Post-Disaster Recovery and A New Economic Growth Path:
A Comparative Study of Three Provinces in Indonesia

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Abstract. The purpose of this study is to examine whether there exists a new regional output growth path in post-disaster situation in three provinces of Indonesia affected by relatively large-scale natural disasters, i.e. Aceh, West Sumatera (Sumbar), and Yogyakarta. By using real Gross Regional Domestic Product time series for the period 2001-2017 obtained from the Central Agency of Statistics, a comparative analysis was made from the differences in the effects across those provinces between pre-disaster and post-disaster periods. This study used a simple model with deterministic trend, post-disaster recovery dummy and autoregressive component to estimate changes in the coefficients of trends for each province’s output growth path. The results show that there is no significant difference in the overall effects of trend changes across provinces, while the effects of trend changes between pre- and post-disaster periods vary across provinces and in general post-disaster interventions do not move upward the long-term effects on regional output trends.

Keywords: post-disaster recovery; new growth path; regional economic growth

1. Introduction

It has been a common case that a post-disaster recovery leads to an increased per capita income and higher employment. A disaster may serve not only as an opportunity to build back the economic foundations better and faster [1], but also for positive community change [2]. However, do interventions to revitalize the economy and disaster risk reduction related policies result in a long-term new trend of output. [3] show that “while the short-term growth consequences of natural disasters are comparatively well studied, little is known about the long-run perspective”. [4] find that even large natural disasters would have no long-term effect on economic growth. Only when they are followed by radical political revolution do they have long-lasting negative effects on the economic growth. In the similar line of thought, post-disaster recovery per se, regardless of its scale, may not lead to large and long-lasting positive effect on output growth.

Many recent studies have focused on disaster loss, disaster resilience, and changes in the government’s behaviour in response to natural disaster shocks, which can be classified [5-10] as studies on the negative effects of disasters. Meanwhile, little has been discussed on the positive effects
of post-disaster recovery, such as the shift in the long-term economic growth. This study is aimed at investigating whether post-disaster recovery leads to a new growth path.

Specifically, this study examines the changes in the Gross Regional Domestic Product (GRDP) growth of three provinces in Indonesia, i.e. Aceh, West Sumatera (Sumbar), and Yogyakarta, that were stricken by natural disasters at different points and of different scales. In other words, whether a post-disaster recovery shock shifts the regional economies to a new long-term growth path. A comparative analysis is made from the differences in the effects of for the three provincial cases. The specific research questions to be addressed are the following: 1) Whether post-disaster recovery intervention, which is assumed to have been a norm following any disaster in a country, has effects on the paths of regional output (measured by Gross Regional Domestic Product); and 2) Are there differences in the effects between pre-disaster and post-disaster as well as across regions.

2. Method

**Estimation of trend changes**

The procedures taken were as follows. First, the data for different provinces were assumed to exhibit random variation and were independent from one another. To compare three provincial GRDP time series trends in terms of magnitude of increases in each province’s GRDP, tests were conducted to check whether trend parameters were significantly different between one province and another by applying a model with deterministic trend and autoregressive component as follows:

\[
GRDP_t^i = \beta_1^i + \beta_2^i \text{TREND}_t + \beta_3^i \text{GRDP}_{t-1}^i + \mu_t^i \\
i = \text{Province } i \\
t = 2001, \ldots, 2017
\]

where \(GRDP^i\) is Gross Regional Domestic Product, TREND is time trend, and \(\mu_t\) is the white noise error term.

The deterministic trend is represented by \(\beta_2^i \text{TREND}\) and a stochastic component by \(\mu_t^i\) which both affect the long-run course of GRDP of province \(i\). Under the assumption of independence of the samples from three different provinces, the difference between coefficients (slopes) of TREND between any two regressions were calculated and divided by the square root of the sum of the squared standard errors. Under the normal assumption, then a Z statistic with \(n-2\) degrees of freedom could be obtained (Clogg, 1995) and (Paternoster, 1998), as follows:

Trend slope difference between Aceh and Sumbar: \((\beta^A - \beta^S)/\sqrt{(SSE_A + SSE_S)}\) \hspace{1cm} (2)

Trend slope difference between Aceh and Yogya: \((\beta^A - \beta^Y)/\sqrt{(SSE_A + SSE_Y)}\) \hspace{1cm} (3)

