Natural Disasters and Labor Emigration: Evidence from Nepal's Earthquake

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Abstract

The 2015 earthquake in Nepal affected approximately 8 million people, resulting in an economic loss of 10 billion US dollars. We exploit the quasi-random spatial and temporal nature of ground tremors to evaluate the impact of the 2015 earthquake on international labor migration per capita in Nepal. Using different sets of difference-in-differences research design, we show that the number of work permits issued to Nepalese individuals for international migration decreased significantly among districts severely affected by the 2015 earthquake. Results further indicate that the earthquake's effect on labor emigration is statistically significant and negative only among males. We offer suggestive evidence that domestic measures of productivity and aid may have affected labor emigration in the aftermath of the earthquake. Together, these results provide strong evidence that natural disasters induce significant changes in labor market outcomes among individuals in a developing country setting.

Keywords: Natural Disasters, Earthquake, Labor Emigration, Gender, Nepal
JEL Classification: J44, I18, H75

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1 Introduction

Recent data from the Center for Research on the Epidemiology of Disasters (CRED) indicate that 7,348 natural disasters were recorded worldwide over the last twenty years, claiming approximately 1.23 million lives and causing economic losses of $2.97 trillion. There exists well-documented evidence on the linkage between environmental shocks and human migration (Berlemann and Steinhardt, 2017; Hunter, 2005). Broadly, prior literature relates environmental migration to internal household displacement, international migration, internal labor migration, and return migration.[1] However, empirical evidence of a clear relationship between natural disasters and migration patterns remains inconclusive because some environmental changes such as droughts take place gradually over a long period, while others such as storms, floods, and earthquakes occur suddenly. Researchers have pointed out that international labor migration can be one of the post-disaster adaptation strategies to recover from disaster-induced income loss and seek better employment opportunities (de Moor, 2011b; Thornton, 2011; de Moor, 2011a; Henry et al., 2004). However, there exists a dearth of rigorous empirical evidence of migration in response to large earthquakes in the developing world.

This study examines the impact of the 2015 earthquake in Nepal on international migration. The 2015 earthquake affected approximately 8 million people, resulting in an economic loss of $10 billion, equivalent to about half of Nepal's Gross Domestic Product (GDP) (Goda et al., 2015). Our focus on Nepal, a disaster-prone and labor exporting developing country in South Asia, is unique for two important reasons. First, Nepal ranks 11th among the world's most earthquake-prone countries, fourth in terms of climate change vulnerability, and thirtieth on flood risks (UNDPR, 2009; IoM, 2018; NEMRC, 2020). Second, remittances contributed to over a quarter of Nepal's GDP, accounting at $8.79 billion in 2019 (MoLESS, 2020).

We exploit the plausibly exogenous incidence of the 2015 April earthquake of 7.8 magnitudes in Nepal and apply the difference-in-differences research design to evaluate changes in international labor migration per capita between severely-affected districts ("treatment") and unaffected counterparts ("control"). Our treatment group includes 14 districts classified by the National Reconstruction Authority (NRA) as severely affected by the earthquake. The compar-

[1] See Black et al. (2011); Landry et al. (2007); Koubi et al. (2016); Queiroz et al. (2019); Mallick and Siddiqui (2015); Paul (2005); Paul and Routray (2010); Raleigh et al. (2008); Sagynbekova (2017); Castles and Miller (2009); Parnell and Walawege (2011); Neumann and Hilderink (2015) for more details.

ison group consists of the rest of the remaining 61 districts (NRA, 2020).[2] To quantify changes in international labor migration per capita, we make use of district-level work permits issued by Nepal's Department of International Employment (DoFE) to citizens for international labor migration from Nepal.[3] **Our empirical research design tries to account for potential unobserved heterogeneity, omitted variable bias, and nationwide time trends by implementing interactive fixed effects within the difference-in-differences.** We also demonstrate that our results are insensitive to numerous robustness checks, supporting the validity of our baseline double differences approach.

Results indicate that the number of work permits issued for international migration decreased significantly among severely-affected districts in the aftermath of the 2015 earthquake. Specifically, the earthquake led to a 37.85% reduction in the number of international labor work permits per 100,000 population among districts severely affected by the earthquake compared to unaffected counterparts. We offer suggestive evidence that domestic measures of productivity and aid may have affected labor emigration in the aftermath of the earthquake. Findings further show that the effect of the earthquake on international work permits among males is statistically significant and negative, while females' impact is not significant. For example, the number of work permits for international migration issued to Nepalese males in severely-affected districts decreased by 49.33% after the earthquake. Our finding on gender disparities is in line with a study by Henry et al. (2004), which documents a reduction in international migration among males in response to a severe rainfall deficit in Burkina Faso.

We attribute this heterogeneity across gender to economic disruptions created by the earthquake.[4] According to Sijapati et al. (2015), the nature of employment generated in the home country in reconstruction was physically intensive and thus more attractive to men compared to women. Uddin (2016) points out that robbery cases increased significantly in the temporary shelters after the earthquake, raising privacy and security concerns among women and causing males to guard the shelters at nights. Finally, several migrant-sending households reported dwindling cases of male migrants leaving the country (Sijapati et al., 2015). This provides ev-

[2]Severely affected districts are Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok (NRA, 2020).

[3]As Nepal shares open borders to India, citizens from both countries do not need work permits or work-related visas for employment. Our analysis doesn't include international labor migration to India (DOFE, 2014)

[4]There exists well-documented evidence of how natural disasters may widen gender disparities across a range of outcomes. For example, Paudel and Ryu (2018) document large gaps in human capital between male and female infants exposed to the 1988 earthquake in Nepal.

idence of factors that likely affected prospective male migrants more than female counterparts in deciding against foreign labor migration in the aftermath of the earthquake.

This study contributes to an influx of recent empirical work exploring the linkage between natural disasters, labor market responses, and migration-related decisions (Gröger and Zylberberg, 2016). More recently, Spitzer et al. (2020) conclude that the Messina-Reggio Calabria Earthquake, one of the devastating natural disasters in Europe, did not have a significant economic impact on emigration or its composition. Their finding on attachment to land as "an impediment to reacting to the disaster through migration" appears to be consistent with our findings in Nepal's context. In a different study, Mahajan and Yang (2020) find that adverse environmental shocks in origin countries such as hurricanes increase migration to the United States. Within the United States, Boustan et al. (2020) explore natural disasters from 1920 to 2010 and report that large disasters increase out-migration rates at the county level by 1.5 percentage points. Our results also contribute to several studies that find an insignificant or negative impact of natural disasters and other environmental shocks on international migration (Beine et al., 2019; Cattaneo and Peri, 2016; Gröschl and Steinwachs, 2017; Halliday, 2006).

This study is broadly related to a growing number of quasi-experimental research design-based studies focused on evaluating a large earthquake's economic impact in South Asia. The majority of studies exploring the exogenous shock of earthquake incidence have investigated subsequent effects on foreign aid, health, and education-related outcomes (Paudel and Ryu, 2020; Nandi et al., 2018; Andrabi and Das, 2017). More recently, Eichenauer et al. (2020) show that the allocation of aid in Nepal correlates positively with the 2015 earthquake damage, but it is not reflective of socioeconomic and physical vulnerabilities. Relatedly, Spoon et al. (2020) provide evidence of difficulty in disaster recovery among displaced households relying on agro-pastoral livelihoods in the aftermath of the 2015 earthquake in Nepal. Policymakers focused on designing sustainable recovery programs from large natural disasters can use our findings on migratory response induced by the earthquake to understand natural disasters' economic cost across different settings.[5]

The remainder of the paper is structured as follows. Section 2 presents a comprehensive literature review on the relationship between natural disasters and migration. Section 3 provides

[5] According to Acosta et al. (2020), a comprehensive understanding of population distribution in a region affected by a sizeable environmental shock has implications for resource allocation to affected communities.

a detailed background of Nepal's earthquake and labor migration. Section 4 explains data used in the study and Section 5 describes the econometric strategy. Section 6 presents the main results and Section 7 concludes.

2 Literature review

2.1 Disasters and international labor migration

Policymakers, public institutions, and scholars on environmental migration argue that a sudden environmental event can, directly and indirectly, induce exposed populations to migrate. However, some call attention towards the possible influence of various non-environmental variables in explaining migration decisions (Castles and Miller, 2009; Parnell and Walawege, 2011; Black et al., 2011). Amidst the debate, recent studies argue that the interaction of both environmental and non-environmental factors determines migration-related outcomes.[6] Other studies suggest that economic motives drive labor migration decisions. Still, they can also induce individuals not to leave because of the increasing employment opportunities in the home country, especially in the reconstruction and rebuilding phase (Pereira, 2009; Noy and Vu, 2010; CBS, 2011). Additionally, prior literature has documented varieties of human migration decision patterns[7] have been well-documented (Neumann and Hilderink, 2015; Pathak et al., 2016; de Moor, 2011b; Sijapati et al., 2015; Thornton, 2011; de Moor, 2011a).

