Recuperation of economy after volcanic eruption in Mt. Merapi, Indonesia: a multiregional input-output analysis

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Research

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Abstract

Indonesia is in one of the disaster-prone points, the ring of fire, which frequently suffer from natural disasters. Mt. Merapi volcanic eruption in 2010 was one of the catastrophic natural disasters, which caused the approximate economic damages of 3,628 trillion Indonesian rupiah. To recover the loss of different sectors of the economy, the central and regional governments allocate special budget for recovery and reconstruction. We assess the induced economic effects of Mt. Merapi eruption recovery fiscal support by using a multiregional input-output (MRIO) model. We utilize the state level data of the 2005 Indonesian interregional input-output table (IRIO) and the 2011–2013 volcano eruption restoration. Our results indicate that the effect of 2010 recovery budget for Mt. Merapi eruption contributed to the economy of the hazard-affected Yogyakarta Special Region. In addition, the forestry sector, other services sector, and construction sectors have a significantly benefited from the induced output by fiscal support.

1. Introduction

The ring of fire is one of the most natural disaster hotspots in the basin of the Pacific Ocean. The region formed 40,000 km (25,000 miles) horseshoe-shaped basin from South America to North America through New Zealand to the Bering Strait, Japan. There are frequent occurrences of various kinds of disasters, such as earthquakes, tsunamis, volcanic eruptions, floods, droughts, landslides, and forest fires. There are 452 volcanoes through the ring of fire length, 75% of which are inactive (De Boer & Sanders, 2012).

Indonesia is located in the ring of fire region with the world's most active volcanoes (United Nations, 1982). In this island nation, the number of volcanoes is around 147, of which 76 are active. The volcanoes are scattered along the Sumatra, Java, Celebes, and the Lesser Sunda islands. The volcanic eruption is one of the most alarming disaster in Indonesia and this eruption further tracked by massive damage to infrastructure and shifts in social organizations as well as long-term financial impact (United Nations, 1982).

In Indonesia, the contemporary and one of the most devastating volcanic eruption, named as the Mt. Merapi eruption, occurred on October 26, 2010 and continued until November 2010. The eruption event results in the loss the massive damage of lives and property. The disaster subsequently designated as a catastrophic natural disaster. The damage caused by Mt. Merapi eruption had an impact on the residential sector, infrastructure, social, economic, across-sector, which resulted in the disruption of public activities and services in the area around Mt. Merapi.

Based on the appraisal results of the Regional Disaster Management Agency, Yogyakarta Special Region Province, the eruption of Mt. Merapi has caused damage and losses of 3,628 Trillion rupiah (Faturay, Lenzen, & Nugraha, 2017). Moreover, Regional Disaster Management Agency of Yogyakarta Special Region (Faturay et al., 2017) explained that as the impact of damage and losses exist long, the estimated total government particular budget, both central and local government, requirements for rehabilitation
and reconstruction after the disaster of Mt. Merapi eruption in Yogyakarta Special Region Province amounted to 772.90 billion rupiah. This particular total budget allocated from 2011 to 2013.

Given Indonesia's geographical appraise and economic varying qualities, it is fundamental that economic, social, and natural assessments make utilize of regionally abrasive and comprehensive information. Therefore, it is necessary to estimate the induced output effect from the recuperation budget of the post-Mt. Merapi eruption and its interaction with other provinces and sectors in Indonesia using the multi-regional input-output (MRIO) table of Indonesia 2005. The MRIO assessment as a helpful instrument for multi-regional and multi-sectoral effect assessment can define the regions as provinces and industries that play a key role in other fields and sections or in the financial structure of Indonesia. The MRIO model is implied in this research in estimating the induced impact of the specific government budget on the eruption of Mt. Merapi's rehabilitation and reconstruction (recovery).

Several earlier studies focus on the analysis of the catastrophe using the input-output model (i.e. Koks and Thissen, 2016; Li et al., 2013; Hallegatte, 2008), mostly assessing short-term or long-term disaster damage and losses. Koks and Thissen (2016) explained that most of the neighboring regions gain from the flood due to increased demand for reconstruction in the affected region. In other words, around 25% of the total increase in production is caused by disaster import which is the direct increase in production demand for the non-affected regions. Meanwhile Li et al., (2013) in their paper mentioned London's economy would recover approximately 70 months by applying some proportion ratio scheme assumption. Policies in transportation and health care are effective proportion scheme to recover economic condition after post-disaster.

Only a few types of studies that evaluate the post-disaster budget for rehabilitation and reconstruction. Haque and Jahan, (2015) investigate expenses and failures, as well as investments in consumer spending and public/private investment to assist restore Bangladesh from the flood disaster. In addition, Haque and Jahan, (2015) found that induced loss has a large share for agriculture, manufacturing, construction, and housing services sectors. Consumer spending and public/private investment have a large impact on the manufacturing and construction sectors to recover from floods damages, while agriculture and housing services struggled to recuperate.

In this study, we evaluate the post-disaster budget for rehabilitation and reconstruction by identifying the induced output by this fiscal support. In Sect. 2, we describe the background on Mt. Merapi eruption and government recuperation budget 2011–2013. In Sect. 3, we explain the methodology and data in detail. In Sect. 4, we report the results and analysis, which containing outcomes for the natural disaster from the induced output of government restoration budget. We conclude and suggest the policy implications in Sect. 5.

