Prioritizing Economic Sectors for Post-Pandemic Recovery:

Examining National and Provincial Scales in Indonesia

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Abstract—The Covid-19 pandemic has resulted in not only health crisis but also economic shocks. It is essential to develop flexible economic models which evaluate the impact of pandemics on different economic sectors. Such assessments are fundamental to inform and to tailor the responses of governments and stakeholders to reduce the adverse impact on the economy during and post-pandemic. In light of this, an overall vulnerability index that takes into account four components namely economic impact, diversity of reach, sector size and income, is developed on the basis of input-output foundations for sectoral prioritization. A comparative assessment between identified key priority sectors is done between the country scale and the regional level. The Indonesian economy as a whole and the province of East Nusa Tenggara (NTT), Indonesia are examined to demonstrate the capabilities of the model. A sensitivity analysis is then implemented to evaluate the possible weighting scenarios of index value and its ranking. The results indicate that the process industry is the most vulnerable sector for the whole country while the service sector has the highest impact for NTT. Finally, policy implications are presented to support government in the development of proper strategies to reduce economic losses during and post-pandemic.

Keywords—covid-19, pandemic, economy, economic impact assessment, supply chain, vulnerability index

I. INTRODUCTION

The recent Covid-19 pandemic has resulted in not just health related issues and concerns but also economic shocks [1]. The pandemic has revealed the vulnerability of supply chains as disruptions in one sector ripple through others in the supply chain [2] thereby resulting to indirect disruptions. For example, when countries started announcing travel bans, the lack of tourists impacted the economic activity of restaurants, hotels and retail industries surrounding tourist spots. The closure of non-essential manufacturing plants such as those dedicated to packaging materials, hampered the productivity of food manufacturing sectors. It is thus essential to develop flexible economic models which analyze these interdependencies to get a better understanding of the impact of pandemics on the economy. Such models can help in the development of more efficient strategies for post-pandemic recovery. Various assessments have been conducted for analyzing the economic impact of the pandemic influenza in the United States [3], SARS in Beijing [4]; MERS in Korea [5] and the recent Covid-19 in UK and China [1]. For Indonesia, the government has made various countermeasures to reduce the impact of the Covid-19 pandemic in various affected sectors during and post-pandemic. For example, the country strives to maintain economic resilience through the implementation of a cash transfer system which included small and medium industrial sectors as well as upstream sectors such as agriculture and fisheries. This is in addition to the provision of temporary wages for workers in these sectors. At the regional level, the Province of East Nusa Tenggara (NTT), whose largest contribution to GDP comes from the agricultural sector, is affected by the pandemic due to disrupted logistics distribution channels that hit the province's economy. This example clearly shows the interdependence of economic sectors. There is thus a need for the government to develop post-pandemic recovery strategies which target the most critical sectors of the economy in order to efficiently allocate resources. Yu et al. [6] developed a vulnerability index for

post-disaster key sector prioritization which identifies critical sectors of an economy based on three components. The components account for the level of disruption experienced by an economic sector, the level of connectivity of a sector and the sector size. This work extends upon the vulnerability index developed by Yu et al. [6] to include the impact of the sectoral contribution on compensation. This aspect is important because it considers the returns to labor input that goes into the production process. Furthermore, it has been recognized that labor plays a critical role in the recovery of an economy.

The rest of the paper is organized as follows. The next section discusses recent related literature. It is then followed by a formal description of the problem being addressed in this work; it is then followed by the development of the extended vulnerability index model. The index is then utilized to evaluate the economy of Indonesia as a case study. Finally, conclusions and directions for future work are provided.

II. LITERATURE REVIEW RELATED TO RECOVERY POST-DISASTER

Interdependence between economic sectors is a very important aspect in the economy which can be modelled using the input output (I-O) model [7]. The I-O model provides information on the transactions between economic sectors, quantifying how much inputs are necessary for a sector to perform its function. This framework accounts for the interdependencies between sectors since outputs from one become inputs to another. This framework has also been used to model the flow of materials, energy, and environmental resources and emissions in industrial process units [8], in industrial complexes [9] and product supply chains [10]. Due to interdependencies, changes experienced by one sector or industry affect others indirectly. The model has thus been successfully used for analyzing the over-all impact of extreme natural conditions which initially impact only specific sectors of the economy. Insights gained from these results can be used alongside other indicators for developing post-disaster recovery strategies. Yu et al. [6] for example included additional components to develop a vulnerability index for key sector prioritization for post-disaster recovery. Santos et al. [11] on the other hand utilized a hybrid I-O and event tree analysis model to account for temporal aspects of disaster recovery.

