Enduring Impacts of Aid Quality on Job Choices

The Case of the 2004 Tsunami in Aceh

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Abstract

After the tsunami in Aceh, Indonesia, the recovery of fishing was limited while non-fishing sectors temporarily expanded. This paper shows that fishermen's ex-post labor supply responses continued to be constrained by the provision of low quality production assets. The average fishing productivity also declined for the negative

selection in response to the aggregate shock. In a natural experiment set-up, it shows widening income inequality after the tsunami for income losses to the recipients of poor quality aid. It suggests the importance of quality monitoring and private market access to sustainably promote rural development after the tsunami.

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Enduring Impacts of Aid Quality on Job Choices: The Case of the 2004 Tsunami in Aceh¹

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1. Introduction

After the complete destruction of the agricultural labor market by disasters, rural households suddenly lose jobs and need to consider how they reallocate their labor between farm and off-farm employment. In such situation, it is essential to restore the agricultural sector to move underemployed households back to work, but investments in the non-agricultural sector may also help reduce rural poverty (Lanjouw and Lanjouw, 2001; Foster and Rosenzweig, 2004). Whether the economy reverts back to the pre-disaster situation or is transformed to a new structure could be driven by the relative aid effectiveness on farm and non-farm growth after the shock.ⁱ

This paper considers the recovery process of the fishing villages in Aceh, Indonesia after the 2004 Indian Ocean tsunami. Following the almost complete destruction of production assets in Aceh, there was a huge influx of humanitarian relief (such as housing and fishing boats) and a reconstruction boom to restore destroyed public infrastructure, funded by the Indonesian government and international agencies. During this recovery process, the share of fishing sector fell, accompanied by a temporary expansion of non-fishing sector as shown in Figure 1.

My main theme is how aid *quality* constrains the well-being of households after natural disasters. A few recent papers have examined the effectiveness of in-kind aid transfers on jobs, but the results are rather mixed.ⁱⁱ In Aceh, the in-kind transfer programs experienced a major challenge in trade-offs between aid quality, aid quantity, and the speed of delivery (Henderson and Lee, 2012; Nose, 2013). In particular, fishing boats from aid agencies were made of low quality materials or were improperly constructed due to a lack of quality monitoring by NGOs, shortage of qualified boat builders, a rush of boat orders with unrealistic delivery times, and limited amounts of resources (FAO, 2005).ⁱⁱⁱ Due to the imperfect credit market, such quality shocks created a sizable income loss for those who were heavily affected by the tsunami.

Using household-level panel data, this paper provides rigorous evaluations of the short-term and long-term impacts of in-kind aid quality on fishermen's job recovery and income growth after the tsunami. It further considers whether an alternative form of disaster-relief (i.e., the development

of private market) could better help fishermen to plan their career and cope with aid quality problem.

Empirical section considers the potential beneficiary selection bias from the non-random quality assignment between treated (the recipients of bad quality aid) and untreated (good aid recipients) groups similar to Chen, Mu, and Ravallion (2009). I offer a balancing test in the later section which supports the exogeneity of the aid quality variation conditional on observable characteristics. Using the survey data on the quantity and quality of housing and fishing reliefs, it also deals with the confounding effect from the multiple treatment problem.

This paper found that the aggregate quality shock (adverse labor demand shock common within a village borne by a supply of faulty aid boats) created substantial income losses, driving many fishermen to choose non-fishing jobs. Moreover, the aggregate shock created a *negative selection effect*, leading to a small-scale and less productive fishing sector. A subset of aid recipients further faced the idiosyncratic shock (loss of production capital due to the imperfect durability) in later years. Households needed to take costly coping actions if they experienced the shocks, creating a new form of income inequality. As private market gradually developed over time, better access to private market helped fishermen to undo the idiosyncratic shock. These results imply that the quality monitoring of in-kind aid and the soft aid for developing private market would be key policy agenda for donors in the post-disaster context.

The paper is structured as follows. Section 2 explains the context and survey. Section 3 provides theoretical predictions. Section 4 and 5 carry out empirical analyses on job choices, while Section 6 studies the impact of aid quality on inequality. Section 7 concludes.

2. Background and survey data

2.1 Labor market developments after the tsunami

Creating permanent jobs is an important challenge in the aftermath of the natural disaster. Figure 1 shows the change in the fraction of workers in each of the four sectors and the underemployment rate.

Each bar is the mean value of employment shares from the overlap sample of 80 villages which were surveyed in all three survey rounds.

In the pre-tsunami period, fishing was the dominant industry in the coastal villages in Aceh.^{iv} The impact of the tsunami on fishing community was substantial: the underemployment rate spiked up to 46% from the pre-tsunami level of 12%, and the fishing reefs and mangroves were devastated. During the first six months after the tsunami, the majority of households worked for cash-for-work programs or made a life by receiving living cost allowances from local governments, which explains the largest share of workers in the “others” job category in 2005 (29%) in Figure 1. Fishing sector temporarily recovered in 2007, but by 2009 the share of fishing industry had declined again.

On the other hand, the non-fishing industry continued to develop due to an increased labor demand in the construction sector (called “spending effect” by Corden (1984)) for rebuilding private houses and public buildings (e.g. hospitals, schools, and mosques). While aid activities were heavily clustered in the north-west part of mainland Aceh, there were only a few agencies which provided assistance in remote areas (further down the south part in Aceh Jaya) and in the isolated island in Pulo Aceh. Except for construction business, non-fishing sector in Aceh was mainly trading (e.g., fish-related retail business and transportation) which relies on fishing activity growth. This is household production on a very small scale, producing simple goods, unlike small modern factories which produce exportable goods in India (Foster and Rosenzweig, 2004). As most aid efforts came close to the end in 2009, public investments wind down, increasing underemployment rate.

Table 2 comes from the household survey and shows a big shift of fishing status from being a captain to crew from 2007 and 2009. This shift indicates limited fishing opportunities for crew in 2007. The fall in the number of boat owners and captains in 2009 also implies that some household-specific shocks occurred in later years. The distribution of workers also became somewhat diversified: many former fishermen, especially those with higher education and with trauma (psychological and physical reactions) from the tsunami, started working in non-fishing jobs.

[insert Table 2]

Figure 2 shows the lasting negative effects of the low aid quality on the post-tsunami labor market developments. It divides villages into two groups: 49 villages with a minor quality problem (i.e., less than 50% of aid boats were in bad quality; left panel) and 31 villages with a major quality problem (right panel). In the former type of villages, the fishing sector recovered to above the pre-tsunami level in 2007, but declined in 2009. On the other hand, in the latter type of villages, fishing did not recover to the pre-tsunami level in 2007 and continued to decline in 2009.

[insert Figure 2]

2.2 Survey

The data are drawn from a large field survey on fishermen and coastal villages in Aceh, Indonesia (“Population and Economic Recovery in Coastal Aceh: Aid and Village Institutions” principally investigated by J. Vernon Henderson (Brown University/NBER) which has been financially supported by the National Science Foundation (SES 0416840) and the National Institutes of Health (R01 HD057188)). The data were gathered at three levels (household, village head, and local heads of fishermen’s association (*Panglima Laot*)) in 2005, 2007, and 2009. In 2005, information on pre-tsunami household characteristics was also retrospectively collected.

The initial survey was conducted in early 2005 and covered 544 pre-tsunami fishermen in 111 fishing villages. The survey covers the universe of fishing villages in the tsunami affected kabupaten (Banda Aceh and Aceh Besar).^v In the fishermen’s survey, the targeted population is fishing households living in these coastal villages which were most heavily damaged by the tsunami.^{vi} The survey on fishing households represents 25% of pre-tsunami boat owners and 45% of surviving boat owners in these villages. The sampling frame was drawn from the list of former fishing boat owners assembled by *Panglima Laot*, and the fishing households were proportionally sampled from the list in each village.

Among 544 households surveyed in 2005, I use 348 pre-tsunami boat owners or captains

who were re-surveyed in late 2007 as a baseline sample (*original sample*). This sample is used to analyze factors affecting initial job decisions in 2007.

In 2007, the survey added 151 new fishing families to our original sample; these families had never owned a boat before the tsunami but donors gave them a chance to be the first time owners. Besides, 288 previous owners were additionally added from Aceh Jaya (kabupaten which is heavy devoted to fishing) which is located in the south of Aceh and was not originally covered in 2005. Of the 439 households, only 244 households could be re-surveyed in 2009.^{vii} I added these to 313 households (which were surveyed in all three rounds among 348 original sample), and formed 557 families (*supplementary sample*). This is the two-year panel between 2007 and 2009 to examine the job switching behaviors (see Figure 3).

Summary statistics for the original sample and the supplementary sample are reported in Table 1. In supplementary sample, new boat owners were oversampled in Aceh Jaya. This sampling heterogeneity needs to be controlled in the later sections.

3. Theoretical predictions

The model is built in two stages where fishermen make career decisions in face of aggregate and idiosyncratic quality shocks (see Appendix 1 for details).

First, donors provide production assets (i.e., fishing boats) with heterogeneous quality across villages. In the first stage, some villages encounter serious quality problem. Households in such communities face a decrease in labor demand (aggregate shock; *AGGSHOCK*) as it reduces the number of boat owners in the community, suppressing labor demand for crew as well. Besides, it could also have a price effect by reducing compensations for crew. In the first stage, actual boat quality is imperfectly observed by individual fishermen.^{viii} After they use the fishing boats, they may discover that their boat is not durable (idiosyncratic shock; *IDIOSHOCK*). If the aggregate quality shock continues to constrain job opportunities, those who initially resumed fishing may have common motives to switch jobs in the second stage.

Under the Roy model, fishermen compare the fishing income and the reservation wage for non-fishing activities in the first stage. Duration of initial job depends on people's earnings in the first job as well as the idiosyncratic shock happened afterwards.

