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The Economic Impacts of Air Safety Rating Downgrade for Malaysia

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Abstract: In 2019, the US Federal Aviation Administration (FAA) downgraded the Civil Aviation Authority of Malaysia (CAAM) from tier one to tier two. Existing research has revealed that downgrading air safety ratings has a detrimental effect on the aviation sector. Although extensive research has been carried out on air safety downgrading, limited studies have delved into the backward and forward linkages and inter-industries framework. By employing a difference-in-differences (DID) panel data econometric and input-output (I-O) analysis to a modified sectoral aggregation of Malaysia's I-O Table 2015, this study is able to simulate the impact of air safety downgrading. The findings show that, apart from being a "key" industry, air safety downgrades could result in a RM722.5 million loss to Malaysia's GDP. A more in-depth inspection of the results indicates that the reduction in GDP mainly results from the air transport industry (RM252.0 million), other transportation services (RM107.0 million), and wholesale and retail trade (RM66.2 million). The findings complement earlier related studies that air safety rating downgrades could be a severe threat to sustainable economic growth.

Keywords: Air safety rating downgrade, air transport, difference-in-differences, input-output analysis, Malaysia
JEL classification: D67, L93, R41

1. Introduction

Recently, the US Federal Aviation Agency (FAA) found that the Civil Aviation Authority of Malaysia (CAAM) did not meet the safety standards of the International Civil Aviation

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Organization (ICAO)[1] (Federal Aviation Administration, 2019). As a consequence, on November 11, 2019, the FAA, through its regular audit programme, the International Aviation Safety Assessment (IASA), downgraded the Malaysian aviation industry to a tier-two rating. A tier-two rating means that the country's aviation sectors do not fulfil at least one of the three standard requirements of its organisational management or operational procedures, i.e., safety measures, human resource management, or data management issues. The FAA specifically mentioned that the downgrade of the Malaysian aviation industry was due to the regulator's non-compliance, not on the airlines. In addition, Malaysia Airlines has met all global safety requirements set by the International Air Transport Association (IATA) Operational Safety Audit (IOSA) programme. Still, safety concerns have invited potential risk to the Malaysian aviation business.[2]

There are two categories of safety rating outcome. First, countries that comply with the FAA standard are rated as tier one. Countries that do not adhere to the safety requirement are classified as second tier. There were two immediate consequences of the FAA's downgrade of the Malaysian carriers: first, Malaysian carriers, including Malaysia Airlines, AirAsia and AirAsiaX were not allowed to explore new routes to the US; and second, the code-sharing arrangement between US airlines and Malaysian airlines was terminated. Indirectly, the downgrade has impacted the coalition between Malaysian and US airlines. The revenue at risk for the Malaysian aviation sector is estimated at RM371.6 million, of which RM360.8 million is at risk for Malaysian airlines and RM10.8 million for aircraft operators (Malaysian Aviation Commission, 2020). But, more alarming, this downgrade is expected to have a more significant impact on the Malaysian economy overall, not just on new routes or cancellations of flights to the US because of the complexity and the interconnected nature of the aviation sector to other sectors. For the past few years, the aviation sector has contributed substantially to the Malaysian economy. In 2018, the industry offered 460,000 jobs and contributed USD10.3 billion to the GDP, which is equivalent to 3.5% of Malaysia's GDP (International Air Transport Association, 2019). Thus, any adverse shocks in the aviation sector could substantially disrupt the contribution of the aviation sector to the economy.

There are several agencies overseeing air safety matters, including technical expertise, personnel training, record-keeping and inspection procedures. Among them are the Federal Aviation Administration (FAA) in the United States, Civil Aviation Authority (CAA) in the United Kingdom, Joint Aviation Authorities (JAA), and the European Union Aviation Safety Agency (EASA) in the European Union (EU). The FAA is regarded as the most influential airworthiness authority in the world (Tao et al., 2014). It is a general

1 The certification of the International Civil Aviation Organization (ICAO) for the Standard and Recommended Practices (SARPs) is the highest safety and security standard for the global aviation industry. Although each member state of the ICAO has its local aviation authority that is responsible for the operation of the industry, international certification is critically essential to guarantee and confirm whether or not the airline is eligible to fly with the international standard (Spence et al., 2015; Wakimoto, 2019).

2 Malaysia was privileged to receive its tier-one safety rank in 1996 and was at risk for a downgrade in 2003 after a second audit. However, the CAAM managed to address all the concerns raised at the time and maintain its privilege (Ministry of Transportation, 2020).

practice by other rating agencies to downgrade the aviation industry that has been downgraded by the FAA. For example, after the FAA downgraded the aviation sector in Indonesia to tier 2 in April 2007, the EASA followed suit by imposing bans on Indonesian airlines from flying to Europe in June of the same year. In a similar case, the EASA imposed a ban on a Philippines carrier in 2010 in response to the FAA's downgrade of the Philippines aviation industry. The aviation industry of other countries categorised under tier two by the FAA including Bangladesh, Costa Rica, Ghana and Thailand have also been banned by the EASA to fly over Europe (Malaysian Aviation Commission, 2020). This further highlights the potential magnitude of the impact of air safety rating downgrades, and thus should be a major concern for the Malaysian authority.

The need to assess Malaysia's vulnerability to aviation safety and security downgrading forms the premise of this research. Specifically, this research aims to analyse the impact of air safety rating downgrades made by the FAA on air passenger demand and the Malaysia economy. The study is carried out in two stages: first, employing a difference-in-differences (DID) panel data econometric analysis to investigate the impact of air safety downgrades on air passenger demand, and second, the estimated parameter from the DID analysis is used to simulate the impact of the downgrade using an input-output (I-O) analysis. The I-O analyses the importance of the air transport sector and estimates the total loss to the whole economy as a result of the reduction in air transport demand. The impact is then adjusted to meet 80% of the local carrier market share.