2. Background
2.1 Mt. Merapi eruption 2010 and government special budget for rehabilitation and reconstruction

Mt. Merapi, 25–30 km north of the Yogyakarta Special Region's metropolitan area, and the surrounding area is home to approximately 1.6 million residents (Jousset et al., 2012). Figure 1 represents the geographic location of Mt. Merapi. It is located on latitude 7° 32′30″ South and longitude 110° 26′30″ East and situated in a seduction zone between the Indo Australian and Eurasian plates. The volcanic activity in Sumatra, Java, Bali and Lesser Sunda guided by this disposition. It is known as the world's most active volcano with pyroclastic streams created by the collapse of the magma arches (Hariyono & Liliasari, 2018).

The early warning system at Mt. Merapi is the same as at all volcanoes in Indonesia and based on the analysis of instrumental and visual observations. It includes four forewarn steps:

Level I: It indicates the activity of the volcano is in the normal phase, with no indication of increasing business, even though poisonous gasses may threaten the area close to the carter.

Level II: set when visual and seismic data indicate that activity in level I is increasing.

Level III: This level defined when a trend of increasing unrest is continuing, and there is a concern that a dangerous eruption may occur.

Level IV: established when the initial eruption starts (i.e., ash/vapor erupts, which may lead to a more massive and more dangerous outbreak).

During the four levels of the explosion, the cautious in level IV was set before the first explosion and remained at IV through the end of the crisis. The vigilant level announced to the public through the National Agency of Disaster Management (BNPB) and the local governments (Jousset et al., 2012).

Furthermore, on October 25, 2010, the forecast proved accurate and timely as 35 h after the cautious issued, a colossal eruption began at 10:02 UTC on October 26, 2010, and ended at ~12:00 UTC. The volcanic eruption killed the renowned mystical guardian of Merapi volcano, Mbah Marijan and 34 others who refused to evacuate from the village of Kinahrejo, located 7 km from the summit. Moreover, Regional Disaster Management Agency (BNPB) statistical data mentioned that 367 people killed, 277 injured, and 410,388 people were displaced. The accurate forecasts by The Indonesian Center of Volcanology and Geological Hazard Mitigation (CVGHM) and immediate dismissions of many tens of thousands of people saved 10,000–20,000 lives (a conservative estimate based on BNPB reports of 2300 settlement ruined and multiplied by 4 to 8 people associated with each household) (Jousset et al., 2012).

Chronology of the eruption of Mt. Merapi based on the institute for investigation and development of mountainous technology, the CVGHM listed in Table 1.
## Table 1
Chronology of the eruption of Mt. Merapi

| Date of activity initiation | Activity detail |
|----------------------------|----------------|
| September 20, 2010         | Activity status of Mt. Merapi increased from Level I (Normal) to Level II (Alert) |
| October 21, 2010           | The status of Mt. Merapi activity increased from Level II (Alert) to Alert in Level III |
| October 25, 2010           | Activity status of Mt. Merapi has increased from Alert in Level III to Level IV (Explosive phase). The safe area outside 10 km from Mt. Merapi Summit for inhabitants. Basic: Letter of the Head of the Center for Volcanology and Mitigation of Geological Disasters through the Head of BPPTK Yogyakarta Number 2044/45 / BGL.V / 2010 RR Action Plan for Mt. Merapi Eruption – 24 October 25, 2010. Subject: Increasing the Status of Mt. Merapi Activities from "Alert in Level III to" Level IV (Explosive phase) ". |
| October 26, 2010           | The first eruption occurred at the distance of the hot clouds reaching 7.5 km from the peak of Mt. Merapi. |
| November 3, 2010           | The activity of Mt. Merapi improved with the existence of constant warm clouds beginning at 11:11 WIB 15:00 WIB without stopping at a warm sliding range of 9 km from Mt. Merapi peak. |
| November 3, 2010           | It was decided that the secure region beyond the 15 km radius from Mt. Merapi’s summit. |
| November 4, 2010           | A continuous eruption has occurred since November 3, 2010 with the gliding range of warm clouds reaching 14 km from the peak of Mt. Merapi with distribution to all the rivers that tipped on Mt. Merapi. |
| November 5, 2010           | A secure zone is located outside a 20 km radius from the Merapi Summit. Preceded by a roar heard from the top of Mt. Merapi up to a range of 28 km. |
| November 14, 2010          | Regional restrictions on safe areas have been decreased based on decreased activity and variety of warm cloud glides, 15 km and 10 km from Merapi Summit. |
| November 19, 2010          | Decrease of the Mt. Merapi hazard zone, where the secure zone is located outside 10 km and 5 km from the Merapi summit. |
| Date of activity initiation | Activity detail |
|----------------------------|-----------------|
| December 3, 2010           | Merapi Mountain activity status was reduced from Level IV (Explosive phase) to Alert in Level III, provided there was no activity within a radius of 2.5 km from the summit and the lahar hazard region was at a range of 300 m from the mouth of the river tipping at the peak of Mt. Merapi. |

Based on the Law number 3/2007 concerning disaster management in chapter III about responsibility and authority, article 5 states that “The government and local government are responsible for the implementation of disaster.” Hence, post-disaster subscriptions need to be done immediately to restore the condition of the community and the environment caused by the disaster that has occurred. According to the regional disaster management agency of Yogyakarta Special Region (Regional Disaster Management Agency of Yogyakarta Special Region, 2011), the Mt. Merapi eruption has caused damage and losses of 3,628 trillion Indonesia rupiah. In addition, the budget requires for rehabilitation and reconstruction estimated at 77,290 billion Indonesia rupiah - the rehabilitation and reconstruction (recovery) budget for this natural disaster allocated from central and local government.

