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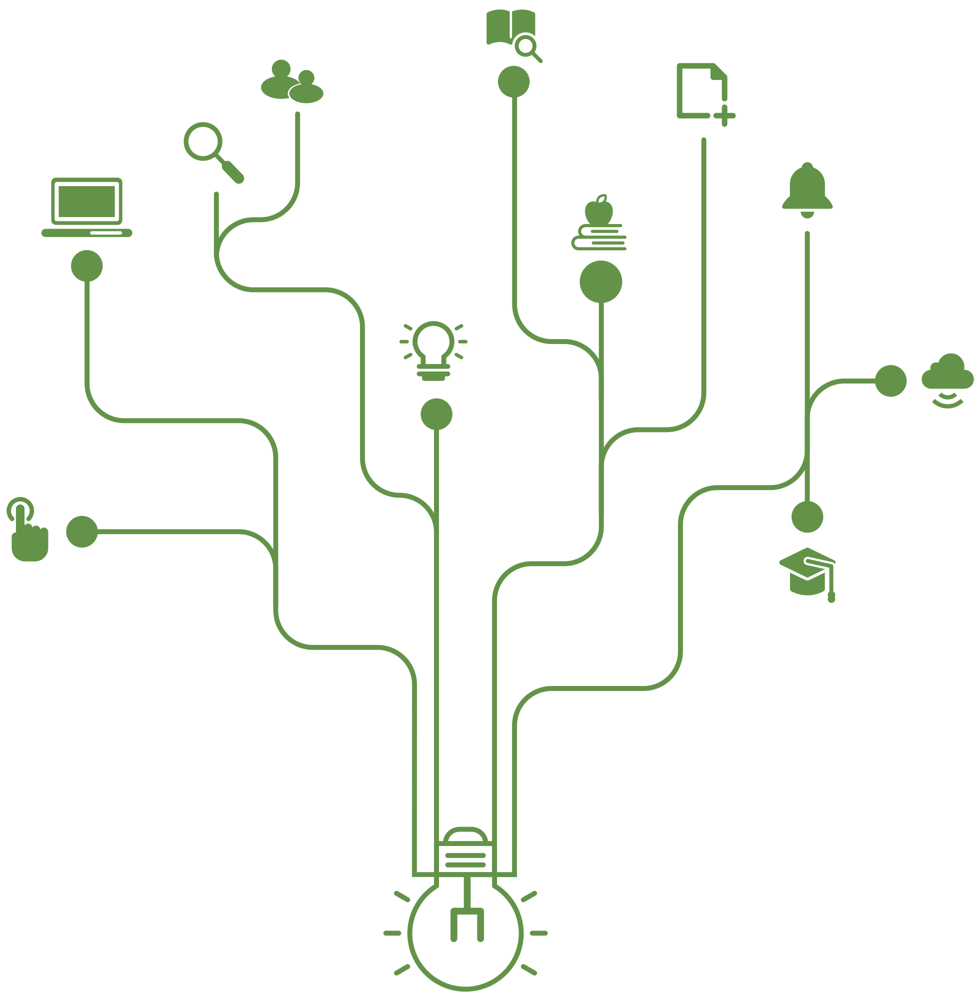

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A. Nilesh Fernando* Chungeun Yoon†

Abstract

We investigate the impacts of the 2004 tsunami on Sri Lanka's labor market using individual-level data. Our findings show a shift from agricultural to service-oriented jobs among those affected by the tsunami. The income levels of these individuals did not decline over the long term. The tsunami also triggered both immediate and sustained migration patterns, and the economic impacts were consistent among both migrants and non-migrants. Our research not only enhances our understanding of how natural disasters can transform labor markets but also suggests policy implications aimed at fostering recovery and resilience in affected communities.

Keywords: Structural change, Natural disaster, Migration

JEL classification: O15, O40, Q54

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1 Introduction

The 2004 tsunami provides a unique context to explore the long-term effects of natural disasters on local economies, labor markets, and individual livelihoods. This catastrophic event, which led to significant loss of life and widespread destruction, also forced a large-scale migration and transformation within the labor force. Understanding these shifts is crucial for developing effective policy responses to natural disasters.

In developing countries, a substantial portion of the labor force is engaged in low-wage agricultural activities. However, these workers could potentially increase their income by moving to non-agricultural sectors (Gollin et al., 2014). While it is widely recognized that natural disasters cause significant short-term losses, the persistence of these effects in the long run remains less understood. Furthermore, the individual impacts of such disasters, which can vary significantly across different demographics, are not well documented in existing literature.

Previous research has primarily focused on the local economy at the administrative unit level, offering limited insight into how natural disasters like tsunamis affect individuals differently across various socio-economic backgrounds. There is a need to understand how forced migrations triggered by such disasters influence occupational decisions and the welfare of both migrants and those who remain.

We explore the individual-level impacts of the 2004 tsunami on Sri Lanka's labor market by utilizing microdata from three sources: the Labor Force Survey (LFS), the Household Income and Expenditure Survey (HIES), and the Census of Population and Household. Our empirical findings show a significant shift in employment patterns, with individuals affected by the tsunami transitioning from agricultural to service-oriented jobs. This shift suggests a broader structural transformation in the labor market prompted by the tsunami.

The data indicate that despite the devastation caused by the tsunami, the income levels of affected individuals did not decline in the long run. Individuals likely experienced an increase in income, attributable to the shift towards more stable and potentially higher-paying service sector jobs. The tsunami also instigated both short-term and long-term migration patterns. Initially, the displacement was a direct consequence of the disaster, but over time, it evolved into longer-term migration trends. Our findings suggest that the economic impacts of the tsunami were similar for both migrants and those who stayed.

To support the validity of our results, we narrowed our focus to individuals in coastal areas, where the socio-economic characteristics were comparable before the tsunami. We supplemented our difference-in-differences analysis with an instrumental variable (IV) approach, utilizing land elevation as a proxy for the intensity of tsunami damage. Areas at lower elevations were more severely affected by the tsunami, thereby experiencing more significant economic and occupational shifts. Our falsification tests confirm the validity of this instrument.

This comprehensive examination sheds light on the resilience and adaptability of individuals affected by the tsunami in Sri Lanka. By transitioning from agriculture to services, these individuals not only navigated the immediate aftermath of the disaster but also positioned themselves for potentially improved economic outcomes in the long run. The consistency of our results across different data sources and robust methodological approaches provides a reliable insight into the transformative effects of natural disasters on labor markets. This research not only enhances our understanding of disaster impacts but also informs policy formulations aimed at fostering recovery and resilience in affected communities.

Economic research on the impact of natural disasters presents a spectrum of findings, ranging from negligible to significantly negative and even positive long-term effects on affected economies. A substantial portion of the literature emphasizes the negative consequences that natural disasters have on countries, documenting the impacts of hurricanes (Bertinelli and Strobl, 2013; Strobl, 2011), earthquakes (duPont Iv et al., 2015; Felbermayr and Gröschl, 2014), and tsunamis Lynham et al. (2017). Other studies highlight the role that country-specific factors such as income level and political systems play in mediating the effects of disasters (Fomby et al., 2013; Loayza et al., 2012; Kahn, 2005).

On the other hand, a growing body of research suggests that natural disasters can have beneficial long-term economic impacts. For instance, Heger and Neumayer (2019) showed that the Indonesian province of Aceh, heavily impacted by the 2004 tsunami, benefited from substantial aid and reconstruction efforts, resulting in enhanced long-term economic output. This study aligns closely with our research, but this study used aggregated-level data, such as night-time lights and local GDP figures. Our study differentiates itself by leveraging microdata, allowing us to examine the effects of the tsunami by individual characteristics and migration patterns. Despite the immediate negative impacts, some studies have documented positive long-term outcomes (Crespo Cuaresma et al., 2008; Gignoux and Menéndez, 2016; Hallegatte and Dumas, 2009; Horwich, 2000; Hornbeck and Keniston, 2017; Skidmore and Toya, 2002), including migration that leads to developments, such as improved agricultural productivity (Hornbeck and Naidu, 2014) or increased earnings and educational attainment of children in volcanic shock-induced relocations (Nakamura et al., 2022).

Our research also contributes to the limited but growing economic literature on Sri Lanka, which has focused on field experiments (Callen et al., 2019; De Mel et al., 2008, 2013, 2014, 2019, 2020) and various socio-political and educational outcomes Sharif (2011); Dower et al. (2017); Aturupane et al. (2014). Direct analyses of the 2004 tsunami's impacts, such as those by Becchetti and Castriota (2010); Becchetti et al. (2017); Conzo (2018); Hollenbach and Ruwanpura (2011); Rodrigo and Deaton (2017), have not previously addressed the structural changes in the labor market that our study aims to illuminate. We fill this gap by providing evidence of how large-scale natural disasters like the tsunami can catalyze long-term economic transformations through shifts in employment from agriculture to services, underscoring the complexity and diversity of disaster impacts on economic systems.