More recently, the Covid-19 pandemic has emphasized the scale by which the pandemic has affected economic activities. Prolonged lockdowns cannot be sustained, and it has been proposed that strategies should be designed in consideration of both epidemic and economic models [2]. Ludvigson et al. [12] examines the risk of infection against the recovery of industries in the German economy, while [13] predicts how the U.S. economy will react due to supply and demand shocks associated with the Covid-19 pandemic at the industrial level [14]. Furthermore, the work of Santos [15] made use of the I-O model to analyze and demonstrate the extent to which mitigation and suppression measures can flatten the curve in the US based on the baseline scenario. He then concludes with reflections on other consequences of pandemics. Guan et al.

[16] on the other hand looked into control measures for global supply chains. The pandemic can also influence other environmental issues linked to climate change as it impacts oil and electricity demand in China [17], food waste management [18] and plastic waste generation [19]. Previous relevant studies have assessed the economic impact of disasters or economic disruptions resulting from strategic option policies implemented for countries, regions and sub-regional levels. The work of Hoa et al. [20] for example, measures the vulnerability of economic sectors using average propagation length, economic loss, and inoperability to derive a composite vulnerability index resulting from the implementation of a bioethanol blending program in Vietnam. McKibbin and Fernando [21] used I-O data from the Global Trade Analysis Project database and demonstrated a significant impact on the global economy due to the Covid19 pandemic in 24 countries and regions. Further [22], proposed to validate algorithms of a data-driven dynamic clustering simulation framework for moderating the adverse economic impact of Covid-19 in Malaysia. The Keynesian [23] supply shock modeling was used to examine the impact of various policies on the post-pandemic economy. Several perspectives have been provided [24] on some emerging concerns on the socio-economic effects of a pandemic to the environment and regarding Covid-19 and the politics of sustainable energy transitions [25].

The development of post-pandemic recovery strategies will be essential as nations slowly ease out of strict lockdowns. Resources will be needed to support highly impacted sectors of the economy. In this regard, proper identification of key sectors is necessary to ensure the proper allocation of resources. However, critical sectors may vary depending on whether one looks at the national or regional scale. In this work, a comparative assessment between identified key priority sectors is done between the national level and the regional level. The provincial region of East Nusa Tenggara, Indonesia is used as the regional case study and is compared against the performance of Indonesia as a whole.

III. PROBLEM STATEMENT

Given economic transactions within a country and within a certain region and with known initial impact of disruptions, the problem is to identify the critical sectors which must be prioritized for post disaster recovery in order to minimize the impact of the pandemic on the economy.

IV. EXTENDED VULNERABILITY INDEX MODEL

The critical sectors in the economy may be identified based on their performance in the indicators initially included in the vulnerability index of [6]. In their work, the three components include economic impact, sector connectivity (or propagation length) and sector size. In this work, we introduce a fourth component which is referred to as the "income multiplier." The interested reader is directed to the work of [6] for a more detailed discussion of the different components of the index. The vulnerability index, V_i, for each sector i is determined using Eq. 1 where p_{ij} refers to the normalized performance of

sector i in component j and ωj refers to an exogenously defined weighting factor associated with component j. The associated weight for each component should be greater than 0 but less than 1 as indicated in Eq. 2. Furthermore, the sum of all the weights should not exceed 1.0 (Eq. 3).

$$V_i = \sum_{j=1}^{n} p_{ij}\omega_j \qquad (1)$$

$$0 \leq \omega_j \leq 1 \qquad (2)$$

$$\sum_{j=1}^{n} \omega_j = 1 \qquad (3)$$

The first component referred to as economic impact is related to the output- inoperability multiplier ratio which can be derived from the level of inoperability experienced by the sector when a disruption occurs. This refers to the level by which the capacity of a sector has been reduced due to the disruption in comparison to it business-as-usual (BAU) capacity. The second component, sector connectivity which is also referred to as propagation length, is associated with the number of forward and backward linkages of the sector. This is an indicator of how connected a sector is with other sectors of the economy. A high connectivity indicates that disruptions experienced by this sector will impact more sectors of the economy. The third component, sector size, refers to the size of an economic sector relative to the rest of the economy. The bigger a sector is, the more is its contribution to the over-all productivity of an economy. The fourth component, income multiplier, considers the income generated by engaging in activities directly and indirectly related to the sector. These components are based on the input-output framework that takes into account inter-industry relationships within an economy.

