Reconstruction following Destruction: Entrepreneurship in the Aftermath of a Natural Disaster

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Abstract: Little is known about the impact on small-scale enterprises of a large negative shock that destroys assets and disrupts local markets. We document the short- and long-run impacts of the 2004 Indian Ocean tsunami using longitudinal household survey data. We leverage topography-driven variation in exposure to the tsunami in coastal Aceh and North Sumatra, Indonesia. There are large short-run declines in business ownership, real profits, and real business assets among those exposed to the tsunami relative to comparison individuals who were not directly exposed. The gap in ownership rates disappears within two years in the non-agricultural sector but persists for 15 years in the agricultural sector. Profits and business assets of the exposed remain substantially lower through the long-term. Tsunami exposure led to increased short-duration transitions into and out of business ownership. Housing aid is linked to higher rates of non-agricultural business ownership and profits.

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I. Introduction

Entrepreneurship has played a central role in models of economic growth at least since Schumpeter (1934) argued that entrepreneurial innovation and entry are pivotal for long-run development. Small and informal microenterprises play a major role in employment and income generation, particularly in low- and middle-income countries (Gindling and Newhouse 2014; Jayachandran 2020; Hsieh and Olken 2014; Feng et al. 2024).

Randomized controlled trials (RCTs) have identified lack of capital, access to credit and managerial expertise as binding constraints on microenterprise performance (De Mel et al. 2008; Karlan and Valdivia 2011; McKenzie and Woodruff 2014; Banerjee et al. 2015; Bruhn et al. 2018; Campos et al. 2017; Anderson and McKenzie 2022).[1] Whereas entrepreneurs are provided with resources or information in these studies, it is not obvious that the effect of loss of resources is symmetric. For example, destruction of assets may result in an entrepreneur shrinking the size of their business or exiting altogether even if an equivalent capital infusion would not have expanded the business. Furthermore, it is unlikely to be feasible to implement an RCT that destroys the assets of some study participants.

More broadly, little is known about how microenterprises and potential entrepreneurs respond to large-scale negative shocks that destroy assets, disrupt markets, and reshape local economic conditions. This is important because negative shocks linked to weather, financial disruptions, conflict, and political upheavals are common and likely to increase in frequency and possibly severity in the future (Cavallo et al. 2010; Schrank et al. 2013; Kennickell et al. 2015; Belitski et al. 2022).[2]

This study uses uniquely rich longitudinal household survey data—the Study of the Tsunami Aftermath and Recovery (STAR)—to provide novel evidence on the evolution of

[1] These interventions often bundle resources with training or consulting. Relaxation of capital constraints can raise profits while standard business training alone frequently yields modest average impacts. More intensive or psychologically oriented training and managerial support can generate larger and more persistent gains.

[2] Most prior natural disaster studies focus on short-term effects: disaster exposure induces a substantial increase in mortality and injury, loss of property, and decline in human capital levels (Guimaraes et al. 1993; Schumacher and Strobl 2011; Anttila-Hughes and Hsiang 2013; Cas et al. 2014; Noy and duPont IV 2018). Macro-level studies investigating the output of exposed communities generally find smaller or null effects (Cavallo et al. 2013; Hsiang and Jina 2014). In particular, Heger and Neumayer (2019) argued that in the aftermath of the 2004 tsunami, regions of Aceh, Indonesia that experienced greater levels of flooding had greater long-term GDP growth, proxied by nightlight. In other disasters, Gitter and Barham (2007) find that Hurricane Mitch destroyed business capital in rural Honduras, and the adverse capital effect lasted for at least 3 years. However, Jakobsen (2012) found that Hurricane Mitch did not have an impact on productive assets in rural Nicaragua.

entrepreneurship after a major natural disaster, the 2004 Indian Ocean earthquake and tsunami. We investigate impacts on entry into and exit from entrepreneurship as well as the real value of profits and capital accumulation in the year after the tsunami and over the following 15 years. The STAR baseline was conducted 10 months before the tsunami and is representative of the population living along the coast of Aceh and North Sumatra, Indonesia—the area in the world that was hardest hit by the tsunami. Over 170,000 people (5% of the population) perished in the tsunami, which destroyed the assets and livelihoods of many tsunami survivors and resulted in over 500,000 people being displaced.

This study makes four key contributions. First, we provide causal evidence on how microenterprise activity is affected by large-scale destruction of the built and natural environments that reshaped the economic landscape. We leverage the fact that the 2004 Indian Ocean tsunami was a natural experiment: it was completely unanticipated, and which coastal communities sustained substantial damage depended on their location relative to the earthquake in the Indian Ocean that spawned the tsunami, in combination with the topography of the seafloor and shoreline (Frankenberg et al. 2016). Otherwise similar coastal communities experienced little or no direct impact of the tsunami, because, for example, they faced the opposite direction of the waves or were protected by a promontory or a cliff. We empirically establish the statistical exchangeability of the exposed and comparison populations, after accounting for topographical features of the coastline. Our empirical models also include individual fixed effects to control for all time-invariant individual characteristics of entrepreneurs as well as all pre-tsunami geographic variation in the community of residence at the time of the tsunami. Under the assumption that tsunami exposure is unrelated to remaining unobserved determinants of entrepreneurial outcomes, our estimates can be interpreted as causal.

Second, we investigate the immediate and longer-term impacts on entrepreneurial success, spanning a 15-year period post-tsunami. Experimental studies have shown that those who owned a business before a disaster are more successful if they are provided with an infusion of capital or information after the disaster; the results parallel those outside of a disaster context (De Mel et al. 2008; 2012; de Mel et al. 2014). We take a different approach: we investigate entrepreneurship for the population living in the post-tsunami economic landscape by contrasting those who were exposed to the onslaught of the tsunami waves with those who were living in coastal communities beyond the reach of those waves.

Whereas before the tsunami business ownership rates were similar in the exposed and comparison communities, in the year after the tsunami, ownership declined in all areas, but more so among the exposed, who were 5.3 percentage points (about 17 percent) less likely to own a business. The gap narrowed over time and by 15 years post-tsunami, the ownership gap was small and insignificant. This masks important sectoral differences. The exposed were 2.4 percentage points less likely to own a non-agricultural business in the year after the tsunami and had reached parity with the comparison population 2 years post-tsunami. In the year after the tsunami, the gap was larger for agricultural businesses (6.1 percentage points) and remained statistically significant 15 years post-tsunami.

We also examine the value of real profits and capital accumulation, taking into account the substantial spatial and temporal variation in inflation rates linked to tsunami exposure by drawing on local-area price data we collected for this project. In contrast to business ownership, profits and capital accumulation remain persistently lower among the exposed relative to the comparison population. In the year after the tsunami, real profits declined by 45% relative to the comparison group; only a small fraction of that deficit was recovered over the next fifteen years. The capital of exposed business owners fell by 30% after the tsunami and never returned to its pre-tsunami level.

The results illustrate the importance of covering all sectors of the economy in studies of entrepreneurship, the value of long-term follow-ups, and the importance of following entrepreneurs who move across sectors. Our third contribution speaks directly to this last point: we track entry, exit, and cross-sector mobility over the long run using a rare post-disaster panel of individuals.

Specifically, we leverage the STAR household survey to build a panel of individuals who enter and exit entrepreneurship in the years after the tsunami and we follow them over the long-term. A negative shock may induce entry by individuals who were never entrepreneurs before—either out of necessity as wage-sector jobs disappeared or because of new opportunities. This would shift the composition of business owners toward less experienced entrants and, among them, possibly privilege those with better access to informal insurance and networks. In fact, we have shown that those exposed to the tsunami were more willing to take on financial risk after the tsunami, at least over the short-run (Ingwersen et al. 2023). Understanding changes in the selectivity of business-owners post-disaster is critical for interpreting evidence on their success

over the long-haul. This is a key strength of our study design particularly since we have kept attrition rates extremely low, in spite of the high rates of post-tsunami displacement, and we follow movers across Indonesia and internationally (Gray et al. 2014; Frankenberg et al. 2023). This is important as displaced individuals have worse business ownership and performance outcomes through the long-term.

There are meaningful changes in the composition of entrepreneurs in exposed locations during recovery. Those exposed to the tsunami were more likely to enter the business sector and they were also more likely to exit after a short period of ownership. This difference is disproportionately concentrated among households with fewer resources (measured by pre-tsunami per capita household consumption). We also show that the long-run gaps in ownership between the exposed and not exposed are concentrated among rural and lower-consumption households. These results are consistent with both physical and human capital constraints.

Our fourth contribution leverages assistance provided under the Build Back Better program—the largest post-disaster reconstruction effort in a developing country—to investigate the role of physical capital constraints in explaining the medium- and long-term effects and sectoral differences. We focus on the housing reconstruction aid, a large transfer of public resources to households whose homes were damaged or destroyed by the tsunami. The staggered rollout of housing assistance due to disbursement logistics provides plausibly idiosyncratic variation in the timing of receipt to examine whether reconstruction resources led to differential recovery in business ownership and performance. We find housing assistance is associated with modest increases in non-agricultural business ownership in the short- and medium-term and increases in agricultural business ownership in the long-term. These changes are accompanied by gains in real profits , without corresponding increases in business capital holdings. The short- and medium-term increase in non-agricultural ownership is large relative to the immediate post-tsunami decline for those directly exposed, suggesting that relieving capital constraints through providing reconstruction assistance may have mitigated some of the adverse effects in the medium- and long-run. This complements work on policies that shape entrepreneurship in developing economies by studying these questions in the aftermath of a disaster (de Mel et al. 2014; Nose 2014; Quinn and Woodruff 2019; Jayachandran 2020).

The rest of this paper is organized as follows. Section II describes the 2004 Indian Ocean tsunami and subsequent reconstruction effort. The STAR data, analysis sample, and empirical

strategy are described in Section III. Section IV presents the main disaster exposure effects. Section V presents heterogeneity in business owners following the tsunami, and heterogeneity in the disaster exposure effects. Section VI examines how housing aid receipt modified entrepreneurial outcomes. Section VII concludes.

II. Setting

II.A. 2004 Indian Ocean Tsunami

On December 26, 2004, a magnitude 9.1 earthquake occurred off the island of Sumatra, Indonesia, approximately 150 miles from the coastline. The earthquake generated a tsunami that reached the coast within roughly 15 minutes and later propagated across the entire Indian Ocean. The largest impacts were in coastal Aceh—the northernmost province on Sumatra(Frankenberg et al. 2011). This paper studies individuals who were residing in coastal Aceh and neighboring North Sumatra at the time of the tsunami.

The tsunami generated large spatial variation in physical destruction in the study area. Estimated damages exceeded 80 percent of Aceh's 2003 GDP (Masyrafah and McKeon 2008). In heavily affected communities, reconstruction needs included debris removal and rebuilding housing, roads, commercial and public buildings and mosques (Frankenberg et al. 2012).

Two features of this setting motivate our empirical strategy. First, the tsunami was largely unanticipated. While seismic activity is common in Indonesia, geological evidence indicates that mainland Sumatra had not experienced a major tsunami for over 600 years (Monecke et al. 2008). In addition, at the time of the event, an effective early warning system was not in place in the Indian Ocean because it was not considered at risk of a tsunami (Frankenberg et al. 2011).

Second, tsunami damage varied across nearby coastal communities. The height, speed and direction of the waves were a complex function of the topography of the sea floor and the rift caused by the earthquake as well as the topography of the coastline. A community in the direct line of the biggest waves that reached 30m in height was severely damaged, while a nearby community that was protected by a promontory or elevation of the land was not directly impacted (Ramakrishnan et al. 2005; Frankenberg et al. 2011).

In contrast to settings in which disaster exposure is closely related to socioeconomic sorting and avoidance behavior (Baker 1991), the variation across communities in tsunami

exposure in Aceh and North Sumatra was driven primarily by local geography and the physical dynamics of the event. In the empirical analysis, we treat exposure as plausibly exogenous conditional on baseline area characteristics and controls for pre-tsunami differences across locations. Empirical support for the assumption is reported in Section IV.A.

II.B. Reconstruction Aid and *Build Back Better*

In the aftermath of the tsunami, reconstruction in Aceh and North Sumatra was financed by an unprecedented inflow of domestic and international relief and recovery assistance, which was, at the time, the largest recovery effort in any developing country. Total commitments were approximately USD 9 billion, drawn from national governments, multilateral and bilateral aid agencies, international and domestic NGOs, and private donors (Jayasuriya et al. 2010), reflecting the enormity of the disaster. In fact, the commitments exceeded the projected need to restore affected areas to pre-tsunami conditions by several billion dollars. The Government of Indonesia's *Build Back Better* program was designed not only to replace destroyed and damaged public and private infrastructure but also to increase the resilience of infrastructure and public services in the face of future disasters (Heger and Neumayer 2019). In other disasters, official post-disaster aid surges have typically covered less than 10 percent of estimated damages (Freeman et al. 2002; Becerra et al. 2014).

Housing assistance, the final element of the reconstruction program, was rolled out several years after the tsunami, in part because of the need to verify land ownership, the complexity of the disbursement and the inclusion of local community members in the process (Frankenberg et al. 2026). More than 400 donor organizations participated in the recovery effort, creating substantial coordination and implementation challenges in a setting where both the built environment and the underlying geography had changed abruptly (Masyrafah and McKeon 2008). To facilitate coordination and oversight, the Government of Indonesia established the Agency for the Rehabilitation and Reconstruction of Aceh and Nias (BRR—*Badan Rehabilitasi dan Rekonstruksi*) (Daly et al. 2012). In parallel, the World Bank's Multi-Donor Fund (MDF) pooled resources from multiple donors with the goal of streamlining financing and reducing transaction costs associated with fragmented aid delivery. Importantly, however, BRR's mandate focused on coordination and monitoring rather than centralized control over program design or

allocation decisions across implementing organizations, and coordination across donors remained limited in practice.

These institutional and logistical features resulted in unpredictable heterogeneity in the timing of assistance receipt across otherwise similar households and communities. In the empirical analysis, we exploit this variation to study how reconstruction aid affects subsequent entrepreneurial activity.

III. Data and Empirical Strategy

III.A. Study of the Tsunami Aftermath and Recovery

We use data from STAR, a long-term longitudinal population-representative survey conducted in Aceh and North Sumatra that is designed to measure the short- and long-run effects of the 2004 Indian Ocean tsunami on survivors.

The baseline is drawn from the February/March 2004 wave of Indonesia's National Socioeconomic Survey (SUSENAS), fielded 9–10 months prior to the tsunami.[3] We selected all 11 *kabupaten* (districts, 1 geographic level below province) along the coast of Aceh and two *kabupaten* along the west coast of North Sumatra (which was at risk of exposure to the tsunami). Every household—and all its members—from all SUSENAS enumeration areas in each selected *kabupaten* are included in the STAR baseline which comprises almost 27,000 adults and children. In this study, we focus on over 16,000 respondents who survived the tsunami and were aged 15 years or older at the time, whom we refer to as adults, for simplicity.[4] The first post-tsunami STAR follow-up, conducted between May 2005 and July 2006, was followed by four annual follow-ups and then follow-ups 10 and 15 years post-tsunami.

In each wave, STAR collects a detailed household roster along with, *inter alia*, information about agricultural and non-agricultural businesses, other sources of income, labor supply, assets, and consumption as well as detailed information about each respondent's experiences during the tsunami. The household surveys are complemented with community surveys, conducted in every study *desa* (village, the lowest administrative level in Indonesia, 3

[3] SUSENAS, a national socio-economic survey conducted by Statistics Indonesia, is population-representative at the *kabupaten* level.

[4] All baseline respondents were eligible to be re-interviewed. 18,200 of the baseline respondents were adults and, of them, 16,622 survived the tsunami. We have not been able to determine survival status for 1.5% of the baseline respondents. Survival status was derived from interviews with household and family members, community leaders and neighbors. When available, we prioritized information from household and family members. For households in which no member could be located, information from community leaders and neighbors was critical.

levels below provinces). Those surveys collected information about markets, prices, infrastructure and public services.

Three features of the STAR study design are key for this study. First, information is collected about each agricultural and non-agricultural business operated by every household including products, sales, costs and, thus, profits; assets used in the business and family and hired labor used in the business. Labor supplied to all activities and earnings of each household member are reported on separately.

Second, STAR fields a comprehensive price survey in every *desa* which we use to account for spatially heterogeneous price dynamics following the disaster. This is important because post-disaster prices diverge systematically across exposed and less exposed areas (Hallegatte and Przyluski 2010; Del Ninno et al. 2003; Kirchberger 2017). We construct a time-varying community-level price index that is linked to the location of each respondent in each wave and used to construct real values for each economic measure used in the analyses. Appendix B2 describes the construction of the price index in detail.[5]

Third, STAR has kept attrition low by tracking all baseline survivors in every survey wave, including those who moved away. This is critical in the context of a disaster in which large numbers of people were displaced and many chose to move in pursuit of new opportunities, including starting new businesses. We tracked movers across Sumatra, the other Indonesian islands, and international movers to Singapore and Malaysia. Over 98% of baseline respondents who survived the tsunami were interviewed in at least one follow-up wave and at least 92% of all survivors in each follow. These are exceptional follow-up rates for a large panel survey, particularly in the context of extensive destruction and large-scale displacement.

III.B. Outcomes and Analysis Sample

We first study how tsunami exposure affected entrepreneurship and small-business activity. Our main outcomes are constructed from STAR household survey modules on agricultural production, non-agricultural enterprises, and business-related assets.

[5] Briefly, household respondents report the *pasar* (markets) and *toko* (shops) they typically visit; enumerators then collect prices and quantities for 60 major food items from up to three listed *pasar* and up to three listed *toko* in each community. Up to three community informants additionally report prices for 26 commonly purchased non-food items. We standardize prices by weight when reasonable and aggregate them using expenditure shares from the household survey to form a localized price index, which we use to recover price-adjusted measures of economic outcomes.

The agricultural and non-agricultural business modules ask whether the household planted and harvested crops or operated any other agricultural or non-agricultural businesses. Conditional on operating a business, respondents reported profits. Given the centrality of rice cultivation in Aceh and North Sumatra, the agricultural module distinguishes rice from other agricultural activities. Non-rice agricultural activities include rubber, cocoa, palm oil, chili, clove, nutmeg, and peanuts. Non-agricultural enterprises include small-scale trade and services such as local merchants, fishing, tailoring, transport and construction services, food preparation, and food sales.

As business activity is recorded at the household level, we assign an individual owner within business-operating households using individual employment reports (described in Appendix B1). Each household is classified as operating an agricultural and/or non-agricultural business in each wave, and then the most likely operator is assigned using self-employment status of household members. We also examine impacts on business capital using the STAR business asset module, which records ownership and self-reported values of assets intended to support business activities. We construct an individual business capital measure, described in Appendix B1.

Since the pre-tsunami baseline only asked about businesses that cultivated rice (with a two-year reference window), in the first post-tsunami STAR follow-up, we elicited retrospective information on all agriculture and non-agriculture businesses owned at the time of the tsunami and profits in the year prior to the tsunami. Appendix C assesses the consistency of these retrospective reports by comparing responses for the same individuals for the same businesses reported in the baseline and first follow-up. We also use baseline data to assess mortality selection. Households in which all members died are necessarily absent from post-tsunami follow-ups; however, baseline information indicates that rice business ownership rates in these households were similar to rice business ownership in households that experienced partial mortality or no mortality in subsequently heavily damaged areas.

Baseline communities are classified as having sustained "heavy damage" based on a combination of high-resolution satellite imagery, direct observations recorded by STAR field supervisors, and reports from community leaders.[6] Of the 407 communities in the baseline, 96

[6] The satellite imagery data is from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS). For each of the study sites, we calculated the proportion of land cover that was damaged (land cover that was reduced to bare

are classified as heavily damaged. Exposure status is assigned to each individual based on their location at the time of the tsunami and fixed over the study period. This avoids confounding from endogenous post-disaster mobility and allows us to estimate how outcomes evolve for the people—rather than the places—most directly exposed to the shock.

The analytical sample includes all pre-tsunami baseline respondents who were at least 15 years old at that time and were re-interviewed in at least one of the eight post-tsunami surveys. Of these 15,734 respondents, 21% were living in communities that sustained heavy damage.[7] Table 1 displays summary statistics at the pre-tsunami baseline for the sample. As shown in columns 2 and 3, which are stratified by whether the respondent was a business operator at baseline, business owners are more likely male, older, less likely married, more likely rural, and wealthier.

III.C. Empirical Strategy

We investigate the effect of heavy tsunami exposure on entrepreneurial outcomes using an individual fixed effects event-study design. Let T_i denote an indicator equal to one if individual i resided, at baseline, in a community classified as heavily damaged by the tsunami. We estimate:

$$y_{it} = \beta_t T_i + \lambda_i + \xi_t + u_{it} \quad [1]$$

where y_{it} is the entrepreneurial outcome for individual i in survey wave t, λ_i and ξ_t are individual and survey-wave fixed effects, and u_{it} captures unobserved heterogeneity. Because exposure is defined by an individual's location at the time of the tsunami, T_i is time-invariant. We consider five main outcomes: indicators for owning any business, owning an agricultural business, and owning a non-agricultural business; the logarithm of total business assets among asset-holders; and the logarithm of total profits across all household businesses among business

earth) in 0.6 km^2 blocks when comparing satellite images of the land 7 days before the tsunami to 3 days after the tsunami. We supplemented these calculations with damage estimates from remotely sensed imagery that was prepared by the USGS, USAID, and the German Aerospace Center, and with flooding estimates from the Dartmouth Flood Observatory (Gillespie et al. 2009). Lastly, within each community, responses from interviews with local leaders and survey field supervisors provided their own assessments of destruction (Frankenberg et al. 2011).

[7] 10,501 individuals appeared in every wave; 2,304 appeared in all but one wave. We do not impose an upper age limit to the sample as the share of elderly individuals is small. Only 5.0% of the analysis sample is aged 65+ at the pre-tsunami baseline.

owners.[8] We convert all reported values to real terms using survey date-specific local price indices constructed at the exposure-by-*kecamatan* (sub-district, 2 levels below province) level (Appendix B2). Standard errors are clustered at the individual level.[9]

Although exposure status is fixed, its effects may evolve over time. We therefore allow β_t to vary by wave, tracing the dynamic trajectory of outcomes for exposed individuals relative to the comparison group throughout the post-tsunami period. Identification requires that, conditional on individual fixed effects, exposure is orthogonal to time-varying unobserved factors that affect entrepreneurship: $E[T_i\, u_{it} \mid \lambda_i] = 0$. As discussed in Section II, fine-scale variation in tsunami damage across nearby communities was largely determined by idiosyncratic coastal and seabed topography interacting with the physical dynamics of the wave. Individual fixed effects absorb time-invariant differences across their baseline environments. It also controls for pre-tsunami household composition, strength, and stamina which predict tsunami mortality (Frankenberg et al. 2011), mitigating concerns that differential survival drives our estimates. We provide additional empirical evidence supporting the validity of the identification assumption in Section V.B.

A further advantage of the individual fixed effects framework is interpretability: by differencing out time-invariant individual attributes—such as baseline entrepreneurial ability, risk preferences, and access to credit—we estimate how exposure alters within-person entrepreneurial trajectories over time.