With heterogeneity in two skill factors (fishing and market skills), the optimal career decision depends on the comparative advantage in each sector as well as the type of capitals given by aid agencies. With the capital-skill complementarity, negative selection in fishing skill would be expected if a household is likely to receive a faulty boat.

4. Empirical framework

The empirical analysis exploits quality variations of fishing boats at village and household levels to estimate their short-term and long-term effects on the labor supply decision. The analysis starts from probit regressions, defined in Eq. (1) and (2) below, to understand job choices in 2007 and 2009. In 2007, the empirical model is only concerned about the aggregate quality shock B , as almost nobody (only 0.6%) in my sample experienced the idiosyncratic shock (see Table 1).

$$P(F_{07,ivk} = 1) = \phi(\alpha_0 + \beta_1 B_{vk} + \gamma_1 X_{ivk} + \gamma_2 W_{vk} + \mu_k) \quad (1)$$

where F_{07} equals one if household i in village v in kabupaten (or kecamatan) k chose to fish in 2007, and zero otherwise. X is a vector of households' pre-tsunami attributes such as their boat size (capturing fishing productivity), fishing status as a boat owner and captain, relationship with middlemen through credit repayment obligation, a higher education dummy, and the number of surviving captains after the tsunami (capturing the aggregate labor demand for crew). An outside option variable (w) controls for the confounding effect due to the *quantity* of other aid programs. With greater number of non-fishing aid implemented in the community, I expect higher elasticity of labor supply to the aggregate quality shock as labor demand in the non-fishing sector increases, providing more attractive market job opportunities. The benchmark regression uses the log of

number of NGOs as a proxy for outside options, and regressions in Appendix 2 use alternative outside option measures to check the empirical robustness. Fixed effect μ purges region specific unobserved characteristics. To adjust seasonal working patterns (e.g., fishing in the peak season and farming in the slack season), it also controls for the months when interview took place.

Eq. (2) estimates career decision to continue fishing in 2009 conditional on those who were fishing in 2007 (see Table 3 for the career transition matrix).

$$P(F_{09,ivk} = 1 | F_{07,ivk} = 1) = \phi(\alpha_0 + \beta_1 q_{ivk} + \beta_2 B_{vk} + \gamma X_{ivk} + \mathbb{I}[s_{orig} = 1] + \mu_k) \quad (2)$$

where q is the actual quality of aid boats; it equals one if the boat became unusable in 2009. Even in 2009, there would be a lack of job opportunities to become crew in villages with many bad boats, which might prevent households from remaining in fishing sector. If the aggregate shock posed a long-term constraint for fishermen's job choices, β_2 will be negatively signed. X includes similar household characteristics as well as the fraction of fishermen in each village, a proxy for the size of fishing sector, capturing an agglomeration effect. $\mathbb{I}[s_{orig} = 1]$ controls for sampling heterogeneity for the supplementary sample. μ controls for the regional differences in the market environment and other unobservable factors.

Households' unobservable characteristics, such as mental conditions or risk preferences, might have driven job choices. To confirm the empirical robustness, endogenous switching regression is employed to account for the self-selectivity between two sectors. (see Appendix 3)

4.1 Endogenous self-financing

Besides a risk-mitigation through labor supply responses, self-financing may be another optimal choice for agents to deal with the quality shocks depending on the level of wealth and/or an access to a private market. With this option, agents compare the relative payoffs of three options: fishing as crew (V_1), fishing as an owner by buying a boat (V_2), and working for non-fishing jobs (V_3).

Assuming the logit error structure, the probability for households i to take each option can be written as follows and the parameters can be estimated using the multinomial logit model.

$$P_{ij} = \Pr(P_i = j) = \frac{\exp(V_{ij})}{\sum_{k=1}^3 \exp(V_{ik})}, \quad j=1,2,3 \quad (3)$$

4.2 Identification issues

A. Exogeneity of quality shock variables

The empirical identifications in Eq. (1)-(3) rely on the exogeneity of B and q . Table 4 provides the balancing test of two quality shock variables.

The aggregate quality shock B can be systematically different by the type of villages. For example, the aid quality could be worse in remote rural areas with poor access to road or in heavily devastated places which were too dangerous for aid agencies to operate. Moreover, as shown by Henderson and Lee (2011), the aid quality is also highly correlated with the type of aid agencies (donor) and village governments (recipient). The upper panel of Table 4 splits villages with major quality issue ($Bad50=1$) vs. not ($Bad50=0$), and shows no significant differences with regard to most village attributes (i.e., the survival rate of population, the supply constraint of aid relative to demand from surviving captains, distance from Banda Aceh, the involvement of donors with inadequate quality monitoring,^{ix} and the local governance structure). Only exception is that the boat quality was worse in places where local government/BRR decided an aid delivery. I include kecamatan fixed effects to balance village characteristics between two groups.

To identify the idiosyncratic effect of q , the characteristics of fishermen who experienced the shocks vs. not needs to be balanced. The bottom panel of Table 4 shows higher likelihood of the idiosyncratic quality failure to smaller boat owners pre-tsunami, especially around a remote region (i.e., Aceh Jaya). Thus, regressions need to control for kecamatan fixed effects and pre-tsunami boat size for q to be plausibly exogenous. Intuitively, non-randomness of q is less of a concern for two reasons. From supply side, although aid boats tended to be targeted to people with stronger social

connection (Nose, 2013), it is unlikely that different quality of boats were selectively assigned to a particular type of fishermen. From the demand side, when fishermen lobbied with village leaders to ask for aid, they were concerned about receiving any boats rather than the actual aid quality given the limited supply of aid. Controlling for pre-tsunami social status (as a boat owner and captain) will minimize the non-randomness associated with the endogenous placement of aid within each village.

B. Confounding effect from the quality of housing aid

Another major form of hard aid was house constructions which also had serious quality problem (Henderson and Lee, 2011). Almost all households in my sample received houses from donors by 2009, but they were often constructed with leaky roofs, cracked walls and poor foundations (see Table 1). By 2007, 41% of house recipients reported at least one form of the quality deficiencies, which rose to 51% by 2009. The faulty houses were more commonly observed for the poor and were clustered in Banda Aceh. Living conditions, such as ownership of houses and land tenure, is found to affect labor supply decisions in developing countries (Field, 2007). As almost all houses were destroyed by the tsunami (survival rate was only 9%), a failure to secure a good quality houses could pose a major constraint for the job and income recoveries. The qualities of boats and houses were not significantly correlated, so I separately control for the quality of housing aid to remove the potential bias.

C. Attrition bias

Figure 3 shows the selection of my sample over time. Internal validity of the estimates faces a potential threat of attrition bias if those dropped out of the study (“droppers”) are systematically different from those who remain in the study (“stayers”). A simple t-test reveals that droppers were more likely to be those who did not own a boat in 2007 and they tended to live in Aceh Besar or Banda Aceh. Intuitively, as the idiosyncratic shock is more serious for those living in Aceh Jaya, which is more likely to remain in my sample, *IDIOSHOCK* would be overestimated.

I employ inverse probability weighted (IPW) estimation which can extend to a general non-linear model and does not require an exclusion restriction (Wooldridge, 2002). The attrition probability is predicted in the first stage based on a regression of the attrition dummy on socio-economic covariates and regional fixed effects. Then, I non-parametrically weight each observation using the inverse probability of non-attrition to obtain consistent and efficient estimates which account for attrition bias.

5. Empirical results

5.1 *Assessing the impact of quality shocks*

A. *Initial career decision*

Eq. (1) is separately estimated for boat owners and non-owners in 2007 as the aggregate shock should matter only for the latter group.

Column (1) shows estimates for 154 owners, among which 74% chose fishing. Their decision was not significantly affected by the aggregate shock as they already had a fishing boat and did not anticipate the possibility that their boats could be unusable in a few years.

The rest of columns are for non-owners. In column (2) and (3), a unit increase in the supply of bad aid boats limits opportunities to be crew and reduces the probability of fishing by 50.4 percentage point with kabupaten fixed effects, which rises to 68.7 percentage point with kecamatan fixed effects. Column (4) controls for the confounding effect of housing aid quality. A receipt of a faulty house significantly reduces fishing probability. Omitting the housing quality creates downward bias to this aggregate shock variable: the magnitude of B rises to 79.6 percentage point after removing the confounding effect. Column (5) includes two dummy variables (which indicates no aggregate shock ($Bad0=1$) and more than half aid boats in poor quality ($Bad50=1$)) to examine the non-linear effect. The marginal effect of the second dummy is -47.9 percentage point (significant at 99%), showing that the aggregate quality shock was critical in the villages with B greater than 0.5.

As a robustness check, column (6) drops unemployed people from the sample and column (7) uses alternative definition of fishing (households are now defined as “fishing families” if any family member reported fishing outputs regardless whether it is their primary or secondary occupation). As the villages with a major quality issue seemed to be more constrained by demand (relative to the supply of *good* aid boats; see upper panel of Table 4), column (8) and (9) separately estimate the number of good and bad aid boats which explicitly accounts for this demand constraint. Even in these specifications, the negative effect of the aggregate shock remains to be robust.

B. Job switching decision

Table 6 shows the regression coefficients of Eq. (2). In column (1) with kabupaten fixed effects, receiving a low quality boat reduced the probability of fishing by -11.4% (significant at 95%) while *AGGSHOCK* is insignificant. This implies that people changed jobs at the extensive margin in response to the idiosyncratic shock, but the aggregate shock did not pose a long-term constraint for job seeking behaviors. In column (2), the interaction term between *IDIOSHOCK* and *AGGSHOCK* is included to examine whether fishermen could better cope with the idiosyncratic shock or not when their villages faced the aggregate quality shock, but there is no interaction effect. In column (3), the sample is restricted to the aid recipients in 2007. As expected, the negative effect of *IDIOSHOCK* increased in magnitude to -15.8% (significant at 95%) as it is specific to aid recipients.

