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The Economic Impact of Workforce Disruptions on the Output during COVID-19 Pandemic

(Kesan Ekonomi daripada Gangguan Tenaga Kerja terhadap Pengeluaran semasa Wabak COVID-19)

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ABSTRACT

This paper examines the economic impact of workforce disruptions on the output, final demand and Gross Domestic Product by applying an extended input-output (I-O) model. In the extended I-O model, workforce disruptions are measured and modelled in two perspectives: loss of employment (LOE) and inter-industry disruptions that limit the number of workers in the production. Results show that the inter-industry disruption / supply shock is likely to give a tremendous impact compared to the LOE. Moreover, the level of economic impact is also influenced by the level of economic integration among sectors. In this regard, the more integrated a sector with the high-risk sectors, the more impacted the sector is. In conclusion, the results suggest the need for balancing the economic and health risks to ensure that the welfare of people is protected.

Keywords: COVID-19; loss of employment; workforce disruptions; input-output model
JEL: C67, D57, J63

ABSTRAK

Pandemik novel Coronavirus (COVID-19) yang tidak pernah berlaku sebelum ini telah mengubah rentak dunia dan diklasifikasikan sebagai salah satu gangguan paling mendadak dalam satu dekad, yang telah mempengaruhi pasaran buruh secara serius. Artikel ini mengkaji kesan ekonomi bagi gangguan tenaga kerja terhadap output, permintaan akhir dan Keluaran Dalam Negara Kasar (KDNK) dengan menerapkan model Input-Output (I-O) yang diperluas. Dalam model tersebut, gangguan tenaga kerja diukur dan dimodelkan dalam dua perspektif, iaitu kehilangan pekerjaan (LOE) dan gangguan antara industri yang membatasi jumlah pekerja dalam pengeluaran. Hasil kajian menunjukkan bahawa gangguan antara industri (kejutan bekalan) cenderung memberi kesan yang besar berbanding LOE. Selain itu, tahap impak ekonomi juga dipengaruhi oleh tahap integrasi ekonomi antara sektor. Dalam hal ini, semakin lebih bersepadu sesebuah sektor dengan sektor berisiko tinggi, semakin besar impak yang dialami oleh sektor tersebut. Secara keseluruhan, dapatan menunjukkan keperluan dalam mengimbangkan risiko ekonomi dan kesihatan untuk memastikan kesejahteraan rakyat terpelihara.

Kata Kunci: COVID-19; kehilangan pekerjaan ; gangguan tenaga kerja; model input-output
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INTRODUCTION

The outbreak of the COVID-19 pandemic that unprecedented brought about one of the most precipitate events of the decade. The localised health-related crisis that has morphed into a global health and economic crisis has inflicted tremendous impact as compared to the past crises as it affects the supply and demand sides of the economy. In addition to the rising death toll and enormous economies' healthcare expenditure, COVID-19 has ravaged the global economy into a severe contraction. The global economy is estimated to contract by 5.2%, indicating the deepest economic downturn since the Second World War (World Bank 2020).

Malaysia is not "immune" from this unprecedented crisis as it has equally impacted the Malaysian economic performance and population's well-being. In

curbing the outbreak of COVID-19, lockdown measures are implemented to contain the pandemic, resulting in the closure of non-essential businesses, reduced demands for goods and services, and disruptions to the workforce. As a result, Malaysia's gross domestic product (GDP) shrank by 17.1% in the second quarter of 2020 (Department of Statistics Malaysia 2020). The economic slowdown had also resulted in an increase in the unemployment rates. Unemployed workers rose from 778.8 thousand in April 2020 to 826.1 thousand in May 2020, recording a surge in the unemployment rates from 5.0% to 5.3%.

Besides the surge in the unemployment rate, another alarming issue caused by the disruption of the workforce is the rise in the loss of employment (LOE) due to business closure, company downsizing or voluntary/mutual separation scheme (VSS/MSS)[1]. During the crisis, the Office of Employment Insurance System (EIS) registered 34,806 individuals in the second quarter of 2020 which has increased by two-folds compared to the same quarter in 2019 with 9,186. The increase in the LOE confirms the emergence of an economic downturn due to business inactivity, where this situation will also impact the inter-industry supply chain. For example, the tourism industry which has been identified as one of the most impacted industries during the pandemic, depends on other industries to supply its production. Therefore, a decline in the tourism industry has affected other supplying industries within its supply-chain process and has also become a contributing factor to the increase in the LOE. In addition, the impact of labour market disruption has also reflected the loss of income in the workforce, which eventually affects the consumption patterns of the employed households. This is evident based on the fact that the private consumption component of GDP has declined by -3.4% from Q4-2019 to Q4-2020 (EU-ERA 2020).