Equation (1) compares individuals from heavily damaged communities ("exposed" individuals) with those from communities that were not heavily damaged (comparison individuals). Not all communities in the comparison group were unaffected. The Sumatra–Andaman earthquake was felt across the study area, and some comparison communities incurred infrastructure damage even in the absence of tsunami inundation. Our exposure measure is intended to isolate tsunami-related destruction, which is also reflected in sharply different

[8] 6% of business owners across the sample have zero profits; they are dropped from regressions using the logarithm transformation. Results are similar when using the square root transformation, which does not drop these observations.

[9] In settings with staggered treatment adoption and heterogeneous treatment effects, two-way fixed effects (TWFE) regressions like Equation 1 identify a weighted average of group-by-time treatment effects where some of those weights may be negative (See de Chaisemartin and D'Haultfoeuille (2022) for a review). In our setting, exposure is binary and occurs at a common time for exposed respondents (i.e., there is no variation in adoption timing), so Equation 1 reduces to a canonical DiD design. As a result, the TWFE negative-weighting problem that arises under staggered adoption is not present (de Chaisemartin and D'Haultfœuille 2020).

mortality rates: mortality is effectively zero in comparison communities but approximately 27 percent of the population died in heavily damaged communities. Because the comparison group may still have experienced disruptions (e.g., to roads and local markets), we often report β_t estimates alongside the pre-tsunami level of each outcome to provide a benchmark that is not contaminated by the Sumatra–Andaman earthquake or 2004 Indian Ocean tsunami.

Finally, the expected sign of β_t is theoretically ambiguous. In the short run, destruction of productive assets and disrupted local demand may depress microenterprise activity and push some entrepreneurs into wage work. At the same time, reduced wage employment opportunities and the need to replace lost livelihoods may induce entry into entrepreneurship. The changing dynamics associated with wage employment and self-employment suggest the potential for re-sorting; those initially employed by others may be pushed into self-employment while those initially operating a business may be pushed into wage work. Over the medium and longer run, reconstruction resources and rebuilding may expand both wage-labor and entrepreneurial opportunities, yielding ambiguous effects in aggregate. Migration responses and shifts in local population composition further complicate these dynamics. The longitudinal STAR design, combined with the flexible event-study specification, is therefore well-suited to characterize how entrepreneurial activity evolves following the shock and during recovery.

IV. Effect of Tsunami Exposure on Entrepreneurial Outcomes

IV.A. Exogeneity Tests

Our empirical strategy relies on the assumption that, conditional on individual fixed effects, tsunami exposure is quasi-randomly assigned with respect to potential entrepreneurial outcomes. Because STAR contains only one pre-tsunami wave for the analysis sample, we cannot directly assess differential pre-trends using these panel data. We provide two complementary sets of evidence. First, we evaluate balance in observed characteristics at baseline of exposed and comparison individuals. Second, we test for differential pre-tsunami trends in exposed versus non-exposed areas using repeated cross-sections from the 2002–2004 waves of SUSENAS for the same *kabupaten* in STAR.

We first test whether baseline socio-demographic characteristics and pre-tsunami business outcomes differ systematically by exposure status, conditional on pre-existing

geographic controls. Specifically, we estimate the following cross-sectional regression in the pre-tsunami baseline wave:

$$T_i = \alpha_0 + \alpha' X_{i0} + \lambda W_{i0} + \varepsilon_i \quad [2]$$

where T_i is an indicator for tsunami exposure, X_{i0} is a vector of baseline covariates and outcomes, and W_{i0} are pre-tsunami *kecamatan* fixed effects, a quadratic in community elevation, and a quadratic in distance to the coastline. If the exposed and not exposed are statistically exchangeable, estimates of α should not be statistically different from zero. The estimates and 95% confidence intervals are displayed in Figure 1. They are all small and none is statistically significant. Moreover, a joint test fails to reject that taken together, they are jointly zero (F = 1.27, p = 0.157). All of the pre-existing geographic differences are absorbed by the individual fixed effects which provides another reason for their inclusion in the empirical models.

Appendix B3 reports the results of a pre-exposure trends test in Aceh, using the 2002-2004 SUSENAS waves to test differential trends in a broad set of outcomes and characteristics prior to the tsunami. We find no evidence of systematically different pre-tsunami trends across exposure groups once we condition on pre-tsunami *kecamatan* and local land characteristics.

Overall, the balance and pre-trends tests support the empirical design. After conditioning on geography, we do not find evidence of systematic selection on observables that would threaten the interpretation of the exposure estimates as causal. These cross-sectional checks cannot include individual fixed effects, but individual fixed effects are included in the panel models and strengthen the argument for treating tsunami exposure as conditionally exogenous.

IV.B. Exposure Effects on Entrepreneurship

We estimate the wave-specific coefficients β_t in Equation (1) for the entrepreneurial outcomes. Figure 2 plots trajectories by exposure status and the corresponding event-study estimates of heavy exposure relative to the non-exposed group.

Business Ownership

Panel A of Figure 2 reports results for an indicator for owning any business for those who were in exposed communities at the time of the tsunami (green solid line) and those in comparison communities (red dashed line) in the left-hand panel. About 25% of households own

a business pre-tsunami and ownership rates are the same for those who were subsequently exposed relative to the rest of the respondents. In the first post-tsunami wave, business ownership rises in the comparison group but increases by less among the exposed, yielding a sizeable negative exposure effect. The difference between ownership rates is displayed in the right-hand panel. Relative to the non-exposed group one year after the tsunami, business ownership among individuals from heavily damaged areas is 5.3 percentage points lower (17% relative to comparison business ownership rates 1 year after the tsunami). Ownership increases for both groups in the second year and then declines modestly, but the exposed group remains persistently below the comparison group through the ten-year follow-up: the estimated effect ranges from roughly 3 to 6 percentage points through year ten. Fifteen years after the tsunami, business ownership in heavily damaged areas converges toward the comparison group, and the estimated long-run effect is small and statistically indistinguishable from zero (0.7 percentage points). The figure clearly documents the importance of having a plausible comparison group to assess ownership of those exposed as business ownership rates varied substantially over time, reflecting broader economic factors not linked to exposure. The figure also highlights the importance of long-term panel data following a large-scale disaster. It is only with the 15-year follow-up that there is evidence of convergence in business ownership of the exposed and those not exposed to the full force of the tsunami.

Sectoral Re-allocation: Agricultural vs. Non-Agricultural Businesses

Panels B and C of Figure 2 decompose business ownership into agricultural and non-agricultural enterprises. The first post-tsunami wave shows sharp contractions in both sectors among the exposed, with especially large declines for agricultural businesses. In year 1, exposure reduces non-agricultural business ownership by 2.4 percentage points (15%) and agricultural business ownership by 6.1 percentage points (31%) relative to comparison areas.

Two features of the agricultural results are notable. First, the short-run effect reflects both a decline in agricultural ownership among exposed households and a contemporaneous increase among comparisons, consistent with tsunami damage being concentrated in heavily damaged coastal areas and loss of arable land accompanied by entry into agriculture in comparison areas. Second, the agricultural ownership gap widens and remains substantial for at least a decade: estimated differences range from roughly 5 to 9 percentage points through year 10. Although the

magnitude of the exposure effect attenuates in the long run, it remains negative and statistically significant in year 15 (2.6 percentage points).

Appendix Table A2 further decomposes agricultural enterprises into rice and non-rice activities. The short-run decline is larger for rice businesses, but the effect attenuates by year 15. By contrast, non-rice agricultural businesses exhibit persistent declines: the year-15 estimate remains economically meaningful (4.5 percentage points). These patterns are consistent with long-run constraints on agriculture in exposed areas, including land degradation due to seawater inundation and salinization. Non-rice, primarily cash crops, were the most deleteriously impacted.

In contrast, Panel C of Figure 2 shows that adverse exposure effects for non-agricultural business ownership dissipate quickly. After a large decline in year 1, estimated differences are close to zero from year 2 onward. Both exposed and non-exposed groups increase non-agricultural ownership through the early post-tsunami years, followed by a decline around year 5 and gradual increases thereafter. Overall, the sectoral decomposition indicates that the persistent entrepreneurship decline in heavily damaged areas operates primarily through agriculture rather than through sustained suppression of non-agricultural enterprise formation.[10]

Figure 2 yields three implications for the literature on post-disaster enterprise dynamics. First, it is important to follow households over the long-term: we document that overall business ownership rates in the exposed and comparison populations have converged 15 years post-tsunami. The persistence of the ownership gap indicates substantial medium-run reduction in entrepreneurship activity even in a context with a massive reconstruction effort.

Second, the persistence is sector-specific: the long-run entrepreneurship gap persists for agricultural enterprises, whereas non-agricultural ownership rebounds quickly after the initial shock. This pattern is consistent with a shock that durably degrades land-based productive capacity and shifts activity away from agriculture rather than uniformly depressing business formation. This may reflect constraints such as inadequate capital to rehabilitate agricultural land, to adopt new technologies, or to switch to crops that flourish in salinized soil. Inadequate capital has been shown to limit recovery in the fishing sector after the tsunami (Nose 2014;

[10] To examine whether attrition in- and out- of the sample may explain any of the dynamics we document, Figure A2 re-estimates Figure 2 but limited to the 10,501 respondents that were interviewed in all waves. None of our conclusions are altered: the empirical results are very similar in direction and magnitude.

Wong 2022). The distinct trajectory in the agriculture sector underscores the importance of studying all self-employed businesses and not just manufacturing or services.

Third, the sectoral split helps reconcile why some macro evidence finds limited average output losses after disasters (Cavallo et al. 2013): aggregate recovery may mask persistent distributional and compositional change, including large contractions in land-intensive businesses even as other sectors recover. In fact, Deryugina, Kawano, and Levitt (2018) conclude Hurricane Katrina caused large and persistent displacement but only transitory effects on income, underscoring how aggregate measures can mask substantial reallocation of resources in the economy.

Profit and Business Capital

Figure 3 reports event-study estimates of the differences between the exposed and comparison groups for business profits and business asset holdings.

Panel A considers real business profits, conditional on owning a business in that wave. Profits fall sharply in the first post-tsunami wave: heavy exposure is associated with an immediate 58.5 log points (45%) decline in real business profits. The deficit remains large throughout the sample period, ranging between 24% and 49%. Appendix Figure A3 and Appendix Table A3 indicate that profits among the non-exposed group rise modestly through year 4, decline in year 5, and then increase again by years 10 and 15. The exposed group does not exhibit comparable recovery, implying persistent productivity or demand-side damage among surviving businesses.

Panels B and C of Figure 3 further disaggregate profits by sector. Profit declines are substantial in both agricultural and non-agricultural enterprises in the short run and remain negative at longer horizons. Although estimates for agricultural profits are imprecise in several intermediate waves (years 2–4 and year 10), point estimates remain negative. Further, the profit decline for non-agricultural businesses tends to be larger than the decline for agricultural businesses. Appendix Figure A3 shows that these intermediate dynamics reflect temporary increases in agricultural profits among exposed businesses rather than improvements in the comparison group.

Several mechanisms potentially contribute to these profit patterns. First, lower real profits may, in part, reflect the impact of higher local prices in heavily damaged areas through 10 years

post-tsunami, as shown in Appendix Figure A1. Second, conditional on remaining in business, exposed enterprises exhibit weaker recovery, consistent with persistent constraints on production, access to markets, including the credit market, and levels of local demand.

To more directly assess supply-side constraints, Panel D examines business assets, conditional on owning positive business assets. This result shows severe and persistent destruction of business capital in heavily damaged areas. Real business asset values fall by 37.0 log points (31%) in the first post-tsunami wave and remain between roughly 36 and 64 percent lower throughout the sample. Appendix Table A3 shows that even the comparison group experiences meaningful asset declines in the immediate aftermath but recovers substantially by year 5; by contrast, heavily exposed households do not rebuild business asset holdings over the 15-year study period.[11]

Figure 3 therefore clarifies that post-tsunami business losses are not explained solely by firm exit or selective survival. Surviving firms in heavily damaged areas also experience substantial and persistent profit shortfalls. This aligns with evidence that recovery can be constrained by damaged productive capacity and limited access to capital, so that firms that remain active nonetheless operate at lower scale or profitability (De Mel et al. 2012). Consistent with this interpretation, Panel D shows large and enduring reductions in business assets, indicating incomplete capital rebuilding long after the immediate disruption has passed.

A key takeaway from Figures 2 and 3 is that enterprise participation and enterprise performance did not recover in tandem. Non-agricultural ownership converges relatively quickly, but profits and capital remain persistently depressed, suggesting that post-disaster recovery was accompanied by a shift toward less capital-intensive, lower-profit activities rather than a full restoration of pre-tsunami productive conditions. This divergence motivates our additional explorations described below focusing on reconstruction policies. If housing assistance relax capital constraints, they may restore participation more rapidly than contribute to increasing business capital, with implications for longer-run profits.

[11] The 10- and 15-year follow-up waves record the number of workers at the respondent's firm. Because we do not observe firm size prior to the tsunami, these specifications cannot include individual fixed effects; instead, we condition on *kecamatan* fixed effects and the same geographic controls used throughout the paper. We find a small and statistically insignificant effect of tsunami exposure on firm size among self-employed respondents. Firm size is small in this population: roughly 50% report a one-person firm, and about 75% report two or fewer workers.

In sum, tsunami exposure generates sharp and persistent losses in entrepreneurship that are concentrated in agriculture. While non-agricultural ownership largely recovers after the initial shock, agricultural business ownership remains depressed through 15 years. Real profits in both sectors as well as business capital exhibit sustained damage through the long-term. The next section examines whether these patterns reflect changes in selection into business ownership after the tsunami and how treatment effects vary across baseline characteristics.

V. Composition of Business Owners and Heterogeneous Effects

V.A. Pre-Tsunami Business Owner Characteristics

To lay a foundation for studying how the characteristics of entrepreneurs change over time after the tsunami, we estimate linear probability models in the pre-tsunami baseline wave to characterize who operates a business prior to the disaster. The outcomes are indicators for business ownership and wage labor. Regressors include baseline socio-demographic characteristics and household resources X_{i0} as well as the same geographic controls W_{i0} used throughout (pre-tsunami *kecamatan* fixed effects and quadratics in elevation and distance to the coastline).

Table 2 reports the results of these regressions. Entrepreneurship is common in the baseline: 24% of adults operate a business, compared with 14% who earn a wage as an employee. Agricultural enterprises account for the majority of baseline business ownership (16% of adults), split roughly evenly between rice (10%) and other agricultural activities (10%), while 11% operate non-agricultural businesses. (Respondents can own multiple businesses.)

Table 2 also shows clear sorting in baseline entrepreneurship by gender, age, education, marital status, and location. Business ownership is substantially higher among men in both agricultural and non-agricultural enterprises. Entrepreneurship is also concentrated among prime-age and older adults: relative to the 1965–1979 cohort, individuals born after 1979 are less likely to operate a business, while those born before 1965 are more likely to do so. Education is strongly associated with labor-market workers. Individuals with 10 or more years of schooling are considerably more likely to be wage laborers, whereas education gradients in business ownership are comparatively modest.

Marital status is also predictive of occupational choice. Married men are substantially less likely to operate a business—particularly an agricultural business—while marital status is

only weakly related to wage labor. Finally, sectoral patterns align with geography and baseline resources. Urban residents are less likely to operate agricultural enterprises and more likely to operate non-agricultural businesses. Baseline household consumption per capita is positively associated with non-agricultural business ownership and only weakly associated with agricultural business ownership, consistent with higher-resource households concentrating in non-farm enterprise. In addition, conditional on the geographic controls used throughout, heavy tsunami exposure is not strongly related to baseline entrepreneurial status, consistent with the balance evidence in Section IV.A.

The baseline sorting documented in Table 2 motivates the analyses in the next section. Because entrepreneurship differs systematically by sector and household characteristics, exposure-induced shifts in entry, exit, and sectoral allocation can change the composition of observed business owners over time.

V.B. Compositional Changes in Business Owners

We turn next to describe how the composition of business owners differs between heavily exposed and non-exposed areas over time and estimate linear probability models separately by survey wave. In each wave t, the outcome is an indicator for business ownership in that wave. Regressors include the same baseline characteristics X_{i0} (measured prior to the tsunami) as in Section V.A., an indicator for heavy exposure T_i, and interactions $X_{i0} \times T_i$, along with the same geographic controls W_{i0} used throughout. The coefficients on X_{i0} describe how baseline characteristics are associated with business ownership in the non-exposed group in wave t, while the interaction terms $X_{i0} \times T_i$ capture how those associations differ in heavily exposed areas in the same wave.

Table 3 reports the results for any business ownership, separately by survey wave. Two sets of dynamics are evident. First, the overall incidence of business ownership rises in the post-tsunami period: the mean of the dependent variable increases from 0.24 in the baseline to 0.30-0.35 in subsequent waves, with a temporary dip around the five-year follow-up. Second, the conditional correlates of business ownership evolve over time. The male advantage remains large in every wave but declines slightly in magnitude by year 15. Age sorting also changes: relative to the 1965–1979 cohort, younger individuals (born after 1979) become increasingly less likely to be business owners in the early post-tsunami waves (the coefficient becomes more negative

through year 5) and then partially converges by year 15. In contrast, the positive association between being older (born before 1965) and business ownership in the baseline attenuates over time and becomes slightly negative in later waves. Marital status exhibits a similar attenuation: the negative association between being a married man and business ownership shrinks steadily over the panel. The urban gap becomes more negative in every post-tsunami wave relative to baseline, indicating that business ownership becomes increasingly concentrated in rural areas, conditional on the geographic controls.

The exposure interactions show that compositional differences between exposed and non-exposed areas are not constant over time. In the first post-tsunami wave, the exposure-by-male interaction is negative, indicating a smaller male–female difference in business ownership in heavily exposed areas than in non-exposed areas. The exposure-by-young cohort interaction is positive in the years 1–10 follow-ups, implying that younger cohorts account for a relatively larger share of business owners in exposed areas during the recovery period than would be predicted by the relationship in non-exposed areas; by year 15, this interaction attenuates and changes sign. The exposure-by-older cohort interaction is negative in later waves, consistent with a relative decline in business ownership among older individuals in exposed areas compared with non-exposed areas. Taken together, Table 3 suggests that, beyond the sectoral shifts documented in Section IV, the post-tsunami evolution of entrepreneurship is accompanied by meaningful changes in the age and gender composition of business owners in exposed locations, particularly in the medium run.

As shown in Appendix Table A4, exposure is associated with lower agricultural business ownership in every post-tsunami wave, with particularly large negative coefficients in the medium run. The interaction terms suggest that the remaining agricultural entrepreneurs in exposed areas are drawn from groups that are less represented among agricultural owners in non-exposed areas. For example, the exposure-by-male interaction is negative throughout, consistent with a smaller gender gap in agricultural entrepreneurship within exposed areas. The exposure-by-young cohort interaction is positive across post-tsunami waves, indicating that younger cohorts comprise a relatively larger share of agricultural business owners in exposed areas than in comparison areas, even as overall agricultural ownership remains depressed.

Analogous results for non-agricultural business ownership are in Appendix Table 5. Consistent with Figure 2, the exposure coefficient is small or negative in the baseline and early

post-tsunami waves but becomes positive in later waves (particularly in years 5 and 15), indicating that non-agricultural entrepreneurship is relatively more prevalent in exposed locations conditional on baseline covariates and geography. The interaction terms are generally less pronounced than in agriculture, but the evidence is consistent with shifting selection into non-agricultural activities in exposed areas over time. Notably, baseline consumption per capita is positively associated with non-agricultural ownership in most waves, and the exposure-by-consumption interaction is close to zero, suggesting that the relative shift toward non-agricultural enterprise in exposed areas is not confined to higher-consumption households.

Finally, Appendix Table A6 repeats the exercise for wage labor. Two features stand out. First, the baseline correlates of wage labor differ sharply from those of business ownership: wage labor is strongly increasing in education and is more prevalent among urban residents and married individuals. Second, the exposure coefficients are negative and large in each post-tsunami wave, indicating substantially lower wage-labor incidence in heavily exposed areas conditional on baseline characteristics and geography. This pattern suggests that the post-tsunami adjustment documented in Section IV occurs in a broader labor market environment in which wage opportunities remain weaker in heavily damaged areas, which contributes to both entry into non-agricultural self-employment and changes in the composition of entrepreneurs observed over time.

We next use the panel structure of STAR to characterize business ownership trajectories and investigate whether the wave-by-wave compositional differences primarily reflect short-run entry/exit or sustained re-sorting across sectors. Table 4 summarizes the evidence using linear probability models classifying individuals into four mutually-exclusive business ownership trajectories and restricting the sample to respondents observed in every survey wave.[12] Column 1 defines "never business owner" as those never operating a business in any wave. Column 2 defines "short-term business owner" as those operating a business at least once but never in

[12] The linear probability specification is chosen for simplicity of interpretation of the estimates; none of our conclusions is different with a multinomial logit specification. Attention is restricted to the balanced panel so that long-term entrepreneurs are identifiable and so that sample composition changes do not complicate interpretation of the empirical patterns. The subgroup of respondents that were interviewed in every wave may be selected compared to the respondents in the analysis sample used elsewhere. Figure A2 reports the main exposure effects on the sample of respondents interviewed in every wave, and Table A7 performs the business ownership trajectory analysis from Table 4 but using all respondents. We include a control for "respondent interviewed in every wave" (as well as its interaction with tsunami exposure) and find similar results. Respondents interviewed in every wave are more likely to be consistent or switching business owners and less likely to be never business owners.

consecutive waves. Column 3 defines "consistent business owner" as operating the same type of business (agricultural or non-agricultural) for at least six consecutive years.[13] Column 4 defines "switching business owner" as operating a business for at least two consecutive waves but not maintaining the same type for at least six consecutive years. We then relate these trajectory indicators to baseline characteristics, heavy exposure, and their interactions, controlling for pre-tsunami *kecamatan* fixed effects and quadratics in elevation and distance to the coastline.

Four patterns are important. First, entrepreneurship over the 15-year horizon is widespread but often not persistent. In the balanced panel, one-third of respondents never operate a business, while two-thirds operate a business at least once; among those who ever operate a business, short-lived and switching patterns are common (23% and 27% of respondents, respectively), and only 18% qualify as consistent owners by the six-year definition.

Second, trajectory patterns differ sharply by exposure. Exposure is associated with a large reduction in the probability of never operating a business and a corresponding increase in short-term business ownership. By contrast, exposure is not strongly related to consistent or switching ownership trajectories. Post-tsunami entrepreneurship response in exposed areas is driven primarily by short-term business ownership rather than by an increase in long-duration ownership of a stable business type. This pattern of the exposed being more likely to enter and exit ownership is consistent with a temporary rise in necessity-driven business entry as wage-labor opportunities contracted after the tsunami, as well as with evidence of increased risk-taking among survivors exposed to the tsunami (Ingwersen et al. 2023).

Third, trajectory types are systematically related to baseline characteristics. Men are substantially less likely to be never owners and more likely to be consistent or switching owners. Married men are much less likely to be consistent owners than non-married men, and much more likely to be short-term business owners. Younger cohorts are more likely to never own a business and less likely to be consistent or switching owners. Urban residents are more likely to never own a business and less likely to exhibit persistent or switching ownership, consistent with entrepreneurship being relatively more rural in this setting.