3. Method And Data

3.1 Multiregional Input-Output (MRIO) Analysis

The MRIO analysis can be used to study the interrelationship between sub-national regions within a country and, initially, the theoretical basis of the interregional I-O model was developed by Isard, (1951) for the subnational level. Compared with recent developments of MRIOs at the international level, however, the number of up-to-date subnational MRIO tables and applications are much smaller (Többen & Kronenberg, 2015).

Additionally, Gallego and Lenzen, (2009) stated that if MRIO tables are to construct at the subnational level, non-survey methods are used to build a set of single-regional tables, which are afterward linked to each other via interregional trade estimated. A limited number of attempts have made at generating a sub-national MRIO system for Indonesia. Hulu and Hewings, (1993) created an interregional model consisting of 11 sectors and connecting five central regions of Indonesia: Sumatera, Java and Bali, Kalimantan, Sulawesi, and Eastern Indonesia. Moreover, Resosudarmo et al., (2009) extended a similar model to 35 sectors and embedded the resulting information into a Computable General Equilibrium (CGE) model (Resosudarmo, Yusuf, Hartono, & Nurdianto, 2009).

A similar input-output table can also construct on a regional level. The difference lies in the fact that at the local level, multiplier tends to be smaller in values as opposed to those at the country level. Sectors within the local economy may have to buy inputs from various industries in other regions, although still in the same country. Nevertheless, sectors within a province may also have to sell their products to different segments outside the zone (Resosudarmo, Hartono, & Nurdianto, 2009).
Furthermore, Resosudarmo et al., (2009a) mentioned that to know how these regions inter-connect through trade relations, it is necessary to construct a MRIO table (in annex table A1). The transactions are limited to those conducted between two regions of the same country; in other words, the country divided into two separate or some provinces. Each row in the MRIO table shows the number of goods and services sold to all sectors in both or some regions while each column indicates the number of products and services bought from all industries in the other provinces.

The multiregional input-output (MRIO) table is used to estimate the induced output impact of the special government budget (Central government and Yogyakarta Special Region government) which allocated for rehabilitation and reconstruction after the post-disaster of Mt. Merapi eruption 2010. And according to Miller and Blair, (2009), the induced output can be calculated using the formula:

$$\Delta X = (I - A)^{-1} \cdot \Delta F$$  \hspace{1cm} (1)

Where $[I - A]^{-1}$ is the Leontief inverse matrix, $\Delta X$ is induced output, $\Delta F$ is an independent vector of final demand. This MRIO is treating the import section to put into the row below the intermediate input table, which means the input coefficient table does not include import trades.

### 3.2 Data

There are two kinds of data used to estimate the impact of the reconstruction and rehabilitation budget for Mt. Merapi eruption in 2010. First is the Interregional Input-Output Table of Indonesia 2005, which includes 30 provinces and 35 sectors, collected from Directorate of Regional Development of the National Development Planning Agency, (not published). Table 2 represents province name in Indonesia and Table 3 shows the sectors’ classification of the MRIO table of Indonesia 2005.
Table 2
Province of Indonesia

| Province number | Province's name in Indonesia | Province number | Province's name in Indonesia |
|-----------------|------------------------------|-----------------|------------------------------|
| 1               | Aceh                         | 16              | West Kalimantan              |
| 2               | North Sumatera               | 17              | Central Kalimantan           |
| 3               | West Sumatera                | 18              | South Kalimantan             |
| 4               | Riau                         | 19              | East Kalimantan              |
| 5               | Jambi                        | 20              | North Sulawesi               |
| 6               | South Sumatera               | 21              | Gorontalo                    |
| 7               | Bangka Belitung              | 22              | Central Sulawesi             |
| 8               | Bengkulu                     | 23              | South Sulawesi               |
| 9               | Lampung                      | 24              | South East Sulawesi          |
| 10              | Jakarta                      | 25              | Bali                         |
| 11              | West Java                    | 26              | West Nusa Tenggara           |
| 12              | Banten                       | 27              | East Nusa Tenggara           |
| 13              | Central Java                 | 28              | Maluku                       |
| 14              | Yogyakarta Special Region    | 29              | North Maluku                 |
| 15              | East Java                    | 30              | Papua                        |
Table 3
Sectors in the MRIO table of Indonesia 2005