Section 2 provides an overview of the 2004 tsunami in Sri Lanka. Section 3 presents the tsunami's impact on structural economic change, employing a difference-in-differences approach with microdata. Section 4 examines the instrumental variable approach and explores the robustness of results against various specification issues, discussing threats to inferential validity. Section 5 investigates the mechanisms through which the tsunami influenced structural economic changes, examining differential effects by migration status and individual characteristics. Section 6 concludes.

2 The 2004 Indian Ocean tsunami

The 2004 Indian Ocean tsunami profoundly affected Sri Lanka, causing significant devastation and reshaping the socio-economic landscape. This catastrophic event occurred on December 26, 2004, following an undersea earthquake off the west coast of northern Sumatra, Indonesia. Sri Lanka, located close to the epicenter, was among the hardest hit, with the eastern, southern, and northern coasts experiencing the most severe impacts. 1 illustrates the areas inundated by the tsunami.

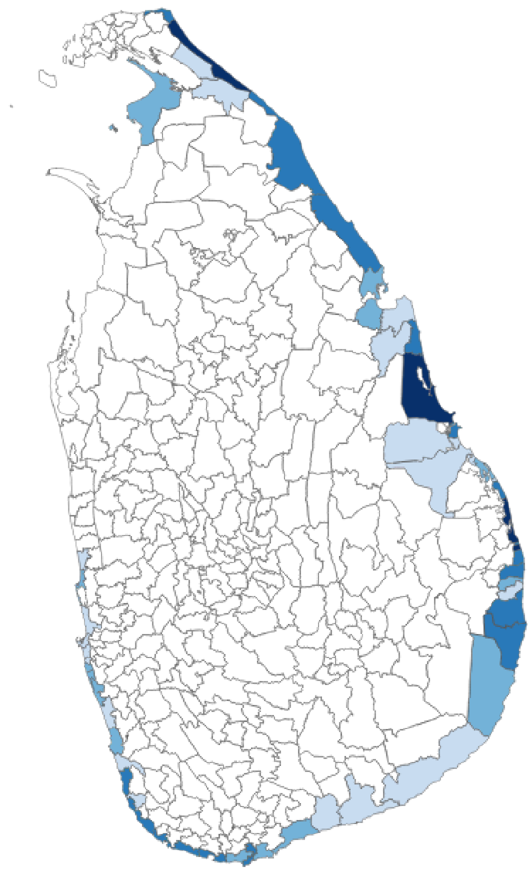
The tsunami claimed approximately 35,000 lives in Sri Lanka, displaced half a million people, and led to widespread property destruction (Abeygunawardena et al., 2006; Weerakoon et al., 2007). The massive loss of life and displacement underscored vulnerabilities in coastal areas, with a significant number of homes destroyed or severely damaged. This destruction necessitated a prolonged phase of reconstruction and rehabilitation. Economically, the tsunami was devastating, especially for the fishing industry, a major livelihood for coastal communities. The destruction of boats and equipment precipitated a collapse of the sector. Many people in southern areas engaged in the coir(coconut fiber) industry, which was severely damaged. The tourism industry also suffered due to the ruined beaches and tourist infrastructure, resulting in a decline in visitor numbers.

To measure the tsunami's effects, the Sri Lankan Department of Census and Statistics conducted the Tsunami Census 2004/2005, collecting data at the district, sub-district (Divisional Secretariats), and village (Grama Niladhari) levels. This detailed census provided data on the number of fatalities or missing persons, population counts before and after the tsunami, damaged buildings, employment in various industries, and the extent of damage across census blocks.

Using the proportion of affected census blocks in each region, we explore the relationship between the extent of tsunami damage and various outcomes. As depicted in 2, regions with high damage saw significant numbers of deaths or disappearances, increased migration out of affected areas, heightened job losses, and extensive building damage. Specifically, regression analysis in 1 shows that approximately 2.7% of the population died or disappeared in areas where all census blocks were affected.

Further analysis focuses on the immediate impact on employment by industry. 2 high-

Figure 1: INUNDATION AREAS OF THE 2004 INDIAN OCEAN TSUNAMI IN SRI LANKA



Notes: The map illustrates the sub-districts (Divisional Secretariats) affected by the 2004 tsunami, with darker shades indicating a higher proportion of damaged census blocks within each region.

Table 1: THE IMMEDIATE EFFECT OF THE TSUNAMI

	Dead/ Disappeared (1)	Out-migration (2)	Unemployment (3)	Damaged buildings (4)
A. Sample: Sub-districts				
Tsunami	0.027	0.142	0.352	0.358
	(0.012)	(0.196)	(0.171)	(0.137)
Dependent variable mean	0.017	0.320	0.452	0.525
Observations	56	55	45	56
B. Sample: Villages				
Tsunami	-	0.286	0.131	0.362
		(0.035)	(0.038)	(0.035)
Dependent variable mean	-	0.254	0.341	0.494
Observations	-	635	636	636

Notes: The table shows the impact of tsunami damage on various outcomes at the sub-district (Divisional Secretariats) level in Panel A and at the village (Grama Niladhari) level in Panel B. The independent variable, Tsunami, is measured by the proportion of affected census blocks in each region. The dependent variables include: the ratio of deceased or missing individuals to the regional population in column (1), the percentage of out-migrants in column (2), the unemployment rate in column (3), and the percentage of damaged buildings in column (4). Standard errors are clustered by sub-district for Panel A and by village for Panel B.

Table 2: THE IMMEDIATE EFFECT OF THE TSUNAMI ON JOB LOSS

	Fishing (1)	Coir (2)	Tourism (3)	Government (4)	Other (5)
Tsunami	0.263	0.208	0.071	0.023	0.133
	(0.051)	(0.043)	(0.043)	(0.016)	(0.035)
Dependent variable mean	0.473	0.200	0.207	0.042	0.298
Observations	636	636	636	636	636

Notes: The table shows the impact of tsunami damage on job loss by industry at the village (Grama Niladhari) level. Job loss is measured by the proportionate decrease in the number of people employed in each industry before and after the tsunami. Standard errors are clustered by village.

lights that the fishing and coir(coconut fiber) industries suffered the most severe damage. For instance, in regions where all census blocks were affected, 26.3% of those employed in the fishing industry before the tsunami were unable to continue working post-disaster.

The data from the Tsunami Census underscores the immediate devastation inflicted on people and the economy. The next chapter will explore the long-lasting economic impacts as well as the immediate repercussions, providing a comprehensive view of the tsunami's effects on Sri Lanka.

3 The tsunami's effect on structural economic change

3.1 Data

We collect various datasets to assess the tsunami's impact on structural economic changes. To determine the intensity of tsunami damage, we use the 2004/2005 Tsunami Census. The proportion of census blocks within regions serves as the independent variable in our regression analysis. Of the 331 divisional secretariats (DS, sub-districts) in Sri Lanka, 56 sub-districts were impacted. Each sub-district contains an average of 94 census blocks, nearly half of which experienced tsunami effects shown in Table 3. Sub-districts unaffected by the tsunami are not included in the census and are assigned a zero value for tsunami intensity.

Our individual-level analysis utilizes datasets from the Labor Force Survey (LFS), Household Income and Expenditure Survey (HIES), and Census of Population and Housing (CPH), including data from before and after the tsunami. The LFS is conducted annually, and we have compiled microdata from 2002 to 2012. The HIES covers the years 2002, 2006, 2009, and 2012, while the census data spans 2001 and 2012, from which we have obtained 5% of the microdata.

The primary variable in our regression analysis is the industry sector in which individuals are employed, identified using the industry codes from the LFS, HIES, and CPH datasets. We categorize employment into the agricultural, manufacturing, or service sectors. Individuals not in the labor force are excluded from this variable. We also analyze monthly income data from the LFS and HIES.

The LFS and HIES allow us to pinpoint districts geographically, while the CPH enables identification at the sub-district level. Although the observations from the CPH are comparatively large, data availability is limited to two time periods pre- and post-tsunami.

In the next chapter, we will elaborate on our methodology for identifying the tsunami's causal effects on various outcomes using these datasets.

