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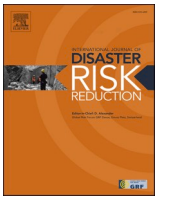

Business recovery in Aceh and North Sumatra following the Indian Ocean Tsunami

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ABSTRACT

This paper looks at patterns in business recovery two years after the 2004 Indian Ocean tsunami using longitudinal household survey data for Aceh and North Sumatra gathered 5–14 months and 17–28 months after the event. The base sample contains 2879 households. Applying a weighted probit model that controls for pre-tsunami characteristics the paper finds that the probability of households discontinuing businesses two years after the event increases significantly by 9.6% points in heavy damage areas compared to no/light damage areas. The paper argues that the differences in business recovery may be due to differences in asset recovery patterns. The tsunami wiped out 2/3rd the value of business assets in heavy damage areas and two years later, stocks were still at only half the pre-tsunami values. For these areas business asset growth was significantly correlated with continuity. Higher business discontinuity in heavy damage areas may also be due to higher losses to family and financial support networks experienced by households in these areas with a third of those that discontinued being in temporary accommodation for 6 months or longer. Increased aid and cash-for-work initiatives are unlikely to have been a disincentive to business continuation. The results suggest that given sufficient reconstruction of public infrastructure, asset recovery through livelihood interventions and formal financial market mechanisms is central to business continuity. It also suggests a closer investigation of households that have been displaced for a longer period as the support they require maybe systematically different to support required by other households.

1. Introduction

One of the most destructive tsunamis in recent times, the Indian Ocean tsunami, resulted from an undersea megathrust earthquake on Sunday December 26, 2004 that registered a magnitude of 9.1–9.3Mw occurring at 07:58:53 in local time (UTC+7), with an epicentre off the west coast of Northern Sumatra, Indonesia. The earthquake created a series of massive tsunami waves that exceeded 25 m as it headed inland [1]. It reached Aceh and North Sumatra around 20 min after the earthquake, devastating communities along 800 km of coastline [2]. Banda Aceh, the closest major city was one of the worst affected. Around 168,000 people were recorded as having perished or missing in Indonesia while over 500,000 were displaced. The total estimate of damage and losses for Indonesia alone was US$4.45 billion–equivalent to about 80% of Aceh's regional gross domestic product.

The disaster was followed by unprecedented aid and financial flows. Along with the Government's substantial assistance program the international community pledged assistance for reconstruction and development totalling US$7.7 billion. By the end of 2007, projects and programs worth US$6.4 billion had been allocated by 463 organizations, 65% of which had been disbursed [3]. Early

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recovery efforts included 'cash-for-work' programs and development of small-scale infrastructure projects [4,5]. Soon, however, livelihood assistance programs became ubiquitous and around 12% of all tsunami relief by September 2007 went towards rehabilitating and developing small and medium-scale enterprises, agriculture, and livestock. This included microfinance programmes and access to other forms of cheap credit [6,7].

Although there is some empirical micro-level evidence on the impact of Indonesian tsunami on mortality, fertility, health, and displacement [8,43,44], little is known about its impacts on household business assets and business recovery in the short and medium term. This trend matches the evidence in general about natural hazards and their impacts. It has been well noted that natural hazards cause high death tolls and severe damage particularly among poorer households in low income countries [9,10]. There is also increasing evidence on the impacts of disasters on household welfare outcomes including poverty, consumption, and labour market earnings [32,45,46]. But evidence on its impacts on household business assets and business recovery is sparse.

Conventional wisdom seems to suggest that the economy recovers quickly [11] and qualitative evidence suggests that some types of household-level enterprises can be resilient in the face of disaster [12]. There is also some evidence for Indonesia that in the longer term, 6–12 years after an earthquake, stocks of productive assets increase, particularly in farms [13]. Business recovery, however, may not be uniform or speedy [14–16] and can depend heavily on access to insurance [17,18]. In developing countries where credit markets are weak and insurance is almost non-existent for small businesses, enterprise recovery can depend heavily on access to capital as seen in the context of Sri Lanka after the 2004 tsunami [40,41]. Even if there is a large, unprecedented influx of aid following an extreme event such as the 2004 Indian Ocean tsunami, there can be several factors that can limit aid efficacy with respect to supporting business recovery. For example, boat aid to support fishing-based livelihoods in Aceh, Indonesia was found to be extremely heterogeneous in terms of quality. Moreover, the politics of distribution of such equipment often meant that poorer households also received poor quality boats [19]. This suggests that asset and enterprise recovery is not necessarily homogenous or fast, even in the presence of massive inflows of aid. Moreover, the presence of aid can be a disincentive to continue with previous livelihoods as was the case in China following the Wenchuan earthquake in 2008 [20].

The aim of this research is to investigate the effect the tsunami had on household business recovery in the medium term, using household longitudinal household survey data popular in microeconomic applications. The data come from two waves of the STAR longitudinal survey carried out 5–14 and 17–29 months after the tsunami. Longitudinal data is particularly suited for this investigation due to the rigour with which specific impacts can be isolated and its ability to capture dynamics in how outcomes change. The specific objectives are as follows. How did asset accumulation and business recovery transpire in the medium term, around two years after the event? To what extent did employment opportunities, business borrowing, and displacement affect business continuity? Was the presence of aid a disincentive to continue with household business activities?

The results of the paper are important to build the evidence base around tsunamis and their impact on business assets and livelihoods in short and medium term to inform disaster mitigation, aid, and its targeting. Better post-disaster policy can have significant permanent improvements in household welfare [21]. The work also contributes to the literature that looks beyond the immediate effects of a disaster by focussing on outcomes in the medium term, two years later. Previous work such as [22] looked at the impact floods in Pakistan had on asset recovery a year after the event while [13] looked at longer term effects of an earthquake in Indonesia on assets and other outcomes. Finally, empirical evidence is important to quantify vulnerability through catastrophe modelling using household survey data as attempted in seminal study [47]. Catastrophe modelling helps understand the risks and damage arising from disasters and can be used to estimate the amount of financial reserves required in the event of a disaster. The modelling process involves simulating synthetic events, merging this with geospatial exposure and a vulnerability module that links damage with hazard intensity. Better understanding of damage to household level business assets in the short term and the medium term and the linking of this to tsunami intensity can help support this nascent field of holistic catastrophe modelling based on innovative vulnerability functions. The catastrophe modelling efforts can also accommodate features unique to the post-2004 tsunami context, such as the massive influx of aid, allowing stakeholders prepare better to support livelihood recovery following a disaster.