The major contributions of this paper to the existing literature are twofold. First, this study investigates pressing issues of key industries in Malaysia, i.e., aviation, which has been downgraded to tier two. An understanding of these issues is vital to providing a clear picture of overall economic loss in the country. Second, this study employs both econometric and IO models. Most past research investigating the impact of downgrades has focused on econometric estimations. The utilisation of both models is able to provide real data estimations of the implications of downgrades on air passenger demand and the economic-wide impact. Thus, the integration of these two well-established models will not only improve the estimation but will also be highly relevant for policy purposes.

This study is organised as follows: Section 2 reviews the related literature. Section 3 presents the integrated modelling framework combining the econometric and I-O models. Section 4 discusses the major findings from the simulation of air safety rating downgrade shock on output and value-added. Finally, section 5 concludes.

2. Literature Review

Many studies have highlighted the long-standing significant contribution of the air transport industry to economic growth (Cardenete & López-Cabaco, 2018; Kucukonal & Sedefoglu, 2017; Njoya, 2020). Besides its high speed and low cost for long-distance destinations, air transport is regarded as the most convenient and safest means of conveyance. During natural disasters and other emergencies, rescue teams always resort to air transport. However, throughout the decades of successful stories, a number of unexpected market downturns or technical disruptions have put a dent in the smooth contributions of the aviation sector to national income (Daramola, 2014; Mhlanga et al., 2017; O'Connell, 2011).

Recently, a considerable amount of literature has arisen around the theme of the negative situational analysis of the air transport industry (Alexander & Merkert, 2021; Corbet et al., 2019; Janic, 2015). The negative shock has at least two sources, namely market-based and structural-based. Market-based shock is due to a particular event that happens in the market that causes grievous concerns for the security and safety of air passengers, such as terrorist attacks, regional conflicts, military war, catastrophic natural disasters, or infectious disease epidemics (Edelman, 2015; Gallego & Font, 2020; Mitra et al., 2018). Structural-based shock is due to non-compliance of the aviation services provider to an aviation standard set by the regulatory bodies, either local or international (Manuela & Vera, 2015). Under the IASA programme, all aviation service providers, including government-owned full-service carriers, low-cost carriers, airport management, infrastructure developers, and aircraft maintenance services, are required to strictly comply with the ICAO safety standard.

Most of the current studies focus on how severely negative market-based situational events impact total air passenger demand and for how long the negative impact lasts in the market (Ito & Lee, 2005; Njegovan, 2006). Ito and Lee (2005) found that the September 11 terrorist attacks had a temporary negative effect on air travel demand not only in the US but also around the world. Other events such as the Iraq war, SARS epidemic, and the 1997 financial crisis also significantly disrupted short-term and long-term air passenger demand (Chi & Baek, 2013; Hsu et al., 2013; Wendt, 2019). Despite the huge implications of air safety downgrades, there is still a lack of studies that investigate its economic consequences. Manuela and Vera's (2015) empirical study showed that the air safety downgrade imposed by the FAA for the Philippines had a minimal impact on the aviation sector. However, their study also found that the ban that followed (imposed by the EU) significantly caused short-term and long-term decline in tourist arrival, tourist receipts and length of stay (Manuela & Vera, 2015). The airline industries in the Philippines is estimated to lose approximately USD13.68 million in the short-term due to a decrease in air passenger demand and travel cancellations to the Philippines. In total between 2008 and 2012, the Philippines economy suffered a total loss of approximately USD450 million annually or 16% of its average annual tourism receipts after being downgraded (Manuela & Vera, 2015).

Further, the closure of EU airspace to Indonesian airlines also subsequently reduced European air passenger demand and increased the number of travel cancellations by Japanese travel groups to Indonesia, which caused the Garuda company to lose at least USD9 million (Henderson, 2009). The recent air safety rating downgrade for the Malaysian aviation sectors is therefore expected to have an adverse effect on the Malaysian economy. However, limited studies have attempted to simulate the impacts of an air safety downgrade on Malaysia's economy. Therefore, this study intends to fill the research gap by analysing the impact of downgrading air safety on the Malaysian economy, as aviation restrictions can have a domino effect on other sectors such as tourism, trade and other service sectors (Jin et al., 2019; Yu et al., 2020).

3. Methodology and Data

This study combines two different modelling techniques, namely econometric and I-O analysis. The integration of these methods has been well-documented in the literature, and the current study's modelling strategy closely follows the works of Maji et al. (2017) and Valadkhani et al. (2014). For instance, Maji et al. (2017) estimated the impact of oil price shocks on crude oil exports using an econometric analysis and used the coefficients to simulate the impact of the reduction in crude oil exports on the economy using the I-O model. Valadkhani et al. (2014) employed an econometric analysis to estimate the share of a non-energy sector in the final demand and then used the estimated coefficient to analyse the implications of an increase in the price of energy on sectoral performance of the non-energy sector using the I-O model.

Several modifications were made to suit the current study's needs. Econometric models were used to estimate the coefficients for air passenger demand with respect to the air safety downgrade. The coefficients were then used as a basis for the I-O estimation of air safety downgrade on sectoral output, value-added and labour income. Figure 1 illustrates the methodological framework utilised in this study. Air safety rating downgrade affects international air transport demand, which then has an economy-

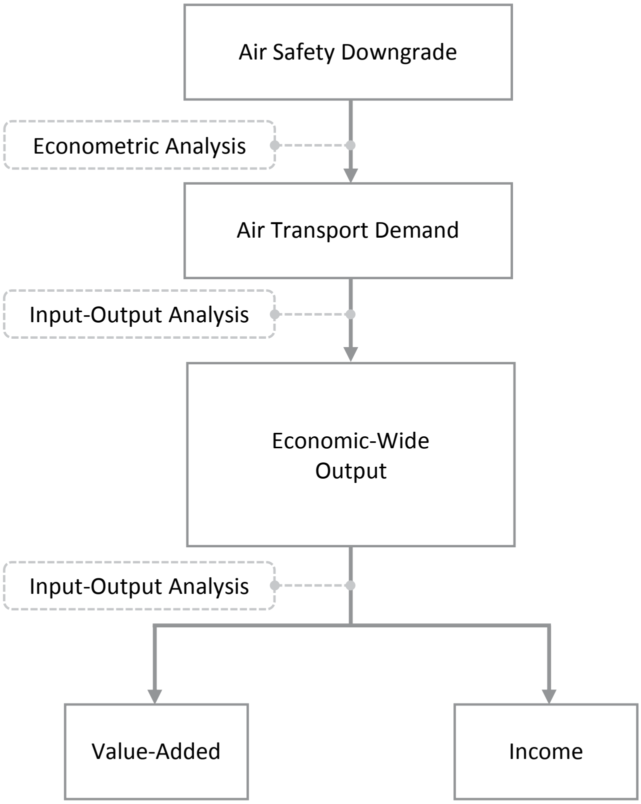

Figure 1. Methodological framework in analysing the impact of air safety downgrade

wide impact due to sectoral interlinkages in the economy. This explains the ripple effect from distortion in a single sector to all other sectors.