The supply-chain disruption and LOE are both supply shock effects that stem from COVID-19 pandemic supply-side disruption. This study attempts to assess the magnitude to which LOE and supply-chain disruption have impacted the macroeconomic indicators in terms of output, GDP and employment income. For this purpose, an extended supply-driven input-output model is developed with two novelties. First, an integration between the real-time administrative data on LOE and the inter-industry interdependencies database is introduced for the first time in the Malaysian literature. Second, a supply-driven model is developed to allow for supply chain disruptions, a measure that is important for the COVID-19 crisis.

The major contribution of this study is on the empirical aspect. Firstly, to the best of our knowledge, empirical studies using an input-output modelling to examine the impact of the pandemic in Malaysia is still limited. Therefore, our work provides a significant contribution to fill the gap with respect to the economic-wide approach that enables one to examine the sectoral impact of supply shock alike. Recently, Suib and Salleh (2021) employed the input-output modelling to forecast labour requirement in the tourism sector in Malaysia due to a decline in tourist arrival during the COVID-19 crisis. Despite using a similar methodology, our work differs to former study with respect to data utilisation and technical approach. Specifically, our work uses labour market administrative data and adopts supply-driven model in quantifying the pandemic-led supply shock effects.

Second, this study becomes the first application to assess the economic impact of LOE in Malaysia by integrating input-output models and administrative data. It is worth mentioning that LOE is a crucial real-time labour market indicator even though the application studies on this job loss indicator are still limited to a survey-based dataset. For example, Bhatt et al. (2021) used the Periodic Labour Force Survey 2018-2019 to assess the risk of job loss during the COVID-19 pandemic. The issue with this survey-based dataset administered by the National Statistical Agency is that it compromises a timely analysis for rapid policy responses. In this regard, another significance of this study is that the model developed in this study is useful to determine the impact of workforce disruptions during the pandemic and other potentially unprecedented events such as natural disasters.

This paper is structured into five sections. Section 2 reviews the relevant past studies on the economic impact of the pandemics with specific attention given to workforce disruptions. Section 3 entails the extended supply-driven input-output model along with the data sources. Section 4 presents the result of the empirical assessment of the macroeconomic impact of the LOE. Finally, Section 5 summarizes and concludes the paper.

LITERATURE REVIEW

From a literature survey, it is learnt that this paper could contribute in two main areas with respect to workforce disruption effects. First, from the methodological perspective, a general equilibrium modelling has been utilised to analyse the impact of pandemics on the labour market. Indeed, there are innovations pertaining to this area, but we offer our work to fill the gap in regards to the integration of real-time administrative data and economic-wide modelling technique. Secondly, from the application perspective, our work focuses on the impact of the pandemic on the Malaysian economy. Whist recent literature emerges to address the outbreak effects on the Malaysian socio-economics, the use of supply-side modelling to uncover sectoral-based impact remains scarce. Thus, these two literature gaps conceive the motivation of this study.

MODELLING TECHNIQUES IN LABOUR FORCE DISRUPTION ANALYSIS

In relation to the modelling technique, our literature survey indicates that there is a large concentration of studies on the workforce disruption impact of pandemics on the economy. These studies, however, can be distinguished into two different application models: i) dynamic inoperability input-output model (DIIM) and ii) computable general equilibrium (CGE) model. The DIIM is widely used to simulate the impact of perturbation in terms of losses in the output production. For example, the pandemic recovery analysis studies by Santos et al. (2009) and Santos et al. (2013) applied the DIIM by assuming that the workforce unavailability was translated to direct the sector productivity effects. The findings from these studies showed that the sectors with high contribution to the Gross Domestic Product such as federal companies, professional freelances, scientific and technical services as well as legal services suffered a large economic loss.

Santos (2020) simulated the impact of pandemic preventive measures on labour during the COVID-19. Four hypothetical simulations were constructed in determining the efficacy of the scenario. The hypothetical simulations included in the studies began from baseline up until suppression and continuity. On top of that, studies from Santos et al. (2009), Orsi and Santos (2010a), Orsi and Santos (2010b), Santos et al. (2013), and Santos (2020) used two metrics which were the economic losses and inoperability to capture the impact of the pandemic. Based on these two metrics, they ranked the sectors according to monetary losses and inoperability.