Although researchers have explored environmental migration responses in the form of internal household displacement, international migration, internal labor migration, and return migration (Black et al., 2011; Landry et al., 2007; Koubi et al., 2016; Queiroz et al., 2019; Mallick and Siddiqui, 2015; Paul, 2005; Paul and Routray, 2010; Raleigh et al., 2008; Sagynbekova, 2017; Castles and Miller, 2009; Parnell and Walawege, 2011; Neumann and Hilderink, 2015), only a limited number of studies have concentrated on international labor migration. For example, prior literature sheds light on the relationship between the environment and the international labor migration through qualitative methods (de Moor, 2011b; Thornton, 2011; de Moor, 2011a). Previous studies indicate that international labor migration is a potential

[6] For example, Black et al. (2011) identifies five families of drivers that affect migration decisions: economic, political, social, demographic, and environmental drivers.

[7] For instance, some people might walk a few yards through refuging with their friends or relatives, while some might cross the international boundaries to flee disaster in the extreme case (Queiroz et al., 2019), or some may respond with return-migration (Landry et al., 2007).

disaster recovery strategy in a developing country setting. Nevertheless, they still do not explain how human decisions on potential international labor migration may be affected in such contexts. Furthermore, they do not provide evidence of the differential impact of environmental shocks on migration across gender in labor exporting, disaster-prone country settings. Whether international labor migration is a demand/citizen-centric post-disaster employment policy solution remains an open question. This existing gap in knowledge implies that there is no clarity on how a developing country may prepare for labor market management and facilitation before and after the incidence of an environmental disaster. This study attempts to determine how a disaster-prone, labor exporting developing country might respond in such a scenario.

2.2 Neo-classical economic viewpoint

Neo-classical economists argue that environmental migration, in general, is a survival strategy in the post-disaster period (Myers and Kent, 1995; Paul, 2005; Walsham, 2010; Koubi et al., 2016; Sagynbekova, 2017; Thornton, 2011). Migration can also be a risk-minimizing strategy, allowing for diversification of the livelihood options among the affected population (Myers and Kent, 1995; Paul, 2005; Koubi et al., 2016; Sagynbekova, 2017; Thornton, 2011; de Moor, 2011b,a). As the 2015 earthquake disrupted almost all sectors of the economy, causing a spike in inflation,[8] one expected a surge in labor outflow from the country. However, the surprising decline in emigration left many questions unanswered.

One argument to explain this change from the economic viewpoint is that the immediate financial loss may have triggered a priority shift. Consistent with this viewpoint, a report concludes that building a new house and accumulating necessary goods and items to get back to everyday life was a significant priority among earthquake victims (Sijapati et al., 2015). For an average Nepali citizen, international labor migration is often costly because of visa costs, ticket fares, and other immigration procedures. Though it is usually against the policy in the home countryDOFE (2015), data suggests that migrant workers from Nepal and some other developing countries often bear high recruitment cost depending upon various destinations and job types (MDP, 2020). Thus it suggests that investment for migration overseas can be a low priority among families struggling to recover from substantial economic loss (Sijapati et al.,

[8]Figures from January 2016 show that Nepal's inflation picked at 12 percentage, pushing up to 1 million Nepalis into poverty in the FY2015/16 (World Bank, 2016).

2015).

Opponents argue that sudden environmental disasters can attract new employment and income opportunities in disaster-afflicted areas. Such opportunities entail the creation of more jobs, especially in the relief works, reconstruction, and rebuilding (Pereira, 2009; Noy and Vu, 2010; NPC, 2015).[9] In the context of Nepal, a robust economic growth of 7.1% in 2019 (Ezemenari and Joshi, 2019) followed a sudden decline in economic growth at 2.7% in 2016 World Bank (2016). A recent report published by the Government of Nepal concludes that the reconstruction works contributed to increasing the country's GDP by 4.5 percentage points after the earthquake(NRA, 2019).

Finally, the economic argument supports the role of remittance in the post-disaster rescue, rebuilding, and livelihood (Savage and Harvey, 2007). Remittance flows to Nepal increased significantly by 27.6% in three months after the earthquake compared to the same period last year (World Bank, 2016).[10] Literature suggests that flow of remittance might have insured individuals against the severity of the post-disaster shock. This relation implies that aspiring migrants from remittance-receiving households are likely to give up their dreams of working in a foreign country. Similarly, the role of foreign aid in supporting victims after a major disaster cannot be understated (Paul, 2005). Nepalese records of receiving an unprecedented amount of technical, financial, and humanitarian aid from around the world (Eichenauer et al., 2020; NPC, 2015).

2.3 Analysing multi-causal influences

Recent studies on environmental migration have explored the impact of disasters on individuals' migration decisions from a multi-disciplinary perspective. Some key determinants of environmental migration include security, political, psychological, social and demographic factors (Koubi et al., 2016; Paul, 2005; Walsham, 2010; Raleigh et al., 2008; Queiroz et al., 2019; Mallick and Siddiqui, 2015; Neumann and Hilderink, 2015; Black et al., 2011). In the context of Nepal, security and psychological factors are likely to influence labor emigration.

The Nepalese context indicates that the earthquake's impact on migration-related outcomes

[9]For instance, there is historical evidence of European countries signing new bilateral labor agreements to fulfill their increased labor demand for the rebuilding on the post World War (Wickramasekara, 2015).

[10]This was an exception because the inflow of remittance in other South-Asian countries declined during the same period. In 2017, Nepal became the fourth highest remittance recipient country as a percentage of GDP in the world DOFE (2017).

may be heterogeneous between males and females. Many rescue and reconstruction work in the aftermath of the earthquake entails physical labor, which is often perceived as a man's job in a male-dominated Nepalese society. Culturally, men are trusted with the responsibilities of protecting vulnerable elderly, children, and women in the family at the time of crisis (Sijapati et al., 2015; Gurung, 2018).[11] Relatedly, a report suggests that migrant-sending families felt the absence of male migrants more (around 71 percentage) than the lack of female migrants (about 21 percentage) (Sijapati et al., 2015). Similarly, Sijapati et al. (2015) provides evidence of return migration in Nepal despite the complicated and expensive procedures. Additionally, a significant number of individuals fail to return despite their strong desire to come back. These circumstances might have influenced aspiring male migrants to reconsider their migration decisions, which have possible effects on emigration (Sijapati et al., 2015).

The political factor plays a vital role in the Nepalese setting (Paudel and de Araujo, 2017). For instance, a study conducted in 2018 suggests that bureaucratic hurdles, political transition, and weak governance kept the victims waiting for relief packages up to "three years" after the shock (Sharma et al., 2018; Titz and Krüger, 2015). In the context of our study, potential migrants might likely have decided to stay to ensure the safety of their vulnerable families.

Finally, lifestyle, culture, and location-specific factors may have influenced decisions to choose to live under the continued vulnerabilities, causing subsequent effects on labor emigration trends. For generations, most rural Nepalese households have relied on family-owned small scale agricultural farms for their livelihoods (Paudel and Crago, 2017). Some reports suggest that the newly built settlements by the government and humanitarian actors faced design failure because they could not understand and address these unique needs (Lal, 2019). This implies that victims chose to live on the original place of their habitat under the existing vulnerabilities despite being offered a new house on a community settlement free of cost (Lal, 2019).[12]

[11] Temporary shelters also faced various security threats such as robbery and reports of inadequate privacy and security among women. This resulted in men guarding the temporary shelters at nights (Uddin, 2016).

[12] Association of the Nepalese living abroad spent 350 million in building Gupswe Pakha Settlement but have failed to convince the families to live (Lal, 2019).

3 Institutional background on Nepal's Earthquake and labor migration

Nepal is a disaster-prone, labor exporting developing county in South-Asia. Nepal experienced a massive earthquake exceeding 7.5 magnitudes in 2015.[13] The earthquake claimed around 9,000 lives and injured more than 22,000 individuals while damaging approximately 712,000 homes and physical infrastructure. While there is no evidence suggesting international displacement after the shock (IoM, 2018), reports indicate that the earthquake forced around 2.6 million people to flee their homes (Bilak et al., 2016).