For the econometric analysis, this study adopted the export demand function introduced by Bahmani-Oskooee (1986), where the world demand for a country's aggregate exports is specified in log-linear terms as follows:

$$lnX_t = \beta_0 + \beta_1 lnYW_t + \beta_2 ln(PX/PXW)_t + \beta_3 lnER_t + \varepsilon_t \quad (1)$$

where X denotes the quantity of exports, YW denotes the weighted average of the gross national product (GNP) of a country's trading partners, PX denotes the export price, PXW denotes the weighted average export prices, and ER denotes the exchange rate. The export demand function that is represented by equation (1) implies that exports are influenced by foreign income, relative prices and the exchange rate.

Equation (1) is then modified to suit the current study's needs by using the air transport demand (proxied by number of air passengers demand) as the dependent variable and the world GDP, price and exchange rate as independent variables. Thus, the air transport demand function is specified as follows:

$$lnAirPassenger_{it} = \beta_0 + \beta_1 lnWGDP_{it} + \beta_2 lnCPI_{it} + \beta_3 lnREER_{it} + \varepsilon_{it} \quad (2)$$

where *AirPassenger* denotes the quantity of air passengers demand, *WGDP* denotes the world GDP, *CPI* denotes the consumer price index, *REER* denotes the real effective exchange rate, ε is the error term, and subscript i and t represent country and time dimension. Since there is a lack of data to investigate the recent downgrade impact on Malaysia's air transport demand, this study used the difference-in-difference (DID) model. In a DID analysis, there is a treatment and control group. The treatment group is made up of countries that are affected by a certain policy, and the control group is made up of countries that are not affected. This study takes into consideration several countries that have been downgraded to tier two (treatment group) and several other countries that have not faced any downgrade issues (control group). Hence, this study includes the DID variable as follows:

$$lnAirPassenger_{it} = \alpha + \beta_1 lnWGDP_{it} + \beta_2 lnCPI_{it} + \beta_3 lnREER_{it} + \beta_4 lnDID_{it} + \varepsilon_{it} \quad (3)$$

where *DID* is an interaction term between $TREAT_i$ and $POST_t$, $TREAT_i$ is a dummy variable where 1 represents the country that has been downgraded before and also currently under downgrade and 0 otherwise, and $POST_t$ is the time dummy variable where 1 represents the period of air safety rating downgrade and 0 otherwise. The world GDP, price and exchange rate were used as control variables.

This study estimated equation (3) by using the DID method in a panel regression using annual data from 1994 to 2018. In this study, countries with data availability were chosen as the control group, which are Australia, Brazil, China, Costa Rica, Germany, Japan, Korea, Malaysia, Nigeria, Singapore, United Kingdom and the United States. The treatment group includes Ghana, India, Indonesia, Mexico, Philippines and Thailand because they have currently ongoing downgrades or have been downgraded in the past, within the current study period. Detailed information on the downgrade period for each country is provided in Appendix I.

However, it should be noted that the estimation results obtained are the effects of air safety rating downgrade on air passenger demand, irrespective of whether it is a local or foreign air carrier. In Malaysia, the local air carrier has around 80% market share (Malaysian Aviation Commission, 2020), and thus, to obtain the implications for the local air carrier, this study multiplied the coefficients obtained from the econometric regression with the market share of Malaysia's local air carrier. This is important, as the I-O analysis in this study focused on the domestic air transport industry only. Hence, the simulations are conducted based on the product of market share and the coefficients for downgrade to produce better results.

Next, this study proceeds with the I-O analysis. Several methods currently exist for the measurement of sectoral linkages. Among these is the I-O model. The I-O model was based on the conceptual framework proposed by Leontief (1951). The analytical base for the I-O model is the I-O table, which shows the usage of inputs and the applications of outputs in each sector. The I-O analysis has been proven to be a good research methodology to establish the importance and sectoral linkages of transportation sectors (Kwak et al., 2005). Following Miller and Blair (2009), the interdependencies among production activities can be shown using the material balance equation as follows:[3]

$$x = Zi + f \tag{4}$$

where x is the total output vector and Zi is the summation vector for matric of inter-mediate sales with i representing columns vector of 1. Vector f includes private consumption, government consumption, gross fixed capital formation, change in inventories and exports. Equation (4) is then transformed and solved to obtain the standard I-O model as follows:

$$x = Ax + f \tag{5}$$

where A ($A = Z\hat{x}^{-1}$ is the technical coefficients matrix with elements a_{ij} to represent interaction among the production sectors. Solving for x, the total production delivered to the final demand is obtained as in equation (6):

$$x = (I - A)^{-1}f \tag{6}$$

where I is the identity matrix and $(I - A)^{-1}$ is known as the Leontief inverse matrix ith element b_{ij}. The Leontief inverse matrix represents the total production every sector must generate to satisfy the 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.

[3] The matrix operations are utilised to explain the I-O model. For notations, capital symbols denote matrices, lowercase symbols denote column vectors, primes denote transposition, and hats denote diagonal matrices where the main diagonals are the elements of a vector.