2. Conceptual framework

This section sets out a simple framework outlining the effects a hazard such as a tsunami can have on business continuity in the medium term. It draws on approaches from development economics that focus on household businesses and coping mechanisms for covariant risks (i.e., those that affect entire groups such as natural hazards rather than individuals such as accidents), in contexts where formal insurance and credit markets are weak or non-existent [23–26].

A destructive hazard such as a tsunami or earthquake is assumed to be a rapid onset event, which has an immediate effect that wears off fairly quickly compared to slow onset events such as droughts [27]. Business owners and workers cannot predict the event and therefore cannot expand or contract or change asset investments beforehand in order to reduce adjustment costs once the disaster strikes. Thus, business inputs such as labour, physical capital and land, as well as supply chains, production, sales, and markets, are all directly and immediately affected by a tsunami. In the case of an area such as Aceh, one of the poorest areas in Indonesia at the time of the tsunami [39], household businesses are likely to have been family-owned, relying heavily on family and friends for labour inputs and financial support. Thus, the death, illness and injury of family and friends would have reduced the speed of business recovery. Monetary and physical capital also has an important role in business survival [40,41]. Following the destruction of assets, if any of the remaining assets were sold to smooth household income fall in the absence of insurance or formal welfare support, then this would have affected business recovery, and the size of business. In theory, livelihood support in terms of equipment or physical capital can support business survival but these items may be sold in secondary markets or been of poor quality having little impact on business recovery. Of course, if the aftermath of the disaster attracted large amounts of aid and opened up opportunities for employment in the

post-disaster construction industry or cash-for-work schemes, this would have reduced a household's need to sell assets for income smoothing, and supported instead, asset accumulation. But asset accumulation on its own would not have been sufficient if labour and capital are complements, and there were labour shortages. Moreover, there can be several factors that can limit aid efficacy with respect to supporting business recovery. This includes the quality of the in-kind physical assets provided as aid, inequitable distribution that does not favour the most affected, the lack of complementary pre-requisites such as training, access to markets, raw material, or poorly timed aid that does not consider local contexts (e.g., seed rice supplied after the planting season). Finally, both aid and opportunities to work could be a disincentive to recover businesses especially if these avenues bring in a secure income sooner than do activities such as farming. This is especially so if the disaster resulted in changes to risk perception [28] and thus caused behavioural changes that affected a household's willingness to continue with a business.

The speed and extent to which destroyed public infrastructure such as roads, ports and bridges are rebuilt is also pivotal to the recovery of disrupted supply chains, markets, forward and backward linkages, as well as business continuity. Similarly, access to public services such as hospitals and post offices as well as the effectiveness of rehousing those who are in temporary shelters matter to the speed and extent of business recovery. In the case of Aceh and North Sumatra, the tsunami also marked the end of the 29-year insurgency between the Indonesian Military and the Free Aceh Movement (GAM) with the signing of a peace accord in August 2005 encouraging business activity and entrepreneurship as it eased the difficult conditions due to the conflict, particularly in areas more interior. Thus, business recovery and its speed in the medium term is the combined effect of many factors and it remains an empirical question as to how it transpired in the local context of Aceh and North Sumatra and what factors explained survival.

3. Data and descriptive statistics

3.1. Data

The data for this paper come from the first and second rounds of the Study of the Tsunami Aftermath and Recovery (STAR), a collaborative project involving investigators at Duke University, the University of North Carolina at Chapel Hill, SurveyMETER.[1] The data are gathered from respondents living in the west and east coast of Aceh, and North Sumatra (including the islands of Pulau Weh, Simuelue, and Nias) provinces, across 13 *kabupaten* (i.e., regencies with their own local governments and parliamentary bodies that are a subdivision of provinces). The areas cover those directly affected by the tsunami as well as areas not directly affected (that tended to be a bit more interior) to serve as comparison groups for affected population. Round 1 data (STAR1) were collected 5–14 months after the event and around 50% of the households in the survey report to have owned business assets and engaged in farming and/or non-farming business activity just before the tsunami. Round 2 data (STAR2) were collected from the same households 17–29 months after the tsunami. The core estimations for this paper are based on 2879 households interviewed in both rounds that report to have had business assets prior to the tsunami and have full information required for the analysis herein. Pre-tsunami characteristics are inferred from the retrospective questions asked from households.

The original frame for the STAR survey was the large cross-sectional population-representative 2004 National Socioeconomic survey (SUSENAS) collected by Statistics Indonesia. Thus, the households in the STAR surveys were first enumerated before the tsunami, in February/March 2004. However, these pre-tsunami data (STAR0) are not available to us due to Indonesian data protection laws. Moreover, no geographic identifiers are available apart from province. Across all survey rounds at least one interview was obtained for over 95% of target respondents. Some households identified in STAR0 who were not contactable in STAR1, were added onto STAR2. These households have not been included in our sample as pre-tsunami data on profits, business type etc., were not available for these 'new' households. The survey gathers information at the individual, household and community levels on income, consumption, livelihoods, health, education, and other aspects, following the same households overtime. The enumerators interview individual households and its members based on pre-prepared piloted survey instruments over several days or even weeks, revisiting sites when needed. The primary respondent for household surveys is usually the household head. The reliability of the data is supported by having low survey attrition across rounds of less than 5% as well as using techniques to reduce the incidence of missing data. Such techniques include the use of brackets when respondents do not provide point-based answers questions requiring monetary values as responses (e.g., incomes, profits) and the use of different instruments to elicit responses for the same question (e.g., earnings explored in the household questionnaire as well as individual questionnaire). To support validity, several modules such as the asset, consumption and health modules use components standardized across other household surveys including the Indonesia Family Life Survey. Some instruments are repeated in both rounds. We use this feature to check for robustness of results later in this paper.

The intensity of the tsunami varied depending on distance to coast, topography, and wave strength and type [29,30]. Coastal locations often experienced higher damage while those in more interior mountainous regions experienced less damage. The STAR team classified the intensity of damage as heavy, moderate, or light/no damage based on data from multiple data sources including satellite imagery and Global Positioning System (GPS) measurements. For example, 'One measure was constructed by comparing satellite imagery from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) for December 17, 2004 to imagery for December 29, 2004 (nine days before and three days after the tsunami). The proportion of land cover that changed to bare earth between image dates (through scouring or sediment deposition) was manually assessed for a 0.6 km^2 area centered on each GPS point. This measure was cross-validated with other estimates of damage derived from remotely-sensed imagery that were prepared by the USGS, USAID, the Dartmouth Flood Observatory, and the German Aerospace Center' [8]. Damage classification also verified using field-level data gathered from local community leaders regarding the extent of destruction to the natural and built environment as well as STAR1

[1] The data is publicly available free of charge upon request from the conveners of the project via the STAR website http://stardata.org.

survey supervisor's direct observations.