Besides DIIM, CGE modelling is commonly applied to quantify the impact of pandemics on the economy. Dixon et al. (2010) applied a dynamic CGE model to simulate the effects of a hypothetical H1N1 pandemic in the USA. Their analysis included the three categories of dynamic mechanisms, namely capital accumulation, liability accumulation, and lagged adjustment processes. From the simulation, the study estimated the macroeconomic effects such as employment, GDP, private consumption, investment, exports, and imports.

Smith and Keogh-Brown (2013) also examined the macroeconomic effects of the influenza H1N1 pandemic in the three selected countries namely Thailand, South Africa, and Uganda. In this study, they applied a single-country whole-economy CGE model to calculate the economic impact of workforce disruptions due to the pandemic by assessing loss in terms of GDP, sectoral production and household consumption. They modelled a few scenarios using two important indicators, namely the clinical attack rates (CAR) and case fatality rates (CFR).

DIVERSE IMPACT OF COVID-19 OUTBREAK ON THE MALAYSIAN ECONOMY: A BRIEF SURVEY

As our work focuses on the impact of the pandemic outbreak on the Malaysian economy, our literature survey indicates a growing literature on this analysis. A mixture of approaches has been undertaken to understand the impact of the pandemic on the Malaysian economy, particularly in relation to stock market performance (Lee et al. 2020; Chia et al. 2020; Keh & Tan 2021), sectoral-based analysis (Ratnasingam et al. 2020; Shakeel et al. 2020; Zainuddin et al. 2021, Abd Rahman et al. 2021, Utit et al. 2021), firm-level analysis (Nik Azman et al. 2021) as well as labour (Habibullah et al. 2021a, Habibullah et al. 2021b) and households studies (Baharudin et al. 2021).

In a nutshell, micro-and macro-economic analyses using primary and secondary approaches were adopted in these studies which have provided rich information on the impact of the outbreak. However, given that our study emphasises the assessment of the labour market using the economic-wide macroeconomic modelling with sectoral assessment, we would elaborate on more studies related to this approach in the context of Malaysia particularly during the COVID-19 pandemic. In short, we divide our literature discussion into two main areas: i) sectoral analysis and ii) labour market impact.

The research on the economic impact of COVID 19 in relation to sector analysis spans a variety of studies, including small and medium-sized enterprises (SMEs), performance in specific sectors, and assessments of external sectors. For example, Ratnasingam et al. (2020) conducted an online primary data collection among 748 SMEs in the furniture industry. The study concluded that SMEs in the furniture industry had two major concerns, namely financial management and supply chain disruptions. On the other hand, Utit et al. (2021) adopted a recently developed SME input-output database to observe the impact of COVID-19 on SMEs and large enterprises.

Meanwhile, Shakeel et al. (2020) examined the impact of COVID-19 on tourism, retail market, accommodation, and financial sectors by highlighting the reduction in the percentage of total number arrivals and the revenue obtained from these sectors. Similarly, Kabir et al. (2020) highlighted the cutback in the growth of output for the manufacturing and retail sectors. Next, Nik Azman et al. (2021) focused on the financial well-being of micro-enterprises in the northern region of Peninsular Malaysia that was involved in the agriculture, food and textile industries. They emphasised the importance of Islamic micro-financing to support the growth of micro-enterprises.

External sectors are also one of the main areas of concern during the COVID-19 pandemic in Malaysia

because Malaysia is one of the biggest commodities exporters which showcases its significance in the global value chain (Abd Rahman et al. 2022). In terms of COVID-19 impact, Zainuddin et al. (2021) found that the existence of the pandemic has scaled down bilateral exports for 11 economic sectors, while the spread of local cases has negatively impacted 14 economic sectors which were largely caused by the Movement Control Orders (MCOs).

Until now, it is perceived that COVID-19 has impacted the Malaysian economy from various angles. In addition to that, recent studies have also been focusing on the impact of pandemics on the labour market in Malaysia. The significance of these studies is clear in that the supply shock stemming from the pandemic is closely related to the workforce incapacitation either through virus contraction or business closure and inoperability due to the MCOs. According to Habibullah et al. (2021a), the impact of lockdown on the loss of employment (LOE) is positive which implies that the labour market is severely affected as the repercussion of an economic downturn during the pandemic. As the government has embarked on multiple stimulus packages throughout the pandemic period, Hashim et al. (2021) found that a short-term job retention policy through a wage subsidy programme (WSP) is unlikely to increase the unemployment rate with an overall positive net effect on employment.