| Sectors’ number | Sectors’ name                      | Sectors’ number | Sectors’ name                      |
|-----------------|------------------------------------|-----------------|------------------------------------|
| 1               | Paddy/Rice                         | 19              | Cement Industry                    |
| 2               | Other Food Crops                   | 20              | Basic Metal Industry               |
| 3               | Plantation Crops                   | 21              | Metal products Industry            |
| 4               | Animal Husbandry                   | 22              | Electrical Equipment and Machinery Industry |
| 5               | Forestry                           | 23              | Transportation and Its Repair Industry |
| 6               | Fishery                            | 24              | Other industries                   |
| 7               | Oil, Gas and Geothermal Mining     | 25              | Electricity, Gas and Clean Water   |
| 8               | Coal, Metal Ore and Other Mining   | 26              | Construction                       |
| 9               | Oil Refinery                       | 27              | Trade                             |
| 10              | Palm Oil Industry                  | 28              | Hotel and Restaurant               |
| 11              | Marine Processing Industry         | 29              | Land Transportation                |
| 12              | Food and Beverage Industry         | 30              | Water Transportation               |
| 13              | Textile and Textile products Industry | 31              | Air Transportation                |
| 14              | Footwear Industry                  | 32              | Communication                      |
| 15              | Wood, Rattan and Bamboo products Industry | 33              | Financial Institutions            |
| 16              | Pulp and Paper Industry            | 34              | General Government and Defense     |
| 17              | Rubber and Rubber products Industry | 35              | Other Services                     |
| 18              | Petrochemical Industry             |                 |                                    |

Second is the recovery (reconstruction and rehabilitation) budget from both central and local (Yogyakarta Special Region) government 2011–2013. This budget is a particular budget that the government allocated to restore the condition after the eruption, where the data have been collecting from the regional disaster management agency of Yogyakarta special region (Regional Disaster Management Agency of Yogyakarta Special Region, 2011).
Table 4 depicts the recovery budget 2011–2013 from central and local government which allocated by sectors after it aggregated into sectors’ name in MRIO table. We got amount of the recovery budget from central and local governments respectively by items from 2011 to 2013. Each recovery budget is an accumulated amount over three years. Central government recovery budget is placed in the 3rd column in Table 4 and Yogyakarta government recovery budget is in the 4th column, and the final column shows the total one. According to the MRIO sector classification, 35 sectors, some items in the budget should be combined into certain sectors. The 1st column represents sector names in the MRIO, Indonesia (2005) and the 2nd column shows items included in corresponding sectors. Two rows at the bottom show total amount of each budget and the each share to total recovery budget, meaning that about 90% of recovery budget came from the central government. This total amount of the budget, about 773 thousands million rupiah, is more than 5 times of Yogyakarta’s local government investment in 2005. In addition, we can see that a large amount of central government budget, roughly 266 thousand million rupiah, went to Forestry (Environment (National Park)) and much of Yogyakarta government budget, about 54 thousand million rupiah, was spent in Land Transportation.
### Table 4
Reconstruction and rehabilitation/ recovery budget in 2011–2013

| Sectors name in MRIO table 2005 (sector number) | Sectors name for government recovery budget | Central government recovery budget 2011–2013 | Yogyakarta government recovery budget 2011–2013 | Total recovery budget 2011–2013 |
|-----------------------------------------------|-------------------------------------------|----------------------------------------|----------------------------------------|-------------------------------|
| Construction (26)                             | Housing                                   | 80,460.00                             | 0.00                                   | 80,460.00                     |
|                                               | Resident Infrastructure                   | 2,736.78                              | 0.00                                   | 2,736.78                     |
|                                               | Settlement                                | 1,500.00                              | 0.00                                   | 1,500.00                     |
|                                               | Recovery of housing and settlement        | 18,200.00                             | 0.00                                   | 18,200.00                    |
|                                               | Village land acquisition                  | 27,185.42                             | 0.00                                   | 27,185.42                    |
| Other Services (35)                           | Accompaniment                            | 7,994.70                              | 0.00                                   | 7,994.70                     |
| Land Transportation (29)                      | Road and Bridge                           | 1,095.75                              | 53,692.51                             | 54,788.26                    |
| Electricity, Gas and Water (25)               | Water and Sanitation                      | 4,510.45                              | 3,203.13                               | 7,713.58                     |
|                                               | Water resources infrastructure            | 36,590.00                             | 1,650.00                               | 38,240.00                    |
|                                               | Energy                                    | 26.89                                 | 600.00                                 | 626.89                       |
| Communication (32)                            | Telecommunication                         | 880.00                                | 100.00                                 | 980.00                       |
| Land Transportation (29)                      | Rural Infrastructure                      | 0.00                                  | 0.00                                   | 0.00                          |
| Paddy/Rice and Other Food Crops (1,2)         | Agriculture                               | 19,477.27                             | 2,093.70                               | 21,570.97                    |
| Fishery (6)                                   | Fishery                                  | 3,366.33                              | 8,653.67                               | 12,020.00                    |
| Animal Husbandry (4)                          | Animal husbandry                          | 40,262.50                             | 700.00                                 | 40,962.50                    |
| Plantation (3)                                | Plantation                               | 0.00                                  | 0.00                                   | 0.00                          |