In column (4) and (5), kecamatan fixed effects are included instead. Although the magnitude of q decreases (as q has smaller variations within kecamatans), it is negative and significant.

Those who received bad quality houses tended to maintain fishing jobs suggesting that poor housing conditions constrained their job mobility into the market sector. The positive coefficient on fraction of fishing population in 2007 captures the positive externality as interactions in a fishing team would increase if fishing market was larger.

C. Selection effect

In Eq. (1), regressions in Table 7 add the interaction term of the aggregate quality shock with productivity variables (controlling kecamatan fixed effects) to examine whether a particular type of fishermen was disproportionately affected. With negative selection into fishing, the interaction term should be negatively signed.

I use the type of technology adopted pre-tsunami (i.e., the log of boat length and engine capacity, outliers above 95 percentile are trimmed out), fishing labor productivity (total fishing outputs per boat length), and the location of fishing activities pre-tsunami (near coast within lagoon which does not require a skill to fish in the deep sea) to examine whether skill compositions between two sectors changed due to the aggregate shock. The new fishing boats provided by aid agencies were smaller and homogeneous compared to the pre-tsunami old boats, creating skill mismatch (Nose, 2013) which was likely to affect the incentive on occupational choices.

In column (1), the negative marginal effect of the aggregate shock increases for households with bigger pre-tsunami boat. For those with average sized boats (the average of the log of boat length is 2.151), the marginal effect is equal to -0.859 ($=2.066-1.360 \times 2.151$). Column (2) and (4) show similar findings when I use pre-tsunami engine capacity and the location of fishing activity as proxies of fishing productivity. The empirical results remain robust when alternative outside option measures are used (results available upon requests). This suggests that technologically advanced fisherman or those who had engaged in in-shore fishing pre-tsunami were differentially more affected by quality deficiencies of boats, confirming capital-skill complementarity. Figure 4 describes faster decline of fishing probability for non-owners with more advanced technological fishing skill than for less productive group as the provision of low quality boats increased.^x

Another possible interpretation is that the cost of job mobility is lower for the productive group simply because they had higher education, and thus had better outside options in their village. However, market and fishing skills (i.e., ability to use better technology boats) are not positively correlated, eliminating this story of positive selection based on market skill. It is thus more

plausible in our context that productive fishermen simply did not prefer to fish as crew since the new boat type did not fit the fishing technology which they used to work pre-tsunami.

As a result of this negative selection effect, the average fish productivity (defined by total fish catch in 2007) is significantly lower in the villages with major quality problem compared to those with minor problem (significant at 99%). This drove the former villages into a small-scale fishing with lower compensations for crew, widening income gap between fishing and non-fishing jobs in such communities.

[insert Figure 4]

5.2 *Private market transaction*

Table 8 examines another coping strategy to deal with the quality shocks by purchasing a private boat in the local boat market. Column (1) and (2) present the probit estimation with different levels of fixed effects, showing that the self-financing decision was not significantly affected by *AGGSHOCK*. Those receiving a faulty house were less likely to buy a boat, and people had less incentive to buy a boat if more market opportunities were available in the village. The multinomial logit estimation in column (3) also finds that *AGGSHOCK* did not trigger self-financing strategy in the initial period of 2007 as private markets were less developed right after the tsunami.

On the other hand, self-financing became a feasible coping strategy in the later period of 2009 after local markets developed. In column (4), *IDIOSHOCK* increases the probability of self-financing by 17.8% (significant at 95%). The result also shows that wealthier households were more likely to buy one to undo the idiosyncratic shock. Those living further away from Banda Aceh were less able to take this option, implying that the transaction cost was higher in the remote area.

Column (5) examines the hypothesis that self-financing is easier if households have access to credit unions as it reduces transaction costs. The sample is divided based on the access to credit unions in 2007, and the estimates show that those living in villages with the credit access were more likely to self-finance a boat in response to both aggregate and idiosyncratic shocks. This suggests

that access to credit remained to be the key constraints for adopting self-financing strategy. Column (6) employs the multinomial logit regression which confirms the same narrative that private resources available in the local economy helped recipients of poor aid boats undo it in the later stage.

6. Post-tsunami evolution of income inequality

Finally, I examine how the two types of quality shocks affected income distribution over time. In the rural economy without formal social insurance system, the loss of jobs or production capacity could bring fishermen into poverty. Therefore, if they could not cope with the quality shock in each stage through two measures (labor adjustment and self-financing), I would expect to see a significant income disparity between the treated group (those affected by the quality shock) and the control group (those not affected).

Figure 5 shows the change in per capital income distribution (in real term) from pre-tsunami to 2009. The income inequality was determined by the initial wealth endowments before the tsunami, but was equalized as almost all financial and physical assets were wiped out by the tsunami (*leveling effect*). However, income inequality has diverged over time, especially with increasing number of poor households at the lower tail of income distribution in 2009. This suggests that both aggregate and idiosyncratic quality shocks created a *new form of inequality* depending on the type of aid and jobs household obtained after the tsunami. The following first-differenced (FD) model is used to estimate the effect of the quality shocks on income growth.

$$\Delta \ln(y_{ivk}) = \alpha_0 + \alpha_1 F_{07,ivk} + \beta_1 q_{ivk} + \beta_2 B_{vk} + \gamma X_{ivk} + \mu_k + \Delta \varepsilon_{ivk} \quad (4)$$

where $\Delta \ln(y_{ivk})$ is real income growth for household i , in village v and kecamatan k . It is the log difference of real per capita income: $\Delta \ln(y_{ivk}) = \ln\left(\frac{I_{09,ivk}}{n_{09,ivk}}\right) - \ln\left(\frac{I_{07,ivk}}{n_{07,ivk}}\right)$ where I_t is weekly earning (in real term, deflated by the consumer price index in Aceh province from BPS (*Badan Pusat Statistik*) website) and n_t is household size in year t . Right hand side includes a dummy for fishing

decision in 2007, two quality dummies, other controls, and kecamatan fixed effects.

This regression controls for the pre-tsunami boat size (as it is correlated with q ; see Table 4). FD model removes time invariant unobservables, such as households' taste for fishing and inherent wealthiness, which might be correlated with their income growth. I control for kecamatan fixed effects to remove a concern that local governments provided other welfare programs during the same time period. The fixed effect also controls for the change in job opportunities and production activities at each region which may affect income growth. There is a potential concern of "spill-over" effect of the quality shock happened in a community to neighboring places which could bias our estimates (Chen, Mu, and Ravallion, 2009). However, bias from spill-over effects of the quality shock is less of a concern in my case as people rarely move across communities after the tsunami and the inter-regional trade was also not common in 2007.

To better identify the effect of idiosyncratic quality shock on income growth, the sample is restricted to those who initially chose to fish in 2007.

$$\Delta \ln(y_{ivk}) | (F_{07,ivk} = 1) = \alpha_0 + \beta_1 q_{ivk} + \beta_2 B_{vk} + \gamma X_{ivk} + \mu_k + \Delta \varepsilon_{ivk} \quad (5)$$

The idiosyncratic shock is expected to dampen income growth, which could be mitigated by switching into a non-fishing job or self-financing a new boat. The relative magnitude of two types of quality shocks can be examined by comparing β_1 and β_2 . β_2 captures the lasting effect of initial inter-village quality differences which could constrain income growth.

The top panel of Figure 6 compares income distribution between two groups divided by the aggregate shock, while the lower panel compares two groups by the idiosyncratic shock. The figure confirms that those who experienced each shock experienced slower income growth.

In Table 9, column (1) shows estimates of Eq. (4) for the original sample and column (2)-(8) for the supplementary sample. If households were in the villages with a major quality problem, their fishing income would be lower due to lower equilibrium wage for the increase in B and for the decrease in average fishing productivity.^{xi}

In column (2)-(8), the negative effect of idiosyncratic shock on real income growth was marginal when holding other covariates constant, suggesting that self-insurance actions helped to mitigate negative income shocks. In column (3), I added the interaction term of two shocks, but found no interactive effect. Column (4) estimates Eq. (5) for those who were fishing in 2007, and column (6) further restricts the sample to those who received aid boats by 2007. Even in these specifications, the negative effect of the idiosyncratic shock remains to be insignificant while the aggregate shock had significant negative impacts on income growth. Column (6)-(8) use alternative outside option measures which are explained in Appendix 2. In any specifications, the negative effect of *AGGSHOCK* on the real income growth is significantly large, implying that the initial covariate demand shock was difficult for fishermen to cope with and it persistently had negative impact on their income recovery. All outside option measures except the predicted reservation wage are positively signed, showing faster income growth when more aid related business were available.

7. Conclusion

During the recovery process after the tsunami in Aceh, disaster aid programs offered various job opportunities. However, whether the aid helped the sustainable recovery of the rural economy remains an open question. My finding shows that the deficiency of in-kind aid quality persistently constrained fishermen's job choices and income growth. Driven by a large labor demand in construction, non-fishing jobs provide alternative income sources, but the expansion of the non-fishing sector was a temporary event. I also found that the aggregate shock created the negative selection effect, driving down average fishing productivity, and it created a new form of income inequality in the post-tsunami economy.

As there is a positive linkage between fishing and non-fishing activity growth, it is essential for aid agencies to improve the quality monitoring in order to effectively recover the fishing sector as a basis for the sustainable rural development after the tsunami. On the other hand, I also found

that soft aid in the private sector could be an alternative to complement the quality deficiencies associated with public transfer programs to improve the aid efficacy.