Not only that, the hiring incentive programme that was implemented during the pandemic is another initiative introduced by the government to increase employment among people. Ahmad Kamal et al. (2021) concluded that the labour market intervention has successfully improved job matching efficiency and has also increased job growth, particularly for semi-skilled workers. In addition, demographic factors are also important determinants to secure jobs during the pandemic. Abu Bakar et al. (2021) found that female and high educated jobseekers would suffer from getting faster jobs compared to their lower educated and male counterparts. The findings from both studies are not surprising given that there are heterogeneous effects of employment in the Malaysian labour market that are biased towards semi- and low-skilled workers as well as a high dependency on foreign labour (Abd Rahman et al. 2021).

METHODOLOGY AND DATA

INPUT-OUTPUT MODEL WITH WORKFORCE AND INTER-INDUSTRY DISRUPTIONS

The methodology developed in this study deals with supply-demand interactions with a limited application to the loss of employment (LOE). There are two novel approaches considered in this study. First, we focus on the linkages between the real-time LOE database and inter-industry interdependencies. Specifically, we develop a supply-driven input-output model to measure the output loss due to LOE before connecting it with the demand-driven model through income-consumption reaction. Secondly, this study develops an input-output model with inter-industry disruption. During the movement control order (MCO) periods, factories were either closed or operated well below capacity which resulted in a lack of intermediate supplies and contributed to the output loss.

The input-output method is an established economic modelling approach with the purpose of providing an understanding of the interaction among production sectors. Explicitly, it exhibits the interrelation among various production sectors that obtain goods and services from other sectors as their production input. Sequentially, they produce outputs in the form of goods and services that are then sold to other sectors in the form of intermediate goods and also to end consumers in the form of finished goods. The input-output analysis is capable of taking the whole production interdependencies and contributes to the application of the model for economic impact assessments (for a basic introduction to input-output analysis, see Miller & Blair 2009).

Table 1 illustrates the simplified structure of an input-output table. Based on the standard input-output matrix representation in the literature, the (n x n) matrix $\mathbf{Z}$ denotes the intermediate deliveries and each element of z_{ij} indicates the quantity of commodity sector i utilized by sector j in the production of the final goods. Final goods are sold to the (n x k) vector of $\mathbf{f}$ that indicates the final demand consumers. The final demand for consumers consists of private consumption (**c**), investment (**s**), public consumption (**g**) and exports (**e**)[2]. In producing the output for final demand consumers, the production also demands primary inputs—the (1 x n) vector $\mathbf{m}$ gives the imports, (1 x n) vector $\mathbf{e}$ denotes the labour income and (1 x n) vector $\mathbf{k}$ shows the capital income[3]. In the input-output table, labour income is defined as the compensation of employees and capital income is denoted by the operating surplus.

The supply-driven input-output model in which also known as the Ghosh model. In the supply-driven model, import, labour and capital inputs are the exogenous variables, while the final demands are the endogenous variable. It presents an alternative interpretation that links sectoral gross production to the primary inputs, that is, to a unit of value entering the inter-industry system at the beginning of the production process. Technically, the supply-driven model is employed by transposing the vertical (column) perspective of the input-output model to a horizontal (row) perspective.

In short, the Ghosh model can be summarised as follows,

$$\mathrm{x}' = \mathrm{i}'\mathrm{Z} + \left(\mathrm{m}' + \mathrm{e}' + \mathrm{k}'\right) = \mathrm{i}'\mathrm{Z} + \mathrm{d}' \tag{1}$$

TABLE 1. Simplified Structure of an Input-Output Table

	Intermediate deliveries							Final demand				Total output
	S1	S2	S3	.	.	.	Sn	c	i	g	e	
Sector 1 (S1)												
Sector 2 (S2)												
Sector 3 (S3)												
.			Z						f			x
.												
.												
Sector (Sn)												
Imports			m									
Labour			e									
Capital			k									
Total input			x‘									

**Source:* Author, 2021

$$x' = i'\hat{x}B + d' = x'B + m' + e' + k' = x'B + d' \quad (2)$$

where $i'\hat{x} = x'$, B $\left(B = \hat{x}^{-1}Z\right)$ exhibit the output coefficient matrix and d' is the vector of primary inputs (i.e. import, labour income and capital income). The delivery z_{ij} from the commodity sector *i* to sector *j* per unit of the seller's output denotes by each element of the output coefficient matrix. The solution for equation (2) is

$$x' = d'\left(I - B\right)^{-1} = d'G \quad (3)$$

Equation (3) is developed for the case of all workers are fully employed. During the economic crisis, some workers lose their jobs and account for the impact on output (due to employment loss). In such a case, the following expression is used.