Note: in million rupiahs
| Sectors name in MRIO table 2005 (sector number) | Sectors name for government recovery budget | Central government recovery budget 2011–2013 | Yogyakarta government recovery budget 2011–2013 | Total recovery budget 2011–2013 |
|-------------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------|
| Financial Institution (33)                      | Small and Medium enterprises and cooperatives | 1,518.63                                    | 1,590.46                                    | 3,109.09                        |
| Other Industries (24)                            | Industry                                    | 3,155.80                                    | 675.00                                      | 3,830.80                        |
| Trade (27)                                       | Trade/Market                                 | 7,207.00                                    | 0.00                                        | 7,207.00                        |
| Hotel and Restaurant (28)                        | Tourism                                     | 814.38                                       | 662.00                                      | 1,476.38                        |
| Other Services (35)                              | Transmigration                               | 56,000.00                                    | 50.60                                       | 56,050.60                       |
|                                                | Health                                      | 15,879.07                                    | 705.32                                      | 16,584.39                       |
|                                                | Education                                   | 65,931.94                                    | 1,663.32                                    | 67,595.26                       |
|                                                | Religion                                    | 23,963.68                                    | 0.00                                        | 23,963.68                       |
|                                                | Culture                                     | 598.09                                       | 590.04                                      | 1,188.13                        |
|                                                | Social Institution                          | 1,318.33                                     | 648.37                                      | 1,966.70                        |
| General Government and Defense (34)              | Order and security (TNI/Polri)               | 50.00                                        | 745.00                                      | 795.00                          |
| Forestry (5)                                     | Environment (National Park)                 | 265,655.85                                   | 1,008.75                                    | 266,664.60                      |
|                                                | Forestry                                    | 931.00                                       | 460.00                                      | 1,391.00                        |
| Financial Institution (33)                       | Finance and Banking                          | 150.42                                       | 0.00                                        | 150.42                          |
| General Government and Defense (34)              | Government                                  | 2,442.89                                     | 0.00                                        | 2,442.89                        |
| Other Services (35)                              | Disaster Risk Reduction                     | 2,903.40                                     | 0.00                                        | 2,903.40                        |
|                                                | Total                                       | 692,806.57                                   | 79,491.87                                   | 772,298.44                      |
|                                                | Ratio of Budget                             | 89.71%                                       | 10.29%                                      |                                 |

Note: in million rupiahs

Source: Regional Disaster Management Agency of Yogyakarta Special Region, (2011)
Table 5 shows allocation of the budget for all sectors from the recovery budget in Yogyakarta except Paddy/Rice and Other Food Crops. Since these two sectors are given as Agriculture at once in the recovery budget list, according to the proportion of Paddy/Rice and Other Food Crops in the MRIO table, we allocated the budget for each. As a result, we can see that four sectors such as Forestry, Construction, Land Transportation and Other Services are large sources of the recovery budget. Construction and Other Services become big amount after aggregating detailed items in the recovery budget table (Table 4) to correspond to the MRIO table. Due to the data limitation, we are assuming that industrial structure given by the MRIO, Indonesia 2005 has been unchanged during the period from 2011 to 2013. The last column in Table 5 is an independent (final demand) vector to be given for calculation of induced output in allover Indonesia that we want to get as direct and indirect impact of the recovery budget from Mt. Merapi eruption.
Table 5
Allocation recovery budget of post-Mt. Merapi eruption in 2010 according to proportion each sector

| Sectors' Number | Sectors Name of MRIO Table 2005 | Yogyakarta total output based on MRIO table 2005 | Total aggregate of some sectors | The proportion of each sector (%) | Yogyakarta total recovery budget 2011–2013 |
|-----------------|---------------------------------|-----------------------------------------------|---------------------------------|----------------------------------|------------------------------------------|
| 1               | Paddy/Rice                      | 979,206.88                                    | 3,299,159.61                    | 29.680%                          | 6,402.37                                 |
| 2               | Other Food Crops                | 2,319,952.73                                   |                                 | 70.320%                          | 15,168.60                                |
| 3               | Plantation Crops                |                                              |                                 |                                  | 0.00                                     |
| 4               | Animal Husbandry                |                                              |                                 |                                  | 40,962.50                                |
| 5               | Forestry                        |                                               |                                 |                                  | 268,055.60                              |
| 6               | Fishery                         |                                               |                                 |                                  | 12,020.00                               |
| 7               | Oil, Gas and Geothermal Mining  |                                               |                                 |                                  | 0.00                                     |
| 8               | Coal, Metal Ore and Other Mining |                                             |                                 |                                  | 0.00                                     |
| 9               | Oil Refinery                    |                                               |                                 |                                  | 0.00                                     |
| 10              | Palm Oil Industry               |                                               |                                 |                                  | 0.00                                     |
| 11              | Marine Processing Industry      |                                               |                                 |                                  | 0.00                                     |
| 12              | Food and Beverage Industry      |                                               |                                 |                                  | 0.00                                     |
| 13              | Textile and Textile products Industry |                                         |                                 |                                  | 0.00                                     |
| 14              | Footwear Industry               |                                               |                                 |                                  | 0.00                                     |

