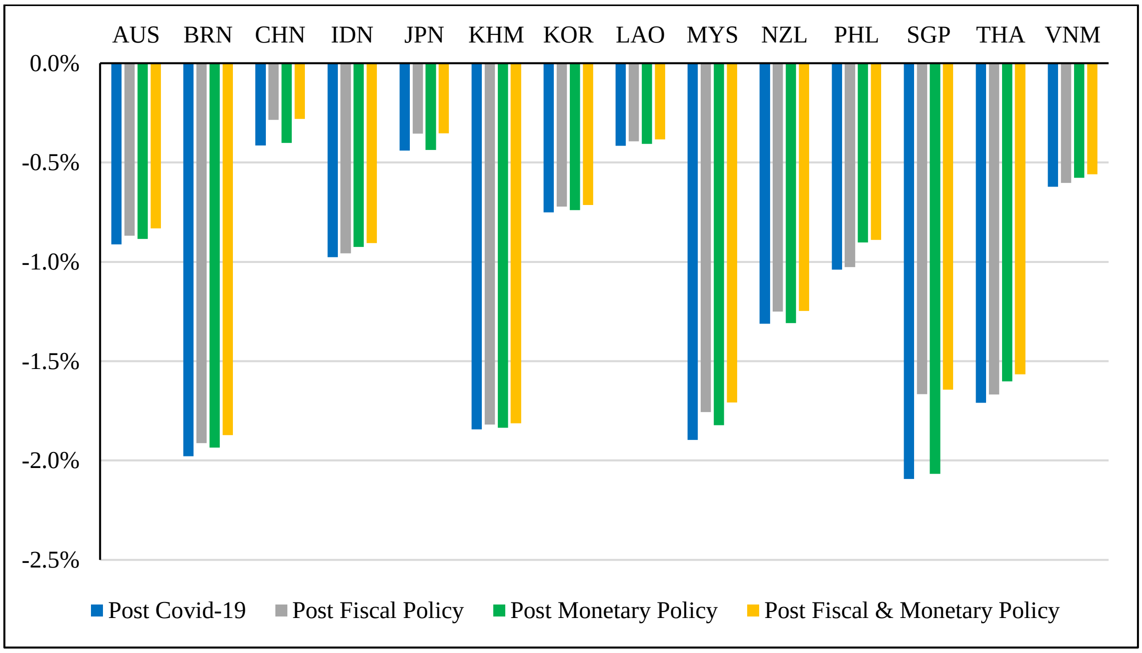
The air transport sector in most countries dominates value-added loss except in Brunei Darussalam, Indonesia, Malaysia, and Viet Nam that have higher value-added losses in the oil sector.

4.5. Fiscal and Monetary Policy Impact

This study simulates the potential implications of the fiscal and monetary policy conducted by ASEAN Plus Five in reducing the negative effect of the pandemic. As noted previously, the fiscal policies that are of concern comprise direct tax and indirect tax policies. Detailed information on country fiscal policies was obtained from IATA (2020c). Information on each country's monetary policies was obtained from the International Monetary Fund (2021). Although there are various monetary policy tools, this study focused on interest rate reductions for simplicity.

The outcome of the fiscal and monetary policy simulations are explained in terms of the value-added (i.e. GDP) growth. Figure 6 shows the overall GDP growth from each simulation, where the post-pandemic scenario has the highest negative GDP growth due to the assumption of no government intervention. Overall, the distortion in the air transport demand itself can reduce GDP growth up to around 2% for countries like Brunei Darussalam, Cambodia, Malaysia, and Singapore. This shows the importance of the air transport sector in supporting domestic economies. The post-pandemic fiscal policy has slightly improved GDP growth due to tax reductions that led to higher consumption in the economy. Most countries have lower negative GDP growth in fiscal policy compared to monetary policy. This does not necessarily mean that the fiscal policy is better than the monetary policy but represents that the simulation scenario is heterogenous amongst countries.