$$x' = e'\hat{w}\left(I - B\right)^{-1} = \tilde{e}'G \quad (4)$$

where the vector of $\tilde{\mathbf{e}}'$ is obtained as a result of multiplication between the vector of labour income (e') with the so-called wage-bridge matrix ($\hat{w}$). The wage-bridge matrix is expressed in a diagonal matrix with the off-diagonal elements equal to 1 when there is no employment loss and thus no income loss. If the first sector faces a 20% income loss due to unemployment, the first element of the diagonal matrix of $\hat{w}$ will be introduced as 0.80. The average income per employee is calculated to link employment-to-income loss.

The next step is to examine the extent to which the output loss measured in Equation (4) affects the gross domestic product (GDP) by the types of the final demand. For this purpose, we use the following expression:

$$f' = x' \times h' \quad (5)$$

where $\mathbf{x}$ denotes cell-by-cell multiplication and h' is the final demand coefficient $\left(h = \hat{x}^{-1}f\right)$.

Equations (4)-(5) are developed by assuming no inter-industry disruption affects the intermediate supplies. However, we have seen that only some industries are allowed to operate below the capacity during the MCO period. This situation also holds for other countries. Let us show the simplest way to measure the inter-industry disruption in the supply-driven input-output model. We specifically modify equation (1) as

$$x' = \hat{q}i'Z + \left(m' + e' + k'\right) = \hat{q}i'Z + d' \quad (6)$$

where $\hat{q}$ is the so-called intermediate-bridge matrix, indicating the proportion of intermediate supplies. It is expressed in a diagonal matrix with the off-diagonal elements equal to 1 when there is no disruption in the intermediate supplies. If the first sector is allowed to operate at 50% of the full capacity, the first element of the diagonal matrix of $\hat{q}$ will be introduced as 0.50. Then equations (2)-(5) are adjusted accordingly. The inter-industry disruption model operates by assuming the affected sectors due to the lack of intermediate supplies are proportional to the existing supplies.

DATA REQUIREMENTS

There are two main datasets used in this study. The first dataset is the loss of employment (LOE) by economic sectors obtained from the Office of Employment Insurance System (EIS) and the Social Security Organization (SOCSO). The EIS collects and monitors the LOE on a daily basis using the data on registered employees in the private sector subscribing to the SOCSO protection schemes. According to Act 800, LOE refers to insured workers terminated from their jobs due to reasons such as business downsizing, business closure, voluntary separation scheme, and mutual separation scheme. Based on this definition, the LOE

and unemployment are interrelated. Those individuals who are reported on the loss of employment will remain unemployed until they receive a placement. Hence, an increase in the LOE will undoubtedly reflect the rise in unemployment. For the purpose of this study, the LOE data are compiled from January 1 to December 31, 2020, and aggregated into ten broad economic sectors.

The second dataset is the most recent input-output table for 2015, released by the Department of Statistics Malaysia (DOSM 2018). There are 124 sectors categorized according to the 2008 Malaysia Standard Industrial Classification in the input-output table (DOSM 2008). Given the limited sectoral breakdown for the LOE dataset, the input-output table sectors are aggregated into 21 sectors and further summarised into ten major sectors. The sectoral aggregation is made similar to the aggregation of the LOE data. The use of the input-output table is sometimes questioned when there is a lag between the availability of the table (i.e. 2015) and other "exogenous" data, which is, in our case, the LOE data. However, the application of the 2015 input-output table is reasonable because the structures of production, particularly input coefficients are fairly stable despite the adjustment in values that take place gradually (see Saari et al. 2014; Saari et al. 2016).

RESULTS AND DISCUSSION

The discussion of the findings is structured into two sub-sections. Section 4.1 presents descriptive statistics on the loss of employment (LOE) by sectors from the first quarter (Q1) to the third quarter (Q4) of 2020. Section 4.2 tabulates the most important findings from the analyses using the cumulative LOE data (Q1 to Q4).