Note: in million rupiahs
| Sectors' Number | Sectors Name of MRIO Table 2005                                      | Yogyakarta total output based on MRIO table 2005 | Total aggregate of some sectors | The proportion of each sector (%) | Yogyakarta total recovery budget 2011–2013 |
|-----------------|---------------------------------------------------------------------|--------------------------------------------------|---------------------------------|-----------------------------------|------------------------------------------|
| 15              | Wood, Rattan and Bamboo products Industry                            |                                                  |                                 | 0.00                              |                                          |
| 16              | Pulp and Paper Industry                                             |                                                  |                                 | 0.00                              |                                          |
| 17              | Rubber and Rubber products Industry                                  |                                                  |                                 | 0.00                              |                                          |
| 18              | Petrochemical Industry                                              |                                                  |                                 | 0.00                              |                                          |
| 19              | Cement Industry                                                     |                                                  |                                 | 0.00                              |                                          |
| 20              | Basic Metal Industry                                                |                                                  |                                 | 0.00                              |                                          |
| 21              | Metal products Industry                                             |                                                  |                                 | 0.00                              |                                          |
| 22              | Electrical Equipment and Machinery Industry                          |                                                  |                                 | 0.00                              |                                          |
| 23              | Transportation and Its Repair Industry                              |                                                  |                                 | 0.00                              |                                          |
| 24              | Other industries                                                    |                                                  |                                 | 3,830.80                          |                                          |
| 25              | Electricity, Gas and Clean Water                                    |                                                  |                                 | 46,580.47                         |                                          |
| **26**          | **Construction**                                                    | **130,082.20**                                  |                                 |                                   |                                          |
| 27              | Trade                                                               |                                                  |                                 | 7,207.00                          |                                          |

Note: in million rupiahs
### Table 2005 Yogyakarta total output based on MRIO table 2005

| Sectors' Number | Sectors Name of MRIO Table 2005 | Yogyakarta total output based on MRIO table 2005 | Total aggregate of some sectors | The proportion of each sector (%) | Yogyakarta total recovery budget 2011–2013 |
|-----------------|---------------------------------|--------------------------------------------------|--------------------------------|----------------------------------|----------------------------------------|
| 28              | Hotel and Restaurant            | 1,476.38                                         |                                 |                                  | 1,476.38                               |
| 29              | Land Transportation            |                                                  |                                 |                                  | 54,788.26                              |
| 30              | Water Transportation           |                                                  |                                 |                                  | 0.00                                   |
| 31              | Air Transportation             |                                                  |                                 |                                  | 0.00                                   |
| 32              | Communication                 |                                                  |                                 |                                  | 980.00                                 |
| 33              | Financial Institutions        |                                                  |                                 |                                  | 3,259.51                               |
| 34              | General Government and Defense|                                                  |                                 |                                  | 3,237.89                               |
| 35              | Other Services                |                                                  |                                 |                                  | 178,246.86                             |

Note: in million rupiahs

Source: author’s calculation

## 4. Results And Discussion

Mt. Merapi located in the Yogyakarta special province, and it erupted in 2010 after the alert of level IV was an announcement before the first eruption. The eruption caused several damages and losses in many sectors. Due to this catastrophic, central and local government, in this term Yogyakarta special region government, attempt to recover the condition of the community and the environment caused by the disaster that has occurred by allocated particular budget to the natural disaster. This budget allocation by sector, as an independence vector of final demand is adjusted to the sectors in the MRIO Table of Indonesia 2005, as mentioned in Table 5.

Calculating the induced output by the Eq. (1), we got Table 6 and Table 7. In Table 6, we show top 20 of the induced output over Indonesia by the recovery budget for the Mount Merapi eruption. In Table 7, we show the induced output in Yogyakarta province by the recovery budget for the Mt. Merapi eruption. In
this table, the total impact by the recovery budget is 1,298,701 million Indonesian rupiahs. It increases the total output of the Yogyakarta Special Region province approximately 2.33% after the disaster occurred. The highest induced appears for the forestry sector (21.66%), followed by other services and construction sectors, which are 17.75% and 10.41%, respectively. These three sectors’ large results are reasonable because the allocation of budget was relatively large as Table 5 shows. For example, the substantial budget for these sectors is required for reforestation, repair facilities, and infrastructure that damaged around the Mt. Merapi area due to its lethality.

According to the Regional Disaster Management Agency of Yogyakarta Special Region (2011), forest restoration or reforestation is more centered on forest regeneration in the National Park Area of Mount Merapi, which has been impacted by vegetation damage events, animal migration (long-tailed monkeys, birds, tigers, pig forests, etc.) in the National Park Area, and ecosystem harm. This is because in balancing the wider regional ecosystem, the Mount Merapi National Park Area plays a significant role. This region of approximately 6,000 hectares is a protected forest area where approximately 4,000 hectares is a vegetated area (approximately 1,128 hectares) destroyed by warm clouds, covered by volcanic ash, and burned during Mt. Merapi eruption.
| Province name | Sectors | Sectors name               | Total output MRIO 2005 | Induce output 2011–2013 | Share to total induced output |
|---------------|---------|----------------------------|------------------------|--------------------------|-----------------------------|
| Yogyakarta    | 5       | Forestry                   | 364,689                | 281,356                  | 21.66%                      |
| Yogyakarta    | 35      | Other Services             | 6,881,704              | 230,583                  | 17.75%                      |
| Yogyakarta    | 26      | Construction               | 5,823,860              | 135,258                  | 10.41%                      |
| Yogyakarta    | 29      | Land Transportation        | 3,360,078              | 71,133                   | 5.48%                       |
| Yogyakarta    | 25      | Electricity, Gas and Clean Water | 447,187              | 56,795                   | 4.37%                       |
| Yogyakarta    | 4       | Animal Husbandry           | 1,177,680              | 48,613                   | 3.74%                       |
| Yogyakarta    | 27      | Trade                      | 3,146,374              | 46,570                   | 3.59%                       |
| Yogyakarta    | 28      | Hotel and Restaurant       | 5,005,519              | 42,866                   | 3.30%                       |
| Yogyakarta    | 12      | Food and Beverage Industry | 4,367,263              | 31,317                   | 2.41%                       |
| Yogyakarta    | 2       | Other Food Crops           | 2,319,953              | 23,797                   | 1.83%                       |
| Yogyakarta    | 21      | Metal products Industry    | 47,367,086             | 21,765                   | 1.68%                       |
| Yogyakarta    | 33      | Financial Institutions     | 795,337                | 20,342                   | 1.57%                       |
| Yogyakarta    | 24      | Other industries           | 1,884,047              | 17,047                   | 1.31%                       |
| Yogyakarta    | 15      | Wood, Rattan and Bamboo products Industry | 1,143,341             | 15,636                   | 1.20%                       |
| Yogyakarta    | 1       | Paddy/Rice                | 979,207                | 14,317                   | 1.10%                       |
| Yogyakarta    | 6       | Fishery                    | 102,556                | 12,191                   | 0.94%                       |
| Central Java | 9       | Oil Refinery               | 67,491,080             | 10,966                   | 0.84%                       |
| Province name | Sectors | Sectors name                        | Total output MRIO 2005 | Induce output 2011–2013 | Share to total induced output |
|---------------|---------|-------------------------------------|------------------------|-------------------------|-----------------------------|
| Jakarta       | 23      | Transportation and Its Repair Industry | 72,172,585             | 10,555                  | 0.81%                       |
| Jakarta       | 33      | Financial Institutions               | 119,600,201            | 9,034                   | 0.70%                       |
| East Java     | 3       | Plantation Crops                     | 15,594,212             | 7,933                   | 0.61%                       |