3.2. Descriptive statistics

Roughly 20% of the households with pre-tsunami business assets were located in areas classified as experiencing heavy damage although only 78% of these households report that there was major loss (i.e., financial loss, death of household member, major injury or relocation due to tsunami). Around 59% of households are in medium damage areas of which 34% experienced some form of major loss. Even among the 20% households in areas of no damage or light damage, around 13% record some from or major loss.

Were the households located in areas that experienced more damage significantly different to those in other areas? We investigate this using several pre-tsunami household characteristics such as the status of the household in terms of engaging in business activity (rice farming or other farm-related business, non-farm business or no business[2]), household wealth[3] and household rural/urban location. We also look at the extent to which households engaged in multiple businesses by constructing a business diversity index. The index equals 0 if the household did not engage in business activity prior to the tsunami, despite having business assets. It equals 1 if it engaged in one of rice farming, other farming or non-farm business, 2 if it engaged in two of these business types and 3 if it engaged in all three businesses. As Table 1 shows, there are only a few statistically significant differences in pre-tsunami characteristics between moderate and no/light damage areas. The key difference is that 47.3% of households in moderate damage areas engaged in other farm business compared to 33.8% in no/light damage areas. However, households in heavy damage areas were significantly different to those located in no/light damage areas at the time of the tsunami, being wealthier and located more in urban areas. Moreover, the value of total pre-tsunami business assets per household in heavy damage areas was more than double that of no/light damage areas at Rupiah 48.4 million versus 23.67 million in 2007 prices, winsorised at 1st and 99 percentiles. The corresponding value for business assets per household in moderate damage areas was Rupiah 16.8 million. This suggests larger businesses in heavy damage areas compared to other areas. Heavy damage areas also had a lower proportion of households engaging in rice farming (39.1 versus 45.8%) and higher proportion of households engaging in other-farming (48.3 versus 33.8) or non-farm-based business (54.1 versus 42.6). There was also more diversity in terms of households conducting multiple types of business with the diversity index of 1.41 in heavy damage areas being significantly different to 1.22 in no/light damage areas. This increase in diversity was possibly due to due 14% more households in heavy damage areas being in urban locations rather than rural locations compared to households in no/light damage areas, allowing them to have non-farm businesses such as shops as well as small livestock such as chicken or goats. Thus 32% of households in heavy damage areas conducted at least two of rice farming, other farming or non-farming business compared 22% in no/light damage areas or 25% in moderate damage areas.

In terms of business asset composition before the tsunami, around 36% of the households owned some type of machinery and equipment including fishing boats, nets, and gear, 21% owned buildings and vehicles, and land ownership was around 34%. The tsunami caused damage and losses across all categories of assets. This was particularly the case for heavy damage areas that saw two thirds of the value of its business assets being wiped out due to loss, damage or sale in the immediate aftermath of the tsunami.[4]

Even two years after the tsunami, there were significant variations in business recovery patterns between households that were in heavy and non-heavy damage areas at the time of the tsunami. As seen in Fig. 1 the proportion of farm and non-farm businesses in operation in no/light and medium damage areas increased over the two years since the tsunami compared to pre-tsunami proportions while businesses that discontinued fell.

Business diversity increased in these areas with households having two or more businesses rising from 24.9% before the tsunami to 37.9% two years later. Correspondingly the business diversity index improved from 1.2 to 1.4. In contrast heavy damage areas saw a fall in farm-based businesses and a slight increase in non-farm based business. It is likely that soil and water salination influenced households to switch from rice-farming to non-farm businesses. The business diversity index fell from 1.4 pre-tsunami to 1.19 two years later, with the number of households conducting two or more businesses falling by 14 percentage points to 21.5 in 2006. There was also an increase in households not continuing with any business two years later in heavy damage areas, with 10% reporting no activity.[5]

Could the unprecedented aid flows and transfers following the tsunami have provided a disincentive to continue with business in heavy damage areas? Matching patterns in aggregate trends, households in our sample indicate receiving significant income transfers and assistance in the immediate aftermath of the tsunami with 87% of the households in heavy damage areas and 69% of households in other areas receiving non-work related income from government or Non-Governmental Organizations (NGOs), as pensions, scholarships, insurance claims and from family and friends. Of these income transfers, those from the government and NGOs were the highest,

[2] This information is only available in the STAR1 survey.

[3] Pre-tsunami household wealth is measured using the wealth index ranging from 0 to 1. To construct the index, the list of common assets (such as house, land, livestock, vehicles, furniture, appliances, gold, cash, etc.) that household j owned before the tsunami according the STAR2 is counted, regardless of its monetary value, and converted into an index as follows: $\frac{\sum \text{assets}_j - \text{assets\_min}}{\text{assets\_max} - \text{assets\_min}}$ where assets_min to assets_max is the range of these items in the dataset.

[4] The changes are calculated as the difference between total asset value for an area of damage pre-tsunami (baseline) and post-tsunami values as a proportion of the pre-tsunami value. The value of pre-tsunami assets in 2004 comprised the total value of business assets held by a household before the tsunami. The value of post-tsunami business assets in the immediate months following the disaster (the short-term) are computed as the value of pre-tsunami assets minus the value of assets lost, damaged or sold after tsunami. It is important to include the value of assets sold since the tsunami, as the sale of raw material and assets offer an important coping mechanism after natural disasters especially in cases where credit access or insurance mechanisms are weak [10].

[5] Business discontinuity in the overall sample was 3%, with 70% coming from heavy damage areas. All households that discontinued a business reported to have actively engaged in business activity pre-tsunami. The sample also contained 5% of households that had business assets pre-tsunami but no active business. All these households reported to have started a new business two years after the event.

Table 1
Mean pre-tsunami household characteristics.