TREND LOSS OF EMPLOYMENT BY SECTORS

The composition of loss of employment (LOE) by sectors and the changes between the four quarters of 2020 are tabulated in Table 2. In total, the LOE registered in 2020 stood at 107,154 with the most significant number of the LOE recorded in Q2, which increases more than double compared to Q1. However, the LOE in Q3 indicates a decreasing trend which is reduced by 4.3% from 34,793 to 33,309. The implementation of the Movement Control Order (MCO) in Q2 contributes to the spike in LOE while the government decided to re-open the economy in Q3 has contributed to the decrease in the LOE. The declining trend continues in Q4 to record an LOE of 23,437 which provides an early signal to the recovery of the labour market in Malaysia.

At the sectoral levels, results show that the LOE is highly concentrated in the Manufacturing, Wholesale and Retail Trade as well as Hotels and Restaurants sectors, which dominate 49.3% of the total LOE. These two sectors dominate 47.6%, 53.5% and 53.5 % of the total LOE in Q1, Q2 and Q3 of 2020, respectively. Employment in these sectors is highly affected because they are the most labour-intensive sectors. In 2018, employment in Manufacturing, Wholesale and Retail Trade, as well as Hotels and Restaurants sectors, are 17.8% and 27%, respectively.

The Health sector registered the lowest LOE with 769 workers, followed by Agriculture, Forestry and Fishing with 867 workers. Health and Agriculture, Forestry and Fishing are the essential sectors that continue their operations during the pandemic. Thus, this sector is not affected by the COVID-19 disruption. Another sector with low LOE is the Mining and Quarrying sector which recorded only 1,620 workers. Although the sub-sectors such as petroleum and natural gas remain operable during the MCO period, they are partly affected by the downstream economic activities such as petroleum refineries and the wholesale and retail of petroleum products.

THE IMPACT OF LOSS OF EMPLOYMENT ON MACROECONOMIC VARIABLES

The cumulative loss of employment (LOE) data (Q1 to Q4) in Table 2 is used to analyse the impact on output, final demand and gross domestic product (GDP) using the input-output model developed in Section 3. Results are tabulated in Table 3.

If only LOE is considered (ceteris paribus) in the analysis, the output, final demand and GDP are likely to be less affected. The LOE only reduces the output, final demand and GDP by 0.26%, 0.28% and 0.28%, respectively. The fact is that the total LOE for the whole period (Q1 to Q4) only represents 13.9% of the total unemployed workers. The number of LOE is low because the EIS database only captures insured workers, representing only 49.7% of the total formal employment in the economy.

At the sectoral levels, the Other Services sector had the highest losses for the three indicators observed particularly 11,455 LOE reported in the Other Services sector led to RM 1.05 billion or 0.81% output loss. In terms of final demand and output, the LOE triggers a 0.77% and 0.90% loss in the final demand and GDP, respectively. One of the explanations for this observation is that the Other Services sector is highly dependent (integrated) on the growth of other sectors. As a result, changes in the production of other sectors affect largely the Other Services. Santos et al. (2009) and Santos et al. (2010) found a similar result which showed that the Other Services sector was ranked as the largest impacted sector in terms of economic losses.

Whilst it is found that Manufacturing, Wholesale and Retail Trade as well as Hotels and Restaurants are two sectors with the highest LOE cases, the economic losses experienced by these sectors are rather modest as compared to the losses recorded by the Other Services

TABLE 2. Trend loss of employment by sectors, Q1 to Q4 of 2020

Sectors	Q1	Q2	Q3	Q4	Grand Total
Agriculture, Forestry and Fishing	286	261	156	164	867
Construction	1,397	2,353	2,225	1,903	7,878
Education	207	700	672	684	2,263
Financial, Real Estate and Professional and Technical Services	2,378	4,973	4,773	3,540	15,664
Health	135	268	232	134	769
Manufacturing	3,814	7,618	8,272	3,707	23,411
Mining and Quarrying	220	463	569	368	1,620
Other Services [4]	1,674	3,755	3,383	2,643	11,455
Utilities, Transportation and Storage, Information and Communication	1,880	3,399	3,493	5,005	13,777
Wholesale and Retail Trade, Hotels and Restaurants	3,611	11,016	9,534	5,289	29,450
Grand Total	15,602	34,806	33,309	23,437	107,154