For my next research, it is very important to investigate whether the new form of income inequality between those affected and unaffected by the quality shocks could persist or not. Especially, in the face of capital market imperfection, inequality can persist with the differences in post-tsunami wealth given by aid agencies (Galor and Zeira, 1993; Banerjee and Newman, 1993; Mookherjee and Ray, 2002). The next round of survey in 2011 will tell us how households' job and income have evolved after the termination of international aid efforts.

Note

ⁱ There are number of papers which look at the short-term and long-term effects of natural disasters or civil conflicts on asset distribution (Carter et al, 2007), capital-labor ratio (Hutchinson and Margo, 2006), wage responses (Mueller and Quisumbing, 2011), and demographic mobility (Hornbeck, 2012) after the shocks. However, there appears to be less focus on the long-term economic impact of a disaster aid on households' welfare.

ⁱⁱ In the post-disaster context, de Mel, McKenzie, and Woodruff (2008) found no statistical difference for the effect of cash and in-kind aid on micro-enterprise's production decisions. However, in Fafchamps, McKenzie, Quinn, and Woodruff (2011), in-kind transfer turns out to be more effective than cash transfer as it overcomes self-control problem on producer's decision making.

ⁱⁱⁱ FAO reports that it would take a boat builder 12 days to make a boat before the tsunami; the surge in demand for boats after the tsunami required that a boat be completed in one day. This evidence is also confirmed by our field survey; 24.7% of aid boats were not operational immediately after they were delivered in 2007. In addition, 19% of fishermen who started fishing with a new boat from NGOs found they were not durable in two years and needed to re-engage in a different job.

^{iv} Based on pre-tsunami SUSENAS survey, the major industry in other parts of Aceh (both inland and coastal) was agriculture. Compared to the inland area, the coastal communities in Aceh, which is the focus of this survey, exhibit higher share of fishing industry (over 30%) before the tsunami as shown in Figure 1.

^v A district (*kabupaten*) is a political subdivision of a province in Indonesia. Districts are divided into sub-districts (*kecamatan*).

^{vi} For this reason, our sample is not representative of the general population of Aceh, but it rather represents the average fishermen in the province and complements the SUSENAS sample (see Nose (2013) for detailed explanations on the sample representativeness).

^{vii} Among the additional 439 households, 50 observations are removed as they did not report any fish outputs.

^{viii} The aggregate shock is the labor demand shock due to the provision of faulty boats only for a subset of fishermen (i.e., those who could not receive boat from donors). The nature of the shock is not same as a regular weather shock which creates harvest failures and direct production risks for all farmers. However, this is the common labor demand shock for non-owners in the same community which affects labor conditions and recovery speed of rural cities in the aftermath of the tsunami. In the empirical section, the share of faulty boats in the village is used to capture the degree of such community-wide shocks on the rural labor market.

^{ix} Several NGOs (e.g. Oxfam, Triangel Generation Humanitaire), local governments and the BRR, and bilateral donors (e.g. Kuwait government) are reported to have serious quality deficiencies of boat aid.

^x Figure 4 depicts the result using the length of boats as a fishing productivity measure, but I found a similar correlation when the engine capacity is used instead.

^{xi} As shown in section 5, fishermen’s job decision was self-selective. I also match their characteristics by occupation and run a regressions where fishing sample is weighted by $1/p(X)$ and non-fishing sample by $1/(1 - p(X))$. The propensity score $p(X)$ of being the 2007 fishermen is predicted based on covariates included in Eq. (1) with those outside (0.15, 0.85) are trimmed out. The results in Table 9 are robust even when the regression is weighted by this propensity score.

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Table 1: Summary statistics

Variables	N	Mean	S.D.	N	Mean	S.D.
	Original sample			Supplementary sample		
Fish in 07	348	0.583	0.494	557	0.734	0.442
Fish in 09	348	0.580	0.494	557	0.661	0.474
Report catch in 07	348	0.644	0.480	557	0.806	0.396
Boat aid in 07	348	0.371	0.484	557	0.587	0.493
Boat aid in 09				557	0.724	0.448
Buy in 07	348	0.144	0.351	557	0.120	0.326
Buy in 09				557	0.298	0.458
Boat owner in 07	348	0.511	0.501	557	0.716	0.451
Boat owner in 09				557	0.488	0.500
<u>AGGSHOCK</u>						
Fraction of bad aid boats in 07	313	0.247	0.384			
Bad0 1/	313	0.617	0.487			
Bad50 1/	313	0.227	0.419			
<u>IDIOSHOCK</u>						
D_have a bad aid boat in 07	348	0.006	0.076	557	0.097	0.296
D_have a bad aid boat in 09				557	0.190	0.393
D_bad house in 07	348	0.382	0.486	557	0.409	0.492
D_bad house in 09				557	0.510	0.500
D_have leaky roof in 09				557	0.255	0.436
D_have cracked wall in 09				557	0.329	0.470
D_have poor foundation in 09				557	0.221	0.415
D_have faulty plumbing in 09				557	0.246	0.431
<u>Outside option</u>						
Number of NGOs in 07	329	15.833	7.267			
Number of aid projects in 07	329	37.246	18.280			
Total housing aid in 07 2/	331	252.752	271.663			
<u>Fishing productivity</u>						
Ln (boat length pre-tsunami) 3/	320	2.159	0.226			
Ln (engine capacity pre-tsunami) 3/	326	3.061	0.479			
Total fish catch/length pre-tsunami 3/	326	26.319	38.056			
In-shore fishing skill	348	0.348	0.476			
<u>Socio-economic characteristics</u>						
Boat owner and captain pre-tsunami	348	0.736	0.442	557	0.610	0.488
D_large boat pre-tsunami	348	0.330	0.471	557	0.305	0.461
High education pre-tsunami	341	0.141	0.348			
D_debt to Toke Bangku	348	0.201	0.401			
High income in 07				556	0.252	0.434
<u>Community characteristics</u>						
Number of boat aid in 07	313	18.217	20.132			
Number of surviving captains in 05	309	23.379	19.561			
D_Banda Aceh	348	0.175	0.381	557	0.158	0.365
D_Aceh Jaya				557	0.140	0.347
Fraction of fishing population in 07				491	0.271	0.270
Credit union in village in 07				522	0.318	0.466

1/ Bad0=1[Fraction of bad aid boats=0], Bad50=1[Fraction of bad aid boats>0.5]

2/ Both temporary and permanent houses.

3/ Observations above the top 5 percentile are trimmed out.

Table 2: Breakdown of primary job of household heads

	2007	2009
Fish (Captain)	374	293
Fish (Crew)	35	71
Other fishing	3	9
Agriculture	20	43
Construction	23	19
Trade	52	73
Service sector	24	22
Unemployed	23	20
	554	554

(Note) Other fishing includes aquaculture and fish processing; trade includes fish related trader, coffee shop, retail shop, restaurant, transportation, and technician (boat builder, mechanics, plumber, electrician, carpenter); service sector includes private service (banker, administrative office), public service (government official, teacher, doctor, police), and manufacturing.

Table 3: Transition matrix of occupations

	Fish in 09	Not fish in 09	
Fish in 07	310	99	409
Not fish in 07	58	90	148
	368	189	557

Table 4: Balancing test of quality shocks

In 2007 (for original sample)

	Bad50=1 (N=14)	Bad50=0 (N=39)	Difference
Survival rate of village population in 2005	0.54	0.62	-0.08
Good aid boat/Surviving captains in 05 1/	0.38	1.76	-1.38*
(Excluding Lhok Nga and Pulo Aceh)	0.38	0.66	-0.28
Ln(distance to Banda Aceh)	2.82	2.64	0.18
Agencies' involvement 2/			
Oxfam	0.07	0.06	-0.01
Kuwait government	0.14	0.06	0.08
Local government/BRR	0.71	0.30	0.41***
Triangle Generation Humanitaire	0.21	0.28	-0.07
Village governance 2/			
Old village head survived	0.36	0.38	-0.02
Old PL head still in the office	0.79	0.69	0.10

*** p<0.01, ** p<0.05, * p<0.1

1/ Total number of good boats provided by donors by 2007 divided by the number of survived captains in 2005. T-test which excludes two outliers (11 villages in Lhok Nga and Pulo Aceh where aid boats were overfunded) is also reported.

2/ Dummy variables.

In 2009 (for supplementary sample)

	<i>q=1</i> (N=93)	<i>q=0</i> (N=322)	Difference
Boat owner pre-tsunami	0.59	0.61	-0.02
Captain pre-tsunami	0.89	0.85	0.04
D_large boat pre-tsunami	0.18	0.32	-0.14**
High education in 2007	0.01	0.01	0
Good aid boat/Surviving captains in 05	1.68	1.42	0.26
(Excluding Lhok Nga and Pulo Aceh)	0.95	0.71	0.24
D_Banda Aceh	0.06	0.17	-0.11***
D_Aceh Jaya	0.39	0.11	0.28***