Figure 6: Gross Domestic Product Growth from Simulation Scenario

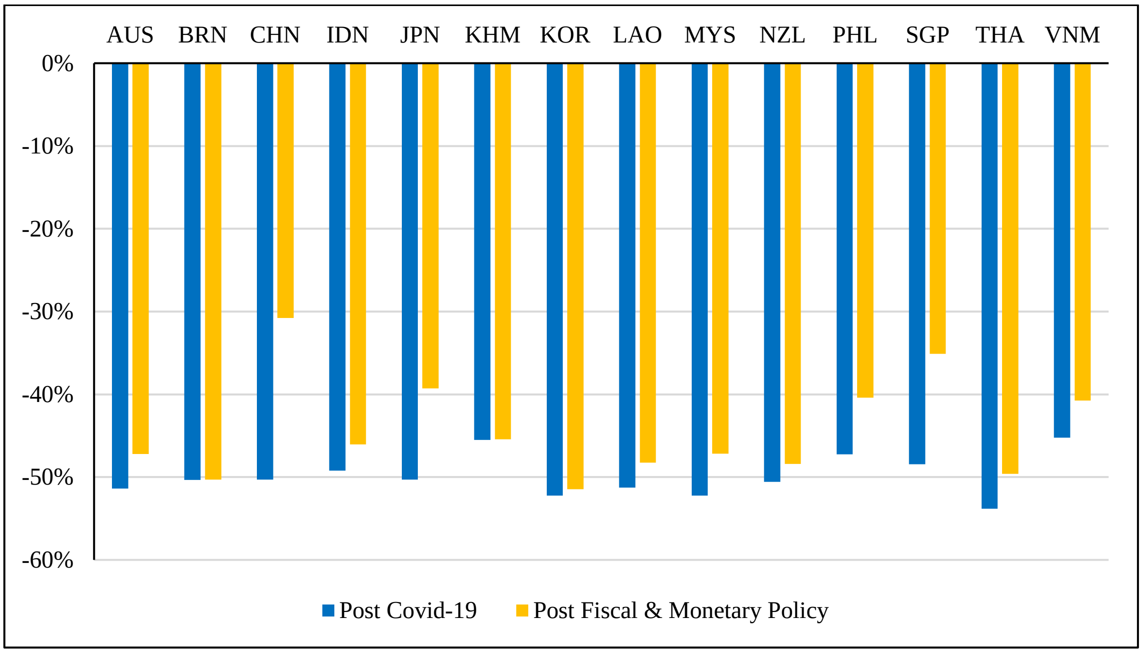


Source: Authors' calculations.

Next, this study looks into the value-added growth for the air transport sector post-pandemic and post-government policies (Figure 7). Unlike the overall economy that has a lower impact, the air transport sector clearly has higher value-added implications. This can be seen from high negative growth. In addition, the simulation output shows that the implementation of fiscal and monetary policies can minimise the negative impact of air transport perturbations on its value added. This supports the idea that intervention policies are necessary in ensuring that the firms are able to withstand the pandemic.

China has the highest negative impact reduction, and this can be explained from the fiscal and monetary policy implemented by the Government of China. China was the first country with a COVID-19 outbreak and has recovered successfully. Thus, the outcome of this study supports measures taken by the government in minimising the negative impact of the reduction in demand for the air transport sector.

Figure 7: Air Transport Value-Added Growth from Simulation Scenario



Source: Authors’ calculations.

5. Conclusion

This study is timely for the aviation industry, which has been heavily affected by the fear of infection and movement controls in most countries. The research finds that first, the aviation industry is a key sector in domestic and regional economic activities. The backwards and forward linkages clearly depict the high interdependence of other sectors with the aviation industry, and the interdependence between countries is stronger if compared to the domestic economy. The output multiplier effect and value-added multiplier also confirm the aviation industry's crucial role in the regional and domestic economy.

The pandemic has caused a substantial output and value-added loss for all countries due to a reduction in consumer demand in the air transport sector. The pandemic is estimated to cause GDP reduction of 0.41% to 2.09%. Government intervention through fiscal and monetary policy has mitigated the severe impact of the pandemic; it is expected to moderate the GDP and value-added losses as well. For instance, the value-added loss could be minimised from 50% to 31% in China, 49% to 46% in Indonesia, and 52% to 47% in Malaysia. Thus, a sound policy prescription for the aviation industry is of utmost importance. The failure to provide the financial support the aviation industry slows down the economic recovery plan.

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Appendix 1: Sectors in the Input–Output Table, 2014

Sector	Sector Group	Description
1	1	Paddy rice
2	1	Wheat
3	1	Cereal grains nec
4	1	Vegetables, fruit, nuts
5	1	Oil seeds
6	1	Sugar cane, sugar beet
7	1	Plant-based fibres
8	1	Crops nec
9	1	Bovine cattle, sheep and goats, horses
10	1	Animal products nec
11	1	Raw milk
12	1	Wool, silk-worm cocoons
13	1	Forestry
14	1	Fishing
15	2	Coal
16	2	Oil
17	2	Gas
18	2	Other extraction (formerly omn Minerals nec)
19	3	Bovine meat products
20	3	Meat products nec
21	3	Vegetable oils and fats
22	3	Dairy products
23	3	Processed rice
24	3	Sugar
25	3	Food products nec
26	3	Beverages and tobacco products
27	3	Textiles
28	3	Wearing apparel
29	3	Leather products