**Source:* Employment Insurance System (EIS), SOCSO.

TABLE 3. Losses of output, final demand and GDP due to LOE

Sectors	Output Loss		Final Demand Loss		GDP Loss	
	RM (Billion)	%	RM (Billion)	%	RM (Billion)	%
Agriculture, Forestry and Fishing	0.05	0.05	0.02	0.05	0.04	0.05
Construction	0.45	0.25	0.36	0.25	0.13	0.25
Education	0.24	0.36	0.23	0.36	0.16	0.36
Financial, Real Estate and Professional and Technical Services	1.05	0.35	0.49	0.35	0.64	0.35
Health	0.07	0.14	0.05	0.14	0.03	0.14
Manufacturing	2.15	0.19	1.10	0.18	0.49	0.20
Mining and Quarrying	0.18	0.15	0.08	0.15	0.15	0.15
Other Services	1.05	0.81	0.85	0.77	0.61	0.90
Utilities, Transportation and Storage, Information and Communication	0.95	0.34	0.52	0.39	0.45	0.36
Wholesale and Retail Trade, Hotels and Restaurants	0.95	0.26	0.57	0.29	0.50	0.25
Grand Total[1]	7.14	0.26	4.29	0.28	3.20	0.28

Note: [1]Grand total is the summation of the output loss from 10 sectors and the share of the grand total obtained from dividing the summation of the grand total by the initial output (see Appendix 1). As an example, 0.26% loss of output was obtained from dividing RM 7.14 by RM 2,762.43.
**Source:* Calculated from Equations (4 and 5)

sector. This finding provides an important insight that the economic impact of the pandemic is not only determined by the employees who lose jobs but also influenced by the degree of inter-industry integration.

THE IMPACT OF LOSS OF EMPLOYMENT AND SUPPLY CHAIN DISRUPTION ON MACROECONOMIC VARIABLES

Results in Table 3 are generated without considering the inter-industry disruptions. During the MCO period, almost all economic sectors operated below their full capacity, leading to supply shocks. This study extends the input-output methodology by allowing the simulation of supply shocks to occur in order to capture the impact of the inter-industry disruptions. Table 4 tabulates the economic losses of 10 selected sectors for two scenarios: when sectors operate at 50% less than their full operating capacity and with LOE.

When combining two significant scenarios of the pandemic in a single simulation, tremendous economic losses are found as compared to the analysis in Table 3 (without inter-industry disruptions). Estimated GDP

TABLE 4. Losses of output, final demand and GDP due to inter-industry disruptions

Sectors	Output Loss		Final Demand Loss		GDP Loss	
	RM (Billion)	%	RM (Billion)	%	RM (Billion)	%
Agriculture, Forestry and Fishing	15.66	13.28	6.77	13.28	11.60	13.31
Construction	69.94	38.71	56.28	38.71	20.93	39.75
Education	15.13	22.72	14.65	22.72	10.07	22.77
Financial, Real Estate and Professional and Technical Services	76.14	25.60	33.75	23.82	46.22	25.50
Health	17.25	36.69	14.15	36.69	7.48	36.92
Manufacturing	412.32	35.76	220.52	36.50	87.49	35.53
Mining and Quarrying	14.84	11.78	6.53	11.78	11.76	11.85
Other Services	40.62	31.47	35.31	31.95	21.16	30.90
Utilities, Transportation and Storage, Information and Communication	90.95	32.71	44.66	33.18	41.89	33.12
Wholesale and Retail Trade, Hotels and Restaurants	96.10	26.20	53.48	27.37	52.46	25.96
Grand Total[1]	848.95	30.73	486.12	31.54	311.07	27.57

Note: [1]Grand total is the summation of the output loss from 10 sectors and the share of the grand total obtained from dividing the summation of the grand total by the initial output (see Appendix 1). For example, 30.73% loss of output is obtained by dividing RM 848.95 with RM 2,762.43.
Source: Calculated from Equation (6)

loss when the economy faces supply shocks and LOE is RM 311.07 billion or approximately 27.6%. Without the pandemic disruption, the output could fully support the final demand for domestic consumers and exports. However, it is evaluated that when the output is reduced by 30.7% due to the supply shock, the economy can only support 69.3% of the final demand for domestic consumers and exports. From the results, it could be inferred that the economic losses are mainly determined by the supply shocks. Thus, this finding provides a "prima-facie" case to ensure that economic activities are allowed to operate during the pandemic period.