Fourth, the interaction terms provide suggestive evidence on which baseline groups most account for the exposure-related shift from "never" to episodic business ownership. The

[13] 6 years was chosen for the threshold as this requires that a respondent operates a given type of business in, for example, all of the 5-, 10-, and 15- year follow-ups.

exposure-by-log(PCE) interaction is positive in Column 1 and negative in Column 2, indicating that the decline in "never ownership" and corresponding rise in short-term ownership in exposed areas is disproportionately concentrated among lower-resource households. Age interactions point in the same direction: for young cohorts, the exposure interaction is positive for never owning a business and being a consistent business owner, but negative for short-term ownership: consistent with relatively muted episodic entry among younger cohorts in exposed areas. For older cohorts, the exposure interaction is positive for never ownership and negative for consistent ownership, suggesting that exposure-related entrepreneurship among older individuals is less likely to take the form of sustained ownership of a stable business type. By contrast, interactions with gender, education, marital status, and urban residence are generally small relative to the main exposure effects, indicating that the primary compositional changes in trajectories operate along baseline resources and cohort.

Overall, the trajectory evidence reinforces the wave-by-wave results: post-tsunami entrepreneurship in exposed areas is characterized by greater episodic entry rather than greater persistence in business ownership. The next subsection therefore turns to treatment-effect heterogeneity in the event-study framework, estimating exposure effects by pre-tsunami subgroups to assess where the sustained business losses as well as long-run profit and capital damage are concentrated.

V.C. Heterogeneity in Exposure Effects

Heterogeneous effects are of interest both because the entrepreneurship literature often finds differential responses by gender, education, and baseline resources,[14] and because the tsunami's damages were spatially concentrated in ways that plausibly interact with pre-existing livelihoods (e.g., rural agricultural production versus urban non-farm enterprise). We re-estimate

[14] Fafchamps et al. (2011) find that the effect of receiving in-kind services (i.e. offered machinery or equipment for their business) or cash grants differs between males and females. An RCT by Field et al. (2016) showed that a lack of female peers may contribute to a documented gender gap in entrepreneurial success. McKenzie and Woodruff (2015) showed that the profit and productivity of smaller firms are related to the education levels of the entrepreneurs.

model (1) separately within baseline subgroups, where subgroup definitions are fixed based on pre-tsunami characteristics.[15]

Urban versus Rural

Figure 4 reports estimates stratified by baseline urbanicity. The recovery in overall business ownership is markedly faster in urban areas than in rural areas. Individuals from heavily damaged urban areas recover the initial decline in business ownership within roughly two years, whereas business ownership among rural residents from heavily damaged areas remains substantially depressed through the ten-year follow-up.

As shown in Panels B and C, the rural deficit is largely driven by the fact that agricultural businesses are dominant in rural areas. Relative to rural comparisons, heavily exposed rural residents experience declines in agricultural business ownership on the order of 6 to 12 percentage points in the mid-run (years 3 through 10), with substantial attenuation by year 15. In urban areas, agricultural ownership also declines, but the magnitude is smaller throughout the panel. For non-agricultural ownership, heavily exposed urban residents recover quickly and, in later waves, exhibit point estimates that are positive, while rural residents exhibit little medium-run change in non-agricultural ownership and a larger decline around the ten-year follow-up.

Panels D and E further show that profit and asset outcomes differ by baseline urbanicity. Profit losses are substantially smaller in urban areas, while rural areas experience large and enduring declines. The partial profit recovery in urban areas appears to be driven by non-agricultural enterprises; agricultural profits remain depressed even in urban settings. Differences in business capital do not fully account for the divergence. Panel E shows large and persistent collapses in business assets in both urban and rural areas, with only modest and statistically imprecise differences between the two. Taken together, the urban-rural splits suggest that differential recovery operates primarily through the non-agricultural margin—activities that are more prevalent in urban areas and typically less dependent on land and agricultural inputs—rather than through a rebuilding of business capital.

[15] All characteristics investigated in these heterogeneity analyses are measured at the pre-tsunami baseline to avoid potential confounding related to behavioral choices after the tsunami. This is particularly important for the location of residence (because of displacement and migration) and consumption.

Household Resources at Baseline

Figure A4 examines heterogeneity by pre-tsunami household resources, measured by baseline per-capita expenditures (PCE). PCE is a standard proxy for longer-run resource availability. We estimate Equation (1) separately by baseline PCE quintile.

Panel A shows that individuals in the highest baseline PCE quintile experience smaller and often statistically insignificant effects on overall business ownership, particularly beyond the immediate post-tsunami year. Panels B and C indicate that this pattern is driven primarily by non-agricultural activity. High-PCE individuals experience negative exposure effects on agricultural business ownership that are similar in direction and timing to other quintiles through the ten-year horizon, but exhibit positive (though often imprecisely estimated) effects on non-agricultural ownership. Panel D shows that profit effects display a comparable pattern: for the highest PCE quintile, profit losses are concentrated in the earliest wave and do not persist as strongly through the medium run, consistent with greater adjustment into non-agricultural enterprises. Panel E reports effects on business assets; point estimates suggest smaller asset losses for the highest-PCE group, although differences across quintiles are generally not precisely estimated.

Education, Gender, and Birth Cohort

Figures A5 through A7 provide additional stratifications by baseline education, gender, and birth cohort. The patterns are suggestive rather than definitive given reduced precision within subgroups. Figure A5 indicates weaker ownership responses among less educated respondents, while higher-educated respondents exhibit relatively smaller profit and asset losses. Figure A6 suggests that women experience smaller exposure effects on ownership and profits, while asset losses are comparable by gender. Figure A7 shows weaker exposure effects on ownership and assets for younger cohorts, with less evidence of systematic differences in profit effects across cohorts.

Post-Tsunami Displacement

We next examine heterogeneity in exposure effects by post-tsunami displacement. The analysis examines respondents interviewed in the 1-year follow-up comparing those who were displaced with those who continuously lived in the same house as prior to the tsunami. Since

displacement is endogenous—individuals may differ in their willingness or ability to move after a major shock, and those differences may be correlated with unobserved determinants of entrepreneurship—we interpret this evidence as descriptive.

Figure A8 reports the results. Effects on business ownership are generally modest for the non-displaced, while displaced survivors exhibit larger short-run declines in participation. Both groups experience declines in agricultural business ownership, but non-displaced respondents appear better able to substitute toward non-agricultural business ownership in the years following the disaster. Differences are sharper on intensive margins: displaced survivors experience substantially larger and more persistent losses in real profits and business assets, with large negative effects still evident 10–15 years after the tsunami. These results underscore the importance of tracking movers when assessing long-run impacts of exposure to a disaster on entrepreneurial outcomes.

VI. Potential Mechanism: Role of Tsunami Reconstruction Aid

The tsunami destroyed both private assets and local infrastructure across Aceh and surrounding areas and was followed by a reconstruction effort that was unprecedented in scale. This section studies whether reconstruction assistance contributed to entrepreneurial recovery by focusing on housing assistance, the largest transfer of resources to households in the *Build Back Better* program. The empirical exercise is motivated by the possibility that resources may be invested in businesses or restoring housing and residential stability relaxes constraints on access to credit, time allocation, risk-taking, and local economic participation.

VI.A. Empirical Strategy for Estimating Aid Effects

We estimate the dynamic effects of reconstruction assistance on entrepreneurial outcomes using a staggered-adoption event-study design centered on the timing of housing aid receipt. Two features of the setting motivate this approach. First, aid receipt and its timing may be endogenous. Housing assistance was targeted toward heavily damaged locations, and unobserved post-tsunami conditions correlated with damage and recovery—such as local leadership, political connections, or local economic potential—may also affect entrepreneurial outcomes. Second, treatment adoption is staggered and treatment effects may be heterogeneous, so conventional two-way fixed effects estimators can be biased even under parallel trends (de Chaisemartin and

D'Haultfoeuille 2022; de Chaisemartin and D'Haultfœuille 2020; Goodman-Bacon 2021; Sun and Abraham 2021).

To address these concerns, we employ a staggered-adoption event-study estimator that is robust to treatment effect heterogeneity. Housing support was distributed equitably to those whose homes had been impacted by the tsunami. Specifically, households whose homes had been destroyed received a standard unit, which was typically a single-story 36m^2 home; households whose homes had been damaged received money and/or materials to repair the home (Laurito et al. 2022). Importantly, reconstruction aimed to rebuild in the same location as the pre-tsunami residence whenever feasible and required proof of home ownership in that location at the time of the tsunami, which limits scope for relocating in order to obtain housing assistance. Land-titling constraints were central. The Reconstruction of Aceh Land Administration, introduced in 2005, provided a framework for verifying land titles and resolving disputes, reducing non-compliance with the rebuilding-in-place policy (Nazara and Resosudarmo 2007; Frankenberg et al. 2012).

Because housing aid is concentrated in damaged areas, we restrict the analysis sample to individuals from baseline *kecamatan* in which at least one community experienced heavy tsunami damage which makes the treated and comparison households in these analyses even more similar. We further restrict to the post-tsunami period and include individual fixed effects, so identification comes from within-person changes around the timing of first reported housing-aid receipt. Under these restrictions, remaining variation is the relative timing of receipt among individuals in damaged regions, after absorbing time-invariant determinants of both aid receipt and entrepreneurship (including baseline exposure severity, eligibility driven by housing damage, baseline resources, and persistent local conditions).

Formally, we estimate event-time effects using:

$$y_{it} = \sum_{k} \delta_k \, \mathbb{1}[t - Aid_i = k] + \lambda_i + \xi_t + u_{it} \qquad [3]$$

where Aid_i is the first wave in which individual i reports receiving housing assistance and $\mathbb{1}[t - Aid_i = k]$ indexes event time relative to first receipt. We implement the Callaway and Sant'Anna (2021) estimator (as operationalized in Rios-Avila et al. (2021)), which identifies cohort- and event-time-specific average treatment effects using not-yet-treated and never-treated observations as comparisons.

In the restricted sample, 35% of individuals report receiving housing aid. Among recipients, 55% receive aid by the second post-tsunami wave, with the remainder receiving aid between the third and fifth post-disaster years. Figure A9 shows that broad public aid receipt is strongly correlated with observables (e.g., gender, education, rural residence, baseline resources, and baseline entrepreneurship), whereas these correlates are materially weaker for housing aid, consistent with housing assistance being less individually targeted than other transfers. In addition, Table A8 shows that a substantial share (43%) of the variation in housing aid receipt is explained by baseline community-by-wave variation, consistent with disbursement being concentrated at the community level and plausibly shaped by administrative and logistical constraints.

The identifying assumption is that, conditional on individual fixed effects, survey-wave fixed effects, and the sample restrictions above, potential outcomes for individuals treated in different waves would have evolved similarly in the absence of treatment. We interpret this assumption as most plausible if residual variation in timing reflects administrative frictions—coordination across a large number of donor organizations and delays from land-titling and reconstruction logistics—rather than differential trajectories in entrepreneurial potential.

VI.B. Housing Aid Results

Figure 5 and Table A9 report the estimated event-time effects δ_k for the five entrepreneurial outcomes. The estimates compare treated individuals at a given event time to individuals who have not yet received housing aid or who never receive housing aid.

Panel A shows small and imprecise effects on overall business ownership in the short run. Point estimates become positive in later event times, with an estimated long-run increase of roughly 2.0 percentage points (7%), though the long-run estimate is not statistically distinguishable from zero.

Panels B and C reveal sectoral differences. Housing aid is associated with increases in non-agricultural business ownership in the short-term: estimated effects range from 1.5 to 2.6 percentage points (10–17%) in the years following receipt. These gains attenuate in later waves. Agricultural business ownership exhibits a different profile: point estimates are initially negative but rise over time, becoming positive in the longer run (about 2.4 percentage points, 14%). Taken together, the results are consistent with housing assistance facilitating near-term

adjustment into non-agricultural enterprises and supporting longer-run re-entry into agriculture as local conditions stabilize.

Panel D reports effects on real business profits. Consistent with the ownership patterns, housing aid increases profits substantially in the short and medium term (12.1 to 35.0 log point, 13–42 percent), with a positive long-run effect of roughly 19 percent. Panel E shows that these profit gains are not accompanied by increases in business asset holdings; the estimated effects on real business value are negative. A natural interpretation is that housing assistance improves operating conditions and household stability—supporting entry into less capital-intensive activities and raising profitability—rather than directly financing business capital accumulation.[16] This interpretation is consistent with evidence that housing aid improved psychological well-being among recipients (Laurito et al. 2022).

The event-study profiles display negative pre-treatment coefficients for several outcomes. In this setting, "pre-treatment" periods tend to be closer to the immediate post-tsunami years, when exposed households exhibited particularly depressed outcomes. These pre-treatment coefficients likely reflect that earlier event times coincide with the immediate post-tsunami period, when outcomes were particularly depressed among households that later received housing aid. As an additional check, Figure A10 repeats the analysis restricting the sample to eventual recipients, so identification comes solely from timing differences among treated individuals; profit results are similar in direction but less precise, and long-run effects are not identified in that design.

Overall, the housing-aid analysis suggests that reconstruction assistance supported entrepreneurial recovery primarily by increasing non-agricultural business ownership and profits, without rebuilding business capital. The evidence is consistent with housing assistance operating as a stabilizing wealth-and-livelihood shock—facilitating adjustment into less capital-intensive enterprises and improving the profitability of surviving businesses—rather than as a direct mechanism for capital reconstruction.

VII. Conclusion

[16] In the 10-year follow-up, we asked respondents whether there were additional types of assistance they had not received that would have made recovery easier. More than three-quarters reported that no additional assistance was needed. Among those who answered yes, the most commonly cited needs were housing assistance or—among those who had already received housing—business capital or employment opportunities.

Entrepreneurial activity is a key component of household livelihoods in low- and middle-income countries. Relatively little is known about how microenterprises respond to large-scale negative shocks that destroy livelihoods, disrupt markets, and alter local economic conditions. This research contributes to filling that gap by studying the effects of the 2004 Indian Ocean tsunami on entrepreneurship in Aceh and North Sumatra, Indonesia. The tsunami was unanticipated and exposure varied substantially across nearby coastal communities. Combined with a pre-tsunami baseline and fifteen years of follow-up in the population-representative STAR panel, we estimate dynamic causal effects of disaster exposure on entrepreneurial outcomes.

We document large short-run declines in business ownership, profits, and business capital among individuals from heavily damaged areas, and show that recovery differs both across the business outcomes and sectors. Overall business ownership falls substantially in the year after the tsunami and remains depressed through the ten-year horizon, but converges toward the comparison group by year 15. This convergence masks pronounced sectoral divergence: non-agricultural business ownership rebounds quickly after the initial shock, while agricultural entrepreneurship experiences much larger immediate losses and remains persistently lower for at least a decade, with a meaningful deficit still evident fifteen years after the tsunami. These long-run impacts are concentrated in rural areas and are consistent with sustained reduction in the productivity of agricultural land, including salinization from seawater inundation. Consistent with these dynamics, entrepreneurship in exposed areas during recovery is characterized by increased episodic entry—short-term transitions into and out of business ownership—rather than a sustained rise in persistent business operation.

A central finding is that participation and performance do not recover in tandem. Even as business ownership converges in the long run, exposed households experience sustained shortfalls in real profits and especially business assets. These deficits persist even when conditioning on continued business operation or positive assets, indicating that the long-run effects are not driven solely by extensive-margin exit. The evidence is consistent with post-disaster adjustment into lower-capital activity rather than a full restoration of pre-tsunami enterprise scale.

We also examine how entrepreneurship evolves around the staggered rollout of housing reconstruction under the *Build Back Better* program. In this complementary analysis, housing assistance led to increased non-agricultural business ownership in the short- and medium-term,

increased agricultural businesses in the long-term, and higher real profits, with little evidence of rebuilding business capital—suggesting that reconstruction may support re-entry and stabilization while leaving enterprise capital constraints largely unresolved.

The results highlight that post-tsunami recovery was substantially different for enterprise participation, enterprise performance, and sectoral composition. Policies that improve living conditions and relax short-run constraints may support re-entry into self-employment, but restoring profitability and rebuilding capital—particularly in land-dependent rural economies—may require more direct attention to productive assets and sector-specific constraints.

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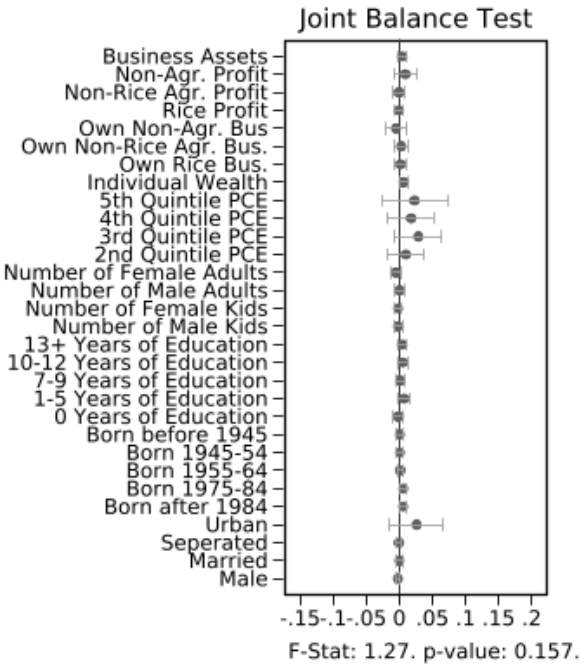
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Table 1: Pre-Tsunami Baseline Summary Statistics

	All	By Business Owner	
		Owner	Not Owner
Individual Characteristics			
Male	0.49	0.83	0.38
Age (years)	35.66	43.73	33.14
Years of Education	8.18	7.53	8.38
Married	0.34	0.07	0.43
Urban	0.29	0.21	0.31
Number of Males in Household 15+	1.81	1.50	1.91
Number of Females in Household 15+	1.90	1.62	1.99
Number of Children 0-14 in Household	1.52	1.58	1.50
Real Monthly Per-Capita Expenditure ('000s Rp)	417	401	422
Individual Real Wealth ('000s Rp)	27,519	33,546	25,636
Business Outcomes			
Household Operates Business?	0.24	1.00	0.00
Rice Business	0.10	0.43	
Non-Rice Agriculture Business	0.10	0.44	
Non-Agriculture Business	0.09	0.38	
Real Household Business Profits ('000s Rp)	1,554	6,516	
Rice Business	119	498	
Non-Rice Agriculture Business	424	1,776	
Non-Agriculture Business	1,244	5,213	
Real Household Business Assets ('000s Rp)	7,018	9,262	6,316
Tsunami Exposure			
Mortality (fraction respondents died in tsunami)	0.07		
Tsunami-Related Injury? (Among survivors)	0.02		
Tsunami Damaged Home?	0.39	0.45	0.37
Heavy Tsunami Exposure	0.21	0.19	0.21
Number of Respondents	15,734	3,780	11,954
Fraction of respondents		0.24	0.76

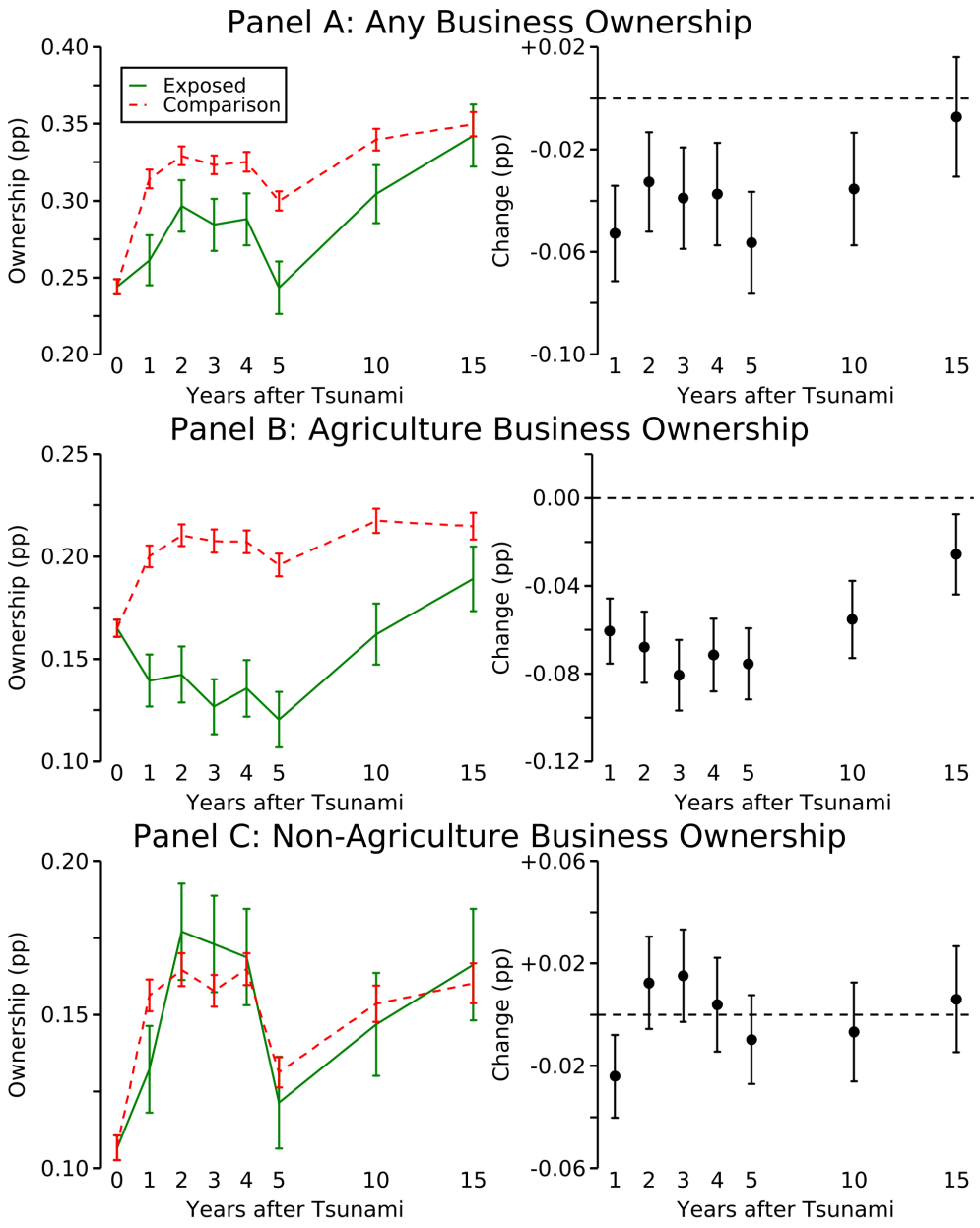
Notes. Column 1 reports averages over the full analysis sample, while Columns 2 and 3 partition based on whether the respondent was a business owner in the pre-tsunami baseline wave. The analysis sample is limited to baseline respondents age >15y at the tsunami who were interviewed at least once post-tsunami. Tsunami mortality and injury rate are estimated using the full set of 2004 SUSENAS respondents (injury rate is limited to survivors); home damages and heavy tsunami exposure are estimated using the analysis sample. Sample weights from the 2004 SUSENAS are used.