Table 3: DESCRIPTIVE STATISTICS

	Mean (1)	SD (2)	Min. (3)	Max. (4)	N (5)
A. Tsunami Census, 2004/2005 (Sub-district level)					
Dead or disappeared (%)	0.017	0.026	0.000	0.108	56
Damaged buildings (%)	0.525	0.228	0.101	1.000	56
Tsunami intensity (affected census blocks, %)	0.535	0.244	0.038	1.000	56
B. Labor Force Survey, 2002-2012					
Female	0.523	0.499	0	1	517,417
Age	40.674	17.020	16	99	517,417
Years of education	9.410	3.876	0	19	515,525
Agricultural industry	0.348	0.476	0	1	268,897
Manufacturing industry	0.168	0.374	0	1	268,897
Service industry	0.485	0.500	0	1	268,897
Monthly income (USD)	134.138	110.160	0	668	166,356
C. Household Income and Expenditure Survey, 2002, 2006, 2009, and 2012					
Female	0.531	0.499	0	1	224,133
Age	41.016	17.031	16	99	222,797
Years of education	8.605	3.798	0	19	222,439
Agricultural industry	0.277	0.447	0	1	99,851
Manufacturing industry	0.171	0.376	0	1	99,851
Service industry	0.553	0.497	0	1	99,851
Monthly income (USD)	156.768	122.079	0	750	70,247
D. Census of Population and Housing, 2001 and 2012					
Female	0.424	0.494	0	1	1,391,127
Age	39.045	15.311	16	119	1,391,127
Years of education	8.595	3.487	0	16	1,338,154
Agricultural industry	0.278	0.448	0	1	873,664
Manufacturing industry	0.229	0.420	0	1	873,664
Service industry	0.492	0.500	0	1	873,664

Notes: The table presents summary statistics derived from various data sources. Panel A focuses on Divisional Secretariats (sub-districts) that were affected by the tsunami. Panels B, C, and D compile data from individuals across different surveys.

3.2 Empirical strategy

Our empirical analysis employs a difference-in-differences approach, comparing highly damaged areas with less damaged ones before and after the tsunami. The key assumption of this analysis is that, in the absence of the tsunami, there would be no pre-existing differences between these areas. We initiate our analysis by conducting a balance check with data from the pre-treatment period. Table 4 presents the baseline characteristics prior to the 2004 tsunami. The first column includes individuals from coastal regions severely impacted by the tsunami, identified by damage levels exceeding the median. Column (2) captures individuals from coastal regions with less extensive damage, where the tsunami impact was below the median. The subsequent columns (3) and (4) confirm that none of the variables displayed significant differences prior to the tsunami, thereby supporting the nonexistence of pre-tsunami differences. This balance check substantiates the reliability of our empirical approach, ensuring that differences in outcomes post-tsunami can be attributed to the effects of the tsunami, rather than to any pre-existing conditions.

To evaluate the causal effects of the tsunami on structural shifts within the economy, we propose the following econometric framework:

$$Y_{ijt} = \beta(Tsunami_j \times Post_t) + X_{ijt} + \theta_j + \tau_t + \epsilon_{ijt} \tag{1}$$

where Y_{ijt} presents the dependent variable for individual i, in district j, at year t. The outcomes specifically relate to sectoral employment, categorizing individuals into agricultural, manufacturing, or service sectors. $Tsunami_j$ represents the proportion of census blocks within district j that were affected by the tsunami, thus serving as a measure of exposure. $Post_t$ is a binary variable indicating the years following the tsunami, specifically post-2005. X_{ijt} comprises a vector of individual-level control variables including gender, age, and educational attainment, which are adjusting for demographic heterogeneity. θ_j and τ_t are sets of fixed effects for districts and years, respectively. These control for all time-invariant characteristics at the district level and common temporal shocks or trends affecting all districts. The standard errors clustered at the district level. This specification allows us to isolate the differential effects of the tsunami by comparing changes in outcomes of individuals in affected districts relative to changes in unaffected districts, while controlling for both observable and unobservable confounding factors. The coefficient of interest β identifies the causal impact of the tsunami on the structural transformation of employment sectors.

We complement our empirical analysis with a time-varying difference-in-differences approach. In addition to our finding of no initial differences in characteristics and outcomes between the treated and control groups during the balance check, this time-varying specification allows us to assess the dynamic effects relative to the year before the tsunami, thereby testing for the parallel trends assumption critical to our identification strategy. We estimate the following event-study equation:

Table 4: BASELINE CHARACTERISTICS BY TSUNAMI: PRE-TREATMENT PERIOD

	Highly damaged (1)	Less damaged (2)	Difference (3)	p-value (4)
A. Labor Force Survey, 2002				
Female	0.517	0.517	0.001	0.923
Age	39.726	39.039	0.686	0.231
Years of education	9.102	9.560	-0.458	0.102
Agricultural industry	0.350	0.270	0.080	0.456
Manufacturing industry	0.173	0.186	-0.013	0.770
Service industry	0.476	0.544	-0.067	0.364
Monthly income (USD)	71.468	88.743	-17.275	0.125
Observations	12,471	15,781	28,252	
B. Household Income and Expenditure Survey, 2002				
Female	0.517	0.519	-0.002	0.736
Age	39.909	38.827	1.082	0.110
Years of education	8.429	8.752	-0.323	0.442
Agricultural industry	0.232	0.127	0.105	0.178
Manufacturing industry	0.191	0.218	-0.027	0.475
Service industry	0.578	0.655	-0.078	0.219
Monthly income (USD)	71.571	85.640	-14.068	0.208
Observations	13,290	20,196	33,486	
C. Census of Population and Housing, 2001				
Female	0.494	0.485	0.010	0.534
Age	38.362	38.084	0.278	0.498
Years of education	8.873	8.886	-0.013	0.968
Agricultural industry	0.135	0.138	-0.003	0.957
Manufacturing industry	0.278	0.300	-0.022	0.718
Service industry	0.587	0.562	0.025	0.768
Observations	156,473	268,981	425,454	

Notes: The table presents baseline characteristics prior to the 2004 tsunami. The first column consists of individuals in coastal regions severely impacted by the tsunami, determined by damage levels above the median as measured by the proportion of damaged census blocks in these areas. Column (2) includes individuals from coastal regions that experienced less damage, with tsunami damage below the median. Columns (3) and (4) report the differences between these groups and the associated p-values, respectively.

$$Y_{ijt} = \sum_t \beta_t (Tsunami_j \times YearDummy_t) + X_{ijt} + \theta_j + \tau_t + \epsilon_{ijt} \quad (2)$$

where $YearDummy_t$ indicates survey year t. The coefficient of interest, β_t, captures the effect of the tsunami on the outcome relative to the year before the tsunami. In our analysis, we utilize three datasets to cover different pre-treatment periods: the Labor Force Survey (LFS) for 2002-2004, the Household Income and Expenditure Survey (HIES) for 2002, and the Census of Population and Housing (CPH) for 2001. The availability of multiple years in the LFS allows us to test the parallel trends assumption, but unfortunately, the single-year data from HIES and CPH precludes such a test. It is expected that β_t will not show statistical significance during the pre-treatment periods if the parallel trends assumption holds. If structural changes occur due to the tsunami and subsequent reconstruction efforts, it is expected that β_t will be negative and statistically significant for agricultural employment, indicating a decline. Conversely, for manufacturing and service employment, β_t should be positive and statistically significant, indicating a shift towards these sectors.

3.3 Results

Tables 5, 6, and 7 show the results from estimating equation 1 for each sectorial employment outcome using three datasets: the Labor Force Survey (LFS), the Household Income and Expenditure Survey (HIES), and the Census of Population and Housing (CPH). The findings suggest that individuals in tsunami-affected regions were more likely to exit the agricultural sector and transition towards the service sector. Specifically, the CPH, with its expansive sample size as shown in Table 5, indicates that residents in fully affected regions were 21.2 percentage points less likely to work in agriculture and 19.7 percentage points more likely to work in services. The shift towards the manufacturing sector was not significant. These patterns are corroborated by results from the LFS and HIES, presented in Tables 6 and 7 respectively.

A concern about the validity of our findings arises due to potential disparities between coastal and inland regions, the latter of which may not serve as appropriate counterfactuals for tsunami-affected coastal areas. Inland districts could differ significantly, often with lower engagement in fishing and tourism. Despite parallel trends observed between treated and control groups, such heterogeneity may still cause issues. To mitigate this, we refined our analysis to include only coastal districts, eliminating inland regions from our study. The refined results in panel B show that individuals from coastal regions affected by the tsunami were 14.3 percentage points less likely to be employed in agriculture but more likely to work in the service sector compared to those from coastal regions unaffected by the tsunami. Changes in manufacturing employment remained insignificant. This more focused analysis still aligns with results from the LFS and HIES.

In addition, the LFS and HIES provide insights into monthly income effects post-tsunami. We find that overall monthly income did not decrease, and indeed showed a positive coefficient across the full sample from all regions. However, a negative and insignificant effect was observed when focusing solely on coastal regions.

Figures 3 and 4 depict the dynamic impacts of the tsunami, comparing pre- and post-tsunami years using equation 2. These results support the narrative that while there was a decrease in agricultural engagement, there was a corresponding increase in service sector employment, with no significant effects in the manufacturing sector. The lack of significant coefficients prior to the tsunami underscores the validity of the parallel trends assumption in our identification strategy. Moreover, the observed effects persisted until 2012, covering the period when tsunami reconstruction aid concluded.

Overall, our findings suggest a significant economic structural shift from agriculture to the service sector, a transformation typically indicative of broader economic development that was catalyzed by the tsunami's impact. This change underscores the profound economic adjustments prompted by natural disasters and the subsequent recovery efforts.