At the sectoral level, the Construction sector turns up as the highest sector with economic losses in terms of output, final demand and GDP. Output and final demand losses increase to 38.7% compared to only 0.25% due to the LOE. The GDP loss also increases from 0.25% to 39.8%. In addition to the Construction sector, the Manufacturing sector also registers significant losses in the output and GDP, compared to the outcome when only the LOE is considered (refer to Table 3). Another sector with high economic losses for the three indicators is the Health sector. Despite the ability of the Health sector to operate during the pandemic, the disruption in supply shock and LOE triggers its output loss of 36.7%. Based on the loss of output due to the shock, it could be deduced that these losses reduced the ability to support the final demand to 63.3%.

Based on the findings, the Construction, Manufacturing and Health sectors are highly affected by the supply shocks because the production of these sectors is immovable which requires specialised on-site operation and comes with a lower degree of substitution. We find similar results conducted in studies in the other countries. For instance, Rio-Chanona et al. (2020) highlighted that the Manufacturing sector has a high probability to be affected by supply shocks in the United States. Santos (2020) also listed Ambulatory Health Care Services, Construction and Hospitals as the critically affected sectors in the United States based on the economic loss.

Our findings emphasise the need for the government to assess the economic impacts on the sectoral level in the decision-making for imposing non-pharmaceutical measures that involved temporary business inoperability or limited operating hours. The implementation of a national lockdown involving all economic sectors without an assessment of the economic risk will have detrimental impacts on the economy. Based on the findings, Construction, Manufacturing and Health could be potentially classified as high-risk sectors as these sectors are highly affected by the shortages in workers due to LOE and supply-chain disruption. Therefore, prolonged non-pharmaceutical measures involving the high-risk sectors will incur significant economic losses.

CONCLUSION

This paper examines the economic impact of workforce disruptions on the output, final demand and gross domestic product (GDP) by applying an extended input-output model. The workforce disruptions are measured and modelled in two ways which are loss of employment (LOE) and inter-industry disruptions that limit the number of workers in the production. Methodologies

developed in this study are the first attempt to integrate input-output tables with administrative data in the workforce analysis during the pandemic-crisis period.

There are two most remarkable findings provided in this study. First, the disruption in the production (supply shocks) is likely to result in a tremendous impact compared to the LOE. This calls for a serious policy implication in balancing the economic and health risks to ensure the welfare of the people is safeguarded. Second, the level of economic impact is also influenced by the level of economic integration among sectors—the more integrated a sector with high-risk sectors, the more impacted the sector is. Therefore, moving forward, there is a need for economic planners of the country to determine the definition of high-risk sectors and identify the potential sectors.

Methodologies developed in this paper may not be the most comprehensive and perfect measures for the workforce disruption analysis. Results should be carefully interpreted by considering the following two limitations. First, although the stability of the input-output table is acceptable empirically, the use of the 2015 input-output table during the large-scale pandemic in 2020 may result in instability in inter-industry relations. This is because COVID-19 has seriously affected economic sectors and the composition of firms in sectors may have changed significantly some shut down their business, and some continue to operate on different scales. Second, the economic impact is analysed without considering the loop effects (second, third and other rounds of effects), which will further affect the outcome. For example, loss in GDP implies losses in income and consequently affects the consumption level and finally the level of GDP.

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NOTES

1 According to EU-ERA (2020), LOE is a sub-set of the unemployment rate despite both indicators being compiled using different methodologies. LOE is real-time administrative data maintained by the Office of Employment Insurance System (EIS), the Social Security Organisation (SOCSO) as per the discussion provided in the data requirement section.

2 The final demand in the investment category comprises the change in stock and gross fixed capital formation.

3 Input-output model involves matrix operations. For clarity, the matrices are shown in bold and upright capital letters; Bold and upright lowercase vectors, italic lowercase scalars. Since the vectors are columns by definition, the row vectors are obtained by transposition and designated by a prime (e.g. x'). A diagonal matrix with the elements of vector x on its main diagonal and all other entries equal to zero is indicated by a circumflex (e.g. xˆ). A summation vector is represented by i.

4 Other Services include Activities of Households; Administrative and Support Services; Arts, Entertainment and Recreation; Defence Compulsory Social Security; and Other Classification of Services.

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APPENDIX

APPENDIX 1. The output of the sectors during the normal period

Sectors	Total Output (RM Billion)
Agriculture, Forestry and Fishing	117.90
Construction	180.71
Education	66.59
Financial, Real Estate and Professional and Technical Services	297.41
Health	47.03
Manufacturing	1,152.96
Mining and Quarrying	125.93
Other Services	129.07
Utilities, Transportation and Storage, Information and Communication	278.05
Wholesale and Retail Trade, Hotels and Restaurants	366.78
Grand Total	2,762.43