Figure 1: Balance Test



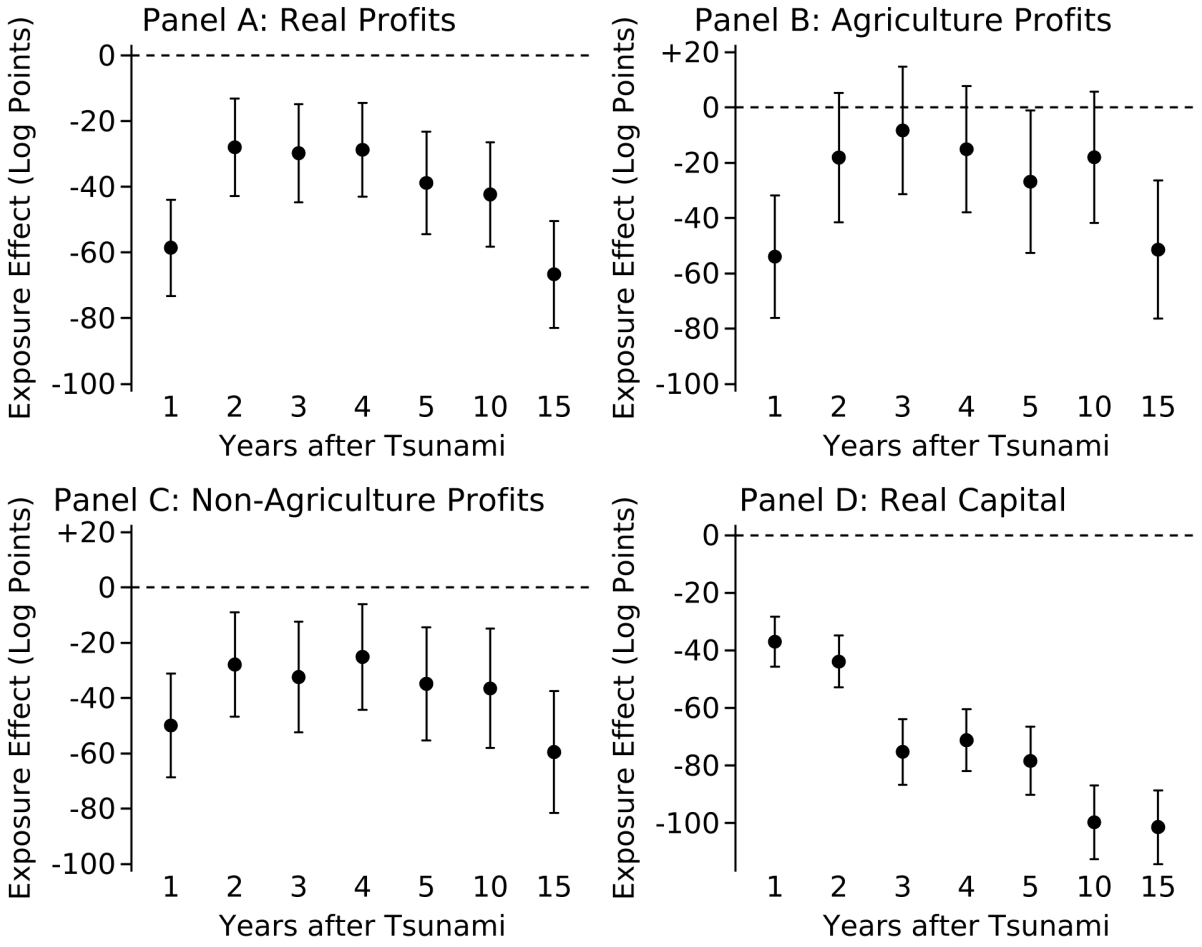
Notes. This figure reports the coefficient estimates of regressing an indicator for exposure to heavy tsunami damage T_i on a flexible set of pre-tsunami baseline descriptive features and business outcomes. All covariates are standardized. Point estimates and 95% confidence intervals are displayed. The geographical controls are pre-tsunami *kecamatan* fixed effects, elevation (quadratic), and distance to coastline (quadratic). The F-statistic of the hypothesis tests that all coefficients on the set of pre-tsunami baseline descriptive features and business outcomes are jointly zero is listed below the figure with the associated p-value. $\ln(x+1)$ transformations are taken of all continuously distributed covariates prior to normalization. Standard errors are clustered at the enumeration area level.

Figure 2: Business Ownership Trajectories and Exposure Effects



Notes. This figure reports the trajectories by damage exposure level and estimated exposure effects, β_t, in each post-tsunami STAR wave across the business ownership outcomes. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level.

Figure 3: Exposure Effects on Profits and Assets



Notes. This figure reports the estimated exposure effects, β_t, in each post-tsunami STAR wave across the profit and asset outcomes. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects. Logarithm transformations are performed on all outcomes, after deflating to real values using the local price index series, so effects represent log point declines. Standard errors are clustered at the individual level.

Table 2: Demographic Correlates with Business Owners and Wage Laborers Prior to Tsunami

	(1)	(2)	(3)	(4)	(5)	(6)
			Agri.	Type of Agri. Business		Non-Agri.
	Business Owner	Wage Laborer	Business Owner	Rice	Other	Business Owner
Male	0.507	0.144	0.358	0.223	0.228	0.215
	(0.012)	(0.011)	(0.014)	(0.013)	(0.012)	(0.010)
Born after 1979 [Rel. to 1965-79]	-0.095	-0.115	-0.059	-0.034	-0.039	-0.042
	(0.008)	(0.011)	(0.007)	(0.005)	(0.005)	(0.006)
Born before 1965 [Rel. to 1965-80]	0.048	-0.000	0.031	0.024	0.017	0.019
	(0.008)	(0.008)	(0.008)	(0.007)	(0.006)	(0.007)
0-6 Years of Educ. [Rel. to 7-9]	0.008	-0.038	0.020	0.020	0.003	-0.014
	(0.008)	(0.008)	(0.007)	(0.007)	(0.006)	(0.006)
10+ Years of Educ. [Rel. to 7-9]	-0.035	0.145	-0.019	-0.013	-0.015	-0.021
	(0.007)	(0.010)	(0.007)	(0.005)	(0.005)	(0.006)
Married	0.041	0.039	0.035	0.024	0.025	0.009
	(0.008)	(0.010)	(0.007)	(0.005)	(0.006)	(0.006)
Male X Married	-0.470	-0.064	-0.334	-0.209	-0.213	-0.202
	(0.013)	(0.012)	(0.015)	(0.013)	(0.012)	(0.011)
Urban	-0.043	0.048	-0.099	-0.053	-0.067	0.044
	(0.011)	(0.017)	(0.012)	(0.012)	(0.011)	(0.011)
Log Real PCE	0.026	0.010	-0.001	-0.005	0.000	0.029
	(0.006)	(0.009)	(0.006)	(0.005)	(0.005)	(0.006)
Tsunami Exposure	0.028	-0.015	0.011	0.008	0.015	0.030
	(0.013)	(0.015)	(0.013)	(0.016)	(0.014)	(0.011)
Mean of Outcome	0.240	0.142	0.161	0.101	0.100	0.106
Observations	15,734	15,734	15,734	15,734	15,734	15,734
R-squared	0.383	0.187	0.315	0.225	0.227	0.161

Notes. This table displays regression correlates of business owner (by type) and wage laborers in the pre-tsunami baseline wave. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses. Note that the business types are not mutually exclusive; an adult may be an agriculture business owner as well as a non-agriculture business owner.

Table 3: Demographic Correlates with Business Owners by Exposure over Time

	(1)	(2)	(3)	(4)	(5)	(6)
			Post-Tsunami Follow-Up Year			
	Prior	1 Year	2 Years	5 Years	10 Years	15 Years
Male	0.501	0.449	0.460	0.408	0.389	0.358
	(0.014)	(0.013)	(0.014)	(0.015)	(0.015)	(0.016)
Born after 1979 [Rel. to 1965-79]	-0.095	-0.159	-0.176	-0.181	-0.154	-0.108
	(0.009)	(0.011)	(0.012)	(0.012)	(0.013)	(0.013)
Born before 1965 [Rel. to 1965-80]	0.056	0.011	0.015	0.009	-0.030	-0.044
	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)	(0.012)
0-6 Years of Educ. [Rel. to 7-9]	0.011	0.004	0.011	-0.010	-0.027	-0.016
	(0.008)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)
10+ Years of Educ. [Rel. to 7-9]	-0.035	-0.020	-0.011	-0.017	-0.017	-0.016
	(0.008)	(0.010)	(0.011)	(0.011)	(0.012)	(0.012)
Married	0.043	0.021	0.038	0.041	0.012	0.004
	(0.009)	(0.013)	(0.013)	(0.013)	(0.013)	(0.015)
Male X Married	-0.467	-0.380	-0.375	-0.277	-0.167	-0.122
	(0.014)	(0.016)	(0.017)	(0.017)	(0.016)	(0.018)
Urban	-0.031	-0.064	-0.064	-0.067	-0.081	-0.077
	(0.012)	(0.014)	(0.015)	(0.014)	(0.016)	(0.017)
Log Real PCE	0.024	0.013	0.003	0.012	0.005	-0.003
	(0.006)	(0.008)	(0.008)	(0.008)	(0.009)	(0.011)
Tsunami Exposure	-0.001	0.028	0.030	0.226	0.011	0.077
	(0.105)	(0.110)	(0.111)	(0.112)	(0.131)	(0.146)
Exposure X Male	0.032	-0.121	-0.056	-0.029	-0.022	-0.047
	(0.031)	(0.027)	(0.027)	(0.030)	(0.035)	(0.036)
Exposure X Born after 1979	0.001	0.023	0.028	0.060	0.059	-0.031
[Rel. to Exposure X 1965-79]	(0.019)	(0.024)	(0.028)	(0.028)	(0.031)	(0.030)
Exposure X Born before 1965	-0.047	-0.004	-0.003	-0.057	-0.034	-0.071
[Rel. to Exposure X 1965-79]	(0.022)	(0.024)	(0.024)	(0.023)	(0.023)	(0.024)
Exposure X 0-6 Years of Educ.	-0.017	0.003	-0.029	0.020	0.037	0.037
[Rel. to Exposure X 7-9]	(0.020)	(0.024)	(0.023)	(0.027)	(0.025)	(0.028)
Exposure X 10+ Years of Educ.	-0.010	-0.007	-0.020	-0.013	-0.036	-0.031
[Rel. to Exposure X 7-9]	(0.019)	(0.021)	(0.023)	(0.026)	(0.027)	(0.027)
Exposure X Married	-0.010	-0.031	-0.035	-0.056	-0.054	0.016
	(0.021)	(0.028)	(0.031)	(0.028)	(0.035)	(0.036)
Exposure X Male X Married	-0.015	0.135	0.100	0.070	0.028	0.002
	(0.034)	(0.033)	(0.036)	(0.033)	(0.040)	(0.044)
Exposure X Urban	-0.048	-0.007	0.004	0.050	0.035	-0.028
	(0.026)	(0.029)	(0.027)	(0.027)	(0.034)	(0.031)
Exposure X Log Real PCE	0.010	0.008	0.004	-0.034	0.000	0.004
	(0.017)	(0.019)	(0.019)	(0.018)	(0.022)	(0.024)
Mean of Outcome	0.240	0.305	0.325	0.291	0.331	0.340
Observations	15,734	14,942	14,273	14,448	13,839	12,892
R-squared	0.384	0.274	0.276	0.237	0.197	0.170

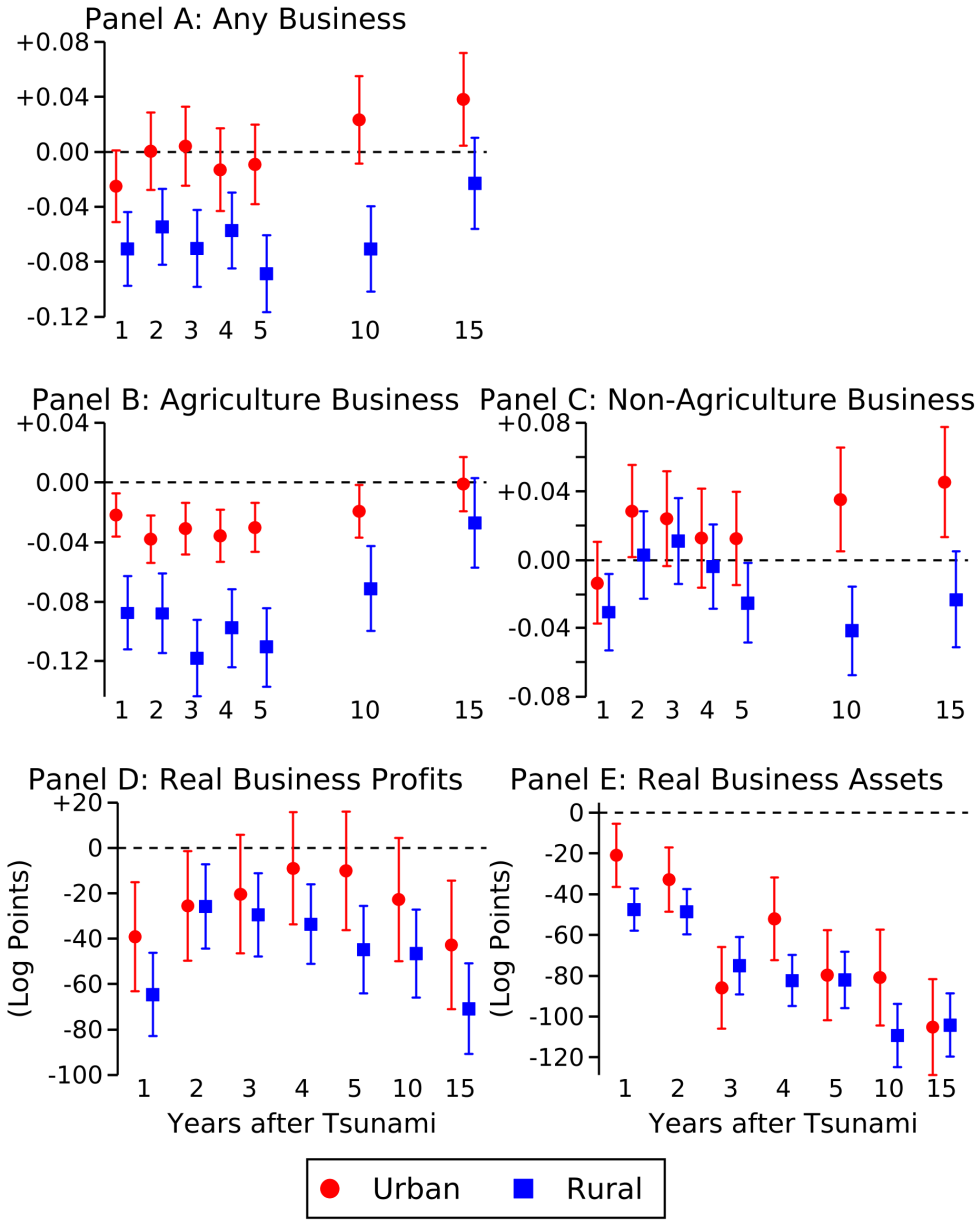
Notes. This table reports regression results for an indicator for being a business owner, separately by survey waves. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Table 4: Dynamics of Business Ownership

	(1) Never Business Owner	(2) Short-Term Business Owner	(3) Consistent Business Owner	(4) Switching Business Owner
Male	-0.359	-0.201	0.370	0.190
	(0.012)	(0.011)	(0.015)	(0.014)
Born after 1979 [Rel. to 1965-79]	0.200	0.017	-0.114	-0.103
	(0.015)	(0.014)	(0.010)	(0.014)
Born before 1965 [Rel. to 1965-80]	-0.035	-0.005	0.007	0.034
	(0.011)	(0.010)	(0.010)	(0.013)
0-6 Years of Educ. [Rel. to 7-9]	-0.009	0.009	-0.003	0.002
	(0.012)	(0.011)	(0.010)	(0.013)
10+ Years of Educ. [Rel. to 7-9]	0.000	0.016	-0.019	0.003
	(0.014)	(0.012)	(0.010)	(0.013)
Married	0.003	-0.015	0.049	-0.037
	(0.018)	(0.016)	(0.010)	(0.014)
Male X Married	0.061	0.230	-0.271	-0.020
	(0.021)	(0.021)	(0.017)	(0.021)
Urban	0.099	-0.001	-0.039	-0.059
	(0.020)	(0.016)	(0.015)	(0.017)
Log Real PCE	-0.014	-0.000	0.009	0.005
	(0.012)	(0.009)	(0.009)	(0.011)
Tsunami Exposure	-0.387	0.330	0.067	-0.010
	(0.148)	(0.138)	(0.125)	(0.131)
Exposure X Male	0.030	0.040	-0.056	-0.014
	(0.026)	(0.027)	(0.031)	(0.033)
Exposure X Born after 1979	0.031	-0.066	0.032	0.003
[Rel. to Exposure X 1965-79]	(0.036)	(0.033)	(0.023)	(0.033)
Exposure X Born before 1965	0.057	-0.019	-0.043	0.005
[Rel. to Exposure X 1965-79]	(0.026)	(0.024)	(0.027)	(0.031)
Exposure X 0-6 Years of Educ.	-0.025	0.018	0.022	-0.015
[Rel. to Exposure X 7-9]	(0.029)	(0.026)	(0.024)	(0.031)
Exposure X 10+ Years of Educ.	-0.002	0.009	0.005	-0.012
[Rel. to Exposure X 7-9]	(0.033)	(0.027)	(0.023)	(0.029)
Exposure X Married	0.032	0.030	-0.019	-0.043
	(0.045)	(0.048)	(0.025)	(0.040)
Exposure X Male X Married	-0.035	-0.052	0.056	0.031
	(0.047)	(0.047)	(0.033)	(0.048)
Exposure X Urban	-0.005	-0.003	0.013	-0.005
	(0.036)	(0.028)	(0.027)	(0.032)
Exposure X Log Real PCE	0.053	-0.057	-0.004	0.008
	(0.025)	(0.022)	(0.021)	(0.022)
Mean of Outcome	0.330	0.227	0.175	0.268
Observations	10,501	10,501	10,501	10,501
R-squared	0.227	0.064	0.237	0.089

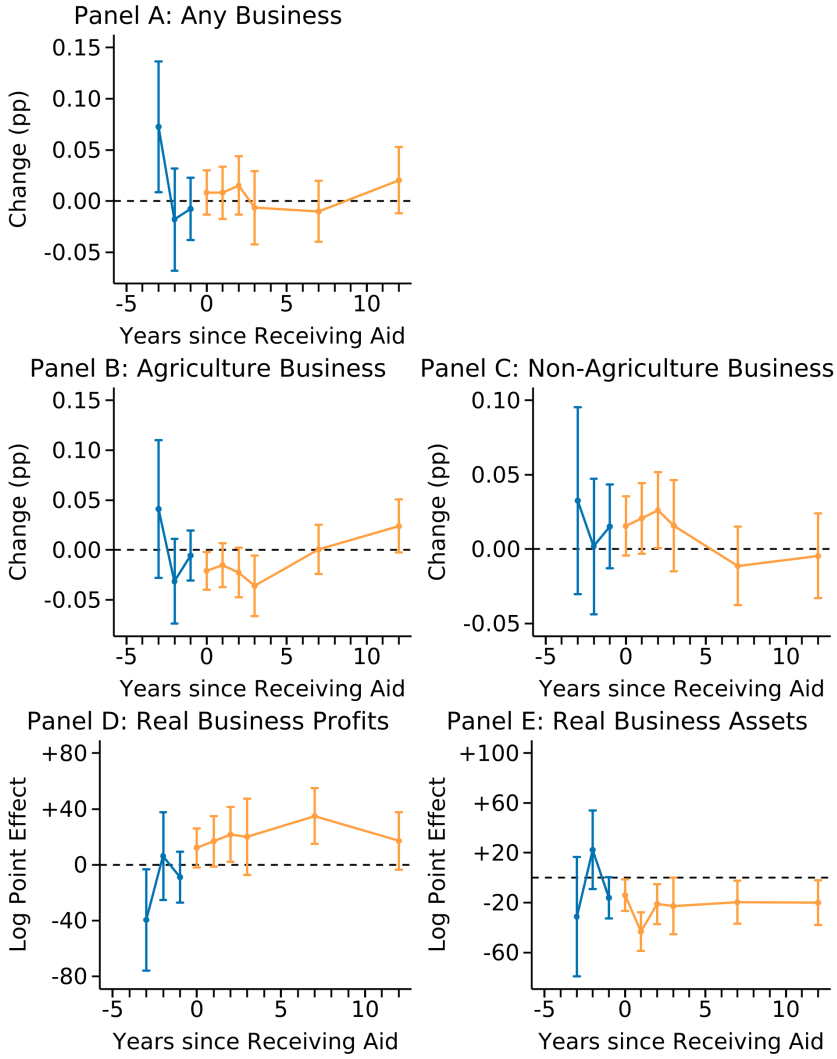
Notes. This table displays regression results for different dynamic measures of business ownership. The sample is limited to participants that were re-interviewed in every survey wave. The outcome of Column 1 is an indicator for never owning a business in any survey wave. The outcome of Column 2 is an indicator for having owned a business at some point, but never for longer than 1 consecutive wave. The outcome of Column 3 is an indicator for participants that owned the same type (agriculture or non-agriculture) business for at least 6 consecutive years. The outcome of Column 4 is an indicator for participants that were overall business owners for at least 2 consecutive waves, but never owned the same type of business for at least 6 consecutive years. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Figure 4: Tsunami Exposure Effects across Urbanicity



Notes. Results from estimating the coefficients β_t in Equation 1 separately for those from rural or urban areas in the pre-tsunami baseline wave. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level. Panel D and E use log of real profit and business asset values, conditional on owning any business (in Panel D) or having non-zero business assets (Panel E).

Figure 5: Effect of Receiving Housing Aid on Entrepreneurial Outcomes



Notes. Estimates of δ_k, the effect of housing aid on entrepreneurial outcomes across pre- and post-treatment periods. Period 0 is the first period in which the individual received housing aid. Point estimates and 95% confidence intervals are displayed. ATTs are estimated via an estimator proposed by Callaway and Sant'Anna (2021) that yields unbiased estimates accounting for individual and time fixed effects in the presence of heterogeneous treatment effects. Asymptotic standard errors are estimated using Influence Functions which account for clustering at the individual level. Logarithm transformation is applied to business profits and assets, after deflating to real values using the local price index series. The sample is limited to the set of individuals from *kecamatan* at the pre-tsunami baseline where at least one community faced heavy tsunami damage, and the time period is limited to post-tsunami waves.

Reconstruction following Destruction: Entrepreneurship in the Aftermath of a Natural Disaster

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Online Appendix

A. Supplemental Figures and Tables

Table A1: SUSENAS Pre-Exposure Effects

	2004 Coefficient	2003 Interaction	2002 Interaction
Male	0.002	-0.003	0.014
	(0.003)	(0.006)	(0.032)
Aged 0-14	0.006	-0.002	-0.070
	(0.008)	(0.017)	(0.064)
Aged 15-29	-0.016	0.014	0.021
	(0.009)	(0.010)	(0.047)
Aged 50+	-0.003	0.017	0.070
	(0.010)	(0.014)	(0.070)
Highest Education:	-0.024	0.023	0.090
None	(0.014)	(0.023)	(0.058)
Highest Education:	-0.015	0.138	0.089
Primary	(0.010)	(0.138)	(0.043)
Highest Education:	-0.002	0.012	0.052
Senior High	(0.016)	(0.020)	(0.032)
Highest Education:	-0.041	0.051	-0.023
Tertiary	(0.024)	(0.035)	(0.055)
Log PCE	0.038	-0.007	-0.008
	(0.018)	(0.003)	(0.006)
F-Statistic for all 2003 interactions: 1.26			
P-Value for all 2003 interactions: 0.258			
F-Statistic for all 2002 interactions: 1.33			
P-Value for all 2002 interactions: 0.221			
F-Statistic for all 2002 and 2003 interactions: 1.26			
P-Value for all 2002 and 2003 interactions: 0.209			
Observations: 29,581			
R-Squared: 0.752			

Notes. This table reports the regression results of testing for pre-trend differences in the areas damaged by the tsunami relative to those not damaged. The results of this table are from one regression: the first column reports non-interacted covariates, the second and third column interacts each covariate with an indicator for if this observation is from the 2003 or 2002 SUSENAS wave, respectively. The sample are SUSENAS respondents from Aceh in any of the 2002, 2003 and 2004 surveys, limited to the 11 *kabupaten* in Aceh used to construct the pre-tsunami STAR wave. Tests of the joint significance of all 2003 interactions, all 2002 interactions, and all 2002 and 2003 interactions, are reported in the bottom panel. In this sample, the exposure outcome is defined at the *desa* level using the 2005 Census; we define a *desa* as experiencing heavy tsunami damage if more than 4% of respondents in that *desa* during the tsunami report that a household member died from the tsunami. The regression include pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic) of the respondent's *desa*, and distance to the coastline (quadratic) of the respondent's desa. Standard errors are clustered at the *desa*-level.