Table 5: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY, CENSUS OF POPULATION AND HOUSING

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. All regions			
Tsunami	-0.212	0.015	0.197
	(0.046)	(0.028)	(0.050)
Dependent variable mean	0.273	0.232	0.495
Observations	787,462	787,462	787,462
R-squared	0.247	0.049	0.121
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes
B. Coastal regions			
Tsunami	-0.143	0.038	0.106
	(0.031)	(0.032)	(0.047)
Dependent variable mean	0.143	0.279	0.578
Observations	322,656	322,656	322,656
R-squared	0.225	0.047	0.084
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The sample consists of individuals from the census of population and housing in 2001 and 2012. Panel A employs the full sample, while Panel B focuses on individuals from coastal districts. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

Table 6: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY, LABOR FORCE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. All regions				
Tsunami	-0.056	-0.003	0.059	11.774
	(0.029)	(0.015)	(0.034)	(9.015)
Dependent variable mean	0.348	0.168	0.484	144.412
Observations	261,437	261,437	261,437	150,581
R-squared	0.223	0.066	0.129	0.348
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
B. Coastal regions				
Tsunami	-0.068	-0.004	0.073	-13.629
	(0.047)	(0.016)	(0.051)	(11.586)
Dependent variable mean	0.298	0.188	0.514	155.715
Observations	181,611	181,611	181,611	103,352
R-squared	0.209	0.064	0.112	0.329
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The sample consists of individuals from labor force surveys between 2002 and 2012. Panel A employs the full sample, while Panel B focuses on individuals from coastal districts. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

Table 7: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY, HOUSEHOLD INCOME AND EXPENDITURE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. All regions				
Tsunami	-0.138	0.001	0.138	17.878
	(0.066)	(0.020)	(0.057)	(9.507)
Dependent variable mean	0.277	0.171	0.553	156.768
Observations	99,688	99,688	99,688	70,145
R-squared	0.190	0.057	0.100	0.373
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
B. Coastal regions				
Tsunami	-0.159	0.015	0.144	-4.676
	(0.070)	(0.020)	(0.065)	(9.717)
Dependent variable mean	0.238	0.188	0.574	168.520
Observations	72,583	72,583	72,583	50,331
R-squared	0.170	0.055	0.078	0.344
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The sample includes individuals from the household income and expenditure surveys of 2002, 2006, 2009, and 2012. Panel A uses the full sample, while Panel B focuses on individuals from coastal districts. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

4 Addressing threats to inferential validity

Potential threats to the inferential validity of our empirical analysis stem from inherent disparities between tsunami-affected and unaffected regions. These discrepancies might confound the structural changes attributed to the tsunami's effects. To mitigate this issue, we refined our analysis to focus solely on coastal regions, excluding inland areas because coastal regions unaffected by the tsunami serve as more suitable counterfactuals for the affected coastal regions. Furthermore, our balance check shown in Table 4, which revealed no significant initial differences in outcomes between treated and control groups prior to the tsunami, supports the inferential validity of our identification strategy. However, concerns may still arise regarding different economic trends between tsunami-affected and unaffected coastal areas, as well as potential distortions from reconstruction aid, economic spillovers, and regional migration.

4.1 Instrumental variable (IV) approach and falsification test

To address these concerns, we introduced the instrumental variable of land elevation to estimate the impact of the tsunami. The rationale behind this instrument is that lower-elevation regions are more susceptible to tsunami damage due to flooding, while higher-elevation regions are less affected. Our analysis is restricted to coastal areas as high inland regions do not serve as appropriate counterfactuals due to distinct socioeconomic conditions. We calculated the instrumental variable by measuring and normalizing the average elevation within each region. The IV estimates shown in Table 5 provide stronger evidence of structural change; individuals were 34.6 percentage points less likely to engage in agriculture and 35.5 percentage points more likely to work in the service sector. The effect on manufacturing employment remains insignificant. The first-stage results are negative and statistically significant, indicating that regions at higher elevations experienced less tsunami damage and flooding.

To further validate our IV approach and the exclusion restriction, we present reduced-form results in Table 9. The exclusion restriction assumes that land elevation affects the outcomes solely through the tsunami, with no other contributing factors. To test this, we examined the impact of land elevation on employment outcomes using different subsamples with varying degrees of tsunami damage. In Panel A of Table 9, which reports reduced-form estimates from coastal regions both affected and unaffected by the tsunami, we found a negative effect of land elevation on agricultural employment and a positive effect on service employment. Given the negative association between land elevation and tsunami damage, these effects align with our prior findings.

Panel B of Table 9 focuses on inland regions, which the tsunami could not have affected. We found no effect of land elevation, providing further support for the vailidity of our instrumental variable approach. Panel C uses a subsample comprising both inland and unaffected coastal regions — areas not affected by the tsunami. There was no impact of land elevation, confirming the robustness of our exclusion restriction.

Overall, the strength of the IV estimates combined with the results of these falsification tests underscore the inferential validity of our empirical analysis, suggesting that the economic structural changes can be attributed to the tsunami's effect.

Table 8: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY, CENSUS OF POPULATION AND HOUSING, IV

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. IV estimates			
Tsunami	-0.346	-0.009	0.355
	(0.097)	(0.089)	(0.107)
Dependent variable mean	0.143	0.279	0.578
Observations	320,433	320,433	320,433
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes
B. First-stage: Tsunami			
Land elevation	-0.057		
	(0.008)		
Kleibergen-Paap F statistic	51.295		

Notes: The sample consists of individuals from the census of population and housing in 2001 and 2012 in coastal regions. The instrumental variable (IV) of land elevation is used to predict tsunami damage, with the first stage results in Panel B. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

4.2 Reconstruction aid

One might argue that reconstruction efforts and aid could bias the effects of the tsunami by disproportionately allocating resources to politically or economically significant regions, rather than according to the severity of tsunami damage. To mitigate this potential bias in our analysis, we incorporate measures of reconstruction aid to more accurately assess the effects of the tsunami. Based on data from sources (Abeygunawardena et al., 2006; Weerakoon et al., 2007), it is estimated that approximately 100,000 houses were damaged by the tsunami. The Tsunami Housing Reconstruction Unit (THRU) has signed Memoranda of Understanding (MOUs) with various donors committed to reconstructing these homes.

We use the proportion of damaged housing scheduled for reconstruction under these MOUs as a weight for tsunami damage. For instance, if a region was fully exposed to the tsunami and all damaged housing is to be rebuilt, the tsunami variable is assigned a value

Table 9: REDUCED FORM ESTIMATES AND FALSIFICATION TEST

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. Coastal regions			
Land elevation	0.020	0.001	-0.020
	(0.005)	(0.005)	(0.006)
Dependent variable mean	0.143	0.279	0.578
Observations	320,433	320,433	320,433
R-squared	0.229	0.047	0.087
B. Inland regions unaffected by the tsunami			
Land elevation	-0.001	0.001	-0.000
	(0.001)	(0.001)	(0.001)
Dependent variable mean	0.364	0.199	0.437
Observations	464,806	464,806	464,806
R-squared	0.231	0.045	0.140
C. Inland regions and coastal unaffected by the tsunami			
Land elevation	-0.001	0.001	-0.000
	(0.001)	(0.001)	(0.001)
Dependent variable mean	0.314	0.225	0.460
Observations	641,753	641,753	641,753
R-squared	0.244	0.058	0.123
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the reduced form relationship between land elevation and individual outcomes. Panel A uses individuals from the census of population and housing in 2001 and 2012 in coastal areas, whereas Panel B focuses on those from inland regions not affected by the tsunami. Panel C includes both coastal and inland areas, but unaffected by the tsunami. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

of one. If a region was fully exposed but only half of the damaged housing is scheduled for reconstruction, the tsunami variable takes a value of 0.5. This method allows us to account for the varying levels of aid and its potential to skew the perceived impact of the tsunami. Table 10 presents results that consistently show more significant findings when considering the reconstruction aid. This approach helps to demonstrate that our estimates of the tsunami's impact are robust.

Table 10: THE EFFECT OF THE TSUNAMI AND RECONSTRUCTION AID ON LOCAL ECONOMY

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. All regions			
Tsunami	-0.389	-0.012	0.401
weighted by reconstruction	(0.099)	(0.051)	(0.104)
Dependent variable mean			
Observations	787,462	787,462	787,462
R-squared	0.246	0.049	0.120
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes
B. Coastal regions			
Tsunami	-0.163	0.005	0.159
weighted by reconstruction	(0.061)	(0.045)	(0.072)
Dependent variable mean			
Observations	322,656	322,656	322,656
R-squared	0.221	0.047	0.084
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: Reconstruction represents the percentage of damaged housing that was scheduled to be rebuilt according to a memorandum of understanding for reconstruction aid. The tsunami variable was weighted by this percentage of housing that was reconstructed. The sample consists of individuals from the census of population and housing in 2001 and 2012. Panel A employs the full sample, while Panel B focuses on individuals from coastal districts. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

4.3 Economic spillovers

Economic spillovers from the capital city of Colombo might complicate the analysis of the tsunami's impact due to distinct economic trends and focused reconstruction efforts there compared to other regions. Colombo, being the economic hub, experienced different dynamics in both the immediate aftermath and long-term recovery phases post-tsunami. Its infrastructure was rapidly targeted for recovery, which could contrast with more remote regions where recovery was slower due to severe infrastructure damage. In addition, the concentration of aid and economic recovery programs in Colombo could lead to biased interpretations of the tsunami's broader economic effects.