Trend slope difference between Sumbar and Yogya: \((\beta^S - \beta^Y)/\sqrt{(SSE_S + SSE_Y)}\) \hspace{1cm} (4)

The standard errors of the difference between slopes were then computed, for example between Aceh and Sumbar as

\[
SE = s\sqrt{SE(\beta^A)/s_A^2 + SE(\beta^S)/s_S^2}
\]

where \(\beta^A\) and \(\beta^S\) are estimated coefficients of Aceh and Sumbar regressions respectively. \(s_A\) and \(s_S\) are the estimated standard errors of the two regressions, and \(s\) is computed as follows

\[
s = \sqrt{\frac{(n_A-2)s_A^2 + (n_S-2)s_S^2}{n_A + n_S - 2k}}
\]

where \(n_A, n_S\) are sample sizes of Aceh and Sumbar, and \(k\) the number of parameters, including constant. The above \(SE\) is used as the denominator for the t-test on \(n-2k\) degrees of freedom.
The comparison is made only to the regressions that give slopes that are significantly different from zero. For the cases being examined, this procedure is used to determine if the effects (coefficients) of the trends are the same for the following cases:

a) If the coefficients of trends for Aceh and Sumbar are statistically equal.

b) If the coefficients of trends for Aceh and Yogya are statistically equal.

c) If the coefficients of trends of Sumbar and Yogya are statistically equal.

For each province, tests were also conducted to check if the slopes were statistically equal between two time points (before and after the disaster). If, for example, \( \beta_A > \beta_B \) of the trend then we could say that the trend of GRDP growth for one province is greater than another. If for a particular province, for example, the trend coefficient for post-disaster is greater than the post-disaster period, then the impact of recovery in terms of growth path change can be compared between before and after the disaster.

**Recovery Dummy Variable**

The second way of testing the effect of post-disaster recovery is to construct a dummy variable, \( \text{RECOVERY} \), such that the following two equations were estimated:

\[
\text{GRDP}_t^i = \beta_1^i + \beta_2^i \text{RECOVERY} + \beta_3^i \text{TREND} + \beta_4^i \text{GRDP}_{t-1}^i + \mu_t^i
\]

\[
\text{GRDP}_t^i = \beta_1^i + \beta_2^i \text{TREND} + \beta_3^i \text{RECOVERY} \times \text{GRDP}_{t-1}^i + \beta_4^i \text{GRDP}_{t-1}^i + \mu_t^i
\]

The \( \text{RECOVERY} \) variable takes the value of 1 for the period one year after the occurrence of the disaster to year 2017 (i.e. 2005-2017 for Aceh, 2010-2017 for West Sumatera, and 2007-2017 for Yogya) and 0 elsewhere.

### 3. Brief overview of the disasters

The December 26, 2004 tsunami greatly devastated the economy of Aceh province. All economic sectors were affected. The total material loss was estimated at around 4.5 billion US dollars, i.e. 2.2% of Indonesia's Gross Domestic Product or 97% of Aceh's Gross Regional Domestic Product [11]. Around 78% of the losses were suffered by the private sector, while the rest was endured by the public sector. Material losses were due to destruction or damage caused by the unprecedented disaster to the private and public infrastructure and facilities. The sectors that suffered the most damage were the productive sectors such as agriculture, fisheries and the trade industry with the scale of the damage of 37%. Before the disaster, the agricultural sector was an important sector because around 62.05% of the Aceh population depended on agriculture and 32.17% of Aceh’s GRDP originated from the sector.

As the result of the destruction, the number of the poor increased drastically due to losses of jobs and shelters. Fishermen lost their jobs due to the destruction of facilities and infrastructure to earn a living (Directorate General of Fisheries and Maritime Affairs). Many corporate businesses, supermarkets, and small-scale businesses were destroyed and even the businesses that survived the disaster became out of business because their places and equipment was either destroyed or disappeared. Substantial support by the Indonesian government through the Agency for Aceh and Nias Reconstruction (BRR) as well as direct assistance by foreign governments and international communities or nongovernmental organizations has built back Aceh better and put Aceh on a new economic growth path.