Nepal's nationwide labor migration outflow exhibited an increasing trend until the end of 2014, followed by a significantly decreasing trend in the post-earthquake period MoLESS (2020). A district-level database from earthquake-affected areas also indicates a similar pattern.[14] Predictably, several studies have been carried out in the post-earthquake Nepal exploring the topic of disaster-induced internal migration (He et al., 2018; Pathak et al., 2016; Uddin, 2016; Wilson et al., 2016; NPC, 2015). A few post-earthquake reports published by the local governmental, non-governmental, and some international aid organizations (Gurung, 2018; Maharjan et al., 2016; DOFE, 2017; Sijapati et al., 2015) attempt to establish both direct as well as an indirect multi-causal relationship to explain the sudden change. Arguments presented in such reports range from economic reasons and security issues to political and psychological perspectives.

3.1 Economic disruptions

The government of Nepal introduced a policy called "free visa, free ticket" in July 2015 for those migrating as international laborers in seven destinations countries.[15] The new policy mandated the employing companies to bear the cost of visa fees and ticket fare of potential migrant workers. However, this resulted in a dispute between Nepal's Department of Foreign Employment and the foreign employment recruitment agencies, primarily because it curtailed

[13]The first earthquake was followed by more than 300 aftershocks over 4.0 magnitude, another 6.8 magnitudes earthquake stroke Nepal after 17 days with the epicenter near the Mount Everest(NPC, 2015).

[14]While 5268 labor permits were issued to prospective migrants laborers from the 14 severely affected districts in two months before the shock, the number decreased by 15 percent to 4480 by mid-May, 2015 (Sijapati et al., 2015).

[15]Those countries include Malaysia and six others from the Gulf Cooperation Council (GCC): Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman. Until 2014, around 85% of the migrant laborers from Nepal worked in these countries DOFE (2014), and this trend continues till date(MoLESS, 2020).

benefits for recruitment agencies. In response, a national strike was called for 18 days, thus disrupting the established operational procedure for out-migration (DOFE, 2015). When foreign labor migration started to become increasingly tricky, evidence indicates creating new economic opportunities in the home country around the same period. Nepal has experienced robust economic growth since 2016, while reaching 7.1% in 2019 (Ezemenari and Joshi, 2019).[16] A recent preliminary report associates this change with increased economic activities in the reconstruction sector. On average, reconstruction works in the aftermath of the earthquake increased the country's GDP by 4.5 percentage points (NRA, 2019). A different nationwide survey carried out in 2017 reports that one in seven Nepalese citizens and one in five male Nepalese citizens were involved in construction-related works (CBS, 2018). This suggests that Nepal's significant economic growth might have contributed to new employment opportunities within the country while inducing people not to migrate.

3.2 New constitution in 2015 and the election in 2017

In September 2015, Nepal promulgated a new constitution for the Federal Republic of Nepal. It proposed a multiparty federal decentralized parliamentary system with three governance levels for the first time in its history. Some claim that this event signaled hope for a stable elected government, localized development, the end of feudalism, and the beginning of democratic socialism (Bhattarai, 2015). In 2017, Nepal held three tiers of elections under the provisions of the "Constitution of Nepal-2015" to elect thousands of representatives for local government, provincial assembly, and the federal parliament (Khalid and Chughtai, 2017). After the long history of monarchy and the decade-long Maoists insurgency period, this new phase increased hope for lasting peace, effective decentralization, robust governance, increased rights and liberty, massive political reform and restructuring (Dahal, 2017). In conjunction with a hope for change, this political transformation likely affected migration decisions among the aspiring Nepalese youth.

[16]The earthquake suppressed the projection of 4.6 percent GDP growth for 2015 by over 1.5 percentage points (NPC, 2015) but the growth significantly increased after that (Ezemenari and Joshi, 2019).

3.3 The 2015 economic blockade

Amidst the new hope for change, Nepal's new constitution was also criticized for not addressing the demands of marginalized Madhesis and Tharus. This triggered the Madhesh Movement, a general strike across Indian borders. Stating security concerns, the Government of India exerted pressure on the Government of Nepal to comply with the terms demanded by the protesting groups. However, Nepal perceived this step as "an external interference in internal affairs" and accused India of an unofficial economic blockade. Consequently, more than two months-long unrest in the border area from the strike and Nepal- India diplomatics turmoil led to a severe national crisis (Sood, 2016). Most importantly, the top 10 origin districts[17] of Nepalese international migrant workers were also in the same region. In 2015, these ten districts accounted for 36.2 percent of all labor permits issued in the past seven years (DOFE, 2015). Nepal is a landlocked country and is dependent on India for petroleum, and the general strike affected the transportation sector the most (Sood, 2016). Therefore, it was impossible to travel to the country's only international airport in the capital city of Kathmandu without any transportation. Also, fulfilling the women, children, and older adults during such political uncertainty and civil unrest might have influenced potential male migrant's decision to stay inside the country.

3.4 Weak oil price and the trouble in Malaysia

On the one hand, the global crude oil price fell sharply from 2015 to 2016. This weakened the economy of major remittance-sending Gulf countriesWorld Bank (2016), increasing the probability of restricted hiring and even repatriation of the existing international workers from these countries (World Bank, 2016; DOFE, 2017). On the other hand, Malaysia received the highest number of Nepalese migrants in 2014, comprising a 42.14% share of the total number of labor permits issued (DOFE, 2015). However, this share drastically dropped to 14.62% in 2016 (MoLESS, 2020). According to DOFE (2017), this sudden drop in labor outflow to Malaysia is a direct consequence of a bilateral labor agreement between Malaysia and Bangladesh in 2016 (DOFE, 2017). Nepal did not have such a contract until 2018 MoLESS (2020), causing Malaysian employers to prefer migrant laborers from Bangladesh (DOFE, 2017). Additionally,

[17] Dhanusa, Jhapa, Mahottari, Morang, Siraha, Nawalparasi, Sunsari, Saptari, Rupandehi, and Sarlahi

poor working conditions and exploitation of Nepalese migrant laborers in Malaysia could be another reason for the drop. A survey among returnee migrants from Malaysia, India, and GCC countries report that the highest number of Malaysia returnees cite disability, injury or sickness, and removal from work as three primary reasons for their return in 2018 (CBS, 2018). Moreover, Malaysia reported the highest number of deaths from suicide and heart attack (MoLESS, 2020).

4 Data

Nepal's Ministry of Labor Employment and Social Security published detailed reports on Nepalese international migrant workers' status for four years: 2014, 2015, 2017, and 2020. The Department of Foreign Employment (DoFE) under the ministry is an authorized institution for the issuance of work permits to Nepalese citizens willing to work abroad (DOFE, 2014, 2015, 2017; MoLESS, 2020). We compile district-level data on work permits issued from the year 2010/11 to 2016/17.

National Reconstruction Authority, an autonomous body established in the aftermath by the government of Nepal, has published data covering all aspects of the 2015 earthquake on its official website (NRA, 2020). According to NPC (2015), 14 districts (out of a total of 75 districts) were "severely affected" by the earthquake. Our binary treatment variable takes a value of '1' indicating a severely affected district and '0' otherwise.

In November 2012, the government of Nepal, National Planning Commission Secretariat and Central Bureau of Statistics[18] jointly published a national report titled "National population and housing census 2011" (CBS, 2011). We compile data on the district-level population projection from this report. Our migration-related outcome variable includes the natural logarithmic transformation of international labor migration per 100,000 population for each district. Finally, we rely on two different sources to explore the role of potential channels in understanding the effect of earthquake on labor emigration. We obtain district-level agricultural productivity from Nepal Living Standards Survey 2010-11 (NLSS III) and 2003-04 (NLSS II) used in Paudel and Crago (2017). Similarly, we apply district-level aid disbursed for years 2011, 2012 and 2013 from the Government of Nepal's Aid Information Management System (AIMS) (AidData, 2016).

[18]The Central Bureau of Statistics, Nepal is a central governmental agency for collecting, processing, analysis, publication, and dissemination of official statistics in Nepal. It is also primarily responsible for the publication of the "National Population Census of Nepal" every ten years. The 2011 census is the most recent of all (CBS, 2020).