Table A2: Exposure Effects on Business Ownership

	(1) Owns Bus.	(2) Owns Agr. Bus.	(3) Owns non-Agr. Bus.	(4) Owns Rice Bus.	(5) Owns non-Rice Agr. Bus.
Exposure Effects					
1 $Year\ X\ T_i$	-0.053	-0.061	-0.024	-0.058	-0.046
	(0.009)	(0.008)	(0.008)	(0.007)	(0.007)
2 $Years\ X\ T_i$	-0.033	-0.068	0.012	-0.064	-0.056
	(0.010)	(0.008)	(0.009)	(0.007)	(0.008)
3 $Years\ X\ T_i$	-0.039	-0.081	0.015	-0.064	-0.071
	(0.010)	(0.008)	(0.009)	(0.007)	(0.008)
4 $Years\ X\ T_i$	-0.037	-0.072	0.004	-0.048	-0.069
	(0.010)	(0.008)	(0.009)	(0.007)	(0.008)
5 $Years\ X\ T_i$	-0.056	-0.076	-0.010	-0.050	-0.065
	(0.010)	(0.008)	(0.009)	(0.007)	(0.008)
10 $Years\ X\ T_i$	-0.035	-0.055	-0.007	-0.019	-0.062
	(0.011)	(0.009)	(0.010)	(0.007)	(0.008)
15 $Years\ X\ T_i$	-0.007	-0.026	0.006	-0.002	-0.045
	(0.012)	(0.009)	(0.011)	(0.008)	(0.008)
Trajectories for Non-Exposed					
Constant (baseline)	0.244	0.165	0.107	0.104	0.102
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
1 $Year$	0.314	0.200	0.156	0.116	0.144
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
2 $Years$	0.329	0.210	0.165	0.120	0.157
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
3 $Years$	0.323	0.207	0.158	0.116	0.160
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
4 $Years$	0.325	0.207	0.165	0.082	0.177
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
5 $Years$	0.300	0.196	0.131	0.099	0.143
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
10 $Years$	0.340	0.217	0.154	0.101	0.166
	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)
15 $Years$	0.350	0.215	0.160	0.100	0.161
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	114,215	114,215	114,215	114,215	114,215
R-squared	0.524	0.522	0.446	0.460	0.485
Individuals	15,734	15,734	15,734	15,734	15,734

Notes. This table reports the trajectories by damage exposure level and estimated exposure effects, β_t, in each post-tsunami STAR wave across the business ownership outcomes. The exposure effects results report β_t in each post-tsunami STAR wave. The trajectories for non-exposed are the comparison trajectories, computed from the wave fixed effects. All regressions include individual and survey wave fixed effects. Standard errors clustered at the individual level.

Table A3: Exposure Effects on Business Profits and Capital

	(1) Log Real Profits	(2) Log Agri. Real Profits	(3) Log Non-Agri. Real Profits	(4) Log Real Assets
Exposure Effects				
1 $Year\ X\ T_i$	-0.585	-0.540	-0.499	-0.370
	(0.075)	(0.113)	(0.096)	(0.044)
2 $Years\ X\ T_i$	-0.279	-0.181	-0.279	-0.439
	(0.076)	(0.119)	(0.096)	(0.046)
3 $Years\ X\ T_i$	-0.297	-0.083	-0.324	-0.752
	(0.076)	(0.118)	(0.102)	(0.058)
4 $Years\ X\ T_i$	-0.287	-0.151	-0.251	-0.712
	(0.073)	(0.117)	(0.097)	(0.055)
5 $Years\ X\ T_i$	-0.388	-0.269	-0.348	-0.784
	(0.080)	(0.132)	(0.105)	(0.060)
10 $Years\ X\ T_i$	-0.423	-0.180	-0.365	-0.997
	(0.081)	(0.121)	(0.110)	(0.066)
15 $Years\ X\ T_i$	-0.666	-0.514	-0.595	-1.013
	(0.083)	(0.128)	(0.113)	(0.065)
Trajectories for Non-Exposed				
Constant (baseline)	8.151	7.505	8.789	7.614
	(0.021)	(0.027)	(0.031)	(0.012)
1 $Year$	8.274	7.650	8.771	6.913
	(0.019)	(0.024)	(0.029)	(0.017)
2 $Years$	8.296	7.696	8.786	7.116
	(0.020)	(0.024)	(0.030)	(0.016)
3 $Years$	8.291	7.722	8.769	7.244
	(0.020)	(0.024)	(0.032)	(0.018)
4 $Years$	8.299	7.694	8.753	7.293
	(0.020)	(0.024)	(0.030)	(0.019)
5 $Years$	8.133	7.665	8.553	7.528
	(0.021)	(0.026)	(0.033)	(0.019)
10 $Years$	8.283	7.752	8.742	7.772
	(0.023)	(0.028)	(0.037)	(0.021)
15 $Years$	8.598	8.140	8.971	8.016
	(0.023)	(0.029)	(0.039)	(0.024)
Observations	30,485	17,282	14,133	75,548
R-squared	0.552	0.523	0.605	0.524
Individuals	7,050	4,307	3,910	13,794

Notes. This table reports the trajectories by damage exposure level and estimated exposure effects, β_t, in each post-tsunami STAR wave across the business performance and capital outcomes. The exposure effects results report β_t in each post-tsunami STAR wave. The trajectories for non-exposed are the comparison trajectories, computed from the wave fixed effects. All regressions include individual and survey wave fixed effects. Standard errors clustered at the individual level.

Table A4: Demographic Correlates with Agriculture Business Owners by Exposure over Time

	(1)	(2)	(3)	(4)	(5)	(6)
			Post-Tsunami Follow-Up Year			
	Prior	1 Year	2 Years	5 Years	10 Years	15 Years
Male	0.360	0.328	0.348	0.296	0.362	0.330
	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)	(0.016)
Born after 1979 [Rel. to 1965-79]	-0.059	-0.101	-0.099	-0.101	-0.109	-0.075
	(0.007)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)
Born before 1965 [Rel. to 1965-80]	0.038	0.006	0.021	0.015	-0.004	-0.007
	(0.008)	(0.009)	(0.008)	(0.008)	(0.009)	(0.010)
0-6 Years of Educ. [Rel. to 7-9]	0.021	0.020	0.021	0.004	0.008	0.006
	(0.008)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)
10+ Years of Educ. [Rel. to 7-9]	-0.019	-0.009	-0.011	-0.012	-0.005	-0.014
	(0.007)	(0.009)	(0.009)	(0.008)	(0.009)	(0.010)
Married	0.034	0.034	0.039	0.020	0.042	0.017
	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Male X Married	-0.336	-0.279	-0.294	-0.204	-0.196	-0.148
	(0.016)	(0.017)	(0.018)	(0.016)	(0.016)	(0.016)
Urban	-0.090	-0.121	-0.106	-0.102	-0.110	-0.083
	(0.014)	(0.015)	(0.015)	(0.015)	(0.017)	(0.016)
Log Real PCE	-0.003	-0.005	-0.017	-0.014	-0.010	-0.020
	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)
Tsunami Exposure	-0.013	0.030	-0.057	-0.019	-0.099	-0.040
	(0.090)	(0.095)	(0.090)	(0.093)	(0.109)	(0.104)
Exposure X Male	-0.011	-0.135	-0.137	-0.100	-0.096	-0.068
	(0.037)	(0.029)	(0.030)	(0.029)	(0.033)	(0.032)
Exposure X Born after 1979	0.006	0.051	0.058	0.055	0.070	0.040
[Rel. to Exposure X 1965-79]	(0.015)	(0.020)	(0.020)	(0.021)	(0.020)	(0.021)
Exposure X Born before 1965	-0.037	0.004	0.002	-0.034	-0.014	-0.036
[Rel. to Exposure X 1965-79]	(0.019)	(0.018)	(0.018)	(0.019)	(0.020)	(0.022)
Exposure X 0-6 Years of Educ.	-0.012	0.001	-0.028	0.021	0.025	0.025
[Rel. to Exposure X 7-9]	(0.018)	(0.019)	(0.021)	(0.022)	(0.023)	(0.024)
Exposure X 10+ Years of Educ.	-0.004	-0.004	-0.015	0.003	-0.030	-0.009
[Rel. to Exposure X 7-9]	(0.016)	(0.016)	(0.018)	(0.019)	(0.021)	(0.021)
Exposure X Married	-0.001	0.000	-0.012	-0.008	-0.028	-0.021
	(0.018)	(0.022)	(0.022)	(0.019)	(0.022)	(0.025)
Exposure X Male X Married	0.011	0.143	0.140	0.078	0.048	0.006
	(0.038)	(0.030)	(0.032)	(0.027)	(0.034)	(0.033)
Exposure X Urban	-0.038	0.015	-0.007	0.031	0.004	-0.036
	(0.023)	(0.025)	(0.026)	(0.024)	(0.024)	(0.031)
Exposure X Log Real PCE	0.010	-0.002	0.014	0.000	0.015	0.013
	(0.014)	(0.016)	(0.015)	(0.015)	(0.017)	(0.017)
Mean of Outcome	0.161	0.188	0.199	0.183	0.206	0.204
Observations	15,734	14,942	14,273	14,448	13,839	12,892
R-squared	0.316	0.247	0.254	0.225	0.260	0.243

Notes. This table displays regression results on an indicator for being an agriculture business owner, separately by survey waves. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Table A5: Demographic Correlates with Non-Agriculture Business Owners by Exposure over Time

	(1)	(2)	(3)	(4)	(5)	(6)
			Post-Tsunami Follow-Up Year			
	Prior	1 Year	2 Years	5 Years	10 Years	15 Years
Male	0.198	0.193	0.188	0.153	0.078	0.058
	(0.010)	(0.012)	(0.011)	(0.010)	(0.010)	(0.010)
Born after 1979 [Rel. to 1965-79]	-0.041	-0.077	-0.091	-0.098	-0.052	-0.044
	(0.006)	(0.009)	(0.010)	(0.010)	(0.010)	(0.011)
Born before 1965 [Rel. to 1965-80]	0.020	-0.002	-0.004	-0.017	-0.040	-0.048
	(0.007)	(0.008)	(0.009)	(0.009)	(0.008)	(0.009)
0-6 Years of Educ. [Rel. to 7-9]	-0.013	-0.014	-0.021	-0.016	-0.034	-0.022
	(0.007)	(0.009)	(0.009)	(0.008)	(0.009)	(0.008)
10+ Years of Educ. [Rel. to 7-9]	-0.021	-0.008	-0.009	-0.006	-0.008	0.000
	(0.007)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)
Married	0.011	-0.011	-0.008	0.022	-0.034	-0.014
	(0.007)	(0.010)	(0.010)	(0.010)	(0.012)	(0.012)
Male X Married	-0.189	-0.168	-0.148	-0.108	-0.002	0.014
	(0.011)	(0.014)	(0.013)	(0.012)	(0.013)	(0.014)
Urban	0.057	0.033	0.020	0.027	0.020	0.001
	(0.012)	(0.013)	(0.014)	(0.013)	(0.014)	(0.015)
Log Real PCE	0.029	0.021	0.015	0.031	0.019	0.020
	(0.007)	(0.008)	(0.007)	(0.008)	(0.008)	(0.009)
Tsunami Exposure	-0.012	0.062	0.118	0.280	0.092	0.206
	(0.088)	(0.095)	(0.092)	(0.106)	(0.119)	(0.135)
Exposure X Male	0.095	-0.011	0.072	0.059	0.067	0.031
	(0.030)	(0.026)	(0.024)	(0.024)	(0.027)	(0.028)
Exposure X Born after 1979	-0.003	-0.025	-0.036	0.013	-0.010	-0.070
[Rel. to Exposure X 1965-79]	(0.016)	(0.018)	(0.024)	(0.025)	(0.025)	(0.028)
Exposure X Born before 1965	-0.010	-0.000	-0.005	-0.029	-0.021	-0.036
[Rel. to Exposure X 1965-79]	(0.019)	(0.020)	(0.023)	(0.023)	(0.021)	(0.024)
Exposure X 0-6 Years of Educ.	-0.009	-0.019	0.003	-0.005	0.003	-0.004
[Rel. to Exposure X 7-9]	(0.018)	(0.021)	(0.024)	(0.023)	(0.024)	(0.024)
Exposure X 10+ Years of Educ.	-0.005	-0.014	-0.009	-0.023	-0.024	-0.031
[Rel. to Exposure X 7-9]	(0.017)	(0.021)	(0.021)	(0.022)	(0.024)	(0.025)
Exposure X Married	-0.010	-0.027	-0.008	-0.053	-0.025	0.029
	(0.019)	(0.023)	(0.027)	(0.024)	(0.031)	(0.034)
Exposure X Male X Married	-0.071	0.019	-0.022	0.008	-0.013	-0.009
	(0.031)	(0.031)	(0.033)	(0.028)	(0.033)	(0.037)
Exposure X Urban	-0.050	-0.022	-0.001	0.014	0.012	-0.003
	(0.024)	(0.025)	(0.024)	(0.025)	(0.028)	(0.029)
Exposure X Log Real PCE	0.006	0.003	-0.011	-0.037	-0.010	-0.020
	(0.015)	(0.016)	(0.016)	(0.018)	(0.020)	(0.023)
Mean of Outcome	0.106	0.153	0.168	0.130	0.151	0.158
Observations	15,734	14,942	14,273	14,448	13,839	12,892
R-squared	0.164	0.117	0.114	0.093	0.051	0.039

Notes. This table displays regression results on an indicator for being a non-agriculture business owner, separately by survey waves. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Table A6: Demographic Correlates with Wage Laborer by Exposure over Time

	(1)	(2)	(3)	(4)	(5)	(6)
	Post-Tsunami Follow-Up Year					
	Prior	1 Year	2 Years	5 Years	10 Years	15 Years
Male	0.149	0.277	0.287	0.249	0.246	0.259
	(0.012)	(0.012)	(0.012)	(0.012)	(0.011)	(0.011)
Born after 1979 [Rel. to 1965-79]	-0.111	-0.143	-0.100	-0.035	0.025	0.013
	(0.012)	(0.013)	(0.012)	(0.014)	(0.015)	(0.014)
Born before 1965 [Rel. to 1965-80]	-0.005	-0.068	-0.081	-0.095	-0.133	-0.176
	(0.009)	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)
0-6 Years of Educ. [Rel. to 7-9]	-0.037	-0.026	-0.027	-0.026	-0.034	-0.032
	(0.009)	(0.010)	(0.011)	(0.011)	(0.011)	(0.012)
10+ Years of Educ. [Rel. to 7-9]	0.147	0.165	0.171	0.167	0.138	0.071
	(0.011)	(0.013)	(0.014)	(0.015)	(0.014)	(0.014)
Married	0.038	0.050	0.058	0.084	0.080	0.115
	(0.011)	(0.013)	(0.015)	(0.016)	(0.016)	(0.018)
Male X Married	-0.063	-0.063	-0.040	0.040	0.077	0.078
	(0.014)	(0.017)	(0.019)	(0.018)	(0.019)	(0.019)
Urban	0.044	0.036	0.038	0.067	0.051	0.048
	(0.020)	(0.021)	(0.020)	(0.020)	(0.020)	(0.018)
Log Real PCE	0.006	-0.031	-0.014	-0.011	-0.007	-0.002
	(0.010)	(0.011)	(0.011)	(0.011)	(0.010)	(0.012)
Tsunami Exposure	-0.135	-0.364	-0.177	-0.489	-0.405	-0.188
	(0.118)	(0.154)	(0.158)	(0.149)	(0.149)	(0.173)
Exposure X Male	-0.033	-0.003	0.001	-0.015	-0.023	-0.057
	(0.025)	(0.026)	(0.023)	(0.024)	(0.023)	(0.027)
Exposure X Born after 1979	-0.025	-0.053	-0.012	-0.011	-0.001	0.030
[Rel. to Exposure X 1965-79]	(0.028)	(0.032)	(0.037)	(0.033)	(0.036)	(0.034)
Exposure X Born before 1965	0.030	-0.014	-0.023	0.009	0.011	-0.033
[Rel. to Exposure X 1965-79]	(0.020)	(0.024)	(0.022)	(0.024)	(0.024)	(0.025)
Exposure X 0-6 Years of Educ.	-0.007	0.037	0.022	0.041	0.026	-0.026
[Rel. to Exposure X 7-9]	(0.017)	(0.029)	(0.025)	(0.025)	(0.026)	(0.029)
Exposure X 10+ Years of Educ.	-0.005	0.020	0.033	0.017	0.019	-0.007
[Rel. to Exposure X 7-9]	(0.024)	(0.027)	(0.026)	(0.027)	(0.034)	(0.030)
Exposure X Married	0.006	0.049	0.017	0.034	0.060	-0.018
	(0.028)	(0.030)	(0.038)	(0.039)	(0.039)	(0.043)
Exposure X Male X Married	0.002	-0.006	0.008	-0.045	-0.038	-0.002
	(0.029)	(0.039)	(0.037)	(0.036)	(0.038)	(0.041)
Exposure X Urban	0.015	-0.022	-0.055	-0.027	0.002	0.019
	(0.030)	(0.034)	(0.034)	(0.033)	(0.033)	(0.035)
Exposure X Log Real PCE	0.022	0.060	0.031	0.080	0.063	0.036
	(0.020)	(0.026)	(0.027)	(0.025)	(0.025)	(0.029)
Mean of Outcome	0.142	0.296	0.314	0.340	0.365	0.358
Observations	15,734	14,942	14,273	14,448	13,839	12,892
R-squared	0.188	0.178	0.190	0.196	0.221	0.239

Notes. This table displays regression results on an indicator for being a wage laborer, separately by survey waves. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Table A7: Full Sample, Dynamics of Business Ownership

	(1) Never Business Owner	(2) Short-Term Business Owner	(3) Consistent Business Owner	(4) Switching Business Owner
Male	-0.372	-0.156	0.309	0.220
	(0.011)	(0.010)	(0.012)	(0.011)
Born after 1979 [Rel. to 1965-79]	0.197	0.015	-0.111	-0.101
	(0.013)	(0.012)	(0.009)	(0.012)
Born before 1965 [Rel. to 1965-80]	-0.014	-0.003	-0.008	0.025
	(0.010)	(0.009)	(0.009)	(0.011)
0-6 Years of Educ. [Rel. to 7-9]	0.011	0.001	-0.013	0.002
	(0.010)	(0.009)	(0.008)	(0.010)
10+ Years of Educ. [Rel. to 7-9]	0.002	0.013	-0.021	0.006
	(0.012)	(0.010)	(0.009)	(0.010)
Married	-0.002	-0.028	0.045	-0.016
	(0.015)	(0.014)	(0.009)	(0.011)
Male X Married	0.112	0.192	-0.217	-0.087
	(0.017)	(0.016)	(0.013)	(0.016)
Urban	0.098	-0.007	-0.024	-0.066
	(0.017)	(0.013)	(0.012)	(0.013)
Log Real PCE	-0.014	-0.003	0.010	0.007
	(0.010)	(0.008)	(0.006)	(0.008)
Tsunami Exposure	-0.255	0.323	-0.043	-0.025
	(0.114)	(0.099)	(0.095)	(0.106)
Interviewed Every Wave	-0.130	-0.005	0.099	0.036
	(0.008)	(0.008)	(0.007)	(0.008)
Exposure X Male	0.023	0.048	-0.049	-0.021
	(0.023)	(0.025)	(0.024)	(0.027)
Exposure X Born after 1979	-0.005	-0.047	0.039	0.013
[Rel. to Exposure X 1965-79]	(0.031)	(0.029)	(0.020)	(0.026)
Exposure X Born before 1965	0.045	-0.012	-0.044	0.011
[Rel. to Exposure X 1965-79]	(0.021)	(0.022)	(0.022)	(0.027)
Exposure X 0-6 Years of Educ.	-0.019	-0.003	0.041	-0.020
[Rel. to Exposure X 7-9]	(0.024)	(0.024)	(0.020)	(0.023)
Exposure X 10+ Years of Educ.	0.012	-0.001	0.002	-0.013
[Rel. to Exposure X 7-9]	(0.026)	(0.023)	(0.020)	(0.022)
Exposure X Married	0.041	0.030	-0.025	-0.046
	(0.040)	(0.041)	(0.020)	(0.031)
Exposure X Male X Married	-0.015	-0.069	0.028	0.056
	(0.037)	(0.038)	(0.026)	(0.038)
Exposure X Urban	0.013	-0.009	0.004	-0.007
	(0.034)	(0.020)	(0.021)	(0.028)
Exposure X Log Real PCE	0.034	-0.055	0.015	0.005
	(0.019)	(0.016)	(0.015)	(0.017)
Exposure X Interviewed Every Wave	-0.021	0.004	-0.022	0.039
	(0.021)	(0.018)	(0.014)	(0.018)
Mean of Outcome	0.367	0.227	0.151	0.256
Observations	15,734	15,734	15,734	15,734
R-squared	0.225	0.041	0.198	0.097

Notes. This table displays regression results for different dynamic measures of business ownership. This regression uses the full analysis sample and includes an indicator for if the respondent was in every wave (and interacting this indicator with exposure).The outcome of Column 1 is an indicator for never owning a business in any survey wave. The outcome of Column 2 is an indicator for having owned a business at some point, but never for longer than 1 consecutive wave. The outcome of Column 3 is an indicator for participants that owned the same type (agriculture or non-agriculture) business for at least 6 consecutive years. The outcome of Column 4 is an indicator for participants that were overall business owners for at least 2 consecutive waves, but never owned the same type of business for at least 6 consecutive years. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Table A8: Geography Role in Explaining Aid Receipt Timing

	Full Sample				Aid Analysis Sample			
	Any Public Aid		Housing Aid		Any Public Aid		Housing Aid	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variation Explained, R^2	0.004	0.275	0.008	0.385	0.010	0.299	0.026	0.426
Wave FE	Y	Y	Y	Y	Y	Y	Y	Y
Wave-by-community FE	N	Y	N	Y	N	Y	N	Y
Observations	56,808	56,808	56,808	56,808	21,252	21,252	21,252	21,252

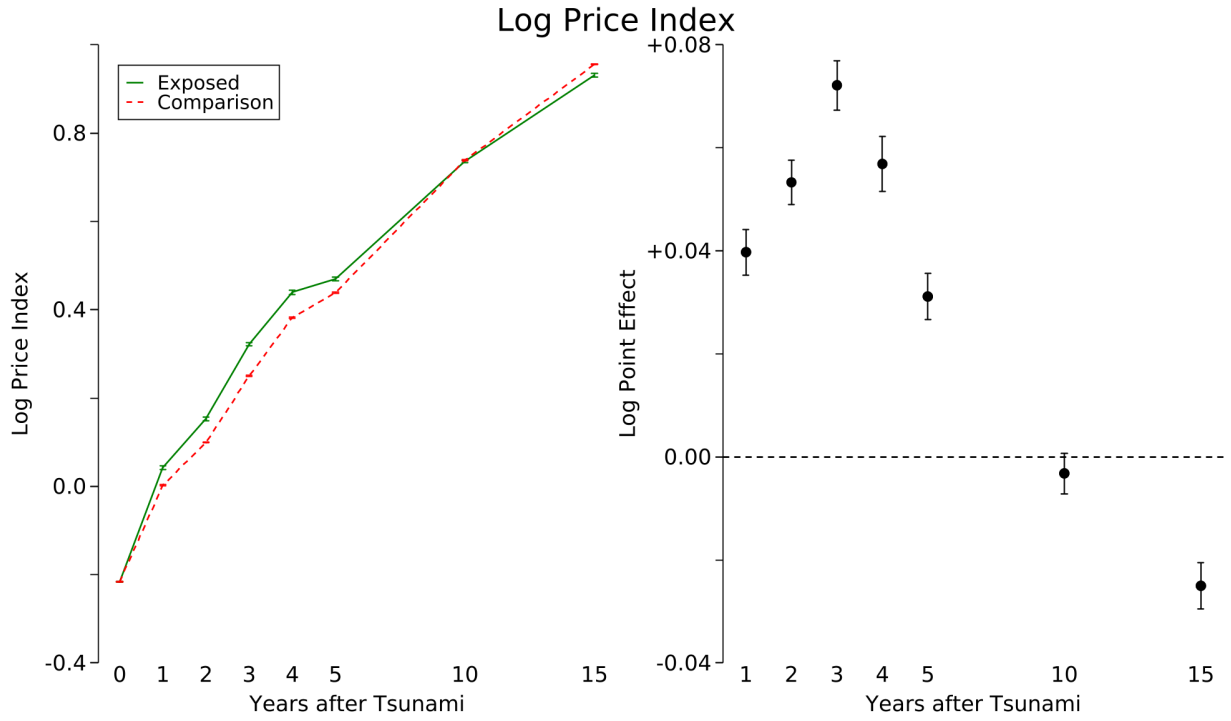
Notes. This table reports the results of regressing whether a respondent reported receiving any new public aid or housing aid on wave fixed effects or wave-by-community fixed effects. The aid analysis sample is limited to the set of individuals from *kecamatan* at the pre-tsunami baseline where at least one community faced heavy tsunami damage, and observations are limited to the 2nd, 3rd, 4th, and 5th post-tsunami waves as these were the waves in which individuals could receive housing aid.