The 6.3 magnitude earthquake in Yogyakarta province that took place on May 27, 2006, caused a total damage and losses of 3,134 million US dollars [12]. Housing, productive sectors, and social facilities were the worst affected. 88.6% of the damage and losses was sustained by the private sector. Therefore, similar to Aceh’s recovery, in Yogyakarta relatively large efforts were devoted to rebuilding houses. As many as 66,000 people added up to the already high poverty rate, around 130,000 jobs were lost, many of them in small scale manufacturing and services. In total districts’ Gross Regional Domestic Products dropped by 5 to 18% varying according to their scales of
destruction. Post-disaster recovery took place quicker because of the lesser scale of devastation and lessons-learned from Aceh’s recovery. Quicker loss assessment also made it possible for the government to make a quicker decision with regards to Yogyakarta recovery interventions.

The 7.6 magnitude earthquake that struck West Sumatera on September 30, 2009 caused 2.3 billion US dollars of losses. Almost 80% of the damage and losses affected infrastructure and housing, while the productive sectors suffered 11% loss. The worst affected area was the provincial capital Padang, the center of businesses. Over 88% of the total damage and losses were suffered by the private sector, including trade, tourism, and financial services. Around 31% of houses were damaged at various scales, 115,000 houses destroyed and 135,000 damaged [13].

To compare the effects on regional output of the three disasters, the impact of them on the regional economy’s output varies across provinces. Figure 1 shows that the GRDP of Aceh dropped drastically as the impact of 2004 tsunami. The regional real output fell by 19.4% in 2005. Only in 2006 after a huge influx of post-disaster funding, real GRDP rose by a very high rate of growth of 66.5% (see Table 1). Very different phenomena were experienced by Sumbar and Yogyakarta provinces where the two provinces recorded a high positive growth in the same year of disaster occurrence. Yogyakarta’s real GRDP grew by 20.5% in 2006 and Sumbar’s grew by 19.4% in 2009. However, on the average annual the post-disaster real output grew slower in all three provinces (see Table 2). Although the long-term trend of output seems to be positively upward, the long-term effect of post-disaster interventions seems to be very small. Real output only returns to its normal rate as before.

![Figure 1](image_url)
Table 1. GRDP Growth Rates of Aceh, Sumbar, and Yogyakarta

| Year | Growth of real GRDP Aceh (%) | Growth of real GRDP Sumbar (%) | Growth of real GRDP Yogya (%) |
|------|------------------------------|-------------------------------|------------------------------|
| 2002 | 19.7%                        | 13.9%                         | 15.6%                        |
| 2003 | 18.2%                        | 15.7%                         | 18.6%                        |
| 2004 | 0.6%                         | 11.3%                         | 11.0%                        |
| 2005 | -19.4%                       | 6.2%                          | 7.4%                         |
| 2006 | 66.4%                        | 29.9%                         | 20.5%                        |
| 2007 | 3.0%                         | 16.2%                         | 14.4%                        |
| 2008 | 1.1%                         | 12.6%                         | 13.8%                        |
| 2009 | 3.8%                         | 19.4%                         | 16.1%                        |
| 2010 | 0.7%                         | -0.1%                         | 0.5%                         |
| 2011 | 9.1%                         | 8.8%                          | 8.7%                         |
| 2012 | 9.2%                         | 7.5%                          | 4.9%                         |
| 2013 | -1.1%                        | -0.3%                         | 2.5%                         |
| 2014 | 4.6%                         | 4.9%                          | 5.9%                         |
| 2015 | 7.6%                         | 17.1%                         | 8.5%                         |
| 2016 | 3.6%                         | 1.1%                          | 5.9%                         |
| 2017 | 6.7%                         | 8.4%                          | 3.3%                         |

Source: Author’s calculation

Table 2. GRDP Average Growth Rates of Aceh, Sumbar, and Yogyakarta

| Year             | Pre-disaster average growth (%) * | Post-disaster recovery average growth (%) * |
|------------------|-----------------------------------|--------------------------------------------|
| Aceh (2001-2004)| 12.9%                             | -                                          |
| Yogya (2001-2006)| 14.6%                             | -                                          |
| Sumbar (2001-2009)| 15.6%                           | -                                          |
| Aceh (2005-2017)| -                                 | 7.3%                                       |
| Yogya (2007-2017)| -                                 | 5.9%                                       |
| Sumbar (2010-2017)| -                               | 7.7%                                       |