5 Models

5.1 Difference-in-differences Method (DID)

We begin the analysis by explaining the difference in change in international labor migration between severely affected districts and the remaining unaffected districts. We estimate the difference-in-differences method (DID) with district and year fixed-effects (FE DID) in the following equation:

$$Y_{it} = \delta D_{it} + \alpha_i + \varsigma_t + \varepsilon_{it} \tag{1}$$

where index i and t represents district and year. Y_{it} is the outcome variable of interest, which is the logarithmic transformation of international labor migrants per 100,000 population for each district i in year t. D_{it} is the binary treatment indicator, which takes a value of 1 for a severely affected district by the April 2015 earthquake and 0 otherwise. δ is the parameter of interest that explains the change in international labor migration in a severely affected district compared to the unaffected comparison district after controlling for time and district-invariant unobserved heterogeneity. α_i and ς_t are additive district-specific and year-specific fixed-effects.

We want to account for possible variables co-varying with the outcome variable (note that our treatment variable of earthquake damage is plausibly exogenous). However, such an endeavor is infeasible in our study because the district level panel-data on the covariates is unavailable for Nepal. This implies that our estimates can be contaminated by omitted variables, resulting in an omitted variable bias. However, it is worth pointing out that two-way fixed-effects allow for absorbing the unobserved heterogeneity invariant to each district and each year. Hence, controlling for year-specific fixed effects and district-specific fixed effects is essential for absorbing the shocks whose impact is restricted to a given year and district.

5.2 Interactive Fixed-effects

One of the main challenges of our research is the time-varying unobserved heterogeneity. Note that unobserved time-varying heterogeneity should not be confused with time-specific fixed-effects. Time-specific fixed-effects are shocks whose impact is restricted to a given time. Allowing for unit-specific trends control for the dependent variable's exogenous trend is not explained by other variables. For example, there are national trends in Nepal's international labor migra-

tion, and only the earthquake does not entirely drive international labor migration.

A possible solution is to directly impose unit-specific linear or quadratic time trends in conventional two-way fixed-effects models. However, we adopt a flexible approach and explicitly model non-linear time-varying heterogeneity using a two-way fixed-effect model augmented with interactive fixed-effect models (IFE) (Bai, 2009). IFE model allows us to control for the nation-wide time trends in the international migration, which may vary across districts depending on their unobserved characteristics. We estimate the following equation:

$$Y_{it} = \gamma + \delta D_{it} + \alpha_i + \varsigma t + \lambda_{it} F_{rt} + \epsilon_{it} \tag{2}$$

where F_{rt} refers to r different unobserved factors common across all districts in each year t. λ_{it} represents district factor loading, which is constant over time, and quantifies how susceptible each district is to international labor migration. δ is the average treatment effect that explains the changes in international labor migration in the severely affected district compared to the remaining unaffected districts after controlling for time and district-invariant unobserved heterogeneity and time-varying unobserved heterogeneity. All remaining notation has the same interpretation as in equation (1).

In equation (1) and (2), we consider three types of international labor migration. These are the logarithmic transformation of the total, male, and female international labor migration per 100,000 population. We cluster standard errors at the district level to allow for an arbitrary auto-correlation process within the district (Bertrand et al., 2004). Furthermore, the standard errors are robust to heteroskedasticity. Our regression estimates' standard errors are cluster-robust, therefore, highly conservative.

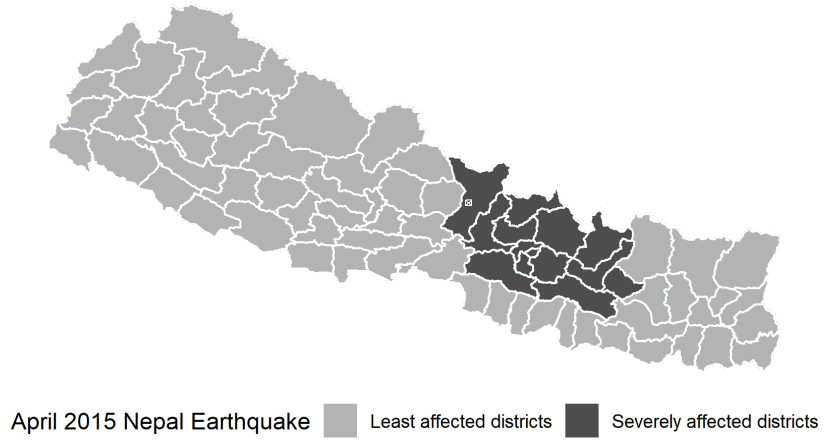
6 Results

6.1 Descriptive Analysis

We begin the analysis by presenting a cheolerpetra map of severely affected and least affected districts from the April 2015 earthquake in Figure 1. Nepal's government defines the district-level severity of Nepal's April 2015 earthquake (NRA, 2020). The white dot mark, in Figure 1, is the epicenter of the April 2015 Nepal Earthquake in the eastern side of Gorkha District at

Barpak, Gorkha. Districts in the south-east proximity of the epicenter are severely affected by the April 2015 earthquake of Nepal.

Figure 1: Severely affected districts from April 2015 earthquake in Nepal



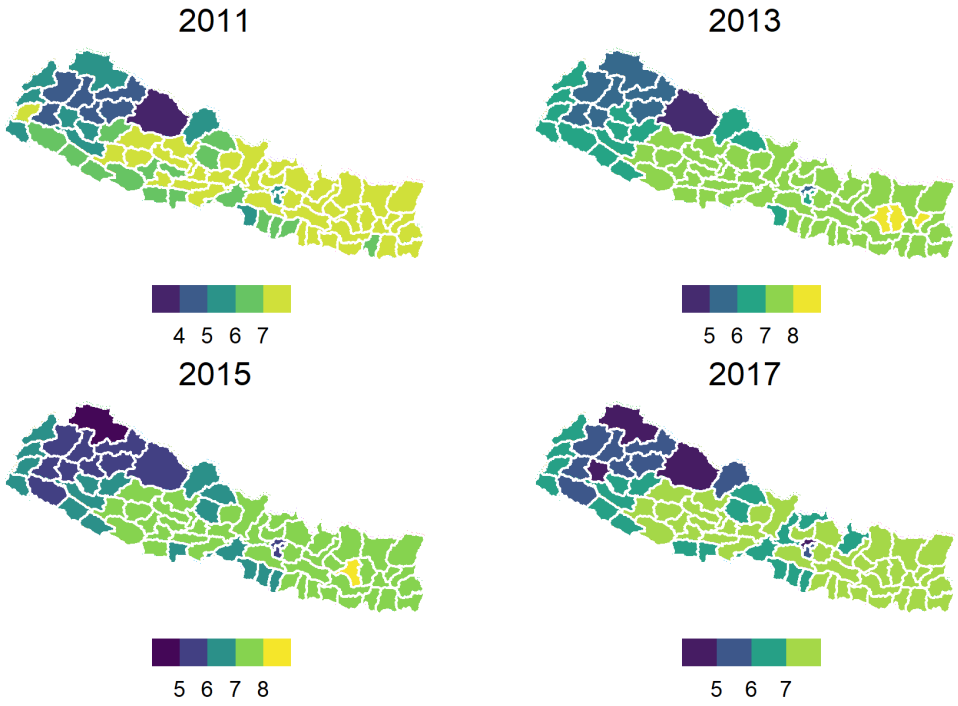
Notes: White dot marks the epicenter of the April 2015 Nepal Earthquake in the Gorkha District's eastern side at Barpak, Gorkha. Nepal' government lists the severely affected districts as Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok (NRA, 2020). The top points toward the North direction.

In Figure 2, we present the Spatio-temporal variation of logarithmic transformation of the ratio total international labor migration per 100,000 population. Figure 2 comprises four panels for 2011, 2013, 2015, and 2017. The north-western districts and three main districts in the Kathmandu valley (including Kathmandu, Bhaktapur, and Lalitpur) have less international labor migration than the eastern part of Nepal. We also develop a similar plot for male and female international labor migration in Appendix A.

In Figure 2, compared to 2011, there is an increase in total international labor migration per 100,000 population in 2013. There are district-level differences as well. For years 2015 and 2017, we observe a decline in total international labor migration. Potentially, two explanations might explain such trends. The first explanation is the change in population size compared to the labor migration. The World Bank reports negative annual population growth rate of Nepal for year 2012 (-2%), 2013 (-1%), 2014 ($\approx$0%) and positive annual population growth rate for year 2015 (0.4%), 2016 (0.9%), 2017 (1.3%). The second explanation is that the migration rate itself is declining over time.