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Fishing decision in 2007

VARIABLES	Owners	Non-owners							
	Fish in 07	Fish in 07				Report catch in 07			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<u>AGGSHOCK</u>									
Fraction of bad aid boats	-0.156 (0.144)	-0.504*** (0.157)	-0.687*** (0.179)	-0.796*** (0.182)		-1.071*** (0.270)	-0.830*** (0.180)		
Bad0					0.151 (0.120)				
Bad50					-0.479*** (0.0959)				
Ln(number of good aid boats by 07)								0.0631** (0.0321)	0.0419 (0.0296)
Ln(number of bad aid boats by 07)								-0.288*** (0.0641)	-0.263*** (0.0618)
D_bad house in 07				-0.230** (0.0900)	-0.224** (0.0902)	-0.231** (0.109)	-0.227** (0.0945)	-0.176* (0.0937)	-0.219** (0.0992)
Boat owner and captain pre-tsunami	0.0413 (0.0903)	-0.0601 (0.0965)	0.00713 (0.105)	0.00233 (0.111)	0.00593 (0.111)	0.0437 (0.126)	-0.0191 (0.115)	-0.0485 (0.114)	0.00405 (0.122)
D_large boat pre-tsunami	-0.0349 (0.0763)	0.0610 (0.0814)	0.0366 (0.101)	0.0372 (0.110)	0.0291 (0.110)	-0.0241 (0.140)	0.0289 (0.113)	0.0240 (0.111)	-0.00797 (0.117)
Ln(number of NGOs in 2007)	-0.0995 (0.0836)	-0.324*** (0.109)	-0.796*** (0.241)	-0.936*** (0.255)	-0.943*** (0.246)	-1.571*** (0.330)	-0.883*** (0.259)	-0.700*** (0.262)	-0.314 (0.209)
D_debt to Toke Bangku	0.234*** (0.0718)	0.150 (0.151)	0.176 (0.144)	0.193 (0.152)	0.193 (0.144)	0.204 (0.207)	0.200 (0.152)	0.108 (0.161)	0.222 (0.177)
High education pre-tsunami	-0.162 (0.124)	-0.125 (0.100)	-0.112 (0.103)	-0.117 (0.0999)	-0.0988 (0.104)	-0.186 (0.159)	-0.133 (0.0984)	-0.134 (0.0947)	-0.0738 (0.101)
Number of surviving captains in 05		0.00563*** (0.00157)	0.00752** (0.00325)	0.00994*** (0.00335)	0.00755* (0.00395)	0.0109*** (0.00408)	0.0100*** (0.00350)	0.0118*** (0.00368)	0.00793*** (0.00300)
Observations	154	148	147	147	147	115	147	147	128
Sample	Original					Original			
Mean of dependent variable	0.740	0.453	0.449	0.449	0.449	0.574	0.463	0.463	0.445
Seasonality is controlled	Y	Y	Y	Y	Y	Y	Y	Y	Y
Regional fixed effects	Kab	Kab	Kec	Kec	Kec	Kec	Kec	Kec	Kec

*** p<0.01, ** p<0.05, * p<0.1; Estimates in column (1)-(9) are marginal effects of probit model. Column (6) drops unemployed households. Column (9) drops households living in two kecamatans (Lhok Nga and Pulo Aceh). Robust standard errors clustered at the village level are in parentheses.

Table 6: Regression coefficients in job switching equation (for fisherman in 07)

VARIABLES	Fish in 09				
	(1)	(2)	(3)	(4)	(5)
IDIOSHOCK	-0.114** (0.0540)	-0.138** (0.0679)	-0.158** (0.0648)	-0.0881* (0.0531)	-0.145** (0.0651)
AGGSHOCK	0.00203 (0.0597)	-0.0151 (0.0673)	-0.0663 (0.0769)	-0.0643 (0.0661)	-0.112 (0.0978)
AGGSHOCK * IDIOSHOCK		0.0639 (0.0884)			
Boat aid in 09	0.233** (0.103)	0.237** (0.104)		0.225** (0.107)	
D_bad house in 09	0.0382 (0.0455)	0.0380 (0.0454)	0.0963* (0.0536)	0.0431 (0.0462)	0.0876* (0.0497)
D_large boat pre-tsunami	0.0444 (0.0512)	0.0433 (0.0512)	-0.0326 (0.0628)	0.0272 (0.0458)	-0.00530 (0.0605)
Boat owner and captain pre-tsunami	0.0397 (0.0509)	0.0382 (0.0514)	0.142** (0.0570)	0.0610 (0.0451)	0.127*** (0.0479)
Fraction of fish population in 07	0.121 (0.103)	0.119 (0.103)	0.213* (0.115)	0.194* (0.117)	0.130 (0.143)
Observations	357	357	242	355	241
Sample	Supplementary & Fish in 07=1				
	All	All	Boat aid in 07=1	All	Boat aid in 07=1
Mean of dependent variable	0.762	0.762	0.747	0.763	0.746
Seasonality is controlled	Y	Y	Y	Y	Y
Sampling heterogeneity is controlled 1/	Y	Y	Y	Y	Y
Regional fixed effects	Kab	Kab	Kab	Kec	Kec

*** p<0.01, ** p<0.05, * p<0.1; All estimates are marginal effects of probit model. Robust standard errors clustered at the village level are in parentheses. The inverse probability of remaining in the sample ("stayers") is used as a weight in Eq. (2) to account for attrition bias and Sampling heterogeneity is controlled by including 1[s_{orig}=1].

AGGSHOCK=Fraction of bad aid boats
IDIOSHOCK=D_have a bad aid boat in 09

Table 7: Heterogeneity by fishing productivity (for non-owners)

VARIABLES	Fish in 07			
	(1)	(2)	(3)	(4)
AGGSHOCK	2.066** (0.938)	1.112 (0.843)	-0.626** (0.254)	-0.545** (0.213)
AGGSHOCK*Ln (boat length pre-tsunami)	-1.360*** (0.446)			
Ln (boat length pre-tsunami)	0.726*** (0.263)			
AGGSHOCK*Ln (engine capacity pre-tsunami)		-0.668** (0.295)		
Ln (engine capacity pre-tsunami)		0.180* (0.107)		
AGGSHOCK*Total fish catch/length pre-tsunami			-0.00473 (0.00503)	
Total fish catch/length pre-tsunami			0.00295* (0.00173)	
AGGSHOCK*In-shore fishing skill				-0.725*** (0.254)
In-shore fishing skill				-0.00111 (0.111)
D_bad house in 07	-0.195** (0.0952)	-0.168* (0.0883)	-0.236** (0.0989)	-0.229** (0.0897)
Boat owner and captain pre-tsunami	0.116 (0.107)	0.0367 (0.104)	0.0947 (0.114)	-0.0189 (0.112)
Ln(number of NGOs in 2007)	-1.048*** (0.270)	-0.989*** (0.229)	-1.181*** (0.303)	-0.957*** (0.258)
D_debt to Toke Bangku	0.177 (0.195)	0.183 (0.151)	0.305** (0.149)	0.170 (0.151)
High education pre-tsunami	-0.0511 (0.126)	-0.125 (0.108)	-0.240*** (0.0789)	-0.103 (0.0940)
Number of surviving captains in 05	0.00960*** (0.00322)	0.0113*** (0.00310)	0.0155*** (0.00435)	0.0115*** (0.00400)
Observations	127	135	135	147
Sample		Original		
Mean of dependent variable	0.441	0.437	0.444	0.449
Seasonality is controlled	Y	Y	Y	Y
Regional fixed effects	Kec	Kec	Kec	Kec

*** p<0.01, ** p<0.05, * p<0.1; All estimates are marginal effects of probit model. Robust standard errors clustered at the village level are in parentheses.

AGGSHOCK=Fraction of bad aid boats

Table 8: Self-financing decision in 2007 and 2009

VARIABLES	In 2007				In 2009 1/				
	(1)	(2)	(3)		(4)	(5)		(6)	
	Probit		Multinomial logit		Probit	Probit		Multinomial logit	
			V1	V2				V1	V2
	Buy in 07		(Crew in 07)	(Buy in 07)	Buy in 09	Buy in 09		(Crew in 09)	(Buy in 09)
IDIOSHOCK					0.178** (0.0694)	0.301** (0.127)	0.134 (0.0880)	-0.204 (0.349)	0.691** (0.328)
AGGSHOCK	-0.0133 (0.0503)	-0.0732 (0.0569)	-1.466** (0.594)	-1.306** (0.616)	-0.0150 (0.0622)	0.336*** (0.111)	-0.0591 (0.0752)	-0.0368 (0.428)	-0.164 (0.430)
D_bad house in 07	-0.0476 (0.0354)	-0.0693* (0.0363)	-0.672*** (0.226)	-0.942** (0.368)					
D_bad house in 09					0.0576 (0.0501)	0.0706 (0.0704)	0.0640 (0.0694)	-0.00851 (0.279)	0.310 (0.320)
Boat owner and captain pre-tsunami	0.00884 (0.0398)	0.00151 (0.0441)	0.452 (0.381)	0.258 (0.464)	0.0696 (0.0570)	0.0903 (0.0880)	0.0517 (0.0791)	0.626** (0.312)	0.826** (0.323)
D_large boat pre-tsunami	0.0620 (0.0544)	0.0497 (0.0544)	-0.303 (0.314)	0.196 (0.355)	-0.00225 (0.0712)	0.0279 (0.125)	0.0294 (0.0990)	0.0679 (0.325)	0.0563 (0.450)
D_high income in 07					0.106 (0.0706)	0.314* (0.178)	0.0202 (0.0802)	0.801** (0.370)	1.038** (0.436)
Ln(number of NGOs in 07)	-0.0819** (0.0331)	-0.186*** (0.0562)	-1.368** (0.626)	-2.087*** (0.572)					
Ln (distance to BA)	-0.0536 (0.0416)	-0.0844** (0.0351)	-0.283 (0.342)	-0.827** (0.405)	-0.163*** (0.0542)	0.710*** (0.191)	-0.173** (0.0689)	-0.638** (0.273)	-1.381*** (0.367)
Aid boats/survived fish captains	-0.0274*** (0.00938)	-0.00753 (0.0120)	0.176** (0.0875)	0.0426 (0.100)					
Constant			4.178* (2.333)	6.865*** (2.467)				2.263** (0.914)	2.462*** (0.915)
Observations	311	285	311		376	117	236	377	
Sample	Original				Supplementary				
						Credit Union in 07=1	Credit Union in 07=0		
Mean of dependent variable	0.148	0.161	0.486	0.148	0.312	0.299	0.342	0.470	0.313
Seasonality is controlled	Y	Y	Y		Y	Y		Y	
Sampling heterogeneity is controlled 1/					Y	Y		Y	
Regional fixed effects	Kab	Kec	Kec		Kec	Kec		Kec	

*** p<0.01, ** p<0.05, * p<0.1; Estimates in column (1), (2), (4) and (5) are marginal effects of probit model. Column (3) and (6) provide multinomial logit estimates. Robust standard errors clustered at the village level are in parentheses.