Source: Author’s calculation
4. Estimation results and discussion

As can be seen from Table 3, the effects of Trend variable are significantly positive for all three provinces in 4 different models. In model 1, the effect of recovery dummy is significant and has positive sign only for Aceh and Yogyakarta. In addition to the trend effects, the shift in intercepts mean that post-disaster recovery has positive upward effects. When recovery dummy is multiplied by GRDP to examine the effect in terms of slope changes, only the coefficient for Yogyakarta regression is significantly positive. Hence, for Yogyakarta in addition to fast post-disaster recovery effect as indicated in Table 1, both trend and slope affect the long-term real output growth. It is not the case for Aceh and Sumbar, although the latter also experiences a fast recovery of real output growth. However, an examination of slope differences between provinces (see Table 4) suggests that the differences between any two provinces in terms of the effects of trend are not statistically significant. Surprisingly, when two periods (pre- and post-disaster) are examined (Models 3 and 4), the regressions for Sumbar and Yogyakarta show significantly positive trend coefficient differences, and not for Aceh (Table 5). However, as can be shown in Table 3 the coefficients in fact fall, which implies that the post-disaster recovery does have impacts, but the impacts are even making the trend slopes lower.

Post-disaster recovery interventions move real regional output trend upward, but for Yogyakarta the slope of the trend has also moved upward. Nevertheless, for all the three regions the average growth of output during the period of recovery is lower than before (see Table 2). The comparison of slope of Trend between Model 3 and Model 4 in Table 3 suggests that the effects of trend changes between two time points are significantly positive for all three provinces. Nevertheless, the effects become smaller in the post-disaster recovery period for Aceh and Sumbar, while for Yogyakarta the effect becomes a little greater. All of these results imply that the post-disaster interventions only put the regional economy’s output back to normal path without changing long term directions. This result is inconsistent with [1] in the sense that long term output growth path is attributable to factors that determine productivity growth as suggested in the endogenous growth theory. The magnitude of negative effect of natural disasters on economic growth differs across disasters [10], it may also differ across regions. Likewise, the magnitude of positive effect of post-disaster recovery may differ across regions even within the same country and across different time periods. In addition, countries and regions may be quite different in their pre- and post-disaster characteristics, and therefore the post-disaster recovery also differs across places. The nonexistence of permanent effect on output growth of post-disaster recovery is similar to nonexistence of the pre-disaster effect on the economic growth found by [4] unless the recovery efforts are accompanied by other reforms that in the long-term determine changes in output growth path.
| Variable                  | Model 1                     | Model 2                      | Model 3                      | Model 4                      |
|--------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|
|                          | (Dep. Var. Real GRDP, full sample 2002-2017) | (Dep. Var. Real GRDP with Recovery_dummy*Real_GRP and lag Real GRDP, full sample 2002-2017) | (Dep. Var. Real GRDP, split samples) | (Dep. Var. Real GRDP, split samples) |
|                          | Aceh | Sumbar | Yogya | Aceh | Sumbar | Yogya | Aceh | Sumbar | Yogya | Aceh | Sumbar | Yogya |
| Constant                 | 38270.75* | 11537.75** | 9986.202* | 38982.68* | 11744.99** | 12288.86* | 34197.12* | 19034.7* | 13294.98* | 34843.88* | 20696.23* | 15768.08* |
| Trend                    | 3782.036* | 4198.277** | 1975.83** | 3906.948** | 4568.173** | 2035.67* | 4921.896** | 6258.002* | 2486.778* | 4033.843* | 5935.318* | 2737.699* |
| Lag Real GRDP            | 0.118487 | 0.402483 | 0.265117 | 0.075036 | -0.058526 | 0.1272** |
| Recovery dummy           | 8963.174** | -5167.337 | 2788.854** |
| Recovery_dummy*Real_GRP  | 0.125515 | 0.353787 | 0.1975.83** |

* significant at 1%
** significant at 5%

Source: Author’s calculation
Table 4. Differences between slopes of two provinces’ regressions

|   | Difference between slopes | SE       | t statistics | t-table at 5% |
|---|----------------------------|----------|--------------|---------------|
| Aceh-Sumbar | -416.241 | 19882.1856 | -0.0209354  | 2.306         |
| Aceh-Yogya  | 1975.83  | 26792.43324 | 0.06741478  | 2.306         |
| Sumbar-Yogya | 2222.447 | 183079497  | 0.00001214  | 2.306         |