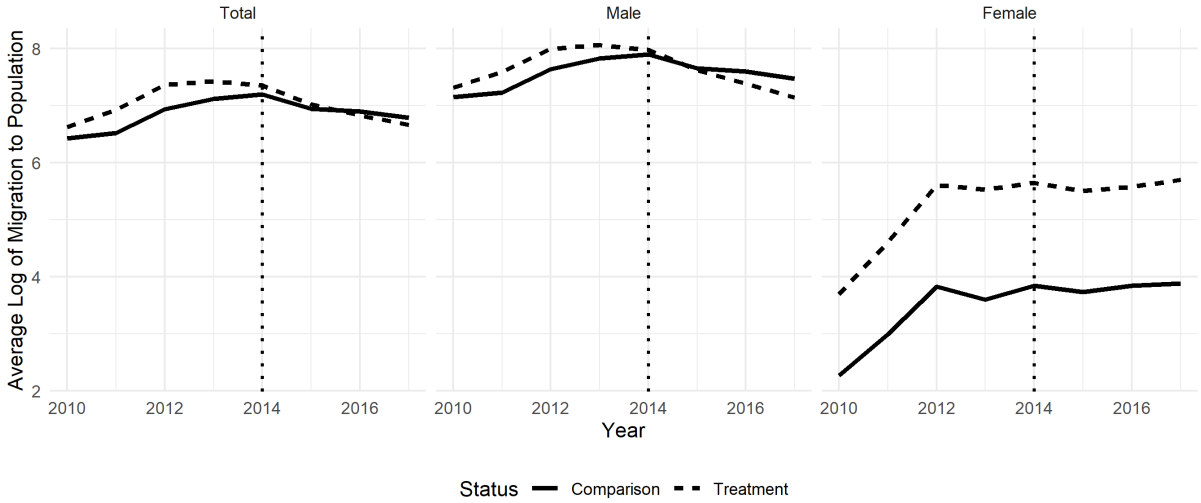
In Figure 3, we show how the average trend of international labor migration among districts severely affected by the 2015 earthquake (treatment districts) is different from the other

Figure 2: Spatio-temporal variation in total international labor migration



remaining unaffected districts (comparison/control districts). Figure 3 exhibits the ratio of the

Figure 3: General trend of international labor migration per 100,000 population



Notes: Nepal's government lists the severely affected districts as Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok (NRA, 2020). We define the severely affected districts as the treatment group and the remaining districts as the comparison group. The dotted vertical line represents the fiscal year 2014/15, and the earthquake occurred in April 2015.

average of the log of the total, male, and female migration to total, male, and female population

(per 100,000) for both treatment districts and comparison districts from 2010/11 to 2016/17. The dotted vertical line represents the fiscal year 2014/15, and the earthquake occurred in April 2015. Figure 3 exhibits the parallel trend of migration for treatment and comparison districts during the pre-earthquake period. However, in post-earthquake periods, there is some divergence of overall and male migration. The female migration does not appear to be affected by the earthquake. We further examine these relationships with the DID FE and IFE models in Table 1.

6.2 Main Results

Table 1: Impact of the 2015 earthquake on Nepal's international labor migration

Variables	Panel A Total Migration		Panel B Male Migration		Panel C Female Migration	
	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)
Treatment	-0.321***	-0.378***	-0.401***	-0.414**	0.096	-0.164
	(0.057)	(0.074)	(0.061)	(0.112)	(0.070)	(0.120)
Intercept		6.922***		7.613***		3.838***
		(0.100)		(0.103)		(0.160)
District FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Factor		1		1		1
HC Robust SE	✓		✓		✓	
Bootstrap SE		✓		✓		✓
Observations	600	600	600	600	600	600

Notes: Nepal's government lists the severely affected districts as Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok (NRA, 2020). Treatment takes a value of 1 for district severely affected by the earthquake and a value of 0 for the remaining 61 comparison districts. The dependent variable is logarithmic transformation of the ratio total international labor migration per 100,000 population, hence estimates can be interpreted as $\%\Delta y = (e^{\delta} - 1) \times 100$. See Appendix B for graphical depictions of Factor F_{rt} and it's coefficients λ_{it}.

Table 1 provides three panels, each representing the estimates of the impact of the 2015 Nepal earthquake on total migration (Panel A), male migration (Panel B), and female migration (Panel C). Each panel comprises two different models. First is the difference-in-difference model with district and year level fixed-effects (DID FE), and second is the interactive fixed-effect model (IFE) in columns (1) and (2), respectively. Treatment indicator refers to variable D as shown in equation 1 and 2. To account for the intra-district correlation, we cluster standard errors at the

district level for all models. The standard errors are also robust to heteroskedasticity for DID FE. However, we generate standard errors based on non-parametric bootstraps (blocked at the district level) of 2,000 iterations for IFE. In the IFE model, the intercept term gives the average value of migration among the comparison districts. In contrast, the treatment effect shows how much the migration level differs between severely affected districts and the comparison group of unaffected districts.

The DID FE estimates in Panel (A) column (1) exhibit a treatment effect of -0.321, which translates to an overall reduction of 27.458% ($\approx (e^{-0.321} - 1) \times 100 \approx -27.458\%$) in total international labor migration per 100,000 population in the post-earthquake period among treated districts compared to earthquake-unaffected comparison districts.

The IFE estimates project slightly more robust estimates than the DID FE but in the same direction. The IFE approach in Panel (A) column (2) provides estimates of $-0.378 \approx (e^{-0.378} - 1) \times 100 \approx -31.477\%$, suggesting an overall reduction of 31.477% in total migration per 100,000 population in districts severely affected by the earthquake compared to comparison districts.

We also explore the effect of the earthquake on male and female international migration in Nepal. This is important because migration varies structurally between males and females in Nepal. Males are primary breadwinners, and women have equally important household chores and care for the family, mainly children and the elderly.

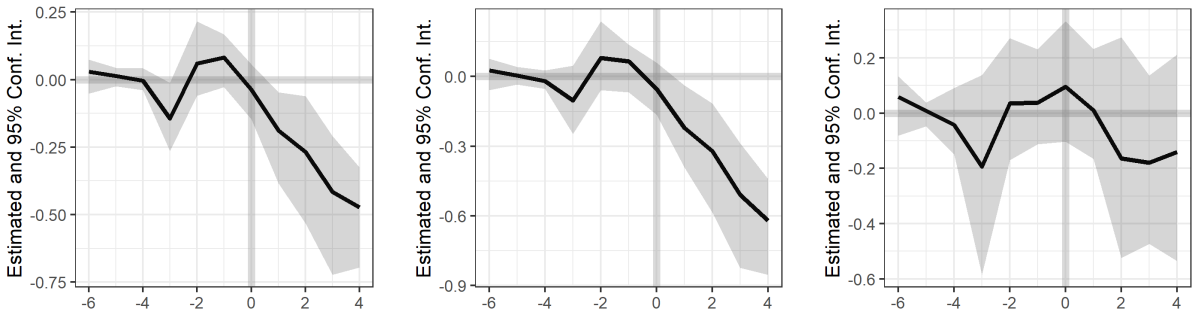
Panel B provides estimates of male international labor migration in response to the 2015 earthquake in Nepal. The DID FE, and IFE models converge to the statistically significant similar estimate of $-0.40 \approx (e^{-0.40} - 1) \times 100 \approx -32.968\%$), indicating a considerable reduction of 32.968% in male international labor migration per 100,000 population in earthquake-affected districts compared to comparison counterparts. Interestingly, Panel C shows that estimates of female international labor migration are statistically insignificant, suggesting that the earthquake did not affect Nepal's female labor migration.

6.3 Robustness Checks

We conduct four sets of different robustness checks in this section to strengthen the validity of our baseline estimates presented in Table 1.

First, we conduct an event study to break down the overall impact of the 2015 earthquake on international migration for each year in the sample. Figure 4 presents the graphical illustration of event study estimates from the interactive fixed effects model. Consistent with the results in Table 1, we see an overall downward trend in total international migration and male international migration. The confidence intervals illustrate that the effect is negative and statistically significant after the earthquake incidence in 2015 (except for female international migration in Panel C). Overall, this event study analysis indicates that estimates of total and male international migration in response to the previous section's earthquake are robust and statistically significant.