In contrast, Ghosh (1958) proposed an alternative supply-driven I-O model that reflects the sectoral gross production to the primary inputs, that is, changes in output due to changes in inputs being used at the beginning of the production process (Miller & Blair, 2009). Ghosh (1958) suggested relating sectoral gross production to primary inputs, that is, to a unit of value entering the interindustry system at the beginning of the process. From a supply perspective, the balance equation shows that total production is equal to sum of intermediate inputs and value-added, as can be seen from the following equation:

$$x' = i'Z + v' \tag{7}$$

where x' is the transpose of total output vector, i' is the row vector of 1, Z is the matrix and denotes interactions among the production sectors, and v' is the transpose of the value-added vector. Similar to the Leontief model, the balance equation is transformed and solved to obtain the standard Ghosh I-O model as follows:

$$x' = Hx' + v' \tag{8}$$

where H ($H = \hat{x}^{-1}Z$) denotes the allocation coefficient matrix with elements h_{ij} to represent the distribution of sector i's outputs across sector j that purchases the interindustry inputs from i. The larger the h_{ij}, the greater the direct driving force of sector i on sector j. Solving for x, equation (9) is obtained:

$$x' = v'(I - H)^{-1} \tag{9}$$

Matrix $(1 - H)^{-1}$ is also known as the Ghosh inverse matrix (G) with element g_{ij}. The Ghosh inverse matrix represents the augmentation of sector j's total outputs due to a single unit augmentation of the primary input in sector i. After deriving the Leontief inverse and Ghosh inverse matrices, prior to a detailed analysis of the impact of air safety downgrades, this research explores the importance of the air transport industry on other sectors by looking into the backward and forward linkages. The backward linkage effect is represented as the power of dispersion, while the forward linkage effect is expressed as the sensitivity of dispersion (Chiu & Lin, 2012). The mathematical calculation of the backward linkage effect (B_i^f) and forward linkage effect (F_j^b) can then be expressed as follows:

$$B_i^f = \frac{\sum_{j=1}^{n} b_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}} \tag{10}$$

$$F_j^b = \frac{\sum_{i=1}^{n} g_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} g_{ij}} \tag{11}$$

where b_{ij} and g_{ij} are the elements in the Leontief inverse matrix and Ghosh inverse matrix, respectively, and n denotes the number of sectors.

Comparison of the values of the backward and forward linkages for each sector in an economy provides a mechanism for identifying the “key” sectors in that country and grouping those sectors into spatial clusters (Miller & Blair, 1985; Saari et al., 2017). Focusing on the air transport industry, the backward linkage effect means that the production activities of the air transport industry may induce greater use of other sectors as an input for air transport production. On the other hand, the forward linkage effect indicates that air transport production may be used as an input for other sectors in their production. Forward and backward linkage effects are then useful in assessing the impact of the air transport industry on the national economy as a whole (Kwak et al., 2005). Next, this study calculates the multiplier effects of the air transport industry to establish the importance of air transport in the domestic economy and understand how injection in the demand-side or supply-side will affect overall economic performances. This study employs the Ghosh model, which is a supply-driven I-O model, to investigate the direct and indirect effects of supply shocks (Yoo & Yoo, 2007). As explained earlier, g_{ij} is the element of the Ghosh inverse matrix, and g_{ij} is called an output to primary input multiplier, which represents the augmentation of sector *j*’s total outputs due to a single unit augmentation of the primary input in sector *i*. The larger the g_{ij}, the greater the complete driving force of sector *i* on sector *j* (Augustinovics, 1972; Miller & Blair, 2009).

For the demand-side, this study employs the Leontief model, which is a demand-driven I-O model to investigate the direct and indirect effects of the final demand multiplier (Miller & Blair, 2009). As explained earlier, b_{ij} is the element of Leontief inverse matrix, and b_{ij} is called an output to final demand multiplier, which represents the augmentation of sector *i*’s total outputs due to a single unit augmentation of the final demand in sector *j*. The larger the b_{ij}, the greater the complete driving force of sector *j* on sector *i* (Miller & Blair, 2009). After analysing the sectoral linkages and multiplier, this study simulated the impact of demand reduction in the air transport industry on the economy-wide output and value-added. For this purpose, equation (6) for the Leontief model can be written as follows:

$$\Delta x = (I - A)^{-1}\Delta f \tag{12}$$

where the Δ symbol represents changes, and equation (12) provides output changes in terms of final demand changes. The changes in output can be further decomposed into direct and indirect output changes. To obtain the direct output changes, this study follows Utit et al. (2020). In Utit et al. (2020), the Leontief inverse in equation (12) was substituted with matrix *A*; meanwhile, to obtain the indirect output changes, the Leontief inverse in equation (12) was substituted with the differences between matrix *A* and the Leontief inverse. After obtaining the output changes, this study followed Maji et al.’s (2017) formula to calculate the value-added changes as follows:

$$\Delta v = \hat{v}(I - A)^{-1}\Delta f \tag{13}$$

where $\hat{v}$ is the diagonal matrix with the value-added coefficient in the main diagonal. The value-added changes can be further disaggregated into domestic and imported value-added. This was done by substituting the term $\hat{v}$ with $\widehat{va}$ and $\widehat{im}$, which is a diagonal matrix with the domestic value-added and imported value-added in the main diagonal, respectively. Similarly, the domestic value-added comprises operating surplus and compensation to employees. Hence, to obtain the loss in operating surplus and compensation to employees, this study used the operating surplus coefficient and the compensation to employees coefficient, respectively, and transformed them into a diagonal matrix form.

Since there is no existing research for the case of Malaysia, this study utilised the coefficients from the econometric analysis as it measured the impact of air safety downgrade on the air passenger demand for Malaysia. This study simulated the reduction in air transport demand based on the product of coefficients from econometric estimation and the local carrier market share. In addition, reduction in air passenger demand can be used as a proxy for the reduction in air transport demand, because air passengers in Malaysia contribute the most to the air transport industry (International Civil Aviation Organization, 2005). Thus, this study evaluated the impact of aviation safety downgrade on Malaysia's economy through the reduction of air transport demand caused by an air safety downgrade. This study used the elasticities of employment with respect to GDP from Maji et al. (2017), which is equal to 0.282, to have an estimate of expected job loss due to overall reduction in GDP.