	Location of household according to damage experienced in the wider area			p-value of *t*-test of equality of means between (1) and (2)	p-value of *t*-test of equality of means between (1) and (3)
	No/light (1)	Medium (2)	Heavy (3)		
Type of household business (%)					
rice farming	45.8	39.1	39.1	.004	.018
other farming	33.8	47.3	48.3	.000	.000
non-farm business	42.6	40.0	54.1	.250	.000
no business	6.4	4.9	5	.150	.302
Wealth index	.479	.477	.606	.805	.000
Rural (%)	82.1	82.9	68.5	.679	.000
Business diversity index	1.222	1.264	1.415	.146	.000
Number of households	598	1697	584		

All households in this sample reported to have some positive value of business assets prior to the tsunami. Data taken from the STAR wave 2 survey. Standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.10.

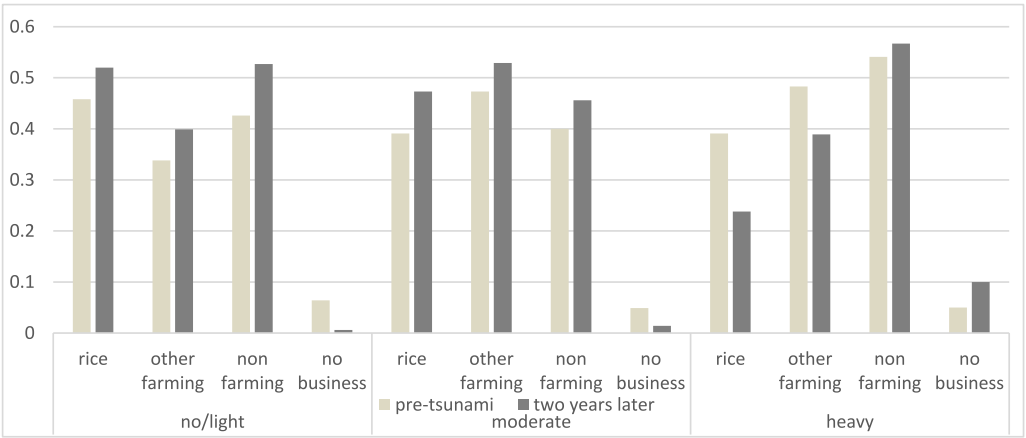

Fig. 1. Proportion of households with businesses in operation pre-tsunami and two years after the tsunami
Note: The proportions are calculated for each area of damage (i.e., no/light, moderate and heavy) separately. The proportions in a particular area do not add up to 1 as some households conducted more than one type of business (for example, rice farming as well as other farming). The sample contains only households that reported to have business assets before the tsunami.

comprising 2/3rd of all non-work income transfers. The income from formal insurance was 0% and informal 'arisans' about 5%. The transfers received by households in heavy damage areas were about four times as high as those received by households in other areas. But two years after the event, fewer households (i.e., 68.3%) in heavy damage areas received such transfers compared to the previous year, as seen in Table 2. Moreover, 9.3% more households in moderate damage areas received transfers in 2006 than those in heavy damaged areas. This suggests misallocations in aid and assistance and/or delays in supporting households located in moderately damaged areas due to prioritising households that were in more heavily damaged areas. However, in terms of the average value of such transfers per capita, the receipts of heavy damage areas remained significantly higher than those for other areas.[6] The table also shows that transfers did not compensate fully for the loss in income due to the tsunami. For example, heavy damage areas received on average Rupiah 183,000 monthly per capita whereas the loss in pre-transfer monthly income per capita was Rupiah 553,000. Households in all areas saw a fall in average monthly per capita employment income between 2004 and 2006 with the highest fall of 44% in heavy damaged areas. Other areas saw a fall of around 25%. There was also a 7.9% point fall in the number of households receiving employment income, in those households located in heavy damage areas at the time of the tsunami. Moreover, in the two years after the tsunami significantly more households in non-heavy damaged areas engaged in employment compared to members of households

[6] The effects of inflation are accounted for in monetary values used in this paper as they are expressed in real terms, as they are converted to 2007 prices before computing changes. All monetary values are first converted to 2007 Indonesia Rupiah values adjusted for spatial variations in price. The deflators used for this come from province-specific price indices reported by Indonesia Statistics (BPS or Badan Pusat Statistik) for 66 cities in Indonesia from 2000 to 2012 and the simple average of BPS cities Banda Aceh and Lhokseumawe are used to reflect price indices for the geographic area enumerated in the STAR survey In monetary terms, the damage to business assets due to the tsunami was Rupiah 2.61×10^7 in heavy damage areas, Rupiah 0.3×10^7 in moderate damage areas and Rupiah 0.2×10^7 in no/light damage areas, in 2007 prices. All the variables indicating change are winsorised at the 1st and 99th percentiles to eliminate outliers.

Table 2
Average monthly income per household member disaggregated by income type, and its coverage.

	No/light damage				Moderate				Heavy			
	2004	2006/7	Δ	%Δ	2004	2006/7	Δ	%Δ	2004	2006/7	Δ	%Δ
Pre-transfer	514	426	−88	−17.1	504	412	−92	−18.2	1118	565	−553	−49.4
income p.c	(958)	(1269)			(1273)	(1356)			(2411)	(1075)		
Transfers p.c	13	30	17	131	19	63	44	231	23	206	183	791
	(56)	(77)			(131)	(306)			(87)	(562)		
% receiving Transfers	24.9	75.7	50.8		33.3	77.6	44.1		32.1	68.3	36.2	
Employment	342	259	−83	−24.2	314	234	−80	−25.4	669	373	−296	−44.2
income p.c	(635)	(673)			(837)	(399)			(1271)	(601)		
% receiving emp. income	93.6	92.6	−1		96.4	95.6	−0.8		97.1	89.2	−7.9	
Business	172	167	−5	−18.6	189	178	−11	−20.9	448	191	−257	−57.3
Profit/loss p.c	(409)	(617)			(621)	(1164)			(1517)	(538)		
% receiving profit/loss	90.1	91.3	1.2		90.6	90.9	0.3		91.6	81.5	−10.1	
Business	120	143	23	19.2	87	30	−57	−65.5	175	91	−85	−48.5
borrowing	(1195)	(1170)			(738)	(313)			(1459)	(604)		
% borrowing	5.3	8.2	2.9		8.2	5.7	−2.5		9.7	7.0	−2.7	
No. of households		598				1697				584		

Notes: All monetary values expressed in Indonesian Rupiah, thousands, 2007 prices. Standard deviations in brackets.
Δ refers to the change.

in heavy damage areas. Average profits per capita also saw the largest fall in heavy damage areas of 57.3% compared to 20.9% and 18.6% in moderate and no/light damage areas. In terms of business borrowing, however, no/light damage areas saw an increase of 19.2% between 2004 and 2006 while other areas saw a sharp fall ranging between 48 and 66%. In summary, although heavy and moderate damage areas continued to receive substantial transfers in 2006, households did not reach pre-tsunami levels of pre-transfer income. Thus, it is unlikely that the higher transfers following the tsunami to areas of heavy damage was a disincentive to work or pursue a business or work.