Source: Author’s calculation

Table 5. Differences between slopes of two periods – pre and post disaster

|   | Difference between slopes | SE       | t statistics | t-table at 5% |
|---|----------------------------|----------|--------------|---------------|
| Aceh pre- and post-disaster | 888.053  | 29764.5883 | 0.02983589  | 2.179         |
| Sumbar pre- and post-disaster | 322.684  | 10.901232 | 223.380074  | 2.179         |
| Yogya pre- and post-disaster  | -250.921 | 183079497  | 479.00      | 2.179         |

Source: Author’s calculation
5. Conclusions
There is no significant difference in the overall effects of trend changes of output growth paths between any two disaster-affected regions. Post-disaster recovery interventions move real regional output trend upward, but the magnitude of the effects differs across regions and across time periods. This implies that the post-disaster interventions in general only put the economies of disaster-affected regions back to normal growth path without changing long term directions. In order for post-disaster recovery to have positive permanent effects, it should always be followed by concomitant reforms as an integral part of recovery.

References
[1] Hosoya K. Recovery from natural disaster: A numerical investigation based on the convergence approach. Econ Model [Internet]. 2016;55:410–20. Available from: http://dx.doi.org/10.1016/j.econmod.2016.02.029
[2] Mochizuki J, Chang SE. Disasters as opportunity for change: Tsunami recovery and energy transition in Japan. Int J Disaster Risk Reduct. 2017;21:331–9.
[3] Berlemann M, Wenzel D. Hurricanes, Economic Growth and Transmission Channels - Empirical Evidence for Developed and Underdeveloped Countries. Work Pap [Internet]. 2016;105(October 2016):231–47. Available from: https://www.cesifo-group.de/de/ifoHome/publications/working-papers/CESifoWP/CESifoWPdetails?wp_id=19241745
[4] Cavallo E, Galiani S, Noy I, Pantano J. Catastrophic Natural Disasters and Economic Growth. 2013;95(December):1549–61. Available from: http://www.mitpress
[5] Songwathana K. The Relationship between Natural Disaster and Economic Development: A Panel Data Analysis. Procedia Eng [Internet]. 2018;212(2017):1068–74. Available from: https://doi.org/10.1016/j.proeng.2018.01.138
[6] Marin G, Modica M. Socio-economic exposure to natural disasters. Environ Impact Assess Rev [Internet]. 2017;64:57–66. Available from: http://dx.doi.org/10.1016/j.eiar.2017.03.002
[7] Keerthiratne S, Tol RSJ. Impact of natural disasters on income inequality in Sri Lanka. World Dev [Internet]. 2018;105:217–30. Available from: https://doi.org/10.1016/j.worlddev.2018.01.001
[8] Fang Y ping, Zhu F biao, Qiu X ping, Zhao S. Effects of natural disasters on livelihood resilience of rural residents in Sichuan. Habitat Int [Internet]. 2018;76(May):19–28. Available from: https://doi.org/10.1016/j.habitatint.2018.05.004
[9] Benali N, Abdelkafi I, Feki R. Natural-disaster shocks and government’s behavior: Evidence from middle-income countries. Int J Disaster Risk Reduct. 2018;27(August):1–6.
[10] Klomp J, Valckx K. Natural disasters and economic growth: A meta-analysis. Glob Environ Chang [Internet]. 2014;26(1):183–95. Available from: http://dx.doi.org/10.1016/j.gloenvcha.2014.02.006
[11] The Consultative Group on Indonesia. Indonesia: Preliminary Damage and Loss Assessment The December 26, 2004 Natural Disaster. Consult Gr. 2005;
[12] Bappenas. Preliminary Damage and Loss Assessment Yogyakarta and Central Java Natural Disaster. 2006;(June):140. Available from: http://siteresources.worldbank.org/INTINDONESIA/Resources/226271-1150196584718/PackageJune13_HIRES_FINAL.pdf
[13] WHO. West Sumatra earthquake: humanitarian response plan. 2009; Available from: http://www.who.int/hac/crises/idn/indonesia_response_plan_2009.pdf

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