This study employed two sets of Malaysian I-O data consisting of years 2010 and 2015 and 124 sectors (Department of Statistics Malaysia, 2014; 2018). To have a detailed and comprehensive sectoral analysis, this study aggregated the base data into 46 sectors, as can be seen in Appendix II. The I-O analysis comprises two parts, with the first part using both I-O tables to have an overview of the dynamics of sectoral linkages and multiplier, especially for the air transport industry to emphasise its importance. For the second part of the analysis, this study simulated the impacts of air safety downgrades on the sectoral output and value-added in Malaysia's economy, based on the coefficient obtained in the econometric analysis. For this purpose, the latest I-O data (base year 2015) was utilised, as it reflects the current technological coefficients.

4. Results

The results are reported based on the estimation methodology, which has two parts: the econometric estimations and the I-O analysis. In the first part, this study discussed the findings from the econometric estimations. In the second part, this study performed an I-O analysis to investigate the sectoral linkages and multiplier effects. Then, using the coefficients from the econometric estimations, this study simulated the economy-wide impact of an air safety downgrade for Malaysia.

The DID model was estimated using the Stata statistical software. Table 1 depicts the estimated results of equation (4) using the DID technique. The result shows the impact of air passengers on the treatment and control group. The estimated coefficient for air passengers with respect to the air safety rating downgrade is -0.257. The coefficient is negative and significant, suggesting that downgrades reduced air passenger demand by 22.7% ($e^{-0.257} - 1 = 0.227$). The coefficient of most control variables is in accordance to the theory.

Table 1. Econometric estimation result

Dependent variable: $lnAirPassenger_t$		
Variables	Coefficient	Std. error
$lnWGDP_t$	0.913***	0.025
$lnCPI_t$	0.251***	0.089
$lnREER_t$	-0.426**	0.214
DID_t	-0.257*	0.147
Constant	-6.751***	1.079
Diagnostics	Statistics	
R^2	0.834	
Observations	445	

Note: *, ** and *** shows significance level at 10%, 5% and 1% respectively.

After obtaining the elasticities from the econometric estimation, this study proceeded to the I-O analysis to understand the sectoral impact. Prior to shock simulation, this study investigated the sectoral linkages by calculating the backward and forward linkages. The results are shown in Table 2 and Table 3, respectively. The analysis of inter-industry linkages provides an implication on the structure of an industry in the national economy. Both the backward and forward linkages for the air transport industry are, on average, relatively higher compared to the other sectors for all years. The increment shows that there are significant changes in the economy throughout time and implies that the air transport industry is becoming more critical and is a vital input to the national economy.

The high value of backward linkages ranking the air transport industry, as shown in Table 2, emphasises the importance of the air transport industry. Furthermore, industries that had both backward and forward linkages higher than 1 are called “key” industries in economic development and in supporting other sectors, as well as in boosting other industries (Temurshoev & Oosterhaven, 2014; Giammetti et al., 2020). The linkages show that air transport had an index value higher than 1 for its backward and forward linkages for the year 2015. This result indicates that the air transport industry is a key industry in Malaysia’s economy. Thus, any shocks in the air transport industry will have an impact on Malaysia’s economy as a whole.

Table 4 shows the sectors with the highest output to the primary input multiplier for the air transport industry in both years. The result shows that the total multiplier values increased from 1.68 in 2010 to 2.05 in 2015, which indicates that changes in primary inputs for the air transport industry in Malaysia had more implications on the overall economy in 2015. A unit increase in the primary inputs for the air transport industry in 2015 will lead the total output in the economy to increase by 2.05. Other than the building and construction sector, the air transport industry in Malaysia has high multiplier effects for the production in services sectors, namely other services, postal and communication services, business services, and financial services.

Table 2. Backward linkages

Sector	Description	2010		2015	
		Value	Rank	Value	Rank
1	Agriculture products	0.718	45	0.730	42
2	Rubber planting	0.888	34	0.728	43
3	Oil palm estates	0.761	43	0.710	45
4	Livestock farming	1.027	20	1.012	27
5	Forestry and logging	1.212	4	0.763	41
6	Fishing	1.052	19	0.724	44
7	Crude oil and natural gas	0.684	46	0.700	46
8	Mining and quarrying	0.762	42	1.074	14
9	Food and beverage	1.076	14	1.118	9
10	Oil and fats	1.525	1	1.416	1
11	Animal feeds	1.063	17	1.286	2
12	Tobacco	0.781	39	0.773	40
13	Textile	1.053	18	0.904	35
14	Clothing	0.911	29	0.991	30
15	Leather and footwear	1.001	23	1.040	20
16	Wood product	1.435	2	1.161	7
17	Furniture and paper products	1.195	6	1.167	5
18	Publishing and printing	0.991	24	1.016	25
19	Petroleum refinery	0.988	25	1.047	18
20	Chemical products and others	1.137	10	1.093	13
21	Drugs and medical product	0.808	38	0.971	32
22	Processed rubber and rubber products	1.404	3	1.093	12
23	Plastic products	1.108	13	1.007	28
24	Non-metallic mineral products	1.207	5	1.200	3
25	Basic metal	1.010	21	1.120	8
26	Fabricated metal products	1.009	22	1.018	23
27	Industrial machinery and equipment	0.903	31	1.042	19
28	Household machinery and equipment	0.777	41	0.991	29
29	Household electric appliance and apparatus	0.778	40	1.021	22
30	Precision equipment	0.854	37	1.014	26
31	Motor vehicle	0.929	27	1.072	15
32	Other transport equipment	1.180	7	1.071	16
33	Other manufacturing products	0.898	32	1.060	17
34	Electricity, gas, and waterworks	0.888	35	0.942	34
35	Building and construction	1.135	11	1.162	6
36	Wholesale and retail trade	0.905	30	0.892	36
37	Hotels and restaurants	1.157	9	1.104	10
38	Other transportation services	1.069	15	1.030	21
39	**Air transport**	**1.161**	**8**	**1.186**	**4**
40	Postal and communication services	1.133	12	1.017	24
41	Financial services	1.063	16	0.846	38
42	Real estate and ownership of dwellings	0.919	28	0.790	39
43	Business services	0.893	33	0.951	33
44	Education services	0.735	44	0.870	37
45	Healthcare services	0.873	36	1.099	11
46	Other services	0.944	26	0.975	31