**Note**

in million rupiahs
Table 7
Induced output by recovery budget of post-Mt. Merapi eruption in 2010 (Top 20) in Yogyakarta provinces

| Provinces | Sectors | Sectors name                        | Total output MRIO 2005 | Induce output 2011–2013 | Share to total induced output |
|-----------|---------|-------------------------------------|------------------------|-------------------------|------------------------------|
| Yogyakarta | 5       | Forestry                            | 364,689                | 281,356                 | 21.66%                       |
| Yogyakarta | 35      | Other Services                      | 6,881,704              | 230,583                 | 17.75%                       |
| Yogyakarta | 26      | Construction                        | 5,823,860              | 135,258                 | 10.41%                       |
| Yogyakarta | 29      | Land Transportation                 | 3,360,078              | 71,133                  | 5.48%                        |
| Yogyakarta | 25      | Electricity, Gas and Clean Water    | 447,187                | 56,795                  | 4.37%                        |
| Yogyakarta | 4       | Animal Husbandry                    | 1,177,680              | 48,613                  | 3.74%                        |
| Yogyakarta | 27      | Trade                               | 3,146,374              | 46,570                  | 3.59%                        |
| Yogyakarta | 28      | Hotel and Restaurant                | 5,005,519              | 42,866                  | 3.30%                        |
| Yogyakarta | 12      | Food and Beverage Industry          | 4,367,263              | 31,317                  | 2.41%                        |
| Yogyakarta | 2       | Other Food Crops                    | 2,319,953              | 23,797                  | 1.83%                        |
| Yogyakarta | 33      | Financial Institutions              | 795,337                | 20,342                  | 1.57%                        |
| Yogyakarta | 24      | Other industries                    | 1,884,047              | 17,047                  | 1.31%                        |
| Yogyakarta | 15      | Wood, Rattan and Bamboo products Industry | 1,143,341        | 15,636                  | 1.20%                        |
| Yogyakarta | 1       | Paddy/Rice                          | 979,207                | 14,317                  | 1.10%                        |
| Yogyakarta | 6       | Fishery                             | 102,556                | 12,191                  | 0.94%                        |
| Yogyakarta | 8       | Coal, Metal Ore and Other Mining    | 263,887                | 5,571                   | 0.43%                        |

Source: author’s calculation
Provinces | Sectors | Sectors name | Total output MRIO 2005 | Induce output 2011–2013 | Share to total induced output
---|---|---|---|---|---
Yogyakarta | 32 | Communication | 970,166 | 5,475 | 0.42%
Yogyakarta | 16 | Pulp and Paper Industry | 352,032 | 5,306 | 0.41%
Yogyakarta | 34 | General Government and Defense | 3,582,312 | 3,239 | 0.25%
Yogyakarta | 13 | Textile and Textile products Industry | 1,551,075 | 2,492 | 0.19%

Source: author’s calculation

In addition, land transaction, electricity, gas and clean water, animal husbandry, trade, hotel and restaurant are induced with relatively large scale, where the share to total induced output is about 3–5%. Sectors like land transaction, and electricity, gas and clean water are infrastructure related sectors, which are necessarily required for the recovery. Interestingly, among many agricultural goods, animal husbandry is frequently traded goods for farmers in Yogyakarta. Trade, hotel and restaurant are also seen as necessary activity for their daily life.

This induced output from a particular government budget for Mt. Merapi eruption in 2010 has a prominent contribution not only for Yogyakarta special region province but also for other regions nearby, for instance, Central Java, West Java, Jakarta, and East Java. And has contribution in many sectors i.e. metal products industry sector in West Java, transportation and its repair industry sector in Jakarta, oil refinary sector in Central Java, and also plantation crop sector in East Java equal to 1.68%, 1.51%, 0.84%, and 0.61% respectively.