To address this potential bias, our analysis tests the robustness of the tsunami's impact by excluding Colombo from the dataset, as shown in Table 11. This exclusion helps to isolate the effects of the tsunami from the unique economic dynamics of the capital city. Furthermore, to control for economic influences emanating from Colombo that might affect nearby regions, we incorporate a variable measuring the distance from Colombo. This approach allows us to account for any diminishing impact of Colombo's economic activity with increasing distance. The results remain robust, suggesting that the tsunami's effects on economic structures and employment patterns are significant and not merely a reflection of the capital city's economic influence or its concentrated reconstruction efforts.

Table 11: ROBUSTNESS TEST: THE CAPITAL CITY

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. Dropping the capital city			
Tsunami	-0.163	0.014	0.149
	(0.025)	(0.036)	(0.037)
Observations	234,227	234,227	234,227
B. Distance to the capital city			
Tsunami	-0.138	0.026	0.112
	(0.032)	(0.026)	(0.044)
Observations	322,656	322,656	322,656
C. Dropping the capital city and distance to the capital city			
Tsunami	-0.161	0.014	0.147
	(0.025)	(0.035)	(0.039)
Observations	234,227	234,227	234,227
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The sample consists of individuals in coastal regions from the census of population and housing in 2001 and 2012. Panel A excludes the capital city of Colombo, while Panel B controls for the distance to the capital city interacted with yearly trends. Panel C incorporates both factors. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

5 Mechanism

5.1 The tsunami's effect by migration

The 2004 tsunami in Sri Lanka caused migration and displacement, profoundly affecting the country's demographic landscape and labor market structures. In the immediate aftermath, over half a million people were displaced as their homes were either destroyed or severely damaged by the waves. The displacement was exacerbated as many affected areas were designated as buffer zones where rebuilding was prohibited, prompting both involuntary and voluntary relocations. Many displaced individuals moved to other parts of Sri Lanka to join relatives or seek new employment opportunities, settling in transitional or permanent housing developments inland.

These migration patterns have the potential to confound the effects of the tsunami on structural changes in the labor market. As indicated in Table 1, there was immediate out-migration from the tsunami-affected regions. To examine the longevity of this displacement and its implications for labor market structures, we utilized data from the 2012 Census of Population and Housing (CPH), which tracks previous district residency and year of migration. According to Table A7, a significant number of individuals who moved from tsunami-affected districts had not returned by 2012, highlighting a trend of sustained displacement and the absence of return migration.

We further explore the effect of these migration patterns by comparing employment outcomes between migrants and non-migrants. In Table 13, we measure the tsunami's differential effects by migration status. Interestingly, no substantial difference in the tsunami's impact on employment between migrants and non-migrants existed. Specifically, both groups show a decrease in agricultural engagement by 20.7 percentage points. The shift towards service employment was more pronounced among migrants than non-migrants, and increases for both cohorts were statistically significant.

This suggests that both voluntary and involuntary migrants, displaced by the tsunami, actively sought new employment opportunities predominantly outside of agriculture, favoring the service sector. Similarly, non-migrants affected by the tsunami, although not relocating, also transitioned their employment from agriculture to services. These findings underscore a broad, structural shift in the labor market post-tsunami, driven by both displacement and the adaptive responses of the affected populations.

This structural shift likely reflects a combination of necessity—due to the destruction of agricultural infrastructure and jobs—and opportunity, as the post-tsunami reconstruction efforts and economic aid focused on service-oriented sectors. Such insights highlight the interplay between natural disasters, migration, and labor market dynamics, offering lessons for understanding and planning recovery and resilience strategies in post-disaster scenarios.

Table 12: THE EFFECT OF THE TSUNAMI ON MIGRATION

Dependent variable:	Migration		Return migration	
	(1)	(2)	(3)	(4)
Tsunami	0.008	0.009	0.015	0.014
	(0.002)	(0.002)	(0.021)	(0.021)
Dependent variable mean	0.024	0.024	0.055	0.055
Observations	119,557	119,557	477,637	477,637
Controls	No	Yes	No	Yes

Notes: The sample focuses on individuals who migrated from the 2012 census of population and housing. The dependent variable, Migration, indicates whether individuals migrated in 2004, and Return migration denotes whether individuals returned to their birthplace after 2004. We include controls for individual characteristics such as gender, age, and education, in addition to district population in columns 2 and 4. Standard errors in parentheses are clustered at the district level.

Table 13: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY MIGRATION STATUS

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. Migrants			
Tsunami	-0.207	-0.053	0.260
	(0.057)	(0.042)	(0.035)
Dependent variable mean	0.191	0.260	0.549
Observations	209,781	209,781	209,781
R-squared	0.261	0.082	0.097
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes
B. Non-migrants			
Tsunami	-0.207	0.027	0.180
	(0.050)	(0.023)	(0.056)
Dependent variable mean	0.305	0.221	0.475
Observations	571,206	571,206	571,206
R-squared	0.239	0.037	0.133
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The sample consists of individuals from the census of population and housing in 2001 and 2012. Panel A focuses those who migrated, while Panel B focuses on those who did not migrate. We include controls for individual characteristics such as gender, age, and education, in addition to district population. Standard errors in parentheses are clustered at the district level.

5.2 The tsunami's effect by individual characteristics

The rich individual-level datasets allow us to investigate how the tsunami impacted people based on personal attributes. Unlike many previous studies which concentrated on aggregate regional analysis due to data constraints, our study explores the differential impacts of the tsunami across various demographic segments, thereby shedding light on the most vulnerable groups.

Our analysis shows no significant differences in how the tsunami affected males and females. Consistent across multiple datasets, including Table 14 as well as findings from Tables A1 and 7, the results indicate a uniform impact of the tsunami across genders. This suggests that the disaster's effects were broadly similar for both male and female populations in terms of employment shifts from agriculture to services.

Age appears to be a significant factor in determining the impact of the tsunami. Older individuals were disproportionately affected compared to their younger counterparts. Specifically, Table 15 shows that older people were 33.2 percentage points more likely to leave agriculture, while the figure for younger individuals was only 13.3 percentage points. This trend of a greater impact on older populations was also evident in analyses from other data sources, such as Table A2 and A5.

Education level also significantly influenced how individuals were affected by the tsunami. Those with lower educational attainment were more likely to transition out of agriculture and into services compared to those with higher education. Table 16 illustrates this, showing a 33.7 percentage point decrease in agricultural employment among the less educated, compared to a 17.1 percentage point decrease among the more educated. Similar patterns were observed in the data from Table A3, but Table A6 did not show a significant difference.

Overall, our findings highlight that the tsunami's effects were particularly pronounced among older and less educated individuals, while the impact on employment shifts was relatively uniform across genders, showing no significant disparity. There are several reasons why older and less educated individuals were more affected. Agriculture is labor-intensive and requires robust physical health. Older individuals, particularly those impacted by the disaster's physical and emotional toll, may find it challenging to meet these demands. Government and NGO recovery efforts are often geared towards sectors, concentrating on rebuilding urban infrastructure and services. These efforts include training programs and job creation in areas that are more accessible and immediately beneficial to older and less educated individuals, who may find fewer barriers to entry in these fields compared to returning to agriculture. Support programs designed to aid recovery are frequently more accessible to older and less educated individuals. By understanding these differential impacts, policymakers and disaster response organizations can tailor their strategies to better support the most affected groups in the aftermath of such disasters.

Table 14: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY GENDER, CENSUS OF POPULATION AND HOUSING

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. Males			
Tsunami	-0.202	0.016	0.186
	(0.047)	(0.029)	(0.059)
Dependent variable mean	0.265	0.217	0.518
Observations	577,448	577,448	577,448
R-squared	0.138	0.025	0.050
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
B. Females			
Tsunami	-0.335	0.007	0.328
	(0.087)	(0.045)	(0.059)
Dependent variable mean	0.293	0.265	0.442
Observations	247,158	247,158	247,158
R-squared	0.194	0.075	0.067
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

Notes: Individuals from the census of population and housing in 2001 and 2012 are divided into two subsamples: males in Panel A, and females in Panel B.

Table 15: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY AGE, CENSUS OF POPULATION AND HOUSING

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. Young individuals			
Tsunami	-0.133	-0.026	0.159
	(0.042)	(0.053)	(0.061)
Dependent variable mean	0.215	0.277	0.508
Observations	440,957	440,957	440,957
R-squared	0.152	0.045	0.039
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
B. Old individuals			
Tsunami	-0.332	0.048	0.284
	(0.075)	(0.015)	(0.067)
Dependent variable mean	0.340	0.179	0.480
Observations	383,649	383,649	383,649
R-squared	0.155	0.024	0.077
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

Notes: Individuals from the census of population and housing in 2001 and 2012 are divided into two subsamples: individuals aged 16 to 39 in Panel A, those aged 40 or above in Panel B.