Table 3. Forward linkages

Sector	Description	2010		2015	
		Value	Rank	Value	Rank
1	Agriculture products	0.900	28	0.836	32
2	Rubber	0.783	36	0.697	39
3	Oil palm	1.557	3	1.350	5
4	Livestock farming	0.675	39	0.927	24
5	Forestry and logging	1.599	1	1.372	3
6	Fishing	0.889	30	0.879	28
7	Crude oil and natural gas	1.158	13	1.299	8
8	Mining and quarrying	1.571	2	1.312	7
9	Food and beverage	0.803	33	0.810	33
10	Oil and fats	1.017	21	0.888	27
11	Animal feeds	1.099	17	1.444	1
12	Tobacco	0.662	42	0.617	45
13	Textile	0.840	31	0.866	31
14	Clothing	0.722	38	0.661	43
15	Leather and footwear	0.934	27	1.044	21
16	Wood product	1.019	20	0.957	23
17	Furniture and paper products	0.934	26	0.663	42
18	Publishing and printing	1.547	4	1.079	20
19	Petroleum refinery	1.015	22	1.360	4
20	Chemical products and others	1.114	15	1.133	17
21	Drugs and medical product	1.102	16	1.427	2
22	Processed rubber and rubber products	1.115	14	0.975	22
23	Plastic products	0.960	25	0.872	30
24	Non-metallic mineral products	1.346	6	1.338	6
25	Basic metal	1.214	9	1.259	10
26	Fabricated metal products	1.091	18	1.281	9
27	Industrial machinery and equipment	0.789	35	0.805	34
28	Household machinery and equipment	0.598	45	0.744	38
29	Household electric appliance and apparatus	0.603	43	0.903	26
30	Precision equipment	0.666	41	0.769	36
31	Motor vehicle	0.891	29	1.204	14
32	Other transport equipment	0.749	37	0.878	29
33	Other manufacturing products	1.189	11	1.244	12
34	Electricity, gas, and waterworks	1.338	7	1.253	11
35	Building and construction	0.793	34	0.772	35
36	Wholesale and retail trade	0.982	23	1.105	18
37	Hotels and restaurants	0.838	32	0.758	37
38	Other transportation services	1.186	12	1.105	19
39	**Air transport**	**0.964**	**24**	**1.155**	**16**
40	Postal and communication services	1.199	10	0.917	25
41	Financial services	1.369	5	1.195	15
42	Real estate and ownership of dwellings	1.040	19	0.695	40
43	Business services	1.275	8	1.229	13
44	Education services	0.595	46	0.585	46
45	Healthcare services	0.671	40	0.688	41
46	Other services	0.600	44	0.651	44

Table 4. Top sectors with highest output to primary input multiplier of air transport sector

Sector	Description	2010	2015
39	Air transport	1.029	1.027
46	Other services	0.080	0.141
35	Building and construction	0.016	0.117
40	Postal and communication services	0.026	0.089
43	Business services	0.039	0.082
41	Financial services	0.048	0.064
10	Oil and fats	0.026	0.062
29	Household electric appliance and apparatus	0.023	0.055
36	Wholesale and retail trade	0.035	0.044
7	Crude oil and natural gas	0.019	0.037
	Total economy multiplier	1.679	2.050

Note: Sorted in descending order based on the 2015 multiplier effects.

This study also calculated the output to final demand multiplier of the air transport industry, as can be seen in Table 5. It can be noted that the overall output to final demand multiplier in the economy slightly increased from 2.007 in 2010 to 2.089 in 2015. The air transport sector had the highest output multiplier effect, followed by other transportation services, petroleum refinery, and wholesale and retail trade. The differences between Table 4 and Table 5 are from an injection perspective, whether it is in the supply-side (primary input) or the demand-side (final demand), respectively. Hence, it can be noted that there are some differences in the list of top 10 sectors, showing that the varying magnitude of the impact depends on whether the shock is on the supply-side or demand-side.

Table 5. Top sectors with highest output to final demand multiplier of air transport sector

Sector	Description	2010	2015
39	Air transport	1.029	1.027
38	Other transportation services	0.040	0.241
19	Petroleum refinery	0.273	0.180
36	Wholesale and retail trade	0.094	0.110
37	Hotels and restaurants	0.026	0.081
7	Crude oil and natural gas	0.141	0.080
41	Financial services	0.087	0.067
43	Business services	0.074	0.047
32	Other transport equipment	0.044	0.037
31	Motor vehicle	0.004	0.027
	Total economy multiplier	2.007	2.089

Note: Sorted in descending order based on the 2015 multiplier effects.

The results of the air transport demand reduction on the economy-wide output and value-added are shown in Table 6. This study simulates that the recent air safety downgrade will cause air transport demand to reduce by 18%, as obtained from the product of the coefficient from the econometric estimation and the local air carrier market share (22.7% × 80% = 18%). Overall, the simulation conducted in this study estimated that the output in the Malaysian economy will reduce by RM2.1 billion, and almost half is attributed to the reduction of output in the air transport sector itself (RM1.0 billion), followed by other transportation services (RM243.9 million) and petroleum refinery (RM182.1 million). The reduction in output can be further decomposed into direct and indirect output changes. The direct impact of air transport demand reduction is RM614.1 million, while the indirect impact is RM1.5 billion. Hence, it is clear that an air safety downgrade has direct and indirect effects on the production activities of other sectors.