Sector	Sector Group	Description
30	3	Wood products
31	3	Paper products, publishing
32	3	Petroleum, coal products
33	3	Chemical products
34	3	Basic pharmaceutical products
35	3	Rubber and plastic products
36	3	Mineral products nec
37	3	Ferrous metals
38	3	Metals nec
39	3	Metal products
40	3	Computer, electronic and optical products
41	3	Electrical equipment
42	3	Machinery and equipment nec
43	3	Motor vehicles and parts
44	3	Transport equipment nec
45	3	Manufactures nec
46	4	Electricity
47	4	Gas manufacture, distribution
48	4	Water
49	4	Construction
50	5	Trade
51	6	Accommodation, Food and service activities
52	7	Transport nec
53	7	Water transport
54	8	Air transport
55	7	Warehousing and support activities
56	7	Communication
57	9	Financial services nec
58	9	Insurance (formerly isr)
59	10	Real estate activities

Sector	Sector Group	Description
60	10	Business services nec
61	10	Recreational and other services
62	10	Public Administration and defence
63	10	Education
64	10	Human health and social work activities
65	10	Dwellings

nec = not elsewhere classified.
Source: CGTA (2021b)

Appendix 2: Fiscal Policy Measures

Country	Type of Tax	Fiscal Policy Measures	Simulation Scenarios
Australia	Indirect tax	Any businesses experiencing cash flow difficulties may liaise with the Australian Taxation Office for a request for deferred payment schedules and relief from late goods and services tax payments, penalties, and interest liabilities.	Consumption increases due to deferred tax payments for 6 months by 100%.
Australia	Direct tax	Businesses affected by COVID-19 are eligible to apply for a deferral of payment of their income tax liability and may contact the Australian Taxation Office directly to request a deferral.	Consumption increases due to deferred tax payments for 6 months by 100%.
Brunei Darussalam	Direct tax	Target businesses, including airlines, will get a 50% discount on the corporate income tax for the year of assessment 2020.	Consumption increases due to deferred tax payment for 12 months by 50%.
China	Indirect tax	Exempt value-added tax (VAT) on revenue in providing prescribed services (i.e. transport of key supplies under the pandemic, public transport services) from 1 January 2020.	Consumption increases due to VAT exemption for 12 months by 100%.
China	Direct tax	Corporate income tax payment deferrals are subject to individual application and may	Consumption increases due to deferred tax

Country	Type of Tax	Fiscal Policy Measures	Simulation Scenarios
		be granted through a case-by-case review.	payment for 6 months by 100%
Indonesia	Direct tax	Effective on 31 March 2020, the corporate income tax rate is reduced from 25% to 22% for tax years 2020 and 2021 and to 20% for tax year 2022 onwards.	Consumption increases due to deferred tax payment for 12 months by 12%.
Japan	Indirect tax	Filing deadlines for individual consumption tax returns and payments are delayed by a half month until 16 April 2020. Tax payments, including those for consumption tax, may be deferred for up to 1 year without interest and collateral if gross income decreases by 20% or more.	Consumption increases due to deferred tax payment for 12 months by 100%.
Japan	Direct tax	A 1-year deferral of the fuel tax, corporate income tax, and fixed asset tax can be made by taxpayers/airlines upon request to the tax authority; approval will be made on a case-by-case basis. The general conditions for the tax deferral include a decrease in sales/revenues of at least 20% in any 1 month after 1 February, and the tax payment due date falls 1 February 2020 – 31 January 2021.	Consumption increases due to deferred tax payment for 12 months by 100%.

Country	Type of Tax	Fiscal Policy Measures	Simulation Scenarios
Korea	Direct tax	The aircraft property tax payment is suspended or reduced for full service carriers upon request to the tax authority. Previously, a 50% reduction in the tax was only available to low-cost carriers.	Consumption increases due to deferred tax payment for 12 months by 100%.
Korea	Indirect tax	The VAT return due date may be extended by 3 months for businesses directly affected by COVID-19 upon application to the tax authority.	Consumption increases due to deferred tax payment for 3 months by 100%.
Lao People's Democratic Republic	Direct tax	Companies that have not filed and paid taxes for April, May, and June 2020 will be exempted from the usual penalty of 0.1% of the tax due for each day of delayed payment and a ₭500,000 (US$55) fine. Companies that have not filed and paid their taxes from January 2020 will also be exempted from the aforementioned penalties, but this is deferred until 29 May 2020.	Consumption increases due to deferred tax payment for 5 months by 100%.
Malaysia	Direct tax	Monthly income tax instalment payments for businesses in the tourism sector (i.e. travel agencies, hotel operators, and	Consumption increases due to deferred tax