Table 16: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY EDUCATION, CENSUS OF POPULATION AND HOUSING

Dependent variable:	Agriculture	Manufacture	Service
	(1)	(2)	(3)
A. Individuals with low education			
Tsunami	-0.337	0.102	0.235
	(0.094)	(0.032)	(0.082)
Dependent variable mean	0.497	0.200	0.303
Observations	284,470	284,470	284,470
R-squared	0.173	0.043	0.090
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
B. Individuals with high education			
Tsunami	-0.171	-0.017	0.188
	(0.036)	(0.027)	(0.042)
Dependent variable mean	0.143	0.248	0.609
Observations	502,992	502,992	502,992
R-squared	0.092	0.030	0.019
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

Notes: Individuals from the census of population and housing in 2001 and 2012 are divided into two subsamples: individuals with education levels of middle school dropouts or lower in Panel A, and those who are middle school graduates or higher in Panel B.

6 Conclusion

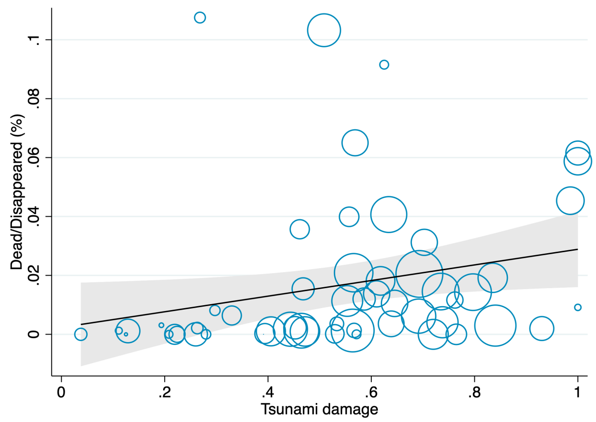
Our research found a structural change in the Sri Lankan labor market, characterized by a shift from agriculture to the service sector. This transformation was particularly pronounced in tsunami-affected areas, where the destruction of the fishing industry and agricultural infrastructure, coupled with subsequent reconstruction efforts, catalyzed a move towards service-oriented employment. This shift is crucial as it represents a transition from labor-intensive work to potentially more sustainable and economically beneficial sectors.

The transition was driven by several mechanisms. The initial loss of agricultural capacity forced many to seek alternative employment, predominantly in the service sector, which was rapidly expanding due to reconstruction needs. Targeted support programs facilitated by the government and NGOs provided training and employment opportunities in new sectors. Investments in infrastructure not only rebuilt what was lost but also created new economic opportunities and efficiencies that favored service sector growth.

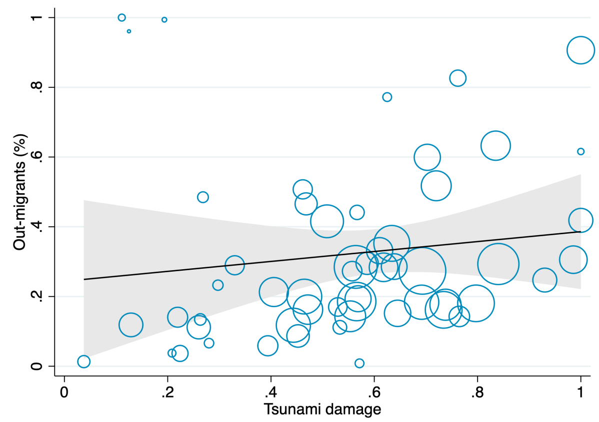
Our findings suggest that the economic shift was not merely a temporary response to the tsunami but has the potential for long-lasting economic benefits. The sustainability of this growth, however, hinges on continued support and the implementation of appropriate policies that reinforce these new economic pathways. The experience of Sri Lanka demonstrates that with sufficient and well-coordinated aid, coupled with strong political will, regions can transform the adverse effects of natural disasters into opportunities for economic improvement and structural transformation. However, the success of such transformations is contingent upon the nature of the aid, the socio-political context, and the specific economic conditions of the affected regions.

In conclusion, our study supports that although major natural disasters cause significant immediate harm, they do not necessarily condemn affected regions to prolonged economic hardship. With strategic, well-managed aid and a focus on transforming economic structures, regions can rebound and even exceed their pre-disaster economic trajectories. This insight is crucial for future responses to natural disasters, emphasizing the need for rapid, coordinated, and well-planned interventions that not only aim to restore but also to improve and innovate on pre-existing conditions.

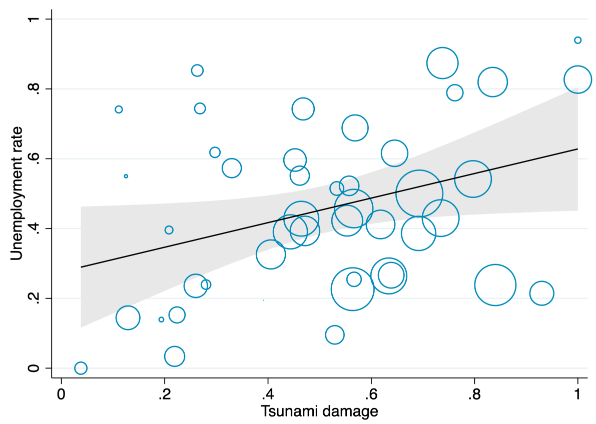
Figure 2: THE IMMEDIATE EFFECT OF THE TSUNAMI



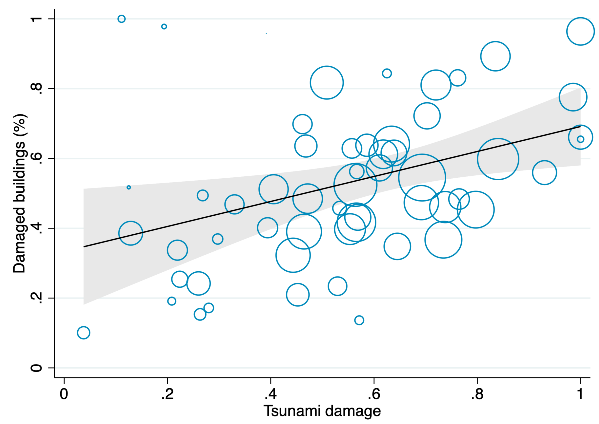
(a) Dead/disappered persons



(b) Out-migrants



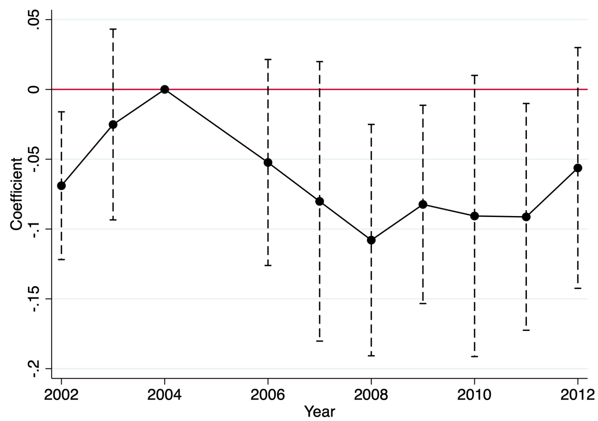
(c) Unemployed persons



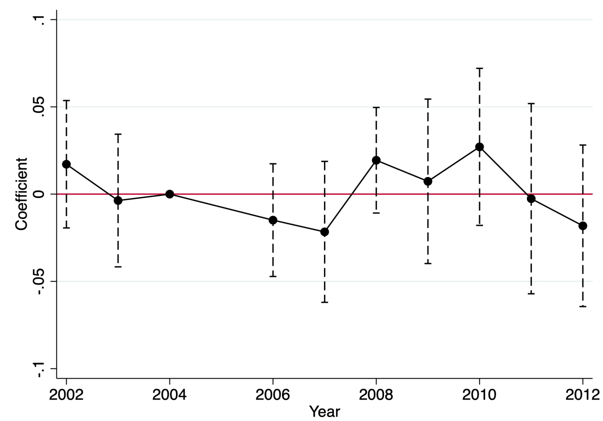
(d) Damaged buildings

Notes: The figure demonstrates the impact of the 2004 tsunami on outcomes at the sub-district (Divisional Secretariats) level. The slope of the linear line represents the regression coefficient, while the gray areas indicate the range from the lower to the upper limit of the slope in the 95 percent confidence interval.