1/ In column (4)-(6), the inverse probability of remaining in the sample ("stayers") is used as a weight to account for attrition bias and sampling heterogeneity is controlled by including 1[s_orig=1].

AGGSHOCK=Fraction of bad aid boats

IDIOSHOCK=D_have a bad aid boat in 09

Table 9: Effect of aid quality on income growth

VARIABLES	Δy							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fish in 07	-0.511*** (0.139)	-0.375*** (0.116)	-0.375*** (0.116)			-0.367*** (0.115)	-0.367*** (0.111)	-0.419*** (0.123)
IDIOSHOCK		-0.152 (0.103)	-0.177 (0.125)	-0.137 (0.108)	-0.0818 (0.125)	-0.139 (0.104)	-0.138 (0.106)	-0.183 (0.113)
AGGSHOCK	-0.257* (0.138)	-0.248** (0.102)	-0.264** (0.108)	-0.253* (0.138)	-0.277 (0.170)	-0.225** (0.103)	-0.192* (0.107)	-0.343*** (0.117)
AGGSHOCK * IDIOSHOCK			0.0856 (0.194)					
D_bad house in 09	0.136 (0.107)	0.0500 (0.0766)	0.0495 (0.0769)	-0.0188 (0.0864)	0.0405 (0.0812)	0.0514 (0.0765)	0.0195 (0.0800)	0.0248 (0.0804)
Ln (number of NGOs in 07)	0.159 (0.160)	0.351*** (0.109)	0.350*** (0.109)	0.396*** (0.133)	0.442*** (0.141)			
Ln (number of aid projects in 07)						0.385*** (0.116)		
Ln (total housing aid in 07)							0.182*** (0.0651)	
Imputed market shadow wage in 07								-0.0420 (0.0849)
Constant	-0.767 (0.552)	-1.554*** (0.426)	-1.549*** (0.427)	-1.820*** (0.473)	-2.160*** (0.485)	-1.990*** (0.514)	-2.073*** (0.657)	0.0515 (1.084)
Observations	282	505	505	377	260	505	506	467
Sample	Original	Supp	Supp	Supp & Fish in 07=1	Supp & Fish in 07=1 & Boat aid in 07=1	Supp	Supp	Supp
Covariates are included	Y	Y	Y	Y	Y	Y	Y	Y
Sampling heterogeneity is controlled		Y	Y	Y	Y	Y	Y	Y
Regional fixed effects	Kec	Kec	Kec	Kec	Kec	Kec	Kec	Kec
R-squared	0.182	0.223	0.223	0.247	0.285	0.228	0.230	0.206

*** p<0.01, ** p<0.05, * p<0.1; Robust standard errors clustered at the village level are in parentheses. Control variables include boat aid in 09, boat owner and captain pre-tsunami, D_large boat pre-tsunami, and Ln (distance to BA). The inverse probability of remaining in the sample ("stayers") is used as a weight in Eq. (5) to account for attrition bias. Sampling heterogeneity is controlled by including $1/[s_orig=1]$.

AGGSHOCK=Bad50(=1[Fraction of bad aid boats>0.5])

IDIOSHOCK=D_have a bad aid boat in 09

(Note) “Other” sector includes transportation, construction, public services and manufacturing industries.

Figure 1: Occupational structure from pre-tsunami to 2009

Figure 2: Share of fishing sector: Good vs. Bad quality villages (from pre-tsunami to 2009)

Figure 3: Attrition from original to supplementary sample

(Note) High productivity group uses more advanced fishing technology (whose pre-tsunami boat size was greater than 9 meters)

Figure 4: Relationship between fishing probability and the aggregate quality shock

(Note) The log of households' weekly income (per household member, in Rupiah) is adjusted based on consumer price index in August 2005 (2005=100).

Figure 5: Widening income inequality

Aggregate quality shock

Idiosyncratic quality shock

(Note) d_inc is the log difference of real per capita income between 2007 and 2009 (i.e., income growth).

Figure 6: Distribution of income growth

Appendix 1: Theoretical framework

This note lays out the predictions about how the provision of low quality in-kind aid translates into income loss and affects labor supply decisions at extensive margin (fishing vs. non-fishing employment). This is related to the risk-coping literature on agricultural households' labor supply decisions in response to natural disasters (Kochar (1999), Rose (2001) and Jayachandran (2006) for weather risks in India; Belasen and Polachek (2009) for hurricanes in Florida; Mueller and Quisumbing (2011) for the 1998 flood in Bangladesh).

1. Timing of events

There are two stages. In *stage 1*, donors arrive at the community and distribute productive assets (i.e., fishing boats). In some villages, a number of low quality boats are provided, creating a labor demand shock to fishermen (aggregate quality shock). In such places, those who could not be the beneficiaries of aid boats faced lower wage of fishing as crew and needed to seek other opportunities. Aid recipients cannot fully observe the actual quality of their boats until they experience fishing activities after the tsunami. In *stage 2*, a part of beneficiaries face idiosyncratic quality shock, i.e. they might discover that their aid boats were not durable, requiring them to stop fishing or self-finance a high-quality boat. The household makes both production and labor supply decisions in each stage.

2. Stage 1:

Assume that a total of N aid boats are provided by NGOs in the village compared to a total village population of P . There is limited supply of boats relative to demand ($N < P$) which divided fishing families into two groups: owners and non-owners.

When the number of unusable aid boats B increases, there are only $N - B$ good aid boats available to be boat owners. A fixed number of fishermen, θ , might choose to purchase private boats and hire crew. While the owners will not be affected by B , how will the non-owners decide their jobs when B increases?

Fishing is conducted in a team which consists of a captain and crew. The captain needs a boat and hires crew: the fishing production function depends on the actual boat quality q_i (which cannot be observed in stage 1), average fishing productivity of the team $\bar{\lambda}_i$, and the number of crew h_i : $y_i = q_i f(\bar{\lambda}_i, h_i)$. Each fishing household is indexed by i . Boat owners need to pay each crew member α_i . Owners maximize profit, written as $\pi_i = q_i f(\bar{\lambda}_i, h_i) - \alpha_i h_i$, by choosing the optimal number of crew h^* . Profit is maximized at the point where the marginal product of labor is equal to the compensation for crew members: $f'(\bar{\lambda}_i, h_i) = \frac{\alpha_i}{q_i}$. Assuming decreasing returns to scale of $f(\bar{\lambda}_i, h_i)$, the labor demand curve is downward sloping: $\frac{\partial h^*}{\partial \alpha_i} < 0$. The aggregate labor demand L_D , which is the total job opportunities for non-owners, is defined as follows.

$$L_D = [N - B + \theta] h^*(\alpha_i, \bar{\lambda}_i, h_i) \quad (\text{A.1})$$

Those who cannot receive aid may find an opportunity to be crew. Under the imperfect credit market, each household will consume all his earning in the same period. When the utility comes only from consumption, the aggregate labor supply function L_S depends on the compensation for crew α_i , the reservation wage in outside job options w , households' observed characteristics X_i , and the number of non-owners (which is expressed as the square bracket in Eq. (A.2)).

$$L_S = [P - (N - B + \theta)] l(\alpha_i, X_i, w) \quad (\text{A.2})$$

I model the labor supply decision of each individual fisherman as a discrete choice between two sectors (fishing vs. non-fishing). Each fisherman chooses to fish if the utility from fishing dominates the reservation wage, i.e. $l(\alpha_i, X_i, w) = 1[\gamma_0 + \gamma_1 \alpha_i + \gamma_2 X_i + \varepsilon_i > w]$ where ε_i is an individual specific error term. $1[\cdot]$ is the indicator function.

If the labor supply curve is upward sloping, $\frac{\partial l(\alpha_i, X_i, w)}{\partial \alpha_i} > 0$. Non-owners have a strong incentive to opt out from fishing as w rises: $\frac{\partial l(\alpha_i, X_i, w)}{\partial w} < 0$. Fishermen have incentives to shift into the non-fishing sector until the reservation wage is equalized to the compensation wage for crew. The degree of sectoral adjustment depends on the elasticity of labor supply with respect to wage $(\alpha_i)^{xii}$ and the mobility cost.^{xiii}

The fishing market clears when the labor demanded by captains equals the labor supplied by crew. Assuming a closed economy, the labor market is segmented at each village. Within each village, the labor market is competitive and clears with equilibrium compensation for crew α^* when $L_D = L_S$.

$$\alpha^* = \alpha_i \left(P, N, \underbrace{B}_{(-)}, \theta, X_i, \bar{\lambda}_i, q_i, w \right)$$

When B rises, the labor demand curve shifts down which reduces the wage (*price effect*; Figure A.1). On the other hand, it could also constrain the labor supply to be crew as fishing opportunities are limited when B rises (*supply effect*). Both effects work in the same direction and make agents more willing to exit from fishing, reducing the number of fishermen.

$$\frac{\partial L^*}{\partial B} < 0 \quad (\text{A.3})$$

Selection effect (heterogeneous labor adjustment by productivity)

Who is affected most by the quality shock? After a large aggregate shock like the tsunami, there could be a compositional change in the affected society.^{xiv} In Eq. (A.2), the wage elasticity of labor supply might differ by the fishing productivity;

$$l(\alpha_i, X_i, \lambda_i, w) = 1[\gamma_0 + \gamma_1\alpha_i + \gamma_2X_i + \gamma_3\alpha_i\lambda_i + \varepsilon_i > w]$$

where $\frac{\partial l(\alpha_i, X_i, \lambda_i, w)}{\partial \alpha_i} = \gamma_1 + \gamma_3\lambda_i$. If the wage elasticity is higher for productive fishermen (i.e., capital and fishing skill are complementary), I expect $\gamma_3 > 0$. In this case, the labor supply curve for productive fishermen is flatter (Figure A.2).

$$\left| \frac{\partial L^*}{\partial B} \right|_{\lambda_H} > \left| \frac{\partial L^*}{\partial B} \right|_{\lambda_L} \quad (\text{A.4})$$

On the other hand, if capital and fishing skill are substitutable, I expect $\gamma_3 < 0$.