Table 8 represents repercussion effects to other provinces as induced outputs by the recovery budget in Yogyakarta. Each share of the result to total induced outputs is relatively small, but this result shows interdependency of Yogyakarta to other provinces through their intermediate and final demand, in particular industries. For example, West Java and Central Java are supplying metal products, petrochemical products and refinery oil to Yogyakarta as well as Jakarta provides transportation and its repairing, financial services and trade services. Interestingly, not only neighboring areas of Yogyakarta but also some remote areas are connecting through the trade (Fig. 2). Papua and South Sumatera are geographically far from Yogyakarta, but they are playing important role of supply base of coal and rubber respectively. East Java also provides plantation crops and cement products to Yogyakarta.
### Table 8
The induced output impact by recovery budget of post-Mt. Merapi eruption in 2010 to the provinces excluding Yogyakarta

| Provinces         | Sectors' number | Sectors name on MRIO table 2005                        | The induced output of recovery budget 2011–2013 | Share to the induced output |
|-------------------|-----------------|--------------------------------------------------------|-------------------------------------------------|-----------------------------|
| West Java         | 21              | Metal products Industry                                 | 21,765                                          | 1.68%                       |
| Central Java      | 9               | Oil Refinery                                           | 10,966                                          | 0.84%                       |
| Jakarta           | 23              | Transportation and Its Repair Industry                  | 10,555                                          | 0.81%                       |
| Jakarta           | 33              | Financial Institutions                                  | 9,034                                           | 0.70%                       |
| East Java         | 3               | Plantation Crops                                       | 7,933                                           | 0.61%                       |
| Papua             | 8               | Coal, Metal Ore and Other Mining                       | 6,689                                           | 0.52%                       |
| South Sumatera    | 17              | Rubber and Rubber products Industry                     | 6,613                                           | 0.51%                       |
| East Java         | 19              | Cement Industry                                        | 5,668                                           | 0.44%                       |
| West Java         | 18              | Petrochemical Industry                                 | 5,539                                           | 0.43%                       |
| Jakarta           | 27              | Trade                                                  | 4,773                                           | 0.37%                       |
| **Total Induce Output of Recovery Budget 2011–2013** | **1,298,701**   |                                                        |                                                 |                             |

Source: author’s calculation

It implies that Yogyakarta Special Region still has interconnection in various sectors of regional economies despite affected by natural hazards and all Indonesian provinces in many sectors provide support and assistance to recuperate Yogyakarta from the catastrophic volcanic eruption in 2010. According to Table 8, it seems that provinces which have relatively strong trade connection with Yogyakarta provide basic needs like energy, infrastructure and fundamental services like transportation and trade.

### 5. Conclusion And Policy Implications

Because of location in most effective natural calamity hotspots, several types of a disaster such as earthquakes, tsunamis, volcanic eruptions, floods, drought, landslides, and forest fires are frequently
occurring in Indonesia. It made the government, both central and local government allocate budget to recuperate it. The rehabilitation and reconstruction (recovery) budget are used to rejuvenate the condition after a disaster happens. This study estimates the induced output of a limited government budget for recovering the natural hazard, in this case, the Mt. Merapi eruption in 2010 by using multiregional input-output (MRIO) table, Indonesia (2005).

Our main findings are, firstly, to recover Yogyakarta region from the disaster, Indonesia’s central and local government put the recovery budget of totally about 773 thousand million rupiah over 2011 to 2013. This magnitude was more than 5 times comparing with Yogyakarta's local government investment in 2005 MRIO, Indonesia. Secondly, Forestry, Other services, and Construction sectors have received a significant share of induced effects (totally around 50% to the total effects) from the particular government budget to recover from the calamity because allocation of recovery budget was mainly concentrated into these sectors. Since forestry is a valuable natural resource in Yogyakarta and construction is necessary cost to recover from the disaster, this result would be reasonable. Finally, the induced effect of this budget also has the effect to other provinces, which has relatively strong connection with Yogyakarta Special Region province through their supply chains. For instance, nearby Central Java province, which supply refinery oil, and remote Papua province, which supply of coal and rubber, benefited from this budget allocation.

Our findings guide several key policy implications regarding the impact of the induced output of fiscal support in developing countries. The induced effect of the recovery budget is essentially beneficial for the damaged region. In addition, the supply chain network also induced potential benefit to nearby trading regions. However, this policy implications need to be evaluated scientifically by taking the actual case study from other developing countries.

Our calculation in this research is based on the MRIO, Indonesia 2005 as mentioned above, but the recovery budget for Mt. Merapi eruption in 2010 was accumulated amount from 2011 to 2013. The economic structure change during the study period can create some inaccuracy in our results. However, the significance of this research is to show the magnitude of interdependency of disastrous region with other areas through their transaction. As we told above, an important policy implication is that not only nearby region of the ground-zero area but also some remote areas linking with there would receive unintentional repercussion effects from the recovery from the disaster, which might lead other regions’ economic development. Our results are the typical example of the case and future study can focus on the impact of the induced output by fiscal support in developing countries.

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Figures

**Figure 1**

Study area in Indonesia

**Figure 2**

Location of provinces with significant impact due to Mt. Merapi eruption in 2010
Supplementary Files

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