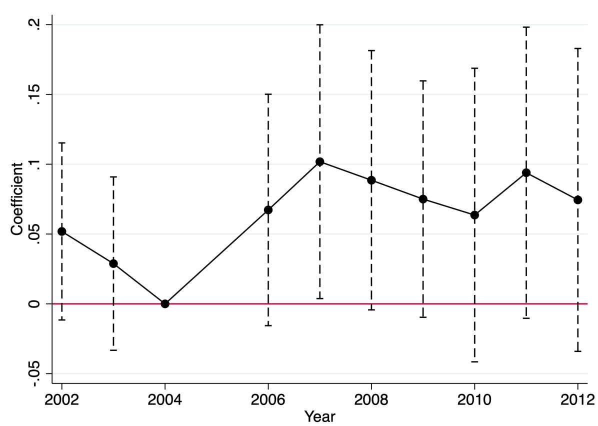
Figure 3: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY, LABOR FORCE SURVEY



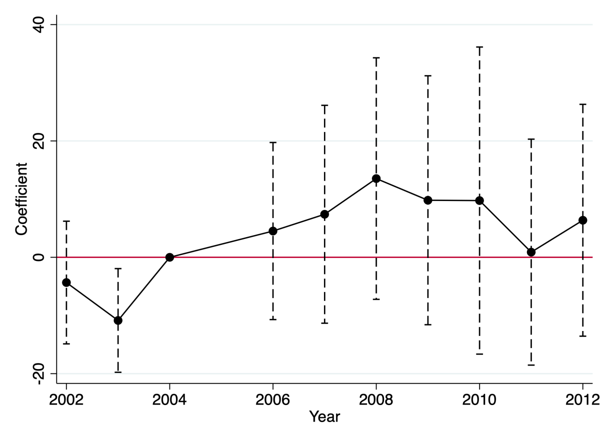
(a) Agriculture



(b) Manufacture



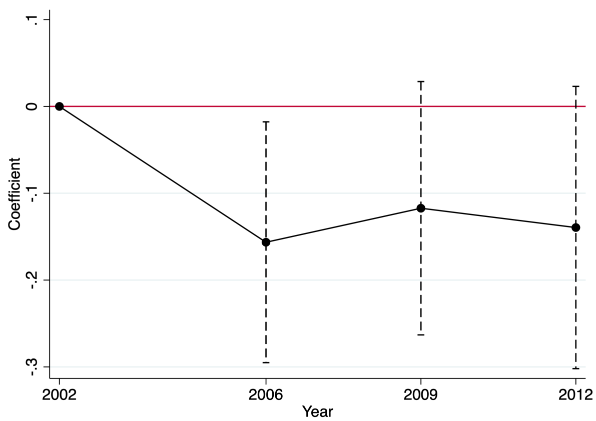
(c) Service



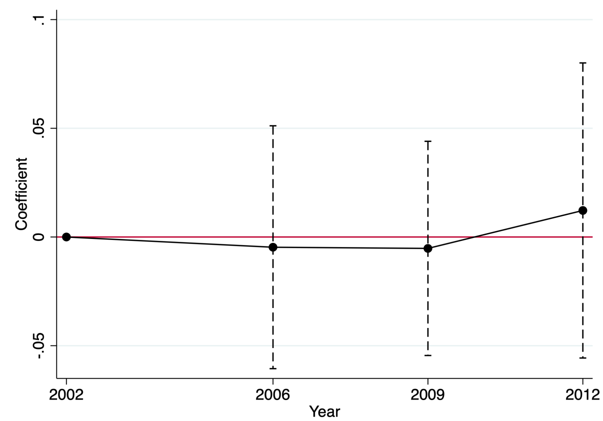
(d) Monthly income

Notes: The sample includes individuals from labor force surveys from 2002 to 2012. The coefficients for each year relative to the year 2004 are presented with the 95 percent confidence intervals.

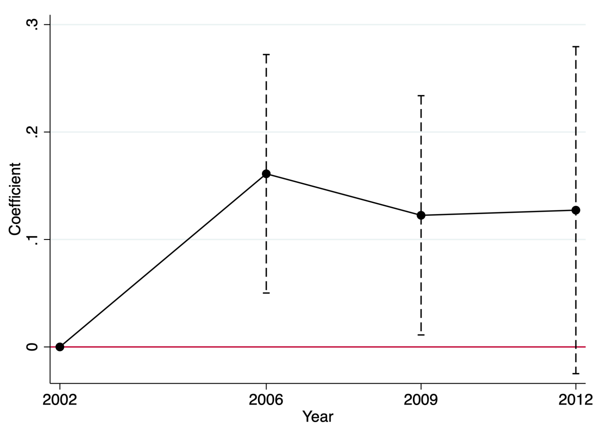
Figure 4: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY, HOUSEHOLD INCOME AND EXPENDITURE SURVEY



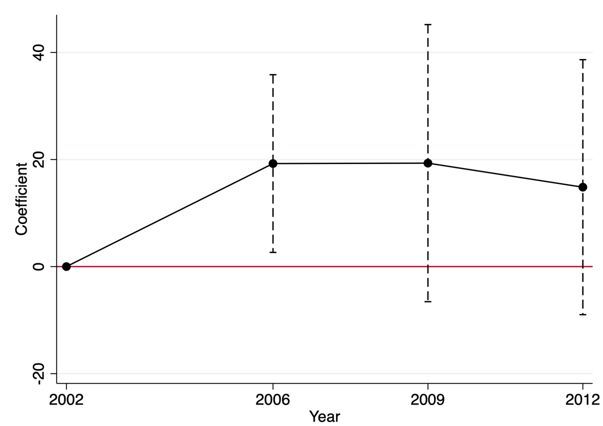
(a) Agriculture



(b) Manufacture



(c) Service



(d) Monthly income

Notes: The sample includes individuals from the household income and expenditure surveys of 2002, 2006, 2009, and 2012. The coefficients for each year relative to the year 2002 are presented with the 95 percent confidence intervals.

References

Abeygunawardena, M., M. Thiagarajah, M. Boestel, M. Kociejowski, and C. Societies (2006). Post tsunami recovery and reconstruction: Sri lanka. *Government of Sri Lanka*.

Aturupane, H., P. Glewwe, R. Ravina, U. Sonnadara, and S. Wisniewski (2014). An assessment of the impacts of sri lanka's programme for school improvement and school report card programme on students' academic progress. *The Journal of Development Studies 50*(12), 1647–1669.

Becchetti, L. and S. Castriota (2010). The effects of a calamity on income and wellbeing of poor microfinance borrowers: the case of the 2004 tsunami shock. *The Journal of Development Studies 46*(2), 211–233.

Becchetti, L., S. Castriota, and P. Conzo (2017). Disaster, aid, and preferences: The long-run impact of the tsunami on giving in sri lanka. *World Development 94*, 157–173.

Bertinelli, L. and E. Strobl (2013). Quantifying the local economic growth impact of hurricane strikes: An analysis from outer space for the caribbean. *Journal of Applied Meteorology and Climatology 52*(8), 1688–1697.

Callen, M., S. De Mel, C. McIntosh, and C. Woodruff (2019). What are the headwaters of formal savings? experimental evidence from sri lanka. *The Review of Economic Studies 86*(6), 2491–2529.

Conzo, P. (2018). Natural disasters and social preferences: The effect of tsunami-memories on cheating in sri lanka. *The Journal of Development Studies 54*(10), 1912–1931.

Crespo Cuaresma, J., J. Hlouskova, and M. Obersteiner (2008). Natural disasters as creative destruction? evidence from developing countries. *Economic Inquiry 46*(2), 214–226.

De Mel, S., C. McIntosh, K. Sheth, and C. Woodruff (2020). Can mobile-linked bank accounts bolster savings? evidence from a randomized controlled trial in sri lanka. *The Review of Economics and Statistics*, 1–45.

De Mel, S., D. McKenzie, and C. Woodruff (2008). Returns to capital in microenterprises: evidence from a field experiment. *The quarterly journal of Economics 123*(4), 1329–1372.

De Mel, S., D. McKenzie, and C. Woodruff (2013). The demand for, and consequences of, formalization among informal firms in sri lanka. *American Economic Journal: Applied Economics 5*(2), 122–50.

De Mel, S., D. McKenzie, and C. Woodruff (2014). Business training and female enterprise start-up, growth, and dynamics: Experimental evidence from sri lanka. *Journal of Development Economics 106*, 199–210.

De Mel, S., D. McKenzie, and C. Woodruff (2019). Labor drops: Experimental evidence on the return to additional labor in microenterprises. *American Economic Journal: Applied Economics 11*(1), 202–35.

Dower, P. C., V. Ginsburgh, and S. Weber (2017). Colonial legacy, polarization and linguistic disenfranchisement: The case of the sri lankan war. *Journal of Development Economics 127*, 440–448.

duPont Iv, W., I. Noy, Y. Okuyama, and Y. Sawada (2015). The long-run socio-economic consequences of a large disaster: The 1995 earthquake in kobe. *PloS one 10*(10), e0138714.

Felbermayr, G. and J. Gröschl (2014). Naturally negative: The growth effects of natural disasters. *Journal of development economics 111*, 92–106.

Fomby, T., Y. Ikeda, and N. V. Loayza (2013). The growth aftermath of natural disasters. *Journal of applied econometrics 28*(3), 412–434.