The discussion in this section was based on descriptive evidence. In the next section we outline the empirically methodology to look at the relationship between the tsunami and various household level outcomes more formally, controlling for observable confounding factors that may have affected outcomes.

4. Empirical methodology

4.1. The effect of the tsunami on business continuity 2 years later

The following model is estimated using the probit estimator to ascertain to what extent tsunami intensity and household characteristics may have influenced businesses to continue/change direction or halt completely, post-tsunami. The time period immediately before the tsunami is denoted by t = 0, the time period two years after the tsunami is denoted by t = 1.

$$y_{j1} = \alpha + \beta H_j + \gamma M_j + \delta X_{j0} + \varepsilon_{j1} \quad (1)$$

for households j = 1…N where.

y_{j1} equals 1 if the household discontinued business 18–29 months after the tsunami and 0 otherwise (i.e., continued with the same business or changed to a different business).

H_j and M_j are measures of tsunami intensity, with H = 1 if the household was in a heavy damage area at the time of the tsunami and 0 otherwise. M = 1 if the household was in a moderate damage area at the time of the tsunami and 0 otherwise.

X_{j0} is a vector of pre-tsunami household characteristics which includes a categorical variable indicating the type of business operated by family (rice and other types of farming, non-farm business or no business activity), rural residence and household wealth index. Unfortunately, no further geographic locators or household characteristics are available due to data limitations. ε_{j1} is the error term. Although the tsunami intensity measure 'heavy' and 'moderate' is a direct measure of the damage caused by the tsunami it carries with it two disadvantages. First, it is measured for an area of 0.6km^2 and not at the household level. Thus, it doesn't capture the variation in damage experienced by households within this area. For example, 22% of the households in heavy damaged areas reported to not have suffered major loss but the measure 'heavy' categorises these households together with rest of the 78% per cent who have. Secondly the extent of damage experienced maybe correlated with unobserved determinants of business continuity through asset quality. For example, if asset quality is higher in wealthy, urban areas (thus causing lower levels of destruction for a given tsunami intensity), and these areas have higher business continuity, then we would falsely conclude that the effect of the tsunami on business continuity is less severe than the true effect. This would result in β being an underestimate for heavy damage areas.[7] The bias could also be in the opposite direction. If asset quality in wealthy, urban areas are such that they are more perishable or susceptible to water damage (e.g., office equipment, stationary) or more fragile (e.g., buildings with glass façade or windows, display units), and unobservable asset quality is important to business continuity, then β would overestimate the effect of the tsunami on business continuity.

[7] α, β, γ and δ are parameters estimated by the regression model.

Controlling for pre-tsunami household characteristics addresses this issue to some extent but we acknowledge that our estimates have limitations. A procedure such as instrumental variable estimation may address this issue provided that a suitable instrument can be found. Unfortunately, we cannot find a strong instrument that is both reliable and valid in this case.

Since some of the pre-tsunami characteristics in Table 1 were not balanced a propensity score is estimated using baseline type of business operated by family (rice and other types of farming, non-farm business or no business activity), household wealth and rural residence as matching variables, and then weighting observations inversely proportional to their propensity score [31,32]. The rationale for weighting is that samples receiving the different treatments may differ in their distributions of pre-treatment variables and, therefore, possibly differ in terms of their observed outcomes in ways that are not attributable to the treatment. If all the variables with pre-treatment differences are observed and groups have at least some members with similar covariates (i.e., the conditions of conditional independence and overlap hold), then in principle, a treatment sample can be reweighted to make the distribution of covariates match that of any of the other treatment groups [33,34]. The identifying assumption in the model is that $E(\varepsilon_{j1}|D_j, X_{j0}) = 0$, so that tsunami destruction, household business activity, wealth status and rural residence in 2004 are not correlated with unobservables determining changes to the outcome variable. Identification relies on the exogenous nature of the tsunami.[8]

4.2. The effect of the tsunami on incomes, transfers, earnings, profits and borrowing

To understand the effect of the tsunami on various household level outcomes such as pre-transfer incomes, transfers, employment earnings, profits/losses and business borrowing the following model is estimated

$$\Delta z_{j1} = \theta + \rho H_j + \tau M_j + \pi X_{j0} + u_{j1} \quad (2)$$

where Δz is change in outcome variable of interest (pre-transfer incomes, transfers, employment earnings, profits/losses and business borrowing) between 2004 and 2006 for household j in terms of 1000 Rupiah in 2007 prices. Apart from borrowing, all the other variables are monthly per capita values. Business borrowing is in monthly terms but not per capita. As before H_j and M_j are measures of tsunami intensity reflecting if the household was in a heavy or moderately damaged area at the time of the tsunami, respectively, while X_{j0}, the vector of pre-tsunami household characteristics, comprising of the pre-tsunami household wealth index, rural residence and business type. u_{j1} is the random error term. The model is estimated using the Ordinary Least Squares estimator and observations are weighted inversely proportional to their propensity score, as discussed in the previous sub-section. θ, ρ, τ and π are parameters estimated by the regression model.

5. Results

5.1. The effect of the tsunami on business continuity and other household outcomes two years after the event

The average marginal effects based on probit estimation results for the impact of the tsunami on the discontinuity of household level business activity 2 years after the event are presented in Table 3, column 1. It shows that the probability of discontinuing a business increases by 9.6% points in heavy damage areas compared to no/light damage areas. The regression is estimated again for those households that were less affected by displacement following the tsunami, i.e., by excluding those that are currently in temporary or makeshift accommodation as well as those households that were in temporary accommodation for 6 months or more since the tsunami. The results in column 2 show that the probabilities of discontinuing a business in heavy damage areas are now lower at 7.4% points. We also re-estimated this regression replacing the dependent variable with the change to business diversity between 2004 and 2006, and using a weighted Ordinary Least Squares estimator. The results (unreported) showed that being in a heavy damage area at the time of the tsunami reduced significantly business diversity two years later with the diversity index falling by −0.34 compared to no/light damage areas. The change in business diversity in moderately damaged areas was not significantly different to that of no/light damage areas.