Figure 4: Event Study with Interactive Fixed Effects



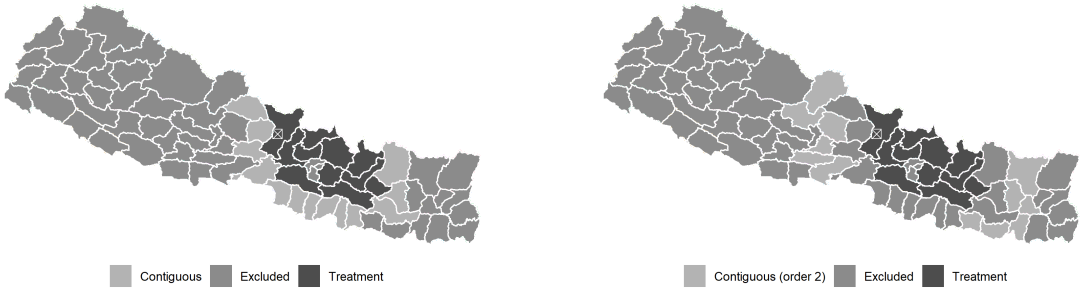
(a) Total **(b)** Male **(c)** Female

Notes: Nepal's government lists the severely affected districts as: Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok NRA (2020). First-order contiguous of severely affected districts are Bara, Chitawan, Dhanusa, Khotang, Lamjung, Mahottari, Manang, Parsa, Rautahat, Sarlahi, Solukhumbu, Tanahu, and Udayapur. Second-order contiguous of severely affected districts are Bhojpur, Dhankuta, Kaski, Mustang, Myagdi, Nawalparasi, Palpa, Sankhuwasabha, Saptari, Siraha, Sunsari, and Syangja. Our analysis excludes Bhaktapur, Kathmandu, and Lalitpur districts. These districts belong to core cities within proximity of the capital city Kathmandu, and withing Kathmandu valley. We implement Auto Regressive Integrated Moving Average (ARIMA) approach to backcasting district-level migration for 2009/10, 2008/09, and 2007/08. The horizontal line index at 0 represents the fiscal year 2014/15, and the earthquake occurred in April 2015.

Second, we repeat our main analysis using a different definition of our treatment variable to explore our baseline estimates' robustness. This is important because our identification strategy in the baseline analysis presented in Table 1 evaluates differences in international labor migration between severe earthquake-affected districts and all the remaining districts. However, it is plausible that international labor migration in a district far away from the earthquake's epicenter is likely to be less affected. Also, three districts (Kathmandu, Bhaktapur, and Lalitpur) listed as severely-affected by Nepal's government tend to be less reliant on international labor migration.

Therefore, we alter the definition of our treatment variable (see Figure 5) to investigate the robustness of our baseline estimates presented in the preceding section.

Figure 5: Spatial distribution using an alternate identification strategy



(a) Comparison between severely affected districts and first-order contiguous districts in Nepal

(b) Comparison between severely affected districts and second-order contiguous districts in Nepal

Notes: Nepal's government lists the severely affected districts as: Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok NRA (2020). First-order contiguous of severely affected districts are Bara, Chitawan, Dhanusa, Khotang, Lamjung, Mahottari, Manang, Parsa, Rautahat, Sarlahi, Solukhumbu, Tanahu, and Udayapur. Second-order contiguous of severely affected districts are Bhojpur, Dhankuta, Kaski, Mustang, Myagdi, Nawalparasi, Palpa, Sankhuwasabha, Saptari, Siraha, Sunsari, and Syangja. Our analysis in Table 2 and Table 3 excludes Bhaktapur, Kathmandu and Lalitpur districts.

Table 2: Impact of the 2015 earthquake on Nepal's international labor migration (Comparison between severely affected districts and first-order contiguous districts)

Variables	Panel A Total Migration		Panel B Male Migration		Panel C Female Migration	
	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)
Treatment	-0.245***	-0.275	-0.299***	-0.280	0.040	-0.010
	(0.067)	(0.323)	(0.070)	(0.311)	(0.076)	(0.181)
Intercept		7.365***		8.019***		4.711***
		(0.111)		(0.102)		(0.234)
District FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Factor		1		1		1
HC Robust SE	✓		✓		✓	
Bootstrap SE		✓		✓		✓
Observations	192	192	192	192	192	192

Notes: Nepal's government lists the severely affected districts as Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok NRA (2020). We categorize severely affected districts as the treatment group and the remaining 61 districts as comparison group. The dependent variable is logarithmic transformation of the ratio total international labor migration per 100,000 population, hence estimates can be interpreted as $\%\Delta y = (e^{\delta} - 1) \times 100$.

Table 2, we re-estimate the DID FE and IFE model for total, male, and female international labor migration excluding the three districts in the Kathmandu valley and including only districts contiguous to severely-affected ones in our comparison group. This allows us to control for potential selection bias induced from the inclusion of districts either far away from the earthquake's epicenter or located in the capital city's proximity. Table 2 shows that DID FE estimates for total migration and male migration are -0.245 and -0.299, respectively. While these estimates are not as pronounced as those from Table 1, they are statistically significant and likely to be free of potential selection bias outlined above.[19] Similarly, we incorporate second-order neighbors in the comparison group using the same logic and re-run the DID FE and IFE model. Table 3. We find that the effects are even less pronounced, estimated to be -0.161 and -0.219 for total and male labor migration, respectively. These estimates based on an alternate identification strategy illustrated in Figure 5 support the validity of our main results presented in Table 1.

Table 3: Impact of the 2015 earthquake on Nepal's international labor migration (Comparison between severely affected districts and second-order contiguous districts

Variables	Panel A Total Migration		Panel B Male Migration		Panel C Female Migration	
	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)
Treatment	-0.161***	-0.770**	-0.219***	-0.426***	0.122	0.030
	(0.057)	(0.465)	(0.057)	(0.359)	(0.110)	(0.643)
Intercept		7.187***		7.943***		4.805***
		(0.144)		(0.131)		(0.299)
District FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Factor		1		1		1
HC Robust SE	✓		✓		✓	
Bootstrap SE		✓		✓		✓
Observations	192	192	192	192	192	192

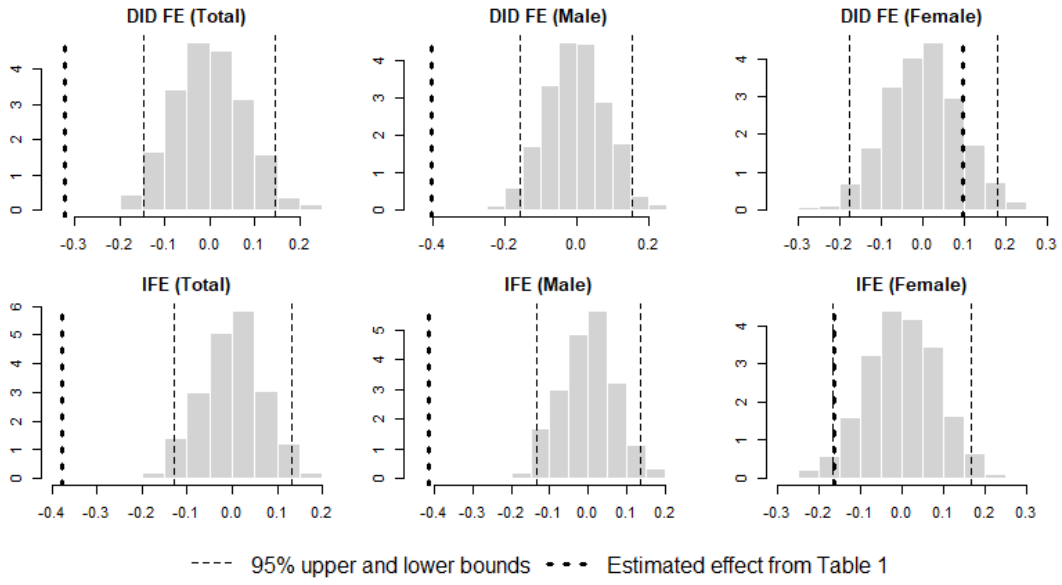
Notes: Nepal government's NRA (2020) lists the severely affected districts as Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok. We define the severely affected districts as the treatment group and remaining 61 districts of Nepal as comparison group. The dependent variable is logarithmic transformation of the ratio total international labor migration per 100,000 population, hence estimates can be interpreted as $\%\Delta y = (e^{\delta} - 1) \times 100$.

Third, we conduct a placebo test to evaluate our baseline results (see Figure 6). We ran-

[19] The IFE models are less suited in this analysis because we only include the sub-sample. Hence, incorporating a nationwide trend using sub-sample analysis is not feasible.

domly assign our treatment variable across a bootstrap sample (random sample with replacement) drawn from the current data set and estimate placebo regressions 999 different times. Suppose the actual treatment effect is significantly further away from the mean distribution of the post-treatment differences generated from placebo regressions. In that case, this provides strong evidence that the earthquake significantly affected international labor migration in Nepal. Figure 6 demonstrates that our baseline DID FE and IFE estimates (except for female migration) from Table 1 are located outside of 2.5% quantile distribution of placebo treatment effects, providing strong evidence that the 2015 earthquake significantly reduced foreign labor migration in Nepal. As expected, the effect is not quite pronounced among females.