Gignoux, J. and M. Menéndez (2016). Benefit in the wake of disaster: Long-run effects of earthquakes on welfare in rural indonesia. *Journal of Development Economics 118*, 26–44.

Gollin, D., D. Lagakos, and M. E. Waugh (2014). The agricultural productivity gap. *The Quarterly Journal of Economics 129*(2), 939–993.

Hallegatte, S. and P. Dumas (2009). Can natural disasters have positive consequences? investigating the role of embodied technical change. *Ecological Economics 68*(3), 777–786.

Heger, M. P. and E. Neumayer (2019). The impact of the indian ocean tsunami on aceh's long-term economic growth. *Journal of Development Economics 141*, 102365.

Hollenbach, P. and K. N. Ruwanpura (2011). Symbolic gestures: The development terrain of post-tsunami villages in (southern) sri lanka. *Journal of Development Studies 47*(9), 1299–1314.

Hornbeck, R. and D. Keniston (2017). Creative destruction: Barriers to urban growth and the great boston fire of 1872. *American Economic Review 107*(6), 1365–1398.

Hornbeck, R. and S. Naidu (2014). When the levee breaks: black migration and economic development in the american south. *American Economic Review 104*(3), 963–90.

Horwich, G. (2000). Economic lessons of the kobe earthquake. *Economic development and cultural change 48*(3), 521–542.

Kahn, M. E. (2005). The death toll from natural disasters: the role of income, geography, and institutions. *Review of economics and statistics 87*(2), 271–284.

Loayza, N. V., E. Olaberria, J. Rigolini, and L. Christiaensen (2012). Natural disasters and growth: Going beyond the averages. *World Development 40*(7), 1317–1336.

Lynham, J., I. Noy, and J. Page (2017). The 1960 tsunami in hawaii: long-term consequences of a coastal disaster. *World Development 94*, 106–118.

Nakamura, E., J. Sigurdsson, and J. Steinsson (2022). The gift of moving: Intergenerational consequences of a mobility shock. *The Review of Economic Studies 89*(3), 1557–1592.

Rodrigo, C. and B. Deaton (2017). Restoring tsunami damaged coastal lands in sri lanka: Evidence of the anticommons? *The Journal of Development Studies 53*(8), 1272–1285.

Sharif, I. A. (2011). Does political competition lessen ethnic discrimination? evidence from sri lanka. *Journal of Development Economics 94*(2), 277–289.

Skidmore, M. and H. Toya (2002). Do natural disasters promote long-run growth? *Economic inquiry 40*(4), 664–687.

Strobl, E. (2011). The economic growth impact of hurricanes: Evidence from us coastal counties. *Review of Economics and Statistics 93*(2), 575–589.

Weerakoon, D., S. Jayasuriya, N. Arunatilake, and P. Steele (2007). Economic challenges of post-tsunami reconstruction in sri lanka. Technical report.

A Appendix

Table A1: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY GENDER, LABOR FORCE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. Males				
Tsunami	-0.057	-0.010	0.067	10.890
	(0.028)	(0.014)	(0.037)	(9.148)
Dependent variable mean	0.328	0.133	0.539	151.869
Observations	174,874	174,874	174,874	101,578
R-squared	0.132	0.027	0.063	0.270
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
B. Females				
Tsunami	-0.078	0.017	0.061	15.175
	(0.048)	(0.021)	(0.040)	(8.525)
Dependent variable mean	0.389	0.238	0.373	128.994
Observations	86,575	86,575	86,575	49,013
R-squared	0.201	0.066	0.075	0.202
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Individuals from labor force surveys from 2002 to 2012 are divided into two subsamples: males in Panel A, and females in Panel B.

Table A2: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY AGE, LABOR FORCE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. Young individuals				
Tsunami	-0.051	-0.003	0.054	12.519
	(0.034)	(0.020)	(0.037)	(8.571)
Dependent variable mean	0.287	0.204	0.510	139.451
Observations	130,277	130,277	130,277	84,626
R-squared	0.166	0.046	0.056	0.283
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
B. Old individuals				
Tsunami	-0.073	-0.004	0.077	16.283
	(0.029)	(0.014)	(0.033)	(9.434)
Dependent variable mean	0.410	0.132	0.459	150.804
Observations	131,172	131,172	131,172	65,965
R-squared	0.146	0.029	0.079	0.208
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Individuals from labor force surveys from 2002 to 2012 are divided into two subsamples: individuals aged 16 to 39 in Panel A, those aged 40 or above in Panel B.

Table A3: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY EDUCATION, LABOR FORCE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. Individuals with low education				
Tsunami	-0.078	0.001	0.077	0.315
	(0.039)	(0.019)	(0.046)	(8.003)
Dependent variable mean	0.223	0.194	0.583	174.471
Observations	156,670	156,670	156,670	92,531
R-squared	0.114	0.029	0.038	0.234
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
B. Individuals with high education				
Tsunami	-0.032	-0.002	0.034	17.444
	(0.022)	(0.012)	(0.025)	(6.964)
Dependent variable mean	0.536	0.128	0.336	96.547
Observations	104,767	104,767	104,767	58,050
R-squared	0.154	0.042	0.085	0.318
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Individuals from labor force surveys from 2002 to 2012 are divided into two subsamples: individuals with education levels of middle school dropouts or lower in Panel A, and those who are middle school graduates or higher in Panel B.

Table A4: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY GENDER, HOUSEHOLD INCOME AND EXPENDITURE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. Males				
Tsunami	-0.115	-0.012	0.127	15.484
	(0.065)	(0.018)	(0.057)	(10.377)
Dependent variable mean	0.266	0.138	0.597	165.103
Observations	69,009	69,009	69,009	48,329
R-squared	0.098	0.024	0.038	0.303
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
B. Females				
Tsunami	-0.176	0.037	0.139	16.922
	(0.096)	(0.063)	(0.070)	(10.146)
Dependent variable mean	0.300	0.245	0.455	138.389
Observations	30,842	30,842	30,842	21,918
R-squared	0.164	0.053	0.054	0.223
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Individuals from the household income and expenditure surveys of 2002, 2006, 2009, and 2012 are divided into two subsamples: males in Panel A, and females in Panel B.

Table A5: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY AGE, HOUSEHOLD INCOME AND EXPENDITURE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. Young individuals				
Tsunami	-0.079	-0.048	0.127	15.779
	(0.050)	(0.026)	(0.045)	(12.277)
Dependent variable mean	0.223	0.207	0.569	152.281
Observations	49,173	49,173	49,173	38,100
R-squared	0.113	0.039	0.030	0.323
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
B. Old individuals				
Tsunami	-0.174	0.050	0.124	20.632
	(0.085)	(0.018)	(0.077)	(10.456)
Dependent variable mean	0.328	0.135	0.536	162.065
Observations	50,663	50,663	50,663	32,140
R-squared	0.108	0.022	0.054	0.228
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Individuals from the household income and expenditure surveys of 2002, 2006, 2009, and 2012 are divided into two subsamples: individuals aged 16 to 39 in Panel A, those aged 40 or above in Panel B.

Table A6: THE EFFECT OF THE TSUNAMI ON LOCAL ECONOMY BY EDUCATION, HOUSEHOLD INCOME AND EXPENDITURE SURVEY

Dependent variable:	Agriculture	Manufacture	Service	Monthly income
	(1)	(2)	(3)	(4)
A. Individuals with low education				
Tsunami	-0.138	0.042	0.096	18.080
	(0.092)	(0.025)	(0.079)	(10.762)
Dependent variable mean	0.454	0.134	0.412	107.035
Observations	39,860	39,860	39,860	27,966
R-squared	0.115	0.031	0.065	0.363
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
B. Individuals with high education				
Tsunami	-0.137	-0.020	0.157	4.837
	(0.057)	(0.017)	(0.053)	(7.618)
Dependent variable mean	0.158	0.195	0.647	189.768
Observations	59,838	59,838	59,838	42,185
R-squared	0.086	0.028	0.020	0.261
District Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Individuals from the household income and expenditure surveys of 2002, 2006, 2009, and 2012 are divided into two subsamples: individuals with education levels of middle school dropouts or lower in Panel A, and those who are middle school graduates or higher in Panel B.

Table A7: THE EFFECT OF THE TSUNAMI ON MIGRATION

Dependent variable:	Migration		Return migration	
	(1)	(2)	(3)	(4)
Tsunami	0.008	0.009	0.015	0.014
	(0.002)	(0.002)	(0.021)	(0.021)
Dependent variable mean	0.024	0.024	0.055	0.055
Observations	119,557	119,557	477,637	477,637
Controls	No	Yes	No	Yes

Notes: The sample focuses on individuals who migrated from the 2012 census of population and housing. The dependent variable, Migration, indicates whether individuals migrated in 2004, and Return migration denotes whether individuals returned to their birthplace after 2004. We include controls for individual characteristics such as gender, age, and education, in addition to district population in columns 2 and 4. Standard errors in parentheses are clustered at the district level.