Table 6. Output and primary input changes due to air transport shocks

Sector	Description	Output changes (RM million)			Primary input changes (RM million)	
		Direct	Indirect	Total	Value-added	Import
39	Air transport	-22.5	-1,017.4	-1,039.9	-252.0	-157.2
38	Other transportation services	-216.3	-27.6	-243.9	-107.0	-25.6
19	Petroleum refinery	-116.1	-66.0	-182.1	-43.7	-28.7
36	Wholesale and retail trade	-47.1	-64.3	-111.4	-66.2	-8.4
37	Hotels and restaurants	-71.5	-10.2	-81.7	-34.8	-7.4
7	Crude oil and natural gas	-1.6	-79.2	-80.8	-66.2	-1.8
41	Financial services	-37.5	-30.5	-68.1	-42.7	-4.6
43	Business services	-25.1	-22.5	-47.7	-24.7	-4.3
32	Other transport equipment	-22.5	-14.6	-37.1	-8.2	-10.5
31	Motor vehicle	-9.1	-18.0	-27.1	-6.5	-7.4
	Total changes	-614.1	-1,500.9	-2,115.0	-722.5	-290.2

Note: Sorted in descending order based on the total output changes.

However, it should be noted that output loss is not equivalent to GDP loss, as some parts of the output are contributed by imported commodities. Thus, this study looks at primary input changes and further disaggregates into domestic (value-added) and imported primary input to have an overview of the potential GDP impact of air safety downgrades. In total, Malaysia's GDP is simulated to be reduced by RM722.5 million (equivalent to 0.06% of total GDP in 2015), broken down as air transport loss of RM252.0 million, other transportation services loss by RM107.0, and the wholesale and retail trade loss by RM66.2 million. The air safety rating downgrade is expected to reduce the total imports in the economy by RM290.2 million. It is clear that the loss in value-added is significantly greater than the loss in import for most sectors. This shows that the magnitude of impact on the domestic economy is more severe. In addition, by using the employment to GDP elasticity value from Maji et al. (2017), this study

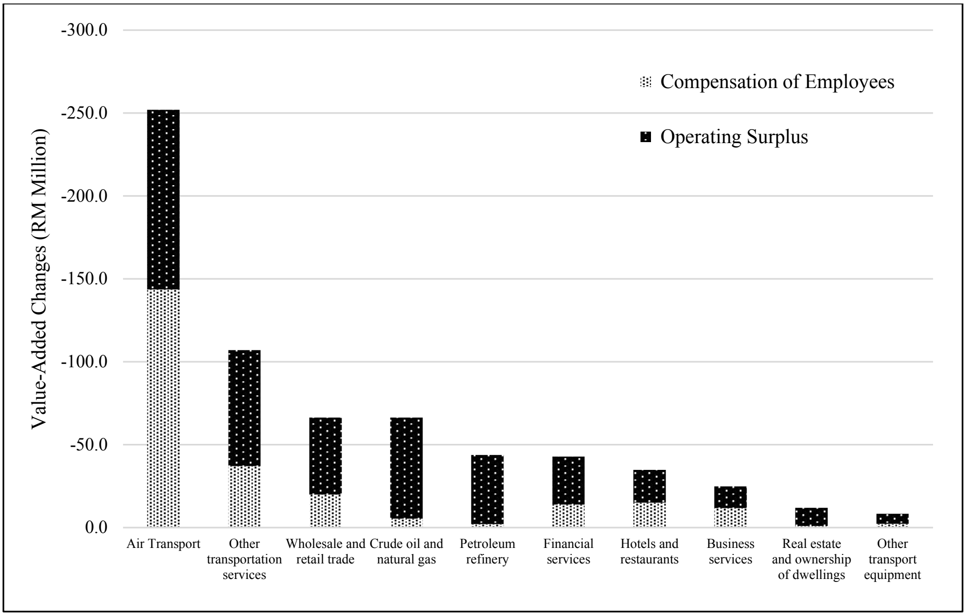

Figure 2. Negative changes in domestic value-added by components

also calculated the potential job loss from the percentage of GDP loss. The calculation results found that a reduction in GDP by 0.06% will lead to job loss of 0.028% (equivalent to 2,540).

After obtaining the potential loss in the domestic value-added, this study disaggregated the value-added changes by components, which are compensation of employees and operational surplus, as shown in Figure 2. These are the top 10 sectors that recorded the highest value-added loss. It can be seen that most are from services sectors. The biggest loser is the air transport sector, followed by other transportation services, wholesale and retail trade, crude oil and natural gas, and also petroleum refinery, postal and communication services, business services, and financial services. The expected total loss in employee compensation and operating surplus from the simulation is equivalent to RM274.2 million and RM448.3 million, respectively. From a sectoral perspective, the air transport sector recorded higher losses in employee compensation compared to operating surplus. Meanwhile, most other sectors have higher losses in the operating surplus.

5. Conclusion

The FAA's decision to downgrade Malaysia's aviation safety ranking in 2019 created new challenges to the Malaysian economy. In a complex and highly integrated economy, a negative shock to the aviation sector has direct and indirect adverse effects on other industries. Thus, this study investigates the relationship between air safety downgrade on the air passenger demand and the associated economy-wide impact.

The econometric estimation results show that the air safety rating downgrade led to a decline in air passenger demand for the treatment group by 22.7%. Using this information and the local air carrier market share, this study simulated the economy-wide impact using an I-O analysis. This study established the vital contribution of the air transport industry to the domestic economy by using linkages and a multiplier analysis.

Furthermore, the simulation results show that reductions in air transport demand will lead to total output loss in the economy by RM2.1 billion. Further, Malaysia's GDP is expected to reduce by RM722.5 million, which leads to 2,540 jobs lost. The outcome of this study highlights the severity of implications of the recent air safety downgrade. Thus, adequate attention by policymakers is necessary. The authorities concerned need to formulate a definitive strategy to regain premier status as soon as possible. The government of Malaysia, through CAAM, should ensure that the aviation industries meet international aviation safety standards set by ICAO and comply with eight aspects of the IASA Assessment Checklists (Federal Aviation Administration, 2020a).

Despite the extensive analysis conducted in this study, there are several limitations. First, the estimated parameter in the DID analysis was assumed to be a fit for the Malaysian case. Adequate data in the future might be able to provide a clear picture of the air safety rating downgrade on the air passenger demand for Malaysia. Secondly, although the I-O analysis can capture economic-wide impacts via industrial linkages and multiplier impacts, the linearity assumption and industrial homogeneity considered in this study might not lead to the most optimal and realistic results. Hence, future studies can consider relaxing the linearity assumptions and take into consideration the dynamic factor to obtain better results.