Table A9: Housing Aid Effects on Ownership and Profits

	(1) Owns Bus.	(2) Owns Agr. Bus.	(3) Owns Non-Agr. Bus.	(4) Log Real Profits	(5) Log Real Assets
Post-Treatment Aid Receipt Effects					
Period of Aid Receipt	0.008	-0.021	0.015	0.121	-0.141
	(0.011)	(0.010)	(0.010)	(0.071)	(0.065)
1 Year after Aid Receipt	0.008	-0.015	0.021	0.168	-0.432
	(0.013)	(0.011)	(0.012)	(0.093)	(0.079)
2 Years after Aid Receipt	0.015	-0.023	0.026	0.217	-0.211
	(0.015)	(0.013)	(0.013)	(0.101)	(0.082)
3 Years after Aid Receipt	-0.007	-0.036	0.016	0.200	-0.227
	(0.018)	(0.015)	(0.016)	(0.140)	(0.115)
Aid Receipt Effect in Medium-Term	-0.010	0.001	-0.011	0.350	-0.197
	(0.015)	(0.013)	(0.013)	(0.102)	(0.089)
Aid Receipt Effect in Long-Term	0.020	0.024	-0.005	0.170	-0.201
	(0.016)	(0.014)	(0.015)	(0.105)	(0.092)
Pre-Treatment Trends					
1 Year before Aid	0.073	0.041	0.033	-0.396	-0.313
	(0.033)	(0.035)	(0.032)	(0.185)	(0.244)
2 Years before Aid	-0.018	-0.031	0.002	0.061	0.224
	(0.025)	(0.022)	(0.023)	(0.161)	(0.162)
3 Years before Aid	-0.008	-0.005	0.015	-0.089	-0.161
	(0.016)	(0.013)	(0.014)	(0.092)	(0.084)
Observations	53,196	53,196	53,196	10,730	26,932

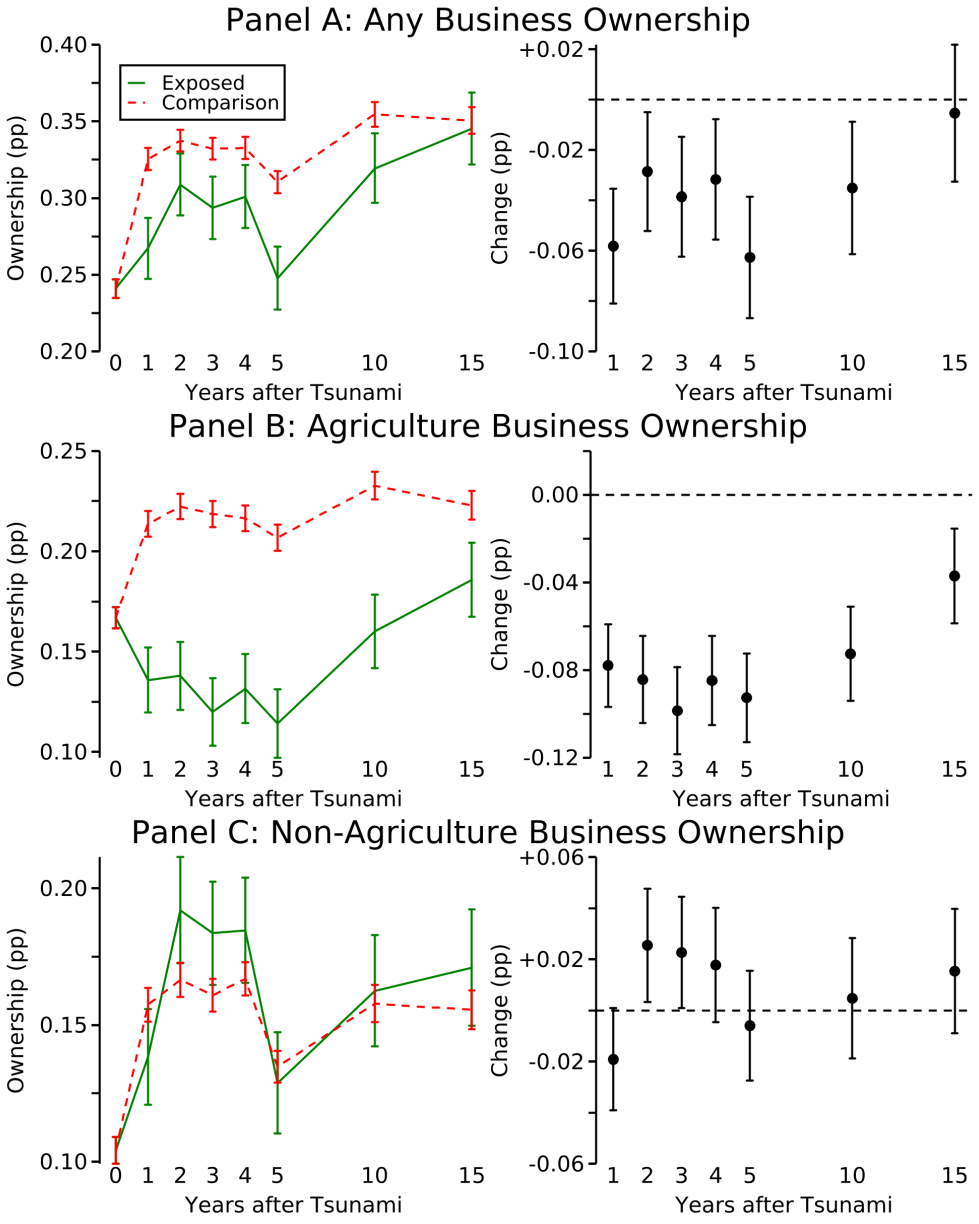
Notes. This table reports estimates of δ_k, the effect of housing aid on entrepreneurial outcomes, across pre- and post-treatment periods. ATTs are estimated via an estimator proposed by Callaway and Sant'Anna (2021) that yields unbiased estimates accounting for individual and time fixed effects in the presence of heterogeneous treatment effects. Asymptotic standard errors are estimated using Influence Functions which account for clustering at the individual level. Logarithm transformation is applied to business profits and assets, after deflating to real values using the local price index series. The sample is limited to the set of individuals from *kecamatan* at the pre-tsunami baseline where at least one community faced heavy tsunami damage, and the time period is limited to post-tsunami waves.

Figure A1: Log Price Index Trajectories and Exposure Effect



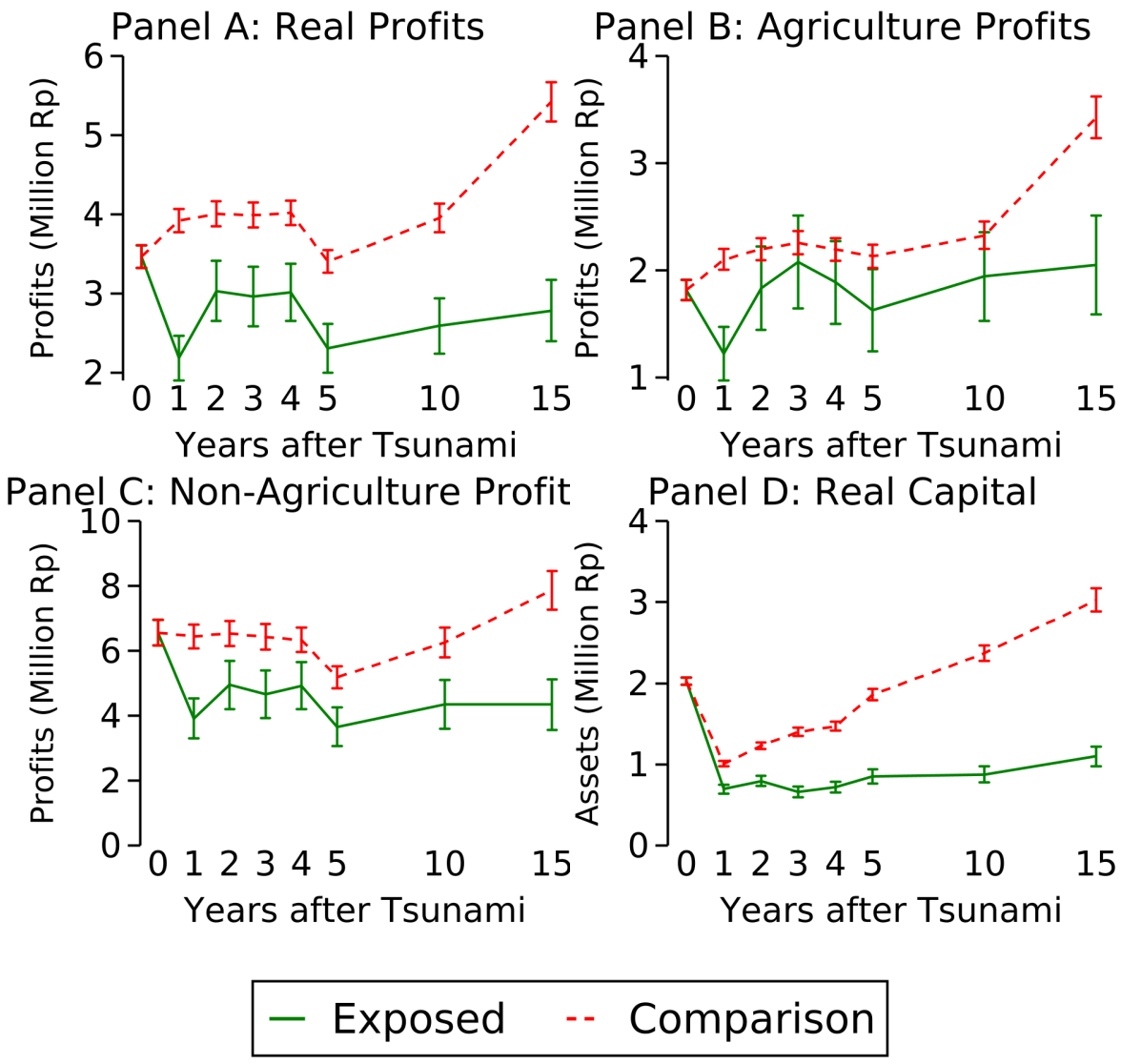
Notes. This figure reports the trajectories by damage exposure level and estimated exposure effects, β_t, in each post-tsunami STAR wave across the log price index level. Construction of the price index is described in Appendix B2. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level.

Figure A2: Ownership Trajectories and Exposure Effects for Respondents in Every Wave



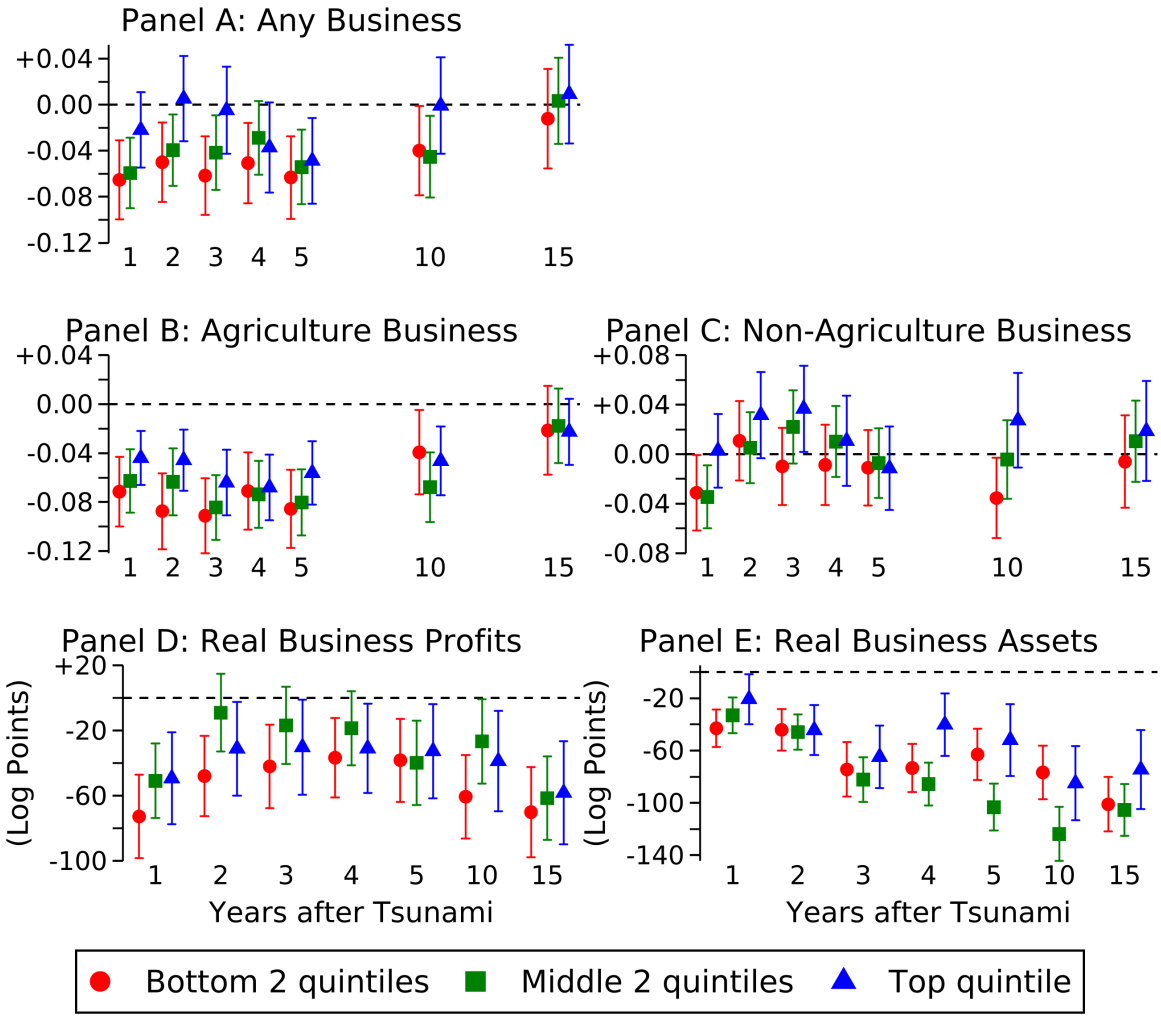
Notes. This figure reports the trajectories by damage exposure level and estimated exposure effects, β_t in each post-tsunami STAR wave across the business ownership outcomes. Regression is limited to the 10,501 respondents (out of 15,734 total) that are interviewed in every wave. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level.

Figure A3: Real Trajectories in Profits and Assets by Exposure Group



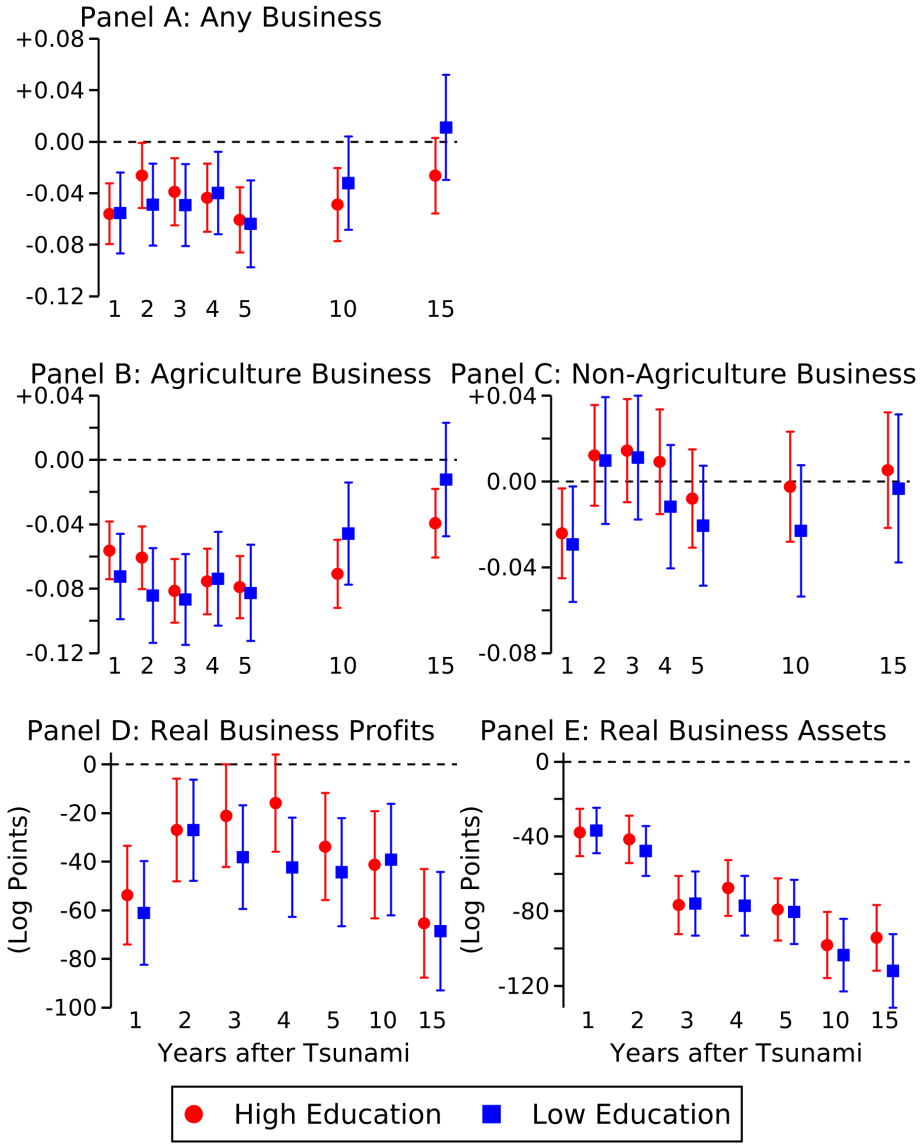
Notes. This figure reports the trajectories by damage exposure level in each post-tsunami STAR wave across the profit and asset outcomes. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level. Logarithm transformations are performed on all outcomes for the regression, after deflating to real values using the local price index series. We then exponentiate the logarithm trajectories to recover implied real profit and capital trajectories by exposure.

Figure A4: Tsunami Exposure Effects across Baseline PCE Quintiles



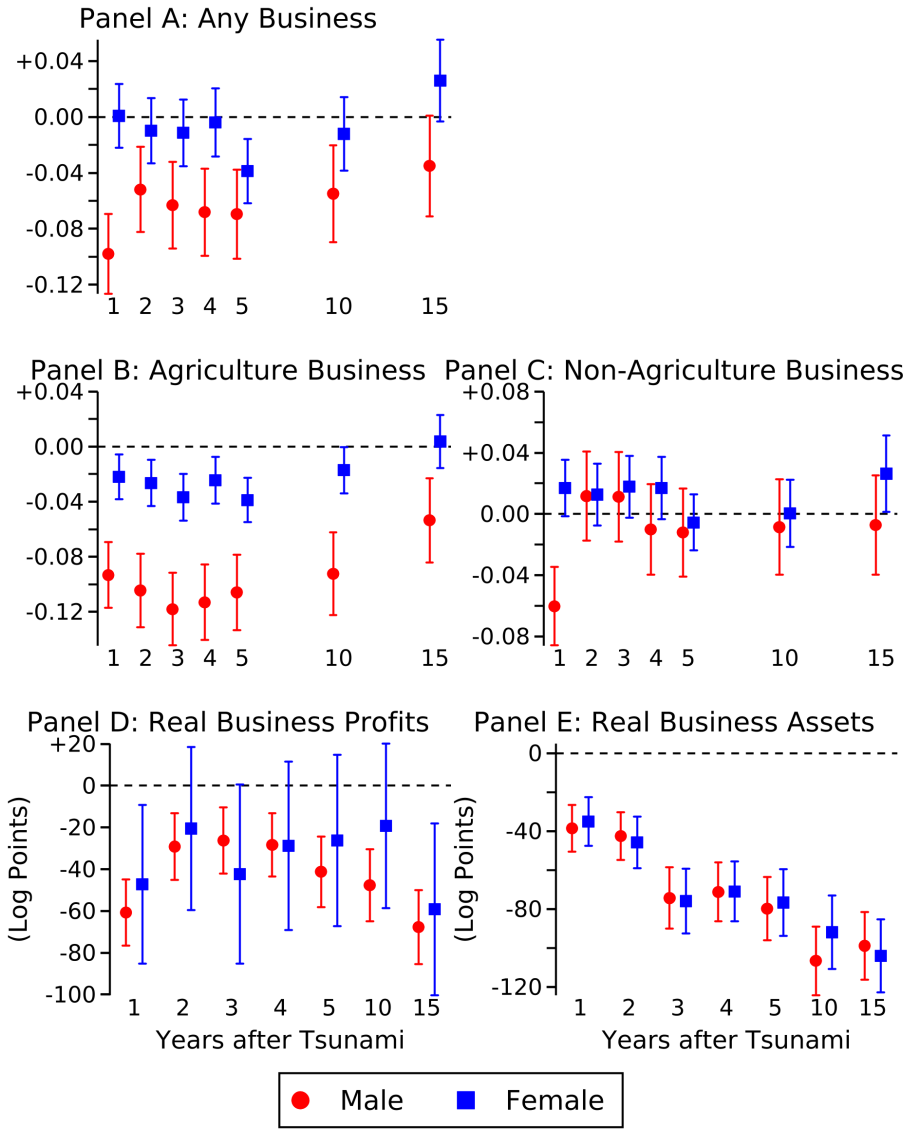
Notes. Results from estimating the coefficients β_t in Equation 1 separately based on three groups of baseline real PCE quintiles: the lowest two quintiles, the 3rd and 4th quintile, or the 5th quintile. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level. Panel D and E use log real profit and business asset values, conditional on owning any business (in Panel D) or having non-zero business assets (Panel E).