Next, we look at the impact of the tsunami on pre-transfer income, transfers, employment income, business profit/loss and business borrowing. Table 4 column 1 shows that households with a business in heavy damage areas at the time of the tsunami correlated with a significant fall of Rupiah 205,600 of pre-transfer income two years after the tsunami compared to pre-tsunami values. The earnings of these households through employment and through business profits/losses are also significantly lower two years after the tsunami compared to pre-tsunami values. Business borrowing, however, does not indicate significant changes due to the tsunami. In terms of income transfers from government, NGOs and family/friends, households in heavy damage areas saw an increases transfers by Rupiah 108,700 and medium damage Rupiah 19,900 on average compared to households in no/little damage areas at the time of the tsunami. Other results in the table indicate that households that were wealthier before the tsunami saw a lower fall in pre-transfer income per capita, employment earnings, profits and business borrowing. They also benefited from higher transfers.

5.2. Robustness checks

In order to check the robustness of results I utilise a special feature in the STAR dataset where the some of the same questions are repeated in both rounds allowing for checking validity of responses. Information on pre-tsunami business assets, the value of assets lost, damaged and sold, for example, was gathered from respondents in STAR1 and STAR2, and the analysis so far used households that

[8] The tsunami was not anticipated as the coast of mainland Aceh had not experienced a major tsunami in the past 600 years. This means a vast majority of the population did not interpret the retreating ocean immediately prior to the waves engulfing the coastline as a sign of danger [36].

Table 3
Impact of tsunami on business continuity. Weighted probit estimations with average marginal effects reported. Dependent variable: discontinued business = 1, 0 otherwise.

	Full sample	Restricted sample excluding households that had been in temporary accommodation for 6 months or more since the tsunami
Heavy	0.096*** (0.022)	0.074***(0.021)
moderate	0.019 (0.012)	0.009 (0.009)
Wealth	0.016 (0.017)	−0.010 (0.016)
Rural	−0.006 (0.008)	−0.005 (0.007)
Observations	2.879	2572

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

Table 4
Impact of tsunami on pre-transfer income, transfers, employment income, business profit/loss and borrowing two years after the event.

	Δpre-transfer income p.c.	Δtransfers p.c.	Δemployment earnings p.c.	Δ profit/loss p.c.	Δbusiness borrowing
	(1)	(2)	(3)	(4)	(5)
Heavy	−205.6*** (55.8)	108.7*** (17.1)	−80.6** (32.5)	−114.9*** (28.7)	−12.1 (23.0)
Medium	4.5 (32.9)	19.9*** (6.2)	22.5 (20.5)	−11.9 (15.6)	−35.6* (18.4)
Wealth index	−372.5*** (109.6)	155.6*** (33.3)	−242.7*** (62.3)	−103.1* (55.4)	−131.6*** (50.0)
Rural	−2.7 (67.0)	10.5 (13.3)	−4.4 (38.3)	−0.6 (33.3)	95.8*** (31.0)
Farm rice	71.4* (39.9)	53.7*** (16.0)	54.3** (23.3)	11.0 (20.9)	−7.5 (15.5)
Farm other	−56.8 (37.8)	58.0*** (13.8)	−2.1 (23.0)	−59.9*** (20.4)	8.5 (17.5)
Nonfarm	−275.4*** (42.6)	20.7 (15.8)	−97.6*** (26.3)	−166.2*** (23.0)	−18.8 (18.7)
Constant	173.9** (80.3)	−118.8*** (27.0)	48.2 (47.3)	116.2*** (41.0)	−15.0 (34.4)
Observations	2879	2879	2879	2879	2879

Notes: Changes are in terms of Indonesia Rupiah, 2007 prices. Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

reported to have business assets before the tsunami when they were asked about it in the second round of data collection (i.e., STAR2). The business asset modules of both STAR1 and STAR2 first ask respondents about value of assets at the time of the tsunami, followed by loss and damage to the assets due to the tsunami, sales since the tsunami and value of assets at the time of the interview. It was assumed that relative 'before-after' values are more comparable when taken from the same survey.[9] As a check of robustness, an alternative sample of 3495 households is constructed based on households that reported to have business assets pre-tsunami at the time of the first round of data collected (i.e., STAR1). Household responses to pre-tsunami asset holdings, losses and damages were not always the same in the two rounds. For example, when asked the question 'Did this household own any business assets just before the tsunami?', 3495 households reported 'yes' in round 1. However, when the same question was repeated in round 2, only 82% of the 3495, responded 'yes'. Of the 3495 households around 13% per cent do not report asset values and profits/losses for 2006/7. Assuming these households discontinued business post-tsunami gives the result that 22% of households in heavy damage areas discontinued business 2 years after the tsunami and 10% from other areas. Moreover, average value of pre-tsunami assets reported in STAR2 is about 20% higher than the value reported in STAR1. Average losses to assets reported in STAR2 are twice as high those reported in STAR1. Finally, around 1000 households that reported not to own any business assets before the tsunami in STAR1 report to have had assets in STAR2. This group of households could not be included in the baseline analysis or robustness checks due to other relevant pre-tsunami characteristics such as business type, profits and transfer earnings that are important for the regression analysis are not repeated in STAR2. Despite the differences in individual responses to asset values on the same question repeated in both rounds, the average impacts estimated in the baseline regressions and robustness checks remain consistent in many respects. For example, we re-estimate specification 1 based on the new sample (with the pre-tsunami household wealth index constructed using STAR1) to find that in heavy damage areas the average marginal effect on the probability of discontinuing a business increases by 10.7% points for the full sample, reported in Appendix Table A1, column 1. This is similar to the base result of 9.4. However, the robustness results do not support the idea that households in temporary accommodation for 6 months or more have lower rates of business continuity. As the results in column 2 indicate, the sample excluding these households show the same probability of discontinuity in heavy damage areas of 10.7% points.