V. CASE STUDY

Indonesia is an archipelagic country and currently has 34 provinces with an annual economic growth of over 5 percent, with the largest contributors from the tourism, energy, industry, and agriculture sectors. Due to the Covid-19 impact, the government has also revised the projection for Indonesia's economic growth to be below 5 percent, which is only around 2.5 percent, from which had grown to 5.02 percent last year. Nationally, Covid-19 has resulted in economic losses that are evenly distributed in various regions in Indonesia. According to Bank of Indonesia [26], the NTT Province's economic growth in the first quarter of 2020 was recorded at 2.84 percent, slowing down compared to the previous quarter which reached 5.32 percent. This slowdown is the impact of Covid-19 which has affected the decline in both private and government consumption as well as investment amid improving performance in the external sector. In terms of employment, the economic slowdown in NTT Province in the first quarter of 2020 was mainly influenced by the decline in labor

performance in the agriculture, forestry and fisheries sectors. In the second quarter of 2020, the economic growth of NTT Province is predicted to slow to a range of 1.15 -1.55 percent, influenced by the continuation of policies to deal with the Covid-19 pandemic, which has an impact on lowering domestic demand, particularly household consumption, for example, an increase in the price of a good plus a decrease in income is a fatal combination that reduces purchasing power. The government must anticipate the decline in consumption, which has so far supported Indonesia's economic growth nationally.

This study considers the case of Indonesia and one of its provinces, NTT, to measure the vulnerability of economic sectors. Using the national and provincial level input-output tables, this study will compare the similarities and differences in the results and show how these can have policy implications. We utilize a 9-sector I-O table which was generated from the Indonesian I-O tables [27] and the NTT regional provincial I-O [28,29]. Table I shows the description of the relevant economic sectors.

TABLE I.   I-O SECTORS

Sector Code	Description
S01	Agriculture, Animal Husbandry, Forestry, and Fisheries
S02	Mining and Quarrying
S03	Processing Industry
S04	Electricity, Gas and Clean Water
S05	Buildings
S06	Trade, Hotels and Restaurants
S07	Transportation and Communication
S08	Finance, Real Estate, and Corporate Services
S09	Services

Table II presents the index values and rankings for each component for Indonesia. At the national level, in terms of economic impact, the electricity, gas and clean water sector has the highest impact among all sectors, followed by transportation and communication and buildings sectors. This is quite interesting as intuitively; the processing industry is typically assumed to have the highest economic impact for emerging economies like Indonesia. However, the current measure of economic impact is a composite of gains and risks. This means that the Indonesian processing industry may have larger gains than the other sectors but the risks that it is exposed to are also huge, thus having the lowest index value among all sectors. In terms of connectivity, the processing industry has the highest-level index value. The trade, hotel and restaurant sector, although ranked second in terms of connectivity, has an index value of less than half of the processing industry sector showing the significance of the process industry sector's influence towards the other sectors. Agriculture and the services industry have the lowest index values in terms of connectivity, meaning they are not reliant or other sectors rely less on these sectors. In terms of sector size, the processing industry has the highest share, which is almost three times the value of the trade, hotel and restaurant sector that is ranked second, and the building sector ranked third. The income multiplier component provides a different ranking such

that the services sector has the highest index value, followed by the transportation and communication sectors and the trade, hotel and restaurant sectors. Although these sectors are not considered as the largest in terms of other components, their returns to the labor force are significant compared to the top sectors. By assigning equal weights to the four individual components, a composite vulnerability index is computed. Overall, the process industry is the top sector in Indonesia, followed by trade, hotel and restaurant sector and services sector. The sector with the lowest composite index value are the mining and quarrying sector and agriculture sector. This is in line with the current national government policy which prioritizes the non-oil and gas sector as an economic prime mover such as tourism and the creative economy which is able to absorb a significant amount of workforce. In general, the existence of medium/small scale industries is drastically larger than large scale industries, thus it is clear that national government policies need to be maintained by ensuring other sectors that also play an important role in maintaining the investment climate for the two sectors while continuing to monitor the impact of Covid- 19 on the national economy which continues to be evaluated.