Figure A5: Tsunami Exposure Effects across Educational Attainment Groups



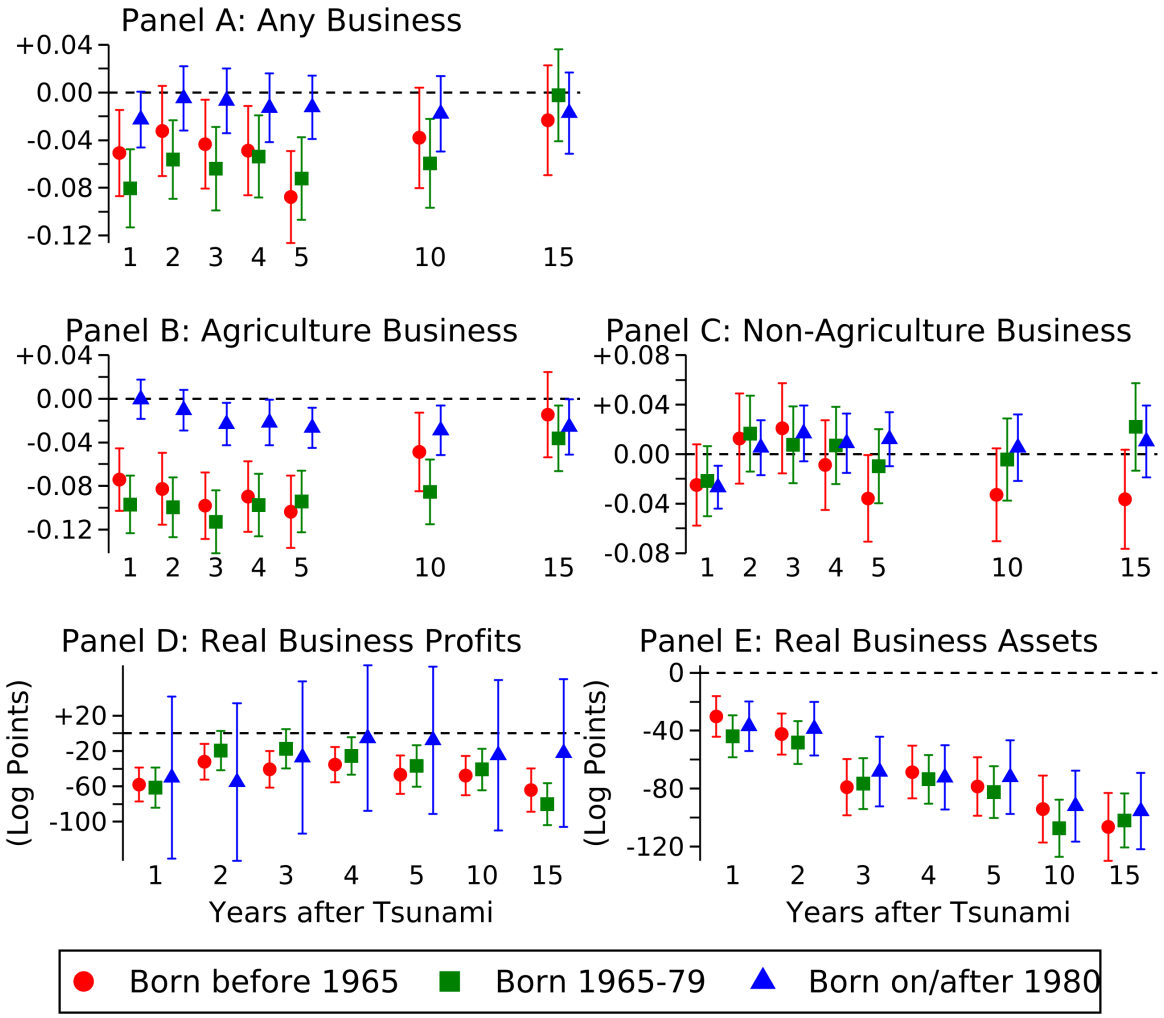
Notes. Results from estimating the coefficients β_t in Equation 1 separately by educational attainment groups. High education individuals are those with at least 9 years of educational attainment at baseline (completion of junior secondary school). Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level. Panel D and E use log real profit and business asset values, conditional on owning any business (in Panel D) or having non-zero business assets (Panel E).

Figure A6: Tsunami Exposure Effects across Gender



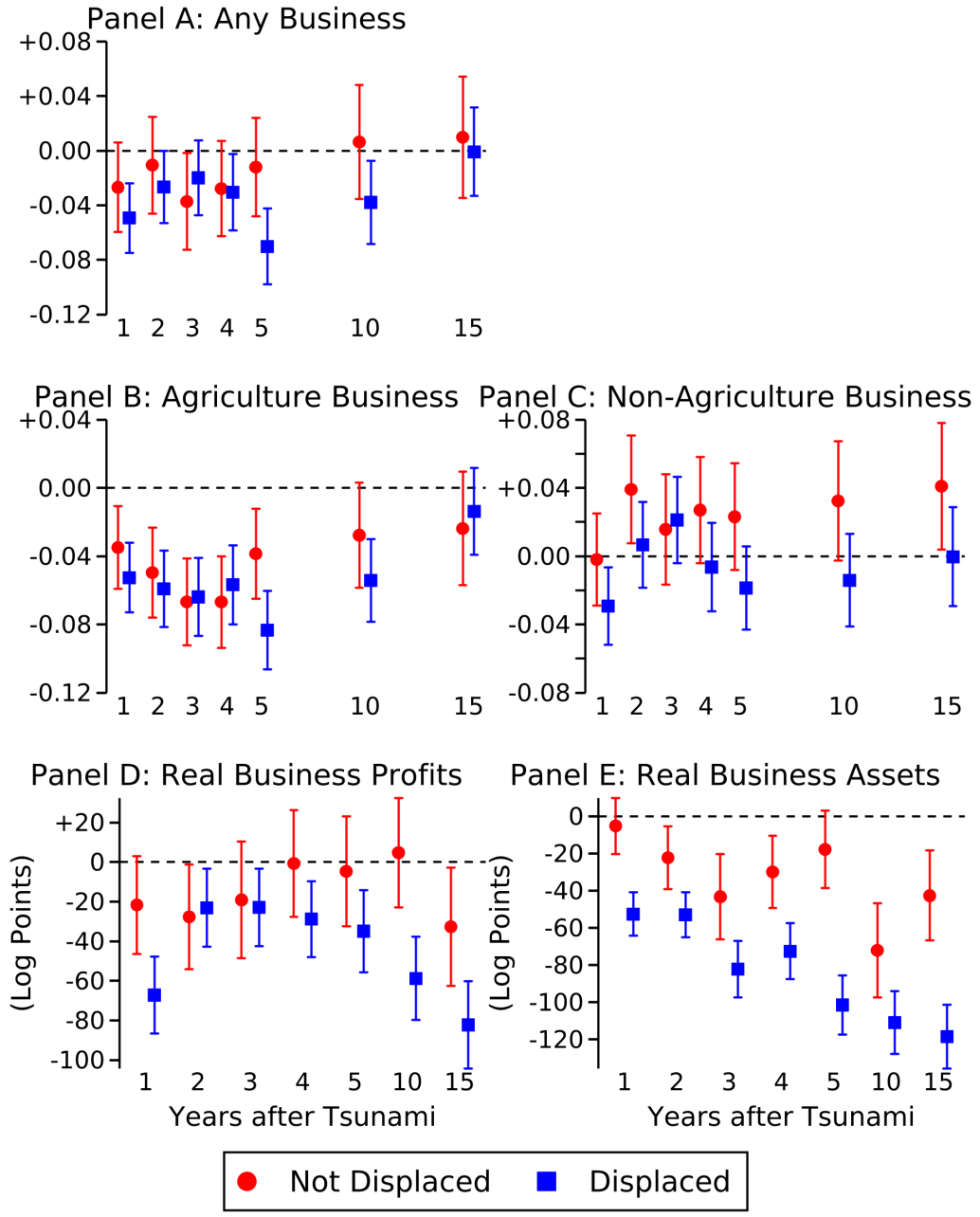
Notes. Results from estimating the coefficients β_t in Equation 1 separately by gender. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level. Panel D and E use log real profit and business asset values, conditional on owning any business (in Panel D) or having non-zero business assets (Panel E).

Figure A7: Tsunami Exposure Effects across Birth Cohorts



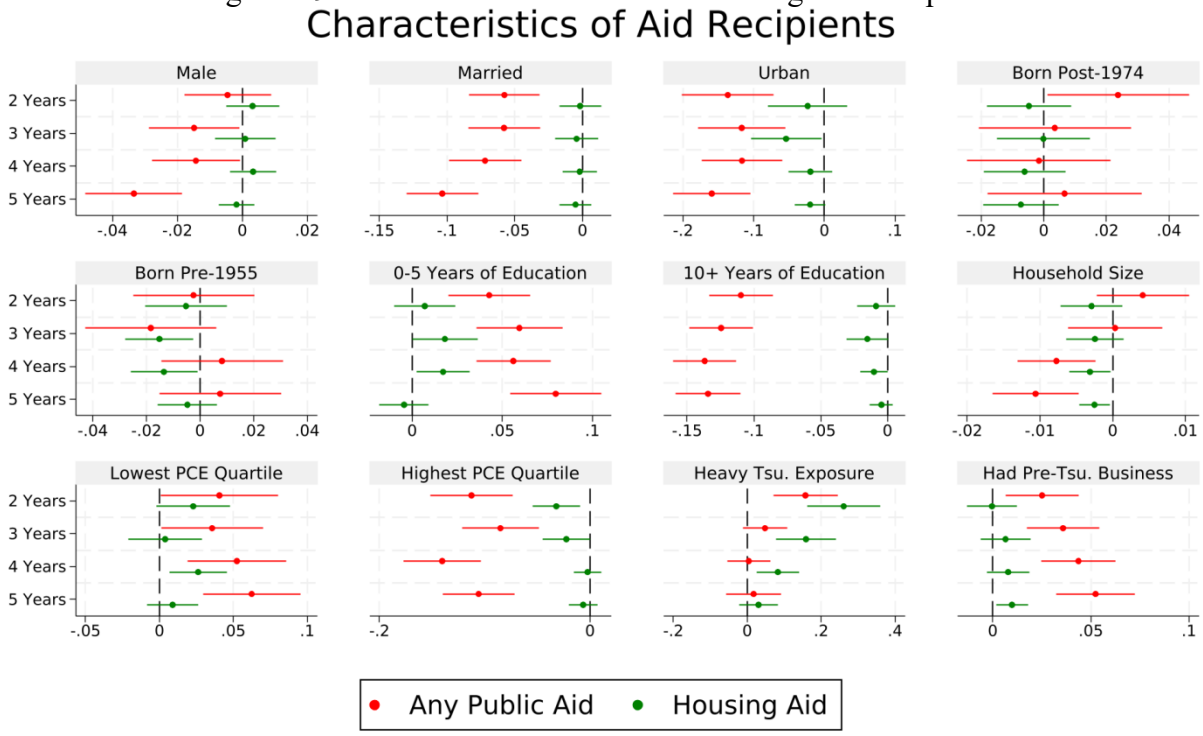
Notes. Results from estimating the coefficients β_t in Equation 1 separately by birth cohort groups. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level. Panel D and E use log real profit and business asset values, conditional on owning any business (in Panel D) or having non-zero business assets (Panel E).

Figure A8: Tsunami Exposure Effects by Post-Tsunami Migration



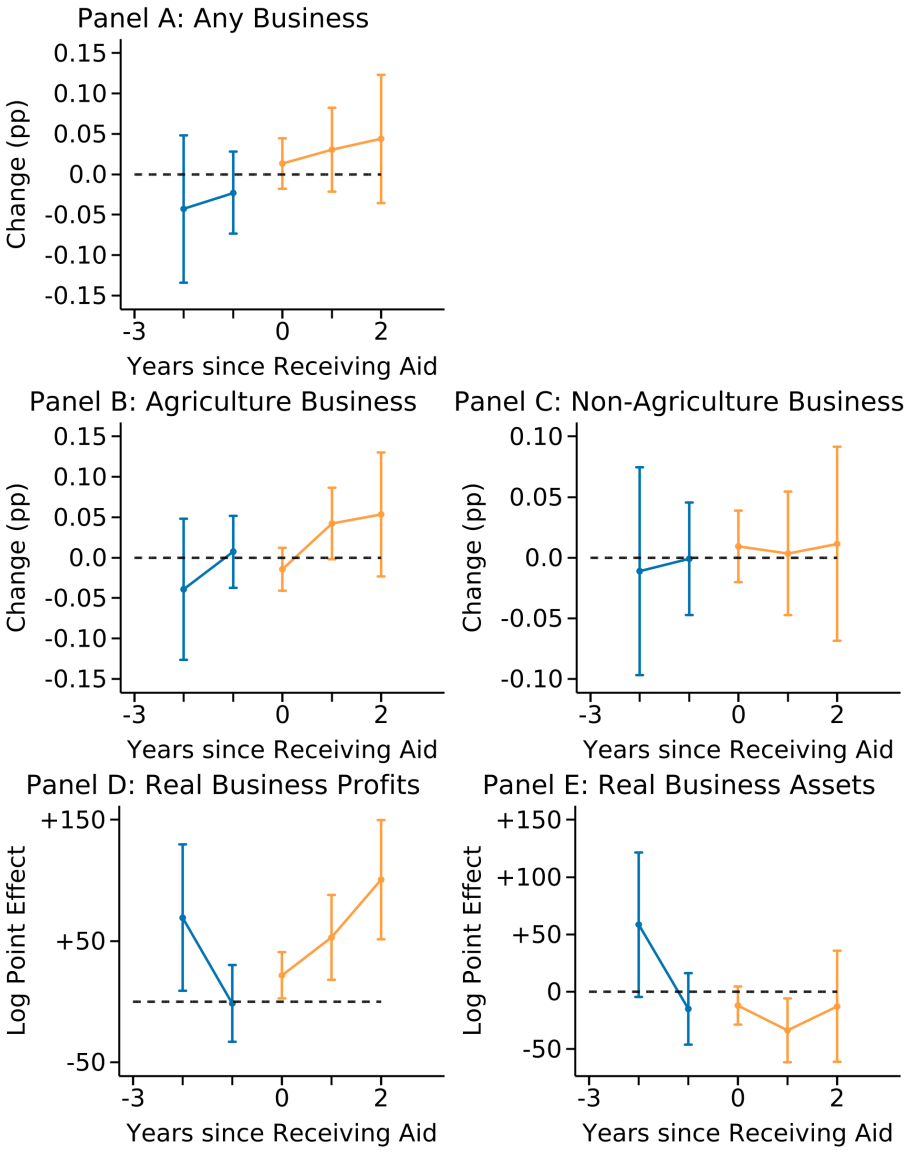
Notes. Results from estimating the coefficients β_t in Equation 1 separately based on whether respondents were displaced following the tsunami. We use migration status reported in the 1-year follow-up, so the sample for this regression is limited to respondents that were interviewed in the 1-year follow-up. Point estimates and 95% confidence intervals are displayed. All regressions include individual fixed effects, with standard errors clustered at the individual level. Panel D and E use log real profit and business asset values, conditional on owning any business (in Panel D) or having non-zero business assets (Panel E).

Figure A9: Correlates with Public and Housing Aid Recipients



Notes. This figure displays regression coefficients from regressing whether a respondent received public aid or housing aid in this wave on socio-demographic and geographical controls. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors are clustered at the baseline enumeration area level. 95% confidence intervals are reported.

Figure A10: Housing Aid Effects on Entrepreneurial Outcomes, Conditional on Receipt



Notes. Estimates of δ_k, the effect of housing aid on entrepreneurial outcomes, across pre- and post-treatment periods. Period 0 is the first period in which the individual received housing aid. Point estimates and 95% confidence intervals are displayed. ATTs are estimated via an estimator proposed by Callaway and Sant'Anna (2021) that yields unbiased estimates accounting for individual and time fixed effects in the presence of heterogeneous treatment effects. Asymptotic standard errors are estimated using Influence Functions which account for clustering at the individual level. Logarithm transformation is applied to business profits and assets, after deflating to real values using the local price index series. The sample is limited to the set of individuals that received housing aid at some point in the study, and the time period is limited to post-tsunami waves.

B. Supplementary Empirical Details

Appendix B provides supplementary empirical details of the main results. We first document the construction of the entrepreneurship outcomes used throughout the paper, including definitions of business ownership and profits, the procedure for assigning an individual business owner within business-operating households, the construction of pre-tsunami baseline measures, and the construction of business capital measures (Appendix B.1). We then describe the construction of the localized price index used to deflate nominal outcomes and account for spatially heterogeneous post-disaster price dynamics (Appendix B.2). Finally, we report an external pre-trends diagnostic using repeated cross-sections from SUSENAS (2002–2004) to assess whether exposed and non-exposed areas exhibited differential trends prior to the tsunami (Appendix B.3).

B.1. Outcome Construction

This appendix subsection describes the construction of the entrepreneurship outcomes used in the main analysis, including: (i) business ownership and profit measures, (ii) the procedure used to assign a primary business owner within business-owning households, (iii) the construction of pre-tsunami baseline measures, and (iv) the construction and cleaning of business asset measures.

Household Business Ownership and Profits

STAR measures business activity at the household level using separate modules for agricultural and non-agricultural enterprises. In each wave, we construct indicators for whether the household operated (a) any agricultural activity and (b) any non-agricultural enterprise during the survey reference period. Given the centrality of rice cultivation in Aceh and North Sumatra, the agricultural module distinguishes rice from other agricultural activities. Non-rice agricultural activities include rubber, cocoa, palm oil, chili, clove, nutmeg, and peanuts. Non-agricultural enterprises include small-scale trade and services such as local merchants, fishing, tailoring, food preparation, and baking.

Because business activity is measured at the household level, we implement a two-step procedure to assign business owners within the household. First, using the agricultural and non-

agricultural modules, we classify households as operating an agricultural business and/or a non-agricultural business in each wave. Second, we use individual-level employment status to identify the primary operator within business-owning households.

The agricultural and non-agricultural business modules ask the household member most responsible for economic activity whether they or someone else planted and harvested crops or operated any other agricultural or non-agricultural businesses. A household is defined as operating a business in each wave as whether they planted any crops or operated any non-agricultural enterprise in the calendar year preceding the survey (for years 1 to 5 post-tsunami) and for the 12 months before the survey (for years 10 and 15) as discussed above.[17]

Conditional on operating an agricultural and/or non-agricultural business, households report profits for that activity. If a respondent was unable to report profits, interviewers follow a two-stage bracketing procedure to estimate their revenues and costs in that period. Prior field experience in Indonesia established this yielded the best estimate of profits (Thomas et al. 2014). Profit values are winsorized at the extreme 0.5% of the distribution.

The owner of each business in a household was assigned using each household member's own report of their primary and secondary employment status (self-employed, private worker, government employee, unpaid family worker). If there was one business and one self-employed worker in the household, that was assigned as the owner. When multiple members report self-employment, we apply a fixed priority rule—prime-age males, then prime-age females, then older adults, then younger adults—to select a single owner.[18] In most cases, the business owner is the respondent to the business module.

[17] For the annual post-tsunami follow-ups in years 1–5, they were asked whether they operated businesses in the calendar year preceding the survey for non-rice agricultural production or non-agricultural businesses, and over 4-month periods for rice production (Jan. to Apr., May to Aug., and Sept to Dec.). For the longer-run follow-ups (approximately years 10 and 15), the modules refer to activity in the 12 months prior to the survey, and we collected plant and harvest dates for rice production instead. We map each wave's responses into wave-specific outcome measures and include wave fixed effects in the main specifications, so differences in recall windows do not mechanically confound time-series patterns. For example, a household owned a business in the pre-tsunami wave if they report operating a business between Jan.-Dec. 2004. The years associated with each wave are 2004 for the pre-tsunami baseline wave, 2005 for the 1-year follow-up, 2006 for the 2-year follow-up, 2007 for the 3-year follow-up, 2008 for the 4-year follow-up, 2009 for the 5-year follow-up. The 10- and 15-year follow-up ask about ownership in the last 12 months, so we use this measure for later waves.

[18] The exact order is male aged 45-54, male aged 35-44, male aged 55-64, female aged 45-54, female aged 35-44, female aged 55-64, male aged 25-34, female aged 25-34, male aged over 64, female aged over 64, male aged 15-24, female aged 15-25, male aged less than 15, female aged less than 15.

In 84.9% of households that report operating a business in a given wave, at least one member is self-employed according to their individual reports or their household roster. For the households where no one reports being self-employed, we assign the business owner among wage laborers, breaking ties using age and gender as before. This assignment strategy is used for 12.6% of households. If no household members report being self-employed nor a wage laborer, we next use unpaid family workers (0.3%) and lastly household members who did not report working (2.3%).

For households reporting both agricultural and non-agricultural activity, we assign two owners when at least two members report self-employment; otherwise, the single self-employed member is designated as the owner of both activities. In two-business households where no member reports being self-employed, we assign two business owners if at least two members are wage laborers and assign one member to both if one member is a wage laborer. If no member is self-employed nor a wage laborer, we iterate this procedure for unpaid family workers and then non-workers as above.

Business Capital

We also examine impacts on business capital using the STAR business asset module, which records ownership and self-reported values of seven assets intended to support business activities. These asset questions were not included in the pre-tsunami baseline, but the one- and two-year follow-ups collect retrospective information on pre-tsunami asset holdings, which we use to construct baseline measures. To mitigate measurement error in self-reported asset values, we flexibly estimate the relationship between asset values and household consumption and use the fitted relationship to identify extreme outliers. See Lombardo et al. (2022) for more complete details on the cleaning process for asset values. As with business activity, assets are measured at the household level, and we proportionally assign to all adult household members in each wave.

B.2. Construction of Local Price Index Series

In the context of a major natural disaster, market distortions resulting from the damage and upheavals in the economy are likely to result in changes in absolute and relative prices (Hallegatte and Przyluski 2010). These price changes, especially increases in food prices, will have the most severe implications for the most impoverished households (Frankenberg et al.