Country	Type of Tax	Fiscal Policy Measures	Simulation Scenarios
		airline companies) are deferred from 1 April 2020 to 31 December 2020.	payment for 9 months by 100%.
New Zealand	Indirect tax	Fines and penalties for late filing of goods and services tax have been suspended.	Consumption increases due to deferred tax payment for 6 months by 100%.
New Zealand	Direct tax	The government introduced a temporary tax loss carry-back rule that enables companies that incur a tax loss in the 2020 or 2021 income year to carry the losses back 1 year. This will enable COVID-19-impacted companies to access cash refunds of taxes paid in prior years.	Consumption increases due to deferred tax payment for 12 months by 100%.
Singapore	Direct tax	A corporate income tax rebate of 25% of tax payable is available, capped at S$15,000 (US$10,700) for the 2020 tax year.	Consumption increases due to deferred tax payment for 12 months by 25%.
Singapore	Indirect tax	The airport development levy (code L7) on passengers has been waived effective for tickets issued on/after 13 April 2020 until on/before 31 March 2021 for travel on/after 13 April 2020 until on/before 31 March 2021.	Consumption increases due to deferred tax payment for 9 months by 100%.

Country	Type of Tax	Fiscal Policy Measures	Simulation Scenarios
Thailand	Indirect tax	Monthly indirect tax (i.e. VAT, specific business taxes, and other taxes) filing and payment for affected operators are extended by 1 month.	Consumption increases due to deferred tax payment for 1 months by 100%.

Source: IATA (2020c).
Note: Simulation rates are obtained by multiplying the share of months, reduction rate, and elasticity. Following Sachs et al. (2019), this study assumes the elasticity to be 0.5, where reduction in tax by 1.0% will led to increased consumption by 0.5%.

Appendix 3: Monetary Policy Measures

Country	Monetary Policy Measures	Simulation Scenario
Australia	On 3 November, the Reserve Bank of Australia reduced the interest rate on its Term Funding Facility by 15 basis points to 0.10% (the cash rate had been at 0.25% following two 25 basis point cuts on 3 March and 19 March).	Consumption increases due to reduction in interest rate by 80%.
China	The People's Bank of China provided monetary policy support and acted to safeguard financial market stability. Key measures include reduction of interest rates by 50 basis points (re-lending facilities).	Consumption increases due to reduction in interest rate by 11%.
Indonesia	Bank Indonesia reduced the policy rate by 125 basis points cumulatively in February, March, June, July, and November 2020 to 3.75%.	Consumption increases due to reduction in interest rate by 25%.
Korea	The Bank of Korea has taken several measures to ensure continued accommodative monetary conditions and to facilitate financial system liquidity. These include lowering the base rate by a cumulative 75 basis points, from 1.25% to 0.50%.	Consumption increases due to reduction in interest rate by 60%.
Lao People's Democratic Republic	The Bank of Lao PDR cut its policy rate from 4% to 3% for 1-week loans, from 5% to 4% for 1–2-week loans, and from 10% to 9% for 2-week to 1-year loans.	Consumption increases due to reduction in interest rate by 25%.

Malaysia	Bank Negara Malaysia lowered the overnight policy rate in three consecutive Malaysia Productivity Corporation meetings on 3 March, 5 May, and 7 July. Including the January rate change, the rate was cut in 2020 by a cumulative 125 basis points, to date to 1.75%.	Consumption increases due to reduction in interest rate by 42%.
Philippines	Bangko Sentral ng Pilipinas reduced its policy rate five times in 2020 by a cumulative 200 basis points to 2.00%, with the latest cut of 25 basis points to become effective on 20 November.	Consumption increases due to reduction in interest rate by 50%.
Thailand	The policy rate has been reduced by 75 basis points from 1.25% to 0.50% during 2020.	Consumption increases due to reduction in interest rate by 60%.
Viet Nam	Effective 1 October, the State Bank of Vietnam cut its benchmark policy rates by 50 basis points, the third time in the year, after the first two cuts by 100–150 basis points on 17 March and 13 May.	Consumption increases due to reduction in interest rate by 50%

Source: International Monetary Fund (2021).
Note: Reduction rates are obtained by comparing interest rates before and after 2020. This study simulates the impact of monetary policy by multiplying the interest reduction rate by elasticity. Following Sachs et al. (2019), the elasticity is assumed to be 0.5.