Table III shows the index values and rankings for each component of the vulnerability index for the NTT province. Based on the economic impact component, the process industry has the highest contribution followed by the electricity, gas and clean water sector and the mining and quarrying. The lowest economic impact is attributable to the service sector. However, in terms of connectivity, the service sector has the highest contribution followed by the building sector and agriculture sector, while the electricity, gas and clean water sector has the lowest level of connectivity. In terms of sector size, the agriculture sector has the largest contribution to the NTT economy, followed by the service sector and the trade, hotel and restaurant sector, with mining and quarrying sector and electricity, gas, and clean water having the least contribution to its economic output. Based on income generation, the service industry provides the highest returns to the followed by building sector and process industry. The lowest returns can be observed from the agriculture sector and the trade, hotel and restaurant sector. The overall composite vulnerability index of the NTT province is computed by assigning equal weights for the four components. The services sector is the most vulnerable sector in the NTT province followed by the agriculture sector and the building sector. The least vulnerable sectors in terms of the

four components are the finance, real estate and corporate services sector and the electricity, gas and clean water sectors. These results show that the current approach by the NTT government for several years and its medium-term policies to improve the regional tourism industry as an economic driving wheel needs special attention through direct funding allocations which are expected to maintain balance and stability of the regional economy where the supporting sectors are related to finance and corporate services can be the main support in supporting the post-pandemic mid-term regional policies, while, the NTT provincial government can continue to promote dryland agriculture as a promising new industrial sector because the rainfall conditions are quite low. Further, in terms of the amount of direct allocation to sectors that are exposed to the impact of Covid-19, further research needs to be carried out.

Comparing the composite vulnerability index values for Indonesia and the NTT province, it can be observed that there are significant differences in results. Provincial policymakers should use their localized tables in order to make policies that are more attuned to their economic structure. Because the influence of the global economy and the new normal transformation after Covid-19 also have an impact on the paradigm towards a new economy which provides space for shifting of the economic structure in a region globally, including the national and regional levels of Indonesia. There are differences and similarities between the general Indonesian economy with the NTT province economy. The difference is in industrialization-based policies and similarities in short-term policies that provide space for the service industry in general including the tourism, hospitality and other related sectors according to the economic structure conditions of each region which refers to the four-component economy impact, connectivity, sector size, income multiplier.

Table II and Table III presented composite vulnerability indices that where we initially considered equal weighting for each component of the index. Using a Monte Carlo simulation, we conduct a sensitivity analysis to account for other possible weighting scenarios that could affect the index value and the rankings of the proposed composite vulnerability index. Fig. 1. shows the illustration of the results of the sensitivity analysis for Indonesian case study. Panel (1a) shows the different values that the index can assume given varying preference weighting mechanisms. Panel (1b) reflects the corresponding ranks for Panel (1a). Based on the illustrations, some sectors show broader possible values such

TABLE II.   COMPONENTS OF THE VULNERABILITY INDEX FOR INDONESIA

Sector Code	Component 1		Component 2		Component 3		Component 4		Composite	
	Value	*Rank*	*Value*	*Rank*	*Value*	*Rank*	*Value*	*Rank*	*Value*	*Rank*
S01	0.11	4	0.03	8	0.08	5	0.09	7	0.08	9
S02	0.11	6	0.09	4	0.06	7	0.06	9	0.08	8
S03	0.05	9	0.34	1	0.37	1	0.09	8	0.21	1
S04	0.16	1	0.12	3	0.01	9	0.09	5	0.10	5
S05	0.11	3	0.09	4	0.10	3	0.10	4	0.10	4
S06	0.09	8	0.15	2	0.12	2	0.11	3	0.12	2
S07	0.12	2	0.06	6	0.07	6	0.12	2	0.09	6
S08	0.11	5	0.06	6	0.06	8	0.09	6	0.08	7
S09	0.11	7	0.03	8	0.09	4	0.20	1	0.10	3

TABLE III.   COMPONENTS OF THE VULNERABILITY INDEX FOR NTT

Sector Code	Component 1		Component 2		Component 3		Component 4		Composite	
	Value	*Rank*	*Value*	*Rank*	*Value*	*Rank*	*Value*	*Rank*	*Value*	*Rank*
S01	0.06	7	0.14	3	0.35	1	0.06	8	0.16	2
S02	0.13	3	0.09	5	0.01	8	0.13	6	0.09	7
S03	0.18	1	0.14	3	0.04	6	0.18	3	0.12	4
S04	0.16	2	0.00	9	0.01	9	0.16	7	0.06	9
S05	0.06	8	0.19	2	0.12	4	0.06	2	0.12	3
S06	0.08	6	0.07	6	0.13	3	0.08	9	0.09	6
S07	0.11	5	0.07	6	0.07	5	0.11	4	0.09	5
S08	0.12	4	0.07	6	0.03	7	0.12	5	0.09	8
S09	0.05	9	0.21	1	0.25	2	0.05	1	0.18	1

as the process industry sector that can span from 0.1 to 0.33 while some sectors have less sensitive values as shown by the building sector. However, Panel (1b) reveals some certainty that the trade, hotel and restaurant sector is one of the high priority sectors as it consistently ranks second to fourth. Finance, real estate and corporate services sector is one of the low priority sectors as it consistently ranks seventh to ninth across the simulations. For other sectors, rankings are inconclusive as they result in wider bands.