We also use the larger dataset to estimate the impact of the tsunami on several household outcomes, reported in Appendix Table A2. Similar to patterns observed in base results discussed in the previous section, the results from the robustness checks indicate larger falls in pre-transfer income, employment income, business profit/loss and business borrowing in heavy damage areas compared to no/light damage areas. Again the results do not support the contention that transfers and opportunities such as cash-for-work may have been a

[9] Offering support to this decision, by 2007 average post-traumatic stress reaction levels of respondents in heavy damage areas at the time of the tsunami were not statistically significantly different to that of those in other areas [37]. Thus, recollections may be clearer and data more reliable, as it is less confounded by effects of trauma. However, data collected further away from the event may be subject to its own recollect biases, so the robustness check compares the baseline results with results based on responses given in round 1. Even outside the context of an extreme event, recall bias can be concerning. For example recent World Bank research on agricultural productivity in Tanzania found that recall biases arise not just due to failures in memory, but also by the mental burdens of reporting on highly variable agricultural work patterns to provide a "typical" estimate. The researchers argued that this can cause labour productivity estimates to be lower than actual, ceteris paribus [38]. In the context of natural disasters, more research needs to be done to determine patterns in recall bias.

disincentive to business continuity as pre-transfer incomes fell significantly two years after the event compared to pre-tsunami levels.

6. Discussion

6.1. Post tsunami business asset growth

What could explain variations in business continuity by areas of damage two years after the event? One reason may lie in business asset recovery patterns in the various areas of damage, post tsunami. Asset stocks two years later had not yet reached pre-tsunami levels in all areas, and non-heavy damage areas saw a further fall in their asset stocks since the initial shock as seen in Fig. 2. However, the gap between business asset stock pre-tsunami and two years later remained highest in heavy damage areas. This meant that significant differences in business size (based on pre-tsunami asset stock per household) prevalent before the tsunami between heavy damage and other areas had reduced two years later. The size fell particularly sharply in heavy damage areas. A regression on business continuity against asset growth rates between 2004 and 2006/7, for the three areas separately suggests that continuity was significantly positively correlated to asset growth in heavy damage areas (Appendix Table A3). Thus, the ubiquitous livelihood assistance programmes post tsunami is likely to have supported more micro and small-scale enterprises rather than help recover larger businesses. Pre-tsunami, the larger businesses were located more in heavy damage areas rather than other areas.

Since our sample contains households that already have experience in running a business, the livelihood assistance efforts would have supported the continuation of businesses unlike the situation outlined in [35] where it was seen that giving ultra-poor productive assets without any training was less effective than a multi-faceted programme including training and financial inclusion. However, the support would have been sufficient to run businesses at a smaller scale. For larger businesses to operate at post-tsunami levels and recover assets lost, the capital based support required is likely to have been much larger than the livelihood-support based efforts. The sample shows no evidence of insurance payments supporting household business activity and indeed, the existence and penetration of formal financial market interventions was low in Aceh and North Sumtra at the time of the tsunami. There is also no evidence of significant asset sale post-tsunami, with the amount sold being about 2% of the value of pre-tsunami assets.

6.2. Wider infrastructure rebuilding efforts

Apart from asset growth rates, business recovery was likely to have been influenced by the rebuilding and further development of public infrastructure and key-services in the two years following the tsunami. If households that discontinued a business had benefited less from these rapid rebuilding efforts then this may have affected business recovery. To see if this may have been the case we look at changes to access, measured as the difference before and after the tsunami in the average distance to key public facilities such as public transportation, post-office, police station, traditional markets, public telephones, *kecamantan* (i.e., district) offices or religious facilities such as mosques. All these facilities are important for networking, business development and growth. The household survey gathers data on the distances in kilometres to reach these key services and we use this information to find the average distance from a household to these services. The measure shows that all households have gained from the reconstruction efforts with the change to average distance travelled falling across all areas. However, households that discontinued business indicate a higher fall of −3.52 km compared to that of those who continued a business of −1.69 km. This suggests that households that discontinued businesses came from areas that benefitted more from the rapid rebuilding efforts. This is unsurprising as 70% of the businesses that discontinued were from heavy damage areas where the rebuilding efforts were most concentrated.

6.3. Family and financial support networks

Despite gains in terms of infrastructure and access to facilities those who discontinued a business may have also been affected by

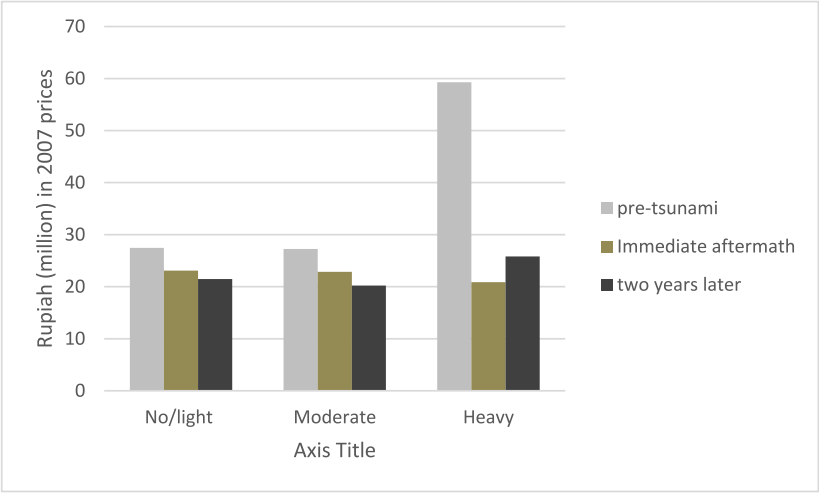

Fig. 2. Average business assets per household pre and post tsunami, by area of damage.

significant changes to financial and emotional support networks available. To see if this aspect may have been important to households in our sample, we use the data to construct a measure, albeit crude, to capture the change to support networks, by calculating the difference between the average number of friends or family the adults in the households could go to for financial help, assistance, and support before the tsunami and the number two years after. Households that continued business saw a change in networks of −0.23 while those that discontinued saw a change of −0.44. The difference is statistically significant with p-value 0.026, suggesting that those households that discontinued a business suffered significantly more than other households in terms of loss to their support networks. Indeed, around 61% of the businesses that discontinued were still living in temporary shelters or makeshift housing or had spent six months or more in temporary accommodation since the tsunami. Thus, despite the rebuilding efforts, longer-term displacement and the loss of family and community support networks seem to correlate negatively with the speed of business recovery. The results in this discussion remain consistent when we reassess these impacts using the sample used previously for robustness checks.