Figure 6: Distribution of placebo regression estimates



Notes: Placebo estimates are generated from 999 different iterations. In each iteration, we randomly assign our treatment variable across a bootstrap sample (random sample with replacement) drawn from the current data set.

Finally, we conduct an additional robustness check to show that the Madhesh Movement does not confound our baseline estimates. We estimate equations (1) and (2). Still, we exclude districts in Nepal's Terai region that witnessed active protests against the government to address the demands of marginalized Madhesis and Tharus. Table 4 shows that our estimates of overall and male international migration in response to the earthquake are similar in magnitude to our baseline estimates in Table 1, giving us confidence in the robustness of our main results presented in the study.

Table 4: Impact of the 2015 earthquake on Nepal's international labor migration (excluding Terai districts)

Variables	Panel A Total Migration		Panel B Male Migration		Panel C Female Migration	
	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)	DID FE (1)	IFE (2)
Treatment	-0.342***	-0.355***	-0.419***	-0.377**	0.043	-0.190
	(0.068)	(0.072)	(0.072)	(0.131)	(0.084)	(0.116)
Intercept		6.884***		7.574***		4.004***
		(0.131)		(0.135)		(0.202)
District FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Factor		1		1		1
HC Robust SE	✓		✓		✓	
Bootstrap SE		✓		✓		✓
Observations	192	192	192	192	192	192

Notes: Nepal's government lists the severely affected districts as Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok (NRA, 2020). We define the severely affected districts as the treatment group and remaining 61 districts of Nepal as comparison group. We exclude Terai districts of Nepal from the comparison districts as Banke, Bara, Bardiya, Chitawan, Dang, Dhanusa, JhapaKailali, Kanchanpur, Kapilbastu, Mahottari, Morang, Nawalparasi, Parsa, Rautahat, Rupandehi, Saptari, Sarlahi, Siraha, Sunsari. The dependent variable is logarithmic transformation of the ratio total international labor migration per 100,000 population, hence estimates can be interpreted as $\%\Delta y = (e^{\delta} - 1) \times 100$.

6.4 Primary Channels

We have shown that the 2015 earthquake in Nepal led to a significant decline in the overall international migration. To better understand the role of different mechanisms behind this documented effect, we explicitly look for two specific channels: domestic productivity and aid.

First, it is possible that the earthquake significantly affected domestic measures of productivity, which subsequently affected international labor migration decisions of individuals. Therefore, we propose baseline labor productivity and agricultural productivity as two primary channels through which the 2015 earthquake significantly influenced international labor migration in Nepal.

Second, we hypothesize that foreign aid allocated to a given district may induce domestic workers to stay within the country and focus on reconstruction efforts in the aftermath of the earthquake. This is important because prior literature highlights foreign aid's role during natural disasters in South Asia (Andrabi and Das, 2017; Eichenauer et al., 2020).

Table 5: Triple difference-in-difference estimates

	Average Labor Migration								
	Channel: Labor productivity			Channel: Agricultural productivity			Channel: Aid disbursement per person		
	(Total) (1)	(Male) (2)	(Female) (3)	(Total) (4)	(Male) (5)	(Female) (6)	(Total) (7)	(Male) (8)	(Female) (9)
treat	0.936***	0.899***	2.391***	0.552*	0.500	1.783***	0.133	0.077	1.546***
	(0.327)	(0.341)	(0.442)	(0.314)	(0.325)	(0.443)	(0.264)	(0.273)	(0.392)
post	0.246	0.240	0.651**	0.209	0.191	0.729**	0.160	0.151	0.636**
	(0.195)	(0.203)	(0.264)	(0.205)	(0.212)	(0.289)	(0.171)	(0.177)	(0.254)
channel	0.529**	0.479**	1.201***	0.030	0.003	−0.288	−0.886***	−0.932***	−0.334
	(0.220)	(0.229)	(0.297)	(0.231)	(0.239)	(0.326)	(0.272)	(0.282)	(0.404)
post × *treat*	−0.309	−0.372	0.095	−0.313	−0.381	0.002	−0.255	−0.338	0.149
	(0.463)	(0.482)	(0.625)	(0.444)	(0.460)	(0.626)	(0.373)	(0.386)	(0.554)
post × *channel*	−0.103	−0.121	0.003	−0.008	0.004	−0.198	0.231	0.214	0.079
	(0.311)	(0.324)	(0.420)	(0.326)	(0.338)	(0.461)	(0.385)	(0.398)	(0.572)
treat × *channel*	−1.453***	−1.489***	−1.744**	−0.760	−0.776	−0.449	1.220	1.173	1.374
	(0.504)	(0.524)	(0.681)	(0.570)	(0.590)	(0.804)	(0.919)	(0.950)	(1.364)
treat × *post* × *channel*	−0.020	−0.059	0.002	−0.033	−0.067	0.255	−0.515	−0.507	−0.613
	(0.712)	(0.742)	(0.963)	(0.806)	(0.835)	(1.137)	(1.300)	(1.343)	(1.929)
Constant	6.544***	7.276***	2.701***	6.740***	7.463***	3.287***	6.926***	7.647***	3.239***
	(0.138)	(0.144)	(0.186)	(0.145)	(0.150)	(0.204)	(0.121)	(0.125)	(0.179)
Observations	150	150	150	150	150	150	150	150	150
R^2	0.134	0.122	0.415	0.046	0.043	0.298	0.120	0.121	0.283
Adjusted R^2	0.091	0.079	0.386	−0.001	−0.004	0.263	0.077	0.078	0.247

Notes: We define severely affected districts identified by Nepal's government (NRA, 2020) as the treatment group ($treat = 1$) and the remaining 61 districts as the comparison group ($treat = 0$). The dependent variable is logarithmic transformation of the ratio total international labor migration per 100,000 population, hence estimates can be interpreted as $\%\Delta y = (e^{\delta} - 1) \times 100$. We group the dependent variable before ($post = 0$) and after ($post = 1$) earthquake and take an average of the dependent variable. Within these districts, we also group them based on three separate channels: above mean labor productivity (2010), above mean agricultural productivity (2010), and above mean aid disbursement per person (2010-2013). We define above mean for each channel as ($channel = 1$) and below mean channel as ($channel = 0$). The coefficient of $treat \times post$ is difference-in-difference estimates and $treat \times post \times channel$ is triple difference-in-difference estimates. Estimates are robust to heteroskedasticity standard errors.

To delve into the significance of each mechanism explained above, we interact baseline measure of each channel with the treatment variable and post-earthquake binary variable in a standard difference-in-differences research design framework. As shown in Table 5, we find suggestive evidence that these channels may have played an essential role in reducing international migration in the aftermath of the earthquake (although none of our triple interaction terms, $treat \times post \times channel$ are statistically significant). For example, Column (7) indicates that treated districts with high amounts of aid disbursed per capita saw a decline in international labor migration after the earthquake with a slope estimate of −0.515. Across all the empirical specifications, the triple interaction term's slope coefficient is negative and statistically insignif-

icant. Although it is beyond this study's scope to causally tease out the significance of these specific channels in explaining the impact of the earthquake on international migration, we interpret our estimates to suggest that some of these channels may have played an important role in influencing our baseline estimates.

7 Concluding Remarks

Previous literature has explored human migration in response to environmental events (Queiroz et al., 2019; Koubi et al., 2016; Paul, 2005; Raleigh et al., 2008). Despite substantial interest in post-disaster adaptation strategies to recover from disaster-induced economic losses, there exists limited evidence of migration in response to large earthquakes in the developing world. To fill this gap in the literature, this study examined the impact of the 2015 earthquake in Nepal, a disaster-prone and labor exporting developing country in South Asia, on international migration.

Exploiting the plausibly exogenous incidence of the earthquake, we applied the difference-in-differences research design to evaluate changes in international labor migration per capita between severely-affected districts and unaffected counterparts. Our empirical research design accounted for potential unobserved heterogeneity, omitted variable bias, and nationwide time trends. We also conducted additional robustness checks to show that our estimates from the double differences approach are valid and statistically significant.

Our results indicate that the number of work permits issued for international migration decreased significantly by 37.85% among severely-affected districts in the aftermath of the 2015 earthquake. There exists some suggestive evidence that domestic measures of productivity and aid may have affected labor emigration in the aftermath of the earthquake. Findings also show that the earthquake's effect on international work permits is statistically significant and negative only among males. While gender disparities in response to environmental shocks have been previously documented in the literature (Henry et al., 2004), we believe economic disruptions caused by the earthquake possible caused this heterogeneity across gender in the context of Nepal. Future research may benefit from a causal identification of the mechanisms through which the earthquake's incidence influenced individual labor emigration decisions.