2003; 1999; Ferreira et al. 2013). For example, prior studies have documented direct relationships between disaster levels of an area and the price of rice, including a study focused on the 2004 tsunami (Kirchberger 2017; Del Ninno et al. 2003). Consequently, it is important to adjust for price fluctuations across communities.

Given the non-random cross-sectional market price distortions caused by tsunami exposure, we use price data collected in each post-tsunami wave of STAR at the community level for this purpose. Price data are *toko* (shops), and expert informants within each community and at the *pasar* (markets) that are served by the community. In the household survey, individuals report the *pasar* and *toko* that they typically visit. We then randomly select up to three listed *pasar* and three listed *toko* within each community to visit, and enumerators collect the price and weight information for up to the 60 major food items. These food items include, for example, several varieties (and qualities) of rice, cooking oil, sugar, chicken, and corn. We also interview up to three expert informants in each community that provide information on 26 other major non-food expenses, such as electricity, fuel, or transportation costs.

We convert each of the 60 food items to common units within the item. If weight is reported, we use that to find the implied proportional price for a common weight. If weight is not reported, enumerators report a standard unit of measurement or a free response. The standard unit of measurements are typically linked to a weight—for example, the enumerator may report the price of a 200g carton of milk or a 400g carton of milk—in which case the conversion to a common unit is straightforward. If a free response is provided, the enumerator is instructed to weigh the item for which they have a price. For example, *kangkung* (a leafy green) is sold in bunches. The enumerator picked a bunch, asked the price, weighed it and reported the weight and price. In some cases, it was not possible to measure the item: a *sendok* (spoon) of oil, for example. We attempted to obtain the usual size for these cases and also used the reported price to confirm the validity of the conversion. We then used that conversion factor for all *toko* and *pasar*. After cleaning easily identified outliers -- large discrepancies from other prices for the same item from nearby sources -- we compute the median price for each of the 60 food items at the *kecamatan*-by-exposure level, across the *pasar* and *toko* in that *kecamatan*-by-exposure area.

We perform a similar strategy for the 26 non-food items reported by expert community informants. After standardizing units and removing extreme outliers, we compute the median price for each of the 26 non-food items at the *kecamatan*-by-exposure level.

Given standardized prices for each of the 97 items, we aggregate the prices to 13 expenditure sub-groups: alcohol & tobacco, clothing, fats & oils, other food, prepared foods, fruits & vegetables, meat & fish, housekeeping services, health services, personal services, rent, rice, and utilities. We have expenditure shares from the household survey for each of these 13 sub-groups, so for each *kecamatan*-by-exposure, we calculate a price index that computes a weighted average of the 13 index sub-group prices, weighted by the mean expenditure share of households for that sub-group in that *kecamatan*-by-exposure area. We normalize this index to have median value 1 in the 1-year post-tsunami wave.

The baseline pre-tsunami wave of STAR was adapted from the national SUSENAS surveys which did not collect price data. However, Statistics Indonesia reports a consumer price index for the three cities in Aceh and North Sumatra: Banda Aceh (capital of Aceh), Lhokseumawe, and Sibolga. Prices in June 2004 were similar in Lhokseumawe and Sibolga, but approximately 20% lower in Banda Aceh according to this price index. We form baseline prices using retrospectively reported prices in the first year after the tsunami. We then proportionally adjust baseline prices so that the inflation in the Statistics Indonesia price series for the three cities from the pre-tsunami wave to the 1st post-tsunami wave matched the average inflation in our price series for the households near each of those cities over the same time period (weighting the city inflation average by the number of households near that city).

Finally, we match each of the household-wave interview observations to a price index value to deflate their nominal values. For households currently residing in the *kabupaten* that we collected price data from in the post-tsunami waves, we merge using the households current *kecamatan*-by-exposure. We take increasing levels of geographical medians if the merge failed. For households currently outside of Aceh or North Sumatra but within a different province of Indonesia, we use the Statistics Indonesia CPI. For households that migrated outside of Indonesia, we use the country-level World Bank CPI. Thus, all households in our sample are matched to a price index value.

We compute daily inflation rates for this household in the current survey wave for this geography, as well as in the wave prior and the wave post. Then, to account for differences in interview date between the household interview and the *toko* and *pasar* interviews, we set the households daily inflation rate to be a weighted average of the daily inflation rates for this geography for the price interview waves in which this household's interview was between. For

example, suppose a household interview occurred in April 2006, and that price interviews in the 1-year post-tsunami wave for this geography occurred in March 2006, and that price interviews in the 2-year post-tsunami wave for this geography occurred in March 2007. Then, the households daily inflation rate would be a weighted average of the 1-year and 2-year daily inflation rates for this geography, with greater weight given to the 1-year post-tsunami wave as that is closer to the household interview date. We then use the daily inflation rate to calculate the price index value that this household faces in its current wave, which we then use to adjust nominal reports to real values.

B.3. Pre-Exposure Trends Test using SUSENAS (2002–2004)

As an additional test for the conditional exogeneity of tsunami exposure, we use repeated cross-sections from SUSENAS (2002, 2003, 2004) to test whether areas that were later heavily damaged exhibit differential pre-tsunami changes in observable characteristics. We restrict the SUSENAS sample to respondents living in the 11 *kabupaten* within Aceh used to construct STAR's pre-tsunami baseline. We them harmonize *desa* and *kecamatan* identifiers across years using the crosswalk from the village census (to account for administrative code changes). We also merge in satellite imagery data at the *desa*-level to record elevation and distance-to-coast measures for this sample.

We define exposure at the *desa* level using the 2005 Aceh–Nias Census as follows: for each *desa* from which the respondents were located during the tsunami, we compute a tsunami mortality share equal to the fraction of census respondents reporting that a household member died in the tsunami. We classify a *desa* as heavily exposed if this share is at least 4 percent. Because desa codes differ across SUSENAS waves and the 2005 Census, we translate all *desa* identifiers to a common *desa* code using the above crosswalk.

We then test whether the relationship between exposure and pre-determined observables is stable across the pre-tsunami SUSENAS waves. Specifically, we estimate one pooled linear probability model of heavy exposure on observables, allowing the coefficients on observables to differ by survey year:

$$T_{it} = \alpha_0 + \alpha X_{it} + \delta X_{it}\mathbb{1}[t = 2003] + \theta X_{it}\mathbb{1}[t = 2002] + \gamma W_{it} + u_{it}$$

Where T_{it} is an indicator for if the *desa* that respondent i is located in during period t will face heavy tsunami damage, and W_{it} are geographical controls (*kecamatan* fixed effects,

elevation [quadratic], distance to coast [quadratic]). The vector X_{it} includes indicators for male, age groups, education categories, and log PCE. Then, δ and θ capture whether the relationship between these observable characteristics and eventual exposure differed across the pre-tsunami period, which would suggest violations of parallel trends. Regressions use SUSENAS sampling weights, and standard errors are clustered at the *desa* level.

Appendix Table A1 shows that the 2003 and 2002 interaction terms are individually small and jointly insignificant: the p-value for the joint test of all 2003 interactions is 0.258, for all 2002 interactions is 0.221, and for all 2002 and 2003 interactions jointly is 0.209. These estimates provide no evidence that heavily exposed areas experienced systematically different pre-tsunami changes in these observable characteristics (conditional on subdistrict fixed effects and local geography), supporting the validity of our exposure design.

C. Validation of Retrospective Business Data, and the Role of Mortality Selection

The pre-tsunami baseline survey asks respondents about their ownership of rice businesses in 2003 and the employment status of respondents at the time of the survey in Feb./Mar. 2004. As a result, in the first post-tsunami survey, we included retrospective questions about rice, other agricultural and non-agricultural business ownership and profits in 2004 in order to have data on pre-tsunami business activity. In this appendix section, we use the pre-tsunami survey data for two purposes. First, we validate that the retrospective business and employment status reports correspond well to the business and employment status reported by the same respondents in the pre-tsunami baseline. Second, we investigate mortality selection using pre-tsunami business outcomes for households where all members died as these households are not observed post-tsunami.

In Table C1, we compare rice business ownership in 2003 and 2004 for respondents in both the pre-tsunami baseline survey and the 1-year post-tsunami wave. Ownership in 2003 is from the pre-tsunami wave, and ownership in 2004 is recalled from the 1-year post-tsunami wave. 7.1% of respondents have a rice business in both 2003 and 2004, and 83.8% of respondents have a rice business in neither year. Thus, only 9.1% of respondents have a different rice business ownership status in 2003 and 2004. Some of these changes are likely to reflect shifts in behavior and some are likely to be recall error. The rate is similar for those who were living in communities that sustained heavy damage (8.2%) and those in other communities (9.4%) suggesting measurement error is likely to be very similar across these two groups of respondents.

Table C2 performs similar analysis using the pre-tsunami reports of employment status. We compare reporting any business ownership in 2004 (reported retrospectively from the 1-year post-tsunami wave) and whether a respondent reported being self-employed at the time of the pre-tsunami baseline wave (Feb. / Mar. 2004). Here, 20.0% of respondents report both having a business in 2004 as well as being self-employed at the time, and 65.0% report neither having a business nor being self-employed. Thus, pre-tsunami and 1-year post-tsunami responses are

inconsistent for 15.0% of respondents, and this rate of inconsistency is similar across tsunami exposure status, 14.7% for the exposed and 15.1 for those not exposed.[19]

We next investigate the characteristics of people that report varying business measures across waves. We set as an outcome whether an individual's retrospective business ownership status in the 1-year post-tsunami wave is inconsistent with their employment status in the pre-tsunami wave and regress this outcome on a vector of pre-tsunami socio-demographic characteristics and geographical controls. The result of this analysis is reported in Column 1 of Table C3. Inconsistent reporters tend to be prime-aged males, completed fewer years of education, and never married or widowed. Those from urban areas are weakly more likely to report inconsistently, but there is no relationship with household size, real consumption, or tsunami exposure. All covariates, including the geographical controls, only explain 8.9% of the variation in inconsistent reporting.

In Columns 2-5 of Table C3, we perform the same regression on indicators for each joint value of retrospective business ownership and the pre-tsunami self-employment status. Columns 2 and 3 are inconsistent reports, while Columns 4 and 5 are consistent reports across waves. Throughout, these joint responses are more strongly correlated with gender, age, educational attainment, and marital status than tsunami exposure or real consumption.

Last, we investigate the role of mortality selection on limiting the households that we observe in this study. If some, but not all, members of a respondent household died in the tsunami, the surviving members would be subject to tracking, even if they joined a different household or splintered into a new household. Thus, these respondents are represented in our study. But, if all members of a respondent household died in the tsunami, there is no member left to re-interview and thus the household does not appear in our sample in this paper. These households were in the pre-tsunami baseline survey, so in Table C4, we compare the characteristics of rice business owners in these households with similar households that are represented in the study. We regress an indicator for if the household was a rice business owner in 2003—from the pre-tsunami wave—on the same vector of pre-tsunami socio-demographic

[19] Note that employment status in the pre-tsunami baseline wave is asked over the last month, whereas the business ownership measure is asked over the entirety of 2004. Thus, inconsistency between the two responses is not necessarily due to recall error or incorrect reporting.

characteristics and geographical controls. Thus, we can compare how the correlates of rice business owners compare across tsunami mortality status.

Column 1 of Table C4 reports the characteristics of rice business owners from the set of households where all members died in the tsunami. Rice business owners tend to be male, prime-aged or older, completed primary school or less, from rural areas. Weakly, they also tend to have higher real consumption levels. Column 2 performs this analysis for the set of households where some, but all members of the household died from the tsunami, and Column 3 performs this analysis for the set of households where no member died from the tsunami. In effort to yield a more similar sample to the set of households where everyone died, Column 4 limits the set of households where no one died to those that are additionally from areas that faced heavy tsunami exposure. Across all specifications, the correlations generally remain true—rice business owners tend to be male, prime-aged, have lower education. They also tend to be non-married in these subsamples and have lower real consumption than their peers. Comparing mean ownership across columns, rice business ownership was most common for the set of households where all members died at 13.2%. This rate is lower for households experiencing only some or no mortality—the largest difference occurs for households that faced some mortality at 7.9%.

Relatedly, Table C5 pools the sample and directly tests whether the observable correlates of pre-tsunami rice business ownership differ for individuals from households where all members died by interacting each baseline covariate with an indicator for full-household mortality. The estimated interaction coefficients are uniformly small and individually imprecise, and the joint test fails to reject equality of the full set of interactions to zero at conventional levels ($F = 1.51$, $p = 0.088$).

The correlates of rice business owners remain stable across household mortality, suggesting that the business patterns of households where all members died are not very different from the patterns of other households. Thus, while we cannot measure the effect of tsunami exposure on business outcomes for these households, the scope for mortality selection in this setting is limited as the business owner characteristics of unobserved households are generally to the business owner characteristics of observed households. Further, the empirical strategy in this paper uses individual fixed effects to control for pre-existing differences that influenced tsunami mortality, such as gender, age, and household composition.

Table C1: Rice Business Prior to Tsunami

	Tsunami Exposure Level		
	Not Heavy Damage	Heavy Damage	Total
Rice business in 2003 and 2004	928	191	1,119
	[7.2%]	[6.5%]	[7.1%]
No rice business in 2003 nor 2004	10,680	2,501	13,181
	[83.4%]	[85.3%]	[83.8%]
Rice business in 2003, not in 2004	813	149	962
	[6.4%]	[5.1%]	[6.1%]
Rice business in 2004, not in 2003	380	92	472
	[3.0%]	[3.1%]	[3.0%]
Total	12,801	2,933	15,734

Notes. This table compares rice business ownership in 2003 and 2004. Rice business ownership in 2003 is recorded in the pre-tsunami baseline survey, and rice business ownership in 2004 is recorded in the 1-year post-tsunami survey. Each observation is an individual. Percent of respondents by tsunami exposure level are reported in brackets below for Column 1 and 2, and percent of respondents overall are reported in brackets below for Column 3.

Table C2: Retrospective Business Ownership and Contemporaneous Self Employment

	Tsunami Exposure Level		
	Not Heavy Damage	Heavy Damage	Total
Retro. business and baseline self-employed	2,531	623	3,154
	[19.8%]	[21.2%]	[20.0%]
No retro. business, not baseline self-employed	8,347	1,881	10,228
	[65.2%]	[64.1%]	[65.0%]
Retro. business, not baseline self-employed	495	131	626
	[3.9%]	[4.5%]	[4.0%]
No retro. business, baseline self-employed	1,428	298	1,726
	[11.2%]	[10.2%]	[11.0%]
Total	12,801	2,933	15,734

Notes. This table compares business ownership in the year prior to the tsunami to self-employment in the year prior to the tsunami. Business ownership is reported retrospectively from the 1-year post-tsunami survey wave. Baseline self-employment status is recorded from the pre-tsunami baseline survey. Each observation is an individual. Percent of respondents by tsunami exposure level are reported in brackets below for Column 1 and 2, and percent of respondents overall are reported in brackets below for Column 3.

Table C3: Correlates with Retrospective Business and Contemporaneous Self-Employment

	(1)	(2)	(3)	(4)	(5)
		By retrospective business and self-employment			
	Inconsistent	Retro. bus., not self emp.	No retro. bus., self emp.	Retro. bus., self emp.	No retro. bus., not self emp.
Male	0.147	0.054	0.093	0.300	-0.448
	(0.008)	(0.004)	(0.007)	(0.010)	(0.011)
Birth Year ('75-84 Excluded)					
After 1984	-0.092	0.004	-0.096	-0.031	0.123
	(0.009)	(0.003)	(0.009)	(0.007)	(0.012)
1965-74	0.025	0.026	-0.001	0.095	-0.120
	(0.010)	(0.005)	(0.009)	(0.009)	(0.010)
1955-64	0.021	0.037	-0.015	0.140	-0.161
	(0.012)	(0.005)	(0.010)	(0.011)	(0.012)
1945-54	-0.011	0.025	-0.037	0.171	-0.160
	(0.013)	(0.007)	(0.012)	(0.014)	(0.015)
Before 1945	-0.024	0.003	-0.026	0.058	-0.034
	(0.016)	(0.007)	(0.015)	(0.016)	(0.017)
Completed Years of Education (6)					
0 Years	0.023	0.003	0.020	-0.099	0.076
	(0.017)	(0.008)	(0.016)	(0.017)	(0.018)
1 to 5 Years	0.002	-0.000	0.003	-0.028	0.025
	(0.011)	(0.006)	(0.010)	(0.011)	(0.012)
7 to 9 Years	-0.001	0.014	-0.016	-0.015	0.016
	(0.009)	(0.005)	(0.008)	(0.009)	(0.010)
10 to 12 Years	-0.013	0.031	-0.044	-0.043	0.056
	(0.009)	(0.005)	(0.008)	(0.010)	(0.010)
More than 12 years	-0.031	0.080	-0.111	-0.145	0.176
	(0.015)	(0.011)	(0.011)	(0.013)	(0.018)
Marital Status (Never Married)					
Married	-0.041	-0.032	-0.008	-0.135	0.176
	(0.010)	(0.005)	(0.009)	(0.010)	(0.012)
Widowed, Separated, or Divorced	0.078	0.048	0.030	0.106	-0.184
	(0.015)	(0.008)	(0.013)	(0.016)	(0.018)
Urban	0.012	0.021	-0.009	-0.067	0.054
	(0.012)	(0.007)	(0.013)	(0.012)	(0.017)
Number of Household Members	-0.007	-0.005	-0.003	-0.008	0.015
	(0.002)	(0.001)	(0.002)	(0.002)	(0.003)
Real PCE Quartile (Middle 50%)					
Lowest Quartile	0.006	0.007	-0.001	-0.007	0.000
	(0.008)	(0.005)	(0.008)	(0.008)	(0.009)
Highest Quartile	0.000	-0.001	0.001	-0.001	0.001
	(0.008)	(0.005)	(0.007)	(0.008)	(0.009)
Heavy Tsunami Exposure	-0.004	0.014	-0.018	0.009	-0.005
	(0.015)	(0.008)	(0.015)	(0.017)	(0.017)
Mean of Outcome	0.149	0.040	0.110	0.200	0.650
Observations	15,734	15,734	15,734	15,734	15,734
R-squared	0.089	0.066	0.077	0.298	0.396

Notes. This table displays regression results comparing retrospective business ownership reports and baseline self-employment status on socio-demographic features and geographical controls. The outcome of Column 1 is whether the retrospective business ownership measure disagrees with the baseline self-employment value. The outcomes of Columns 2-5 are each joint value of retrospective rice business ownership and baseline self-employment. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Table C4: Pre-Tsunami Rice Business Owner Characteristics by Household Mortality

	(1) Full HH died in tsunami	(2) Some HH died in tsunami	(3) None of HH died in tsunami	(4) None of HH died, heavy damaged area
Male	0.237	0.165	0.219	0.189
	(0.048)	(0.023)	(0.013)	(0.030)
Birth Year ('75-84 Excluded)				
After 1984	-0.066	-0.008	-0.007	-0.005
	(0.035)	(0.012)	(0.006)	(0.012)
1965-74	0.023	0.047	0.070	0.057
	(0.044)	(0.023)	(0.008)	(0.015)
1955-64	0.113	0.121	0.091	0.112
	(0.045)	(0.033)	(0.010)	(0.025)
1945-54	0.085	0.129	0.106	0.097
	(0.045)	(0.041)	(0.012)	(0.030)
Before 1945	0.018	0.061	0.052	0.027
	(0.058)	(0.043)	(0.013)	(0.025)
Completed Years of Education (6)				
0 Years	-0.017	-0.101	-0.047	-0.045
	(0.082)	(0.045)	(0.015)	(0.028)
1 to 5 Years	-0.014	-0.083	-0.017	-0.006
	(0.064)	(0.034)	(0.012)	(0.031)
7 to 9 Years	-0.070	-0.064	-0.031	0.028
	(0.046)	(0.028)	(0.008)	(0.020)
10 to 12 Years	-0.064	-0.088	-0.035	-0.009
	(0.045)	(0.027)	(0.008)	(0.019)
More than 12 years	-0.142	-0.048	-0.064	-0.002
	(0.044)	(0.031)	(0.011)	(0.022)
Marital Status (Never Married)				
Married	-0.023	-0.067	-0.097	-0.076
	(0.038)	(0.022)	(0.010)	(0.022)
Widowed, Separated, or Divorced	-0.005	0.000	0.053	0.062
	(0.069)	(0.039)	(0.013)	(0.027)
Urban	-0.251	-0.138	-0.085	-0.110
	(0.036)	(0.026)	(0.015)	(0.042)
Number of Household Members	-0.001	-0.006	-0.009	-0.007
	(0.007)	(0.003)	(0.001)	(0.003)
Real PCE Quartile (Middle 50%)				
Lowest Quartile	-0.016	0.006	0.011	0.026
	(0.050)	(0.021)	(0.007)	(0.021)
Highest Quartile	0.007	-0.022	-0.025	-0.039
	(0.025)	(0.015)	(0.006)	(0.014)
Mean of Outcome	0.132	0.079	0.094	0.088
Observations	555	1,530	16,393	2,681
R-squared	0.309	0.280	0.313	0.349

Notes. This table displays regression results comparing rice business ownership characteristics across tsunami household mortality status. The outcome of all columns is an indicator for if the individual was a rice business owner in 2003, two years prior to the tsunami. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses.

Table C5: Joint Test of Differences by whether Full Household Died

	(1) Coefficient	(2) Interaction with Full HH Died
Male	0.214	0.016
	(0.012)	(0.045)
Birth Year ('75-84 Excluded)		
After 1984	-0.007	-0.051
	(0.005)	(0.034)
1965-74	0.069	-0.046
	(0.007)	(0.038)
1955-64	0.092	0.000
	(0.009)	(0.036)
1945-54	0.107	-0.038
	(0.012)	(0.037)
Before 1945	0.051	-0.063
	(0.012)	(0.055)
Completed Years of Education (6)		
0 Years	-0.052	0.029
	(0.015)	(0.062)
1 to 5 Years	-0.022	-0.012
	(0.011)	(0.056)
7 to 9 Years	-0.033	-0.033
	(0.008)	(0.038)
10 to 12 Years	-0.041	-0.017
	(0.008)	(0.037)
More than 12 years	-0.058	-0.051
	(0.010)	(0.037)
Marital Status (Never Married)		
Married	-0.095	0.055
	(0.009)	(0.037)
Widowed, Separated, or Divorced	0.049	-0.026
	(0.013)	(0.054)
Urban	-0.092	-0.068
	(0.014)	(0.032)
Number of Household Members	-0.009	0.009
	(0.001)	(0.006)
Real PCE Quartile (Middle 50%)		
Lowest Quartile	0.011	0.014
	(0.007)	(0.036)
Highest Quartile	-0.025	0.029
	(0.006)	(0.022)
F-Statistic for all Full HH died interactions: 1.51		
P-Value for all Full HH died interactions: 0.088		
Observations: 18,478		
Dependent Variable Mean: 0.093		
R-Squared: 0.308		

Notes. The results of this table are from one regression: the first column reports non-interacted covariates, the second column interacts each covariate with an indicator for if the full household died during the tsunami. The outcome is an indicator for if the individual was a rice business owner in 2003, two years prior to the tsunami. All socio-demographic covariates are measured from the pre-tsunami baseline wave. The controls are pre-tsunami *kecamatan* (subdistrict) fixed effects, elevation (quadratic), and distance to coast (quadratic). Robust standard errors, clustered at the baseline enumeration area level, are in parentheses. Tests of the joint significance of all full household died interactions are reported in the bottom panel.