7. Conclusion

This paper looked at the impact the 2004 Indian Ocean tsunami had on household business assets and business continuity in the short and medium terms using data for Aceh and North Sumatra gathered in the STAR1 and STAR2 surveys. Household pre-tsunami characteristics revealed that those in heavy damage areas at the time of the tsunami were significantly wealthier, urban, more diverse in terms of their business portfolio and had larger businesses compared to those in no/light damage areas. They also incurred significant damage and loss to business assets due to the tsunami, with values falling by 2/3rd whereas in other areas it was less than 1/6th. Significant disruption to businesses persisted in heavy damage areas even two years after the event despite substantial infrastructure rebuilding efforts, with businesses showing a higher probability of discontinuity compared to no/little damage areas at 9.6% points according to base results. Moreover, household business diversity fell with only 21.5% of the households having 2 or more businesses compared to pre-tsunami levels of 35.6%. In contrast, household business activity thrived in non-heavy damage areas two years after the tsunami. Business discontinuity probabilities in moderately damaged areas was not significantly different to that in no/light damage areas. These results were corroborated by the robustness checks based on a different sample. This sample was created exploiting the STAR longitudinal survey's unique feature of seeking the same retrospective information about pre-tsunami characteristics in both rounds of data collection. This supports cross-validation of participant responses and the extent to which recall bias may be a problem especially in post-disaster contexts. In the case of the STAR dataset, even if individual answers to the same question was different in some cases in the two rounds, the average results were often consistent between the two samples, supporting robustness. This feature of the survey, therefore, is something that may be useful to repeat in other longitudinal household surveys, particularly if data is gathered soon after a major event.

Although households received significantly higher transfers from governments and NGOs, this transfer income did not compensate fully for the fall in pre-transfer income over the two years. Similarly, employment income fell on average, compared to pre-tsunami values. Thus, there isn't enough evidence to support the contention that higher transfers and more opportunities for paid work such as cash for work schemes were a disincentive for business continuity. What could explain the slower recovery in heavy damage areas in the medium term compared to medium and light/no damage areas, as well as the increase in overall business diversity? One reason could lie in different asset recovery patterns in these areas. Two years after the tsunami, asset recovery had not yet reached pre-tsunami levels in all areas and particularly in heavy damaged areas. Thus, the size of businesses were smaller (based on business assets per household) than pre-tsunami levels in all areas, and particularly so in heavy damage areas.

It also suggests that the recovery of larger businesses require different approaches to micro-finance or livelihood schemes that focus more on small scale enterprises. The latter seem to have been successful in supporting the continuity of smaller scale enterprises and even encouraging new enterprises particularly in non-heavy damaged areas. However, the recovery of larger businesses require higher injections of capital and investment support that is more likely to benefit from formal financial market tools such as insurance. The sample showed no evidence of business insurance payments suggesting a strong role for developing such financial market-based tools, adapted for local contexts, in supporting the continuity of non-micro enterprises. Although credit is often used as a tool in the recovery phase, rates of borrowing for business purposes was very low in our sample. It is unclear if this was an issue due to supply side reasons such as low access or demand side reasons based on religious preferences. This aspect, along with the nature of financial market interventions given the local institutional contexts need to be investigated further.

Those households that discontinued a business continued to indicate a higher loss of support networks two years after the event. This corroborates with the observation that nearly a third of these households had been displaced, currently residing in temporary shelters or having been in temporary housing for six months or more. Households in this category also saw asset accumulation over the two years that was significantly lower. It is unclear if this is because temporary housing was away from heavy damage areas, reducing these household's access to aid in terms of business equipment and livelihood support because those in temporary shelters were not eligible for livelihood support, or some other reason. The results suggest, therefore, a closer investigation of households that have been displaced for a longer period as the support they require in terms of business development maybe systematically different to what is suitable for households facing temporary displacement lasting no more than a few months.

Finally, the paper is an illustration of how longitudinal household survey data, widely used applied microeconomic studies can be used to enhance our understanding of disaster risk reduction. The STAR survey was designed particularly to understand the 2004 tsunami aftermath and recovery. However, other household surveys contain similar information and can be exploited to understand household business recovery, providing the dataset contains a module on individual and covariate shocks experienced by the household.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Table A1
Impact of tsunami on business continuity. Probit estimations with average marginal effects reported. Robustness check using larger dataset Dependent variable: discontinued business = 1, 0 otherwise.

	Full sample	Restricted sample excluding households that had been in temporary accommodation for 6 months or more since the tsunami
heavy	0.107*** (0.023)	0.107*** (0.027)
Medium	0.001 (0.017)	−0.001 (0.017)
wealth	−0.046 (0.041)	−0.045 (0.042)
rural	−0.079*** (0.019)	−0.074*** (0.020)
Observations	3495	3114

Notes Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

Table A2
Impact of tsunami on pre-transfer income, transfers, employment income, business profit/loss and borrowing. Robustness check using larger dataset

	Δpre-transfer income p.c.	Δtransfers p.c	Δemployment earnings p.c.	Δ profit/loss p.c.	Δbusiness borrowing
	(1)	(2)	(3)	(4)	(5)
Heavy	−193.0*** (48.7)	95.8*** (11.9)	−79.0*** (26.5)	−110.7*** (26.3)	−18.4 (21.4)
Medium	30.2 (32.4)	21.9*** (5.6)	28.0 (19.2)	4.9 (16.8)	−21.5 (18.8)
Assetindex	−442.9*** (99.1)	83.3*** (22.2)	−287.3*** (52.7)	−128.7** (53.7)	−134.5** (59.5)
Rural	25.9 (56.9)	12.8 (11.0)	6.6 (32.5)	16.7 (29.7)	79.9*** (30.6)
farmrice04	74.2** (36.2)	33.4*** (10.3)	48.8** (19.5)	28.0 (18.6)	−3.6 (16.0)
farmother04	−63.1* (35.7)	32.7*** (9.3)	−10.8 (20.1)	−55.4*** (18.6)	−8.5 (16.9)
nonfarm04	−323.1*** (41.5)	6.2 (11.7)	−118.0*** (23.5)	−189.0*** (21.3)	−29.0 (21.9)
Constant	170.5** (71.6)	−64.0*** (19.9)	70.2* (40.0)	84.6** (38.1)	2.8 (39.9)
Observations	3495	3495	3495	3495	3495

Notes: Changes are in terms of Indonesia Rupiah, 2007 prices. Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

Table A3
Business continuity two years later conditioned upon business asset growth. Probit estimations with average marginal effects reported Dependent variable: discontinued business = 1, 0 otherwise

	No/light damage areas	Moderate damage areas	Heavy damage areas
Asset growth between 2004 and 2006/7	−0.0 (0.0)	0.0 (0.0)	−0.1*** (0.0)
Observations	491	1697	584

Standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

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