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A Appendix A

Figure A1: Spatio-temporal Variation of Foreign Labor Migration (Male) to the Population

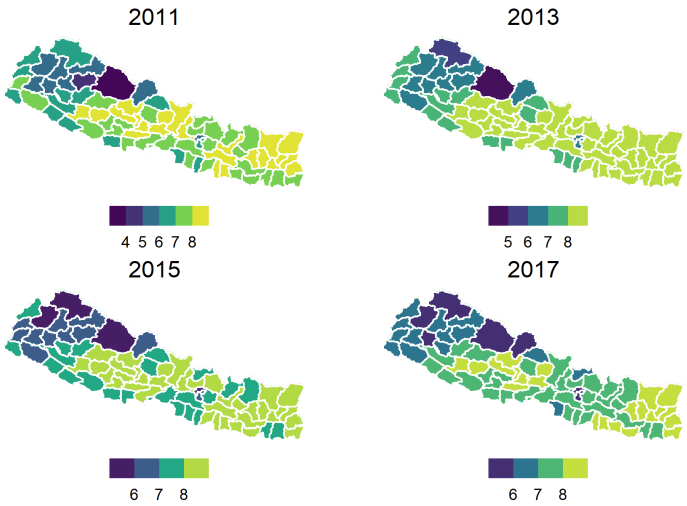
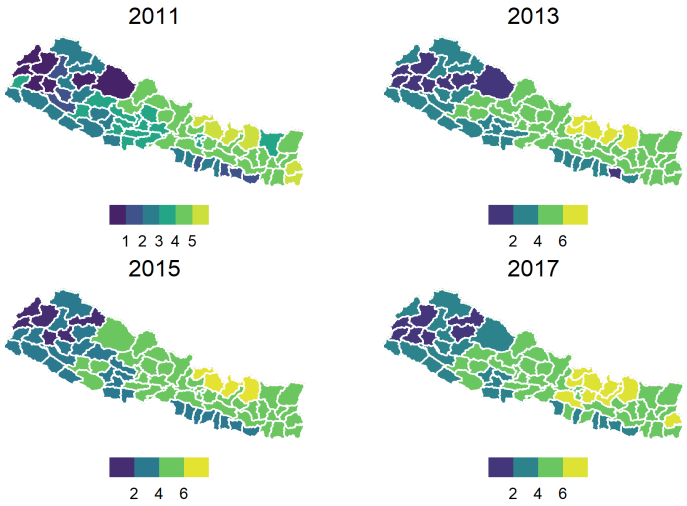


Figure A2: Spatio-temporal Variation of Foreign Labor Migration (Female) to the Population



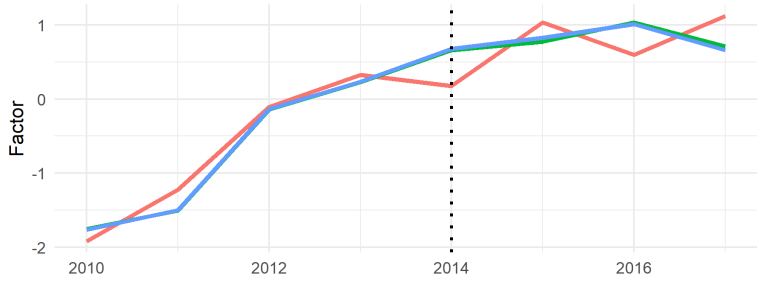
B Appendix B

In each IFE model in Table 1, we try to capture nonlinear nationwide natural trend or inertia in the migration and the district level susceptibility to such a nationwide trend. we explain these concepts further in Figure B1 and B2 respectively.

Figure B1 presents the nonlinear nationwide trend in the total, male, and female international labor migration per 100,000 population. It appears these trends are increasing at a decreasing rate. The female international migration trend seems to follow annual cyclical behavior. However, total and male international labor migration appears to follow the same trajectory. Though there is this national trend, different districts are differently susceptible to the national trend, see Figure B2.

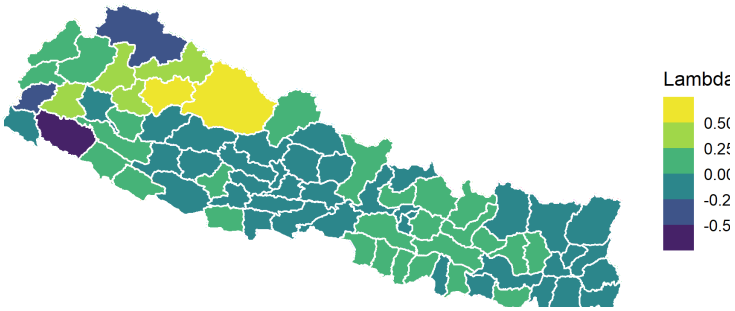
Figure B2 provides a cheolerpetra map of district-level susceptibility to the nonlinear national trend in migration. These are in relative scales. District with darker/lighter color is less/more susceptible to the nationwide trend depending upon the district level unobservables.

Figure B1: Factor: nationwide non-linear trend of international labor migration



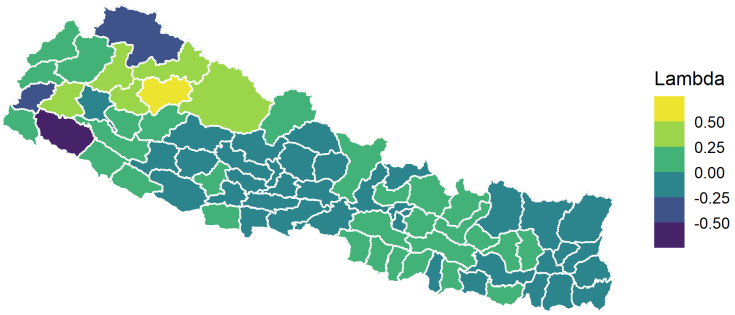
Notes: Nepal government's NRA (2020) lists the severely affected districts as: Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok. We define the severely affected districts as treatment group and remaining districts as comparison group. The dotted vertical line classify before- and after-2015 earthquake.

Figure B2: Lambda: district-level intercept of the nationwide non-linear trend of total international labor migration per 100,000 population



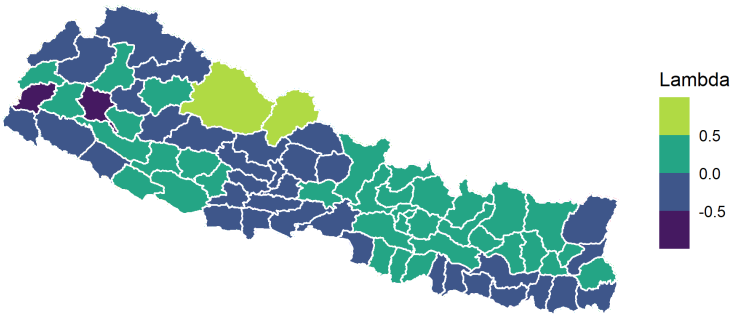
Notes: Nepal government's NRA (2020) lists the severely affected districts as Bhaktapur, Dhading, Dolakha, Gorkha, Kathmandu, Kavrepalanchok, Lalitpur, Makwanpur, Nuwakot, Okhaldhunga, Ramechhap, Rasuwa, Sindhuli, and Sindhupalchok. We define the severely affected districts as the treatment group and remaining districts as a comparison group.

Figure B3: Lambda: District Level Susceptibility on the Nationwide Non-linear Inertia of Foreign Labor Migration, Male.



Notes: Nepal government's NRA (2020) lists the severely affected districts as: Okhaldhunga, Dolakha, Ramechhap, Sindhupalchok, Kavrepalanchok, Sindhuli, Bhaktapur, Kathmandu, Lalitpur, Rasuwa, Nuwakot, Dhading, Gorkha, and Makwanpur. We define the severely affected districts as treatment group and remaining districts as comparison group. The Dotted horizontal line

Figure B4: Lambda: District Level Susceptibility on the Nationwide Non-linear Inertia of Foreign Labor Migration, Female.



Notes: Nepal government's NRA (2020) lists the severely affected districts as: Okhaldhunga, Dolakha, Ramechhap, Sindhupalchok, Kavrepalanchok, Sindhuli, Bhaktapur, Kathmandu, Lalitpur, Rasuwa, Nuwakot, Dhading, Gorkha, and Makwanpur. We define the severely affected districts as treatment group and remaining districts as comparison group. The Dotted horizontal line