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Appendix I. Period of air safety rating downgrade by FAA

No.	Country	Downgrade duration
1	Ghana	January 2008 till present
2	India	January 2014 till April 2015
3	Indonesia	April 2007 till August 2016
4	Mexico	July 2010 till December 2010
5	Philippines	December 2008 till March 2011
6	Thailand	December 2015 till present

Source: Federal Aviation Administration (2020b).

Appendix II. Sectoral aggregation

New code	Aggregated sectors	Basic sectors
1	Agriculture products	Paddy (1), Food crops (2), Vegetables (3), Fruits (4), Flower plants (7), Other agriculture (8)
2	Rubber	Rubber (5)
3	Oil palm	Oil palm (6)
4	Livestock farming	Poultry farming (9), Other livestock (10)
5	Forestry and logging	Forestry and logging (11)
6	Fishing and aquaculture	Fishing and aquaculture (12)
7	Crude oil and natural gas	Crude oil and natural gas (13)
8	Mining and quarrying	Mining of metal ores (14), Quarrying of stone, sand and clay (15), Other mining and quarrying (16)
9	Food and beverage	Processing and preserving of meat (17), Processing and preserving of seafood (18), Processing and preserving of fruits & vegetables (19), Dairy products (20), Grain mill products, Starches and starch products (22), Bakery products (23), Confectionery (24), Other food processing (25), Spirits, wines and liquors (27), Soft drinks, mineral waters and other bottled waters (28)
10	Oil and fats	Vegetable & animal oils and fats (21)
11	Animal feeds	Prepared animal feeds (26)
12	Tobacco	Tobacco products (29)
13	Textile	Preparation, spinning and weaving of textiles (30), Finishing of textiles (31), Other textiles (32)
14	Clothing	Wearing apparel (33)
15	Leather and footwear	Leather products (34), Footwear (35)
16	Wood product	Sawmilling and planning of wood (36), Veneer sheets and wood-based panels (37), Builders' carpentry and joinery (38), Wooden containers and other wood products (39), Paper and paper products (40)

Appendix II. Continued

New code	Aggregated sectors	Basic sectors
17	Furniture	Furniture (41)
18	Publishing and printing	Reproduction of recorded media (42), Printing (43)
19	Petroleum refinery	Coke and refined petroleum products (44)
20	Chemical products and others	Basic chemicals (45), Fertilizers and nitrogen compounds (46), Paints and varnishes (47), Soaps & detergents, cleaning & polishing, perfumes & toilet preparations (49), Other chemicals products (50)
21	Drugs and medical product	Pharmaceuticals, medicinal chemical and botanical products (48)
22	Processed rubber and rubber products	Rubber tyres and tubes (51), Rubber processing (52), Rubber gloves (53), Other rubber products (54)
23	Plastic products	Plastic products (55)
24	Non-metallic mineral products	Glass and glass products (56), Refractory, clay, porcelain and ceramic products (57), Cement, lime and plaster (58), Non-metallic mineral products (59)
25	Basic metal	Basic iron and steel (60), Basic precious and other non-ferrous metals (61), Casting of metals (62)
26	Fabricated metal products	Structural metal products, tanks, reservoirs and steam generators (63), Other fabricated metal products (64)
27	Industrial machinery and equipment	Engines & turbines, fluid power equipment, other pumps, compressors, taps and valves (65), Other general purpose machinery (66), Weapons, ammunition and special purpose machinery (67)
28	Household machinery and equipment	Computers, peripheral, office equipment and machinery (69)
29	Household electric appliance and apparatus	Domestic appliances (68), Electric motors, generators and transformers (70), Electricity distribution & control apparatus, batteries and accumulators (71), Fibre optic cables, electronic and other electric (72), Wiring devices, electric lighting equipment and other electrical (73), Electronic components and boards (74), Communication equipment and consumer electronics (75)
30	Precision equipment	Irradiation equipment, electro medical and electrotherapeutic (76), Measuring equipment, testing, navigating and control (77), Optical instruments, photographic equipment, magnetic and optical media (78), Watches and clocks (79)
31	Motor vehicle	Motor vehicles, trailers and semi trailers (80)
32	Other transport equipment	Motorcycles (81), Ships, boats, bicycles and invalid carriages (82), Other transport equipment (83)
33	Other manufacturing products	Other manufacturing (84), Repair & installation of machinery and equipment (85)

Appendix II. Continued

New code	Aggregated sectors	Basic sectors
34	Electricity, gas, and waterworks	Electricity and gas (86), Water (87)
35	Building and construction	Sewerage, waste management and remediation activities (88), Residential buildings (89), Non-residential buildings (90), Civil engineering (91), Specialised construction activities (92)
36	Wholesale and retail trade	Wholesale & retail trade, repair of motor vehicles and motorcycles (93)
37	Hotels and restaurants	Accommodation (94), Food and beverage (95)
38	Other transportation services	Land transport (96), Water transport (97), Warehousing and support activities for transportation (99), Services incidental to water and air transportation (100), Highway operation services, bridge and tunnel (101)
39	Air transport	Air transport (98)
40	Postal and communication services	Postal and courier activities (102), Publishing activities (103), Telecommunications (104), Motion picture, programming and broadcasting activities (105), Computer and information services (106)
41	Financial services	Monetary intermediation (107), Other financial service (108), Insurance/takaful and pension funding (109), Activities auxiliary to financial service and insurance/takaful (110)
42	Real estate and ownership of dwellings	Real estate (111), Ownership of dwellings (112)
43	Business services	Rental and leasing (113), Scientific research and development (114), Professional (115), Business services (116)
44	Education services	Education (118)
45	Healthcare services	Health (119)
46	Other services	Public administration (117), Public order and safety (120), Other public administration (121), Non-profit institutions serving households (122), Arts, entertainment and recreation (123), Other private services (124)

Sources: Authors' aggregation based on Othman and Jafari (2016) and the Department of Statistics (2014; 2018).