Figure 2 shows the varying vulnerability index values and the different rankings for the sectors in the NTT Province. Panel (2a) and Panel (2b) indicate that the values and rankings for the NTT Province are volatile such that the rankings that each sector has under different preference weighting scenarios vary broadly and one cannot easily determine whether a sector is a high priority or low priority sector.
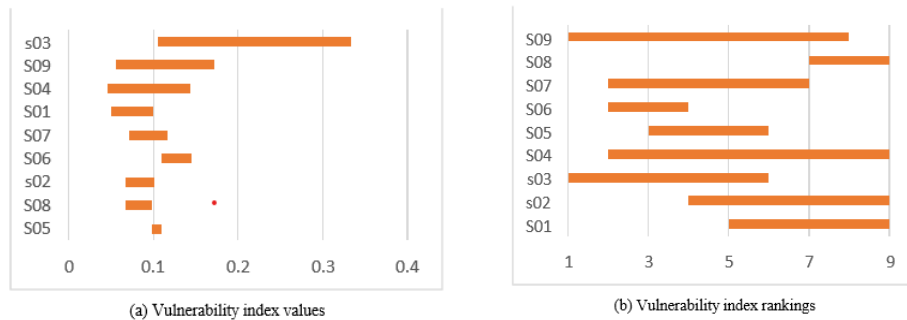

Fig. 1.   Sensitivity analysis result for vulnerability index (a) and rankings (b) for Indonesia.
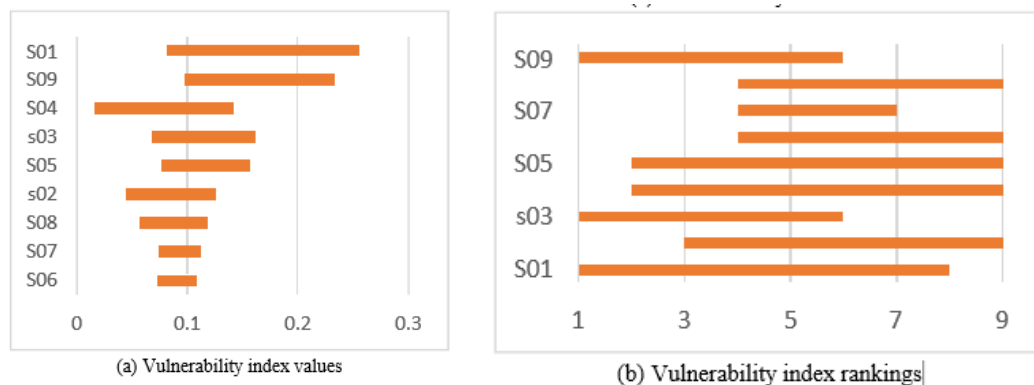

Fig. 2.   Sensitivity analysis result for vulnerability index (a) and rankings (b) for NTT Province.

VI.   CONCLUSIONS AND RECOMMENDATIONS

This study has developed a vulnerability index that considers four dimensions namely economic impact, diversity of reach, sector size and income based on I-O foundations. We used two levels of I-O data for Indonesia, a national level table and a provincial level table, to illustrate the importance of using localized data for policymaking purposes. The results indicate that the process industry is the most vulnerable sector, followed by trade, hotel and restaurant sector and service sector in terms of the whole country. Meanwhile, the service sector

has the highest impact on economy of NTT province, followed by the agriculture sector and the building sector. Variations in sector priority ranking between the national and regional level can provide insights on how governments should allocate resources for recovery efforts targeted on specific regions of a country. Results of the sensitivity analysis show that the priority ranking of most sectors vary broadly depending on the weights assigned to the vulnerability indicators especially for the results obtained at the provincial level. In this regard, both the national and regional province need to pay special attention on short-term policies that provide space for the service industry in general including the tourism, hospitality and other related sectors according to the economic structure conditions of each region which refers to the four component i.e. economy impact, connectivity, sector size, income multiplier. Although, there is a difference in industrialization-based policies. Further, it is important to conduct more rigorous studies which will elicit the appropriate weighting factors from stakeholders.

This research focused on Indonesia and an Indonesian province case study, but similar models can be easily adapted for used in other nations with existing IO tables. Future works can be extended to take into account the impact of this pandemic on global economy using trade factors and multi-regional input-output models. The use of dynamic input-output models can also be implemented to examine the dynamics of recovery of the economic sectors. This will help find the best way to minimize the effect of the economic global crisis resulting from the outbreak of Covid-19.

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