3. Stage 2:

In stage 2, if boats were discovered to be non-durable, they needed to switch jobs, become crew, or self-finance private boats. In other words, the actual quality of boat q is revealed to be either low or high ex-post: $q_i \in \{q_{i,L}, q_{i,H}\}$. As shown in Table 1, the number of fishermen whose aid boats became not durable jumped up to 19% in 2009, suggesting that actual boat quality could not be fully anticipated when boats were delivered from aid agencies in 2007.

4. Endogenous self-financing

So far, the theory assumes the exogeneity of θ . However, self-financing may be another optimal choice for agents to deal with the quality shocks depending on the level of wealth and/or an access to private market. With this option, agents compare the relative payoffs of three options: working as a crew (V_1), working as an owner by buying a boat (V_2), and working for non-fishing jobs (V_3). Then, the selection equation can be re-written as follows.

$$\theta = \max(V_1, V_2, V_3)$$

where $V_1 = \alpha_i + e_{i,1}$, $V_2 = q_i f(\bar{\lambda}_i, h_i) - \alpha_i h_i - I + e_{i,2}$, and $V_3 = w$. I is investment costs plus the transaction cost of the market transactions, and $(e_{i,1}, e_{i,2})$ are individual-level error terms. The transaction cost should be the highest right after the tsunami, but I expect I to decrease as the economy recovers from the tsunami in later years.

The effect of the aggregate quality shock on self-financing decision depends on the wage elasticity to the shock. As $\frac{\partial \alpha_i}{\partial B} < 0$, it should have a distributional impact by decreasing V_1 and increasing V_2 . If the wage elasticity is large (i.e., the distributional effect is substantial), this might drive agents to self-select into a private transaction in stage 1. On the other hand, due to the negative selection effect discussed in Eq. (A.4), the average productivity level $\bar{\lambda}_i$ will decrease as B increases, making the return to non-fishing (w) relatively more attractive than the return to fishing. Due to the two competing effects, the impact of the aggregate shock on a self-financing choice is expected to be small in stage 1, i.e.

$$\frac{\partial \theta}{\partial B} \approx 0.$$

In stage 2, if aid boats become non-durable, $V_1 = 0$. As it is the idiosyncratic shock, this will not affect the average fishing productivity level. In this case, the number of people who self-financed a boat, θ , is expected to increase in stage 2 when $q_i = q_{i,L}$, i.e. $\frac{\partial \theta}{\partial q_i} > 0$.

Figure A.1: Equilibrium wage effect of aid quality

Figure A.2: Heterogeneous effect by fishing productivity
(in case of capital-skill complementarity)

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^{xii} In previous studies, labor supply elasticities in developing countries are shown to be small (Bardhan (1979) for rural households in West Bengal; Abdulai and Delgado (1999) in Ghana). Rosenzweig (1980) estimates that the long-run labor supply curve for men is even backward-bending.

^{xiii} For example, fishermen might not be able to exit from fishing if they owed a debt obligation of repaying debt to the middlemen (called *Toke Bangku* in Aceh). This type of interlinkage between borrower and lender through trade-credit arrangement is widespread in many agricultural economies (Bell, 1988). When borrowers default on their contractual obligation, lenders have various options (such as bonding labor and extracting resources of borrowers) until borrowers satisfy the debt obligation.

^{xiv} Hornbeck and Naidu (2012) shows a large compositional change in the black-white ratios after the 1980s Dust Bowl in the U.S. south, and claims that the compositional shift actually promoted the mechanization of American agriculture.

Appendix 2: Measures of outside options

Non-fishing sector has rapidly developed during the reconstruction period when donors put a large amount of money to reconstruct private houses as well as public road and buildings. The survey contains detailed information on the scale of such infrastructure rebuilding programs (such as the total number of temporary and permanent houses which were constructed by donors and local governments). I use the data to control for the confounding impacts of other aid programs on households job choices and their income growth to identify the quality impacts if production assets (i.e., fishing boats).

The survey collects detailed village-level variations in housing aid program besides fishing aid. In addition, the data contains secondary information of the number of total humanitarian relief projects (including all types of aid) and NGOs at the village level from RAN (Reconstruction Aceh Nias) dataset. Aid programs provided direct labor demand for non-fishing job opportunities from donors (as construction workers, interpreters etc), and they also generated indirect service jobs demanded through reconstruction efforts (retail, food, and hotel business etc) which were all closely related to the scale of aid works.

As shown in the below correlation matrix, three measures are significantly positively correlated (at 99%). The negative correlation between the distance to Banda Aceh and three outside option measures suggest that the aid program tended to be clustered near Banda Aceh, the capital city of Aceh.

	Number of NGOs in 07	Number of aid projects in 07	Total housing aid in 07	Ln (distance to BA)
Number of NGOs in 07	1			
Number of aid projects in 07	0.904*** (0.000)	1		
Total housing aid in 07	0.508*** (0.000)	0.568*** (0.000)	1	
Ln (distance to BA)	-0.377*** (0.000)	-0.201*** (0.000)	-0.423*** (0.000)	1

***p<0.01, **p<0.05, *p<0.1; p-values are in the parentheses. Supplementary sample is used (N=529).

As there is no reliable labor data (such as wage and labor supply) in the market jobs, I cannot directly measure the reservation wage. The majority of households which were engaged in informal jobs (in agriculture, trading, and service sector) were not wage labor. As a result, I cannot estimate the shadow wage from the production function. As an alternative, I impute the average shadow wage of non-fishing job at each village using the following step:

- (1) Regress the real per capita household income in 2007 on a dummy on fishing, village dummies, and their interaction terms. Obtain the predicted shadow wage of non-fishing households which differs across villages.

$$\ln(y_{07,ivk}) = \alpha_0 + \alpha_1 F_{07,ivk} + \alpha_2 D_{vk} + \alpha_3 F_{07,ivk} D_{vk} + \varepsilon_{ivk}$$

$$\widehat{w}_{ivk} = \ln(\widehat{y_{07,ivk}}) | (F_{07,ivk} = 0)$$

- (2) Take the average of the predicted per capita income $\widehat{w}_{ivk}$ to obtain the average reservation wage at each village.

Table A.1 shows that the negative effects of *AGGSHOCK* on fishing in 2007 (robustness check for Table 5) remain to be robust when using any proxy variables and the imputed reservation wage. People living further away from Banda Aceh tended to be engaged in fishing, and they were likely to opt out from fishing if higher reservation wage was offered in the non-fishing sector. The main results in Table 7 and Table 9 are also shown to be robust.

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Table A.1: Robustness check using alternative outside option measures

VARIABLES	Non-owners			
	Fish in 07			
	(1)	(2)	(3)	(4)
Fraction of bad aid boats	-0.776*** (0.193)	-0.605*** (0.168)	-0.505*** (0.192)	-0.651*** (0.164)
D_bad house in 07	-0.212** (0.0891)	-0.166* (0.0924)	-0.134 (0.0980)	-0.162* (0.0967)
Boat owner and captain pre-tsunami	-0.0206 (0.110)	-0.0187 (0.111)	-0.0248 (0.111)	-0.0120 (0.108)
D_large boat pre-tsunami	0.0150 (0.111)	0.0870 (0.117)	0.0714 (0.109)	-0.0308 (0.0972)
Ln (number of aid projects in 07)	-0.661*** (0.186)			
Ln (total housing aid in 07)		-0.166** (0.0657)		
Ln (distance to BA)			0.311** (0.126)	
Imputed market shadow wage in 07				-0.158* (0.0945)
D_debt to Toke Bangku	0.189 (0.143)	0.105 (0.175)	0.149 (0.170)	0.208 (0.155)
High education pre-tsunami	-0.136 (0.0923)	-0.110 (0.0945)	-0.125 (0.0948)	-0.138 (0.0975)
Number of captains in 05	0.00665** (0.00270)	0.00471* (0.00270)	0.00292 (0.00268)	0.000176 (0.00223)
Observations	147	149	149	149
Sample		Original		
Seasonality is controlled	Y	Y	Y	Y
Regional fixed effects	Kec	Kec	Kec	Kec

*** p<0.01, ** p<0.05, * p<0.1; Estimates in column (1)-(4) are marginal effects of probit model. Robust standard errors clustered at the village level are in parentheses.

Appendix 3: Robustness check using endogenous switching regression

To confirm the empirical robustness, endogenous switching regression (Maddala, 1986) defined in Eq. (A.5) below is employed to examine the initial decision in 2007, which accounts for the self-selectivity between fishing ($j=F$) and non-fishing ($j=NF$). I use pre-tsunami social capital endowments (social relationship with middlemen called *Toke Bangku*) and the number of surviving captains after tsunami as instruments Z in the selection equation. Stronger social ties are likely to constrain the switching decision out of fishing but should be uncorrelated with the log of real per capita household income in each sector: $\ln(y_{07,j,ivk}) = \ln\left(\frac{I_{07,j,ivk}}{n_{07,j,ivk}}\right)$. In the main equation, X includes a similar set of covariates as in Eq. (1), but the regression could only control kabupaten fixed effects for this maximum likelihood procedure to converge.

$$\begin{aligned} \ln(y_{j,07,ivk}) &= \beta_{0j} + \beta_{1j}B_{vk} + \gamma_{1j}X_{ivk} + \gamma_{2j}W_{vk} + \mu_k + \varepsilon_{j,ivk} \quad , \quad j=F,NF \\ P(F_{07,ivk} = 1) &= \phi\{\delta_1[\ln(y_{F,07,ivk}) - \ln(y_{NF,07,ivk})] + \delta_2Z_{ivk} + u_{ivk}\} \quad (A.5) \end{aligned}$$

Similarly, endogenous switching model defined in Eq. (A.6) is applied to find robust estimates on the job switching and income growth between 2007 and 2009. I similarly use two pre-tsunami social capital endowments (households' economic relationship with middlemen and social relationship with neighbors through ROSCA called *Arisan group*) as instruments in the selection equation, and the main equation controls for the sampling heterogeneity between original and supplementary samples as well as kabupaten fixed effects.

$$\begin{aligned} \Delta \ln(y_{j,ivk}) &= \beta_{0j} + \beta_{1j}q_{ivk} + \beta_{2j}B_{vk} + \gamma_jX_{ivk} + \mathbb{I}[s_{orig} = 1] + \mu_k + \Delta\varepsilon_{j,ivk} \quad , \quad j=F,NF \\ P(F_{09,ivk} = 1|F_{07,ivk} = 1) &= \phi\{\delta_1[\Delta \ln(y_{F,ivk}) - \Delta \ln(y_{NF,ivk})] + \delta_2Z_{ivk} + u_{ivk}\} \quad (A.6) \end{aligned}$$

Empirical result:

Column (1) in Table A.2 confirms relatively large labor supply elasticity to income risks caused by the aggregate shock in the selection equation of Eq. (A.5). The estimates in the main equation shows that the impact of *AGGSHOCK* on the initial income gaps between two sectors in 2007 is statistically zero. The correlation coefficients $(\rho_{\varepsilon_F,u}, \rho_{\varepsilon_{NF},u})$ are not statistically significant, showing that the switching regression is close to exogenous.

Column (2) shows the estimates of Eq. (A.6). In the selection equation, my instrument on the affiliation with Arisan group are statistically valid and the correlation coefficients suggest that households which chose to work in the fishing sector experienced slower income growth which is consistent with my findings in Table 9. In the main equation, only *AGGSHOCK* significantly reduces the income growth for fishing sector, but the negative effect of *IDIOSHOCK* is not statistically significant. After explicitly controlling for the self-selectivity bias, the negative effect of *AGGSHOCK* is still robust and supports my OLS estimates in Table 9 that the aggregate quality shock had long-term negative impacts on income growth during the recovery stage.

References

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Table A.2: Robustness check using endogenous switching regression

VARIABLES	In 2007			From 2007 to 2009		
	(1)		Selection eq. Fish in 07	(2)		Selection eq. Fish in 09
	Main eq. y_F,07	Main eq. y_NF,07		Main eq. Δy_F	Main eq. Δy_{NF}	
AGGSHOCK	0.480 (0.503)	0.0468 (0.339)	-1.382*** (0.457)	-0.350* (0.189)	-0.218 (0.217)	0.0704 (0.183)
IDIOSHOCK				0.0319 (0.173)	-0.0484 (0.211)	-0.145 (0.196)
D_bad house in 07	0.0346 (0.283)	-0.170 (0.184)	-0.367 (0.293)			
D_bad house in 09				-0.0533 (0.143)	-0.113 (0.249)	0.250* (0.145)
Boat aid in 09				-0.397 (0.263)	-0.338 (0.300)	0.492* (0.253)
Boat owner and captain pre-tsunami	0.240 (0.212)	-0.119 (0.178)	-0.113 (0.260)	-0.151 (0.165)	0.0680 (0.199)	0.214 (0.188)
D_large boat pre-tsunami	0.221 (0.210)	-0.293* (0.176)	0.146 (0.264)			
Ln (number of NGOs in 07)	-0.127 (0.236)	0.213 (0.230)	-0.751*** (0.286)			
Fraction of fish population in 07				-0.806*** (0.244)	-0.838** (0.382)	0.151 (0.320)
Constant	10.66*** (0.570)	10.80*** (0.841)	1.727** (0.864)	0.490 (0.357)	-0.552 (0.746)	0.666 (0.490)
Instrumental variables						
D_debt to Toke Bangku pre-tsunami			0.564* (0.309)			
Number of captains in 05			0.0156** (0.00721)			
D_arisan group in 07						0.493** (0.223)
D_debt to Toke Bangku in 07						0.544 (0.398)
Correlation coefficients:						
ρ_F			0.667 (0.749)			-0.808*** (0.295)
ρ_{NF}			0.077 (0.443)			-0.052 (0.218)
Observations	148			357		
Sample	Original			Supplementary 1/		
Regional fixed effects	Y			Y		
Sampling heterogeneity is controlled	Y			Y 2/		

*** p<0.01, ** p<0.05, * p<0.1; All estimates are marginal effects of probit model. Robust standard errors clustered at the village level are in parentheses. The regression implements the maximum likelihood estimation using *movestay* command developed by Lokshin and Sajaia (2004).

1/ In column (2), the inverse probability of staying in the sample ("stayers") is used as a weight to account for attrition bias and sampling heterogeneity is controlled by including $1[s_{orig}=1]$.

AGGSHOCK=Fraction of bad aid boats

IDIOSHOCK=D_have a bad aid boat in 09

Appendix 4: Variable definitions

1. Quality shock variable:

Aggregate shock (AGGSHOCK)

- *Fraction of bad aid boats in 07*: Proportion of faulty boats from donors in the village by 2007, which is the number of faulty aid boats divided by the total number of aid boats in the village. (from the *Panglima Laot* survey in 2007)

Idiosyncratic shock (IDIOSHOCK)

- *D_have a bad aid boat in 07/09*: Dummy variable indicating whether a household received an aid boat which was discovered to be poor quality by 2007/09 or not. (from the household survey in 2007/2009)
- *D_bad house in 07/09*: Dummy variable indicating whether a household received a temporary or permanent house from donors which had at least one type of quality issues such as a leaky roof, cracked wall, poor foundation, or faulty plumbing by 2007/09 or not. The summary statistics in Table 1 also reports the fraction of households facing each type of housing quality problem for the supplementary sample. (from the household survey in 2007/2009)

2. Household characteristics:

- *Fish in 07/09*: Dummy variable indicating fishing as a primary job in 2007/09 or not. (from the household survey in 2007/2009)
- *Report catch in 07*: Dummy variable indicating any family members reported some amounts of fish outputs in 2007 or not. (from the household survey in 2007/2009)
- *Boat aid in 07/09*: Dummy variable indicating the receipt of a boat from donors by 2007/09 or not. (from the household survey in 2007/2009)
- *Buy in 07/09*: Dummy variable indicating the receipt of a boat by investing own money by 2007/09 or not. (from the household survey in 2007/2009)
- *Boat owner in 07/09*: Dummy variable indicating households owned a boat in 2007/09 or not. (from the household survey in 2007/2009)
- *Boat owner and captain pre-tsunami*: Dummy variable indicating pre-tsunami boat owner and captain or not. (from retrospective data in the 2005 household survey)
- *D_large boat pre-tsunami*: Dummy variable indicating the use of boat with above average boat length (9 meter) pre-tsunami or not. (from retrospective data in the 2005 and 2009 household surveys)
- *High education pre-tsunami*: Dummy variable indicating household heads' education level was above senior high school pre-tsunami or not. (from retrospective data in the 2005 household survey)
- *D_debt to Toke Bangku*: Dummy variable indicating household owed traditional debt to middlemen (*Toke Bangku*) and was still obliged to repay after the tsunami or not. (from retrospective data in the 2005 household survey)

- *High income in 07*: Dummy variable indicating household's weekly earning was more than Rp 500,000 (US \$50) in 2007 or not. (from the 2007 household survey)
- *Ln(boat length pre-tsunami)*: Log of the length of pre-tsunami boat (in meter, outliers above the 95 percentile are trimmed). (from retrospective data in the 2005 household survey)
- *Ln(engine capacity pre-tsunami)*: Log of the boat engine capacity pre-tsunami (in HP/PK, outliers above the 95 percentile are trimmed). (from retrospective data in the 2005 household survey)
- *Total fish catch/length pre-tsunami*: The total amount of fish (which is the sum of reported small fish and tuna catch excluding arthropods, in kilos, outliers above the 95 percentile are trimmed) before the tsunami divided by the length of the pre-tsunami boat (in meter). (from retrospective data in the 2005 household survey)
- *In-shore fishing skill*: Dummy variable indicating a household which was engaged in in-shore fishing (near shore or within lagoon) before the tsunami. (from retrospective data in the 2005 household survey)

3. Village characteristics:

- *Number of NGOs in 07*: Total number of aid agencies which were operating in the village in 2007. (from RAN dataset)
- *Number of aid projects in 07*: Total number of aid projects in the village in 2007. (from RAN dataset)
- *Total housing aid in 07*: Total number of temporary and permanent houses constructed by 2007. (from the 2007 village head survey)
- *Number of boat aid in 07*: Total number of boats received from donors by 2007. (from the *Panglima Laot* survey in 2007)
- *Number of captains in 05*: Number of surviving fishermen working as a boat captain in the village right after the tsunami in 2005. (from the 2005 village head survey)
- *D_Banda Aceh/D_Aceh Jaya*: Dummy variable indicating households living in Banda Aceh/Aceh Jaya or not.
- *Fraction of fishing population in 07*: The fraction of village workers in the fishing sector in 2007. (from the 2007 village head survey)
- *Credit union in village in 07*: Dummy variable indicating the existence of credit unions in the village in 2007 or not. (from the 2007 village head survey)