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ORIGINAL PAPER

How resilient is the labour market against natural disaster? Evaluating the effects from the 2010 earthquake in Chile

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Abstract

Natural disasters are one of the main channels through which ecological and socio-economic systems interact. In particular, the severe impacts of earthquakes could disrupt activities in the labour market. However, the literature barely researched the long-term effects of such events. To investigate this issue, this article is concentrated in Chile that is subject to recurring seismic movements. The 27 February 2010 Bío-Bío Chile earthquake (M_w 8.8) was the second strongest in the history of the country. This natural disaster can be used to evaluate the response of the labour market to an exogenous shock. Besides, the capacity for resilience in the labour market is crucial for people who rely on their job. This document analyses the impacts of the 2010 Bío-Bío earthquake and tsunami on Chilean labour market outcomes, in particular, the quality of employment. With this objective, different data are combined for analysing the effect in the short and long term. Also, distinct econometric techniques and exogenous measurements of seismic acceleration are used. The evidence shows that these catastrophes harmed the labour market in the short term. However, in the long term, the government's reconstruction efforts and other factors could have attenuated the adverse effects over some variables in the most affected zones.

Keywords Natural disasters · Earthquake · Labour markets · Quality of employment · Reconstruction

JEL Classification J2 · J3 · J46 · Q54 · O10

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1 Introduction

A natural disaster is an event that can cause a perturbation to the normal functioning of the economic, social and political system of a country. The potential impact (negative or positive) of these events will depend directly on the resilience of a country or region to cope with natural disasters. The economic dimension of resilience refers to the capacity to reduce both direct and indirect economic losses resulting from natural disasters (Bruneau et al. 2003) and differs significantly between developing and developed countries. Since the former group is characterized by poor construction infrastructure and conditions of political, economic and social vulnerability, natural disasters have strong destructive power in these regions. This is compounded by complex socio-economic conditions, political interests and environmental and military instability. Developed countries, on the contrary, have greater resilience because, among other things, they have technology that allows them to monitor and even predict some future catastrophes. Also, building construction and infrastructure are carried out following increasingly stringent safety regulations and with more efficient evacuation procedures (Giovene di Girasole and Cannatella 2017).

In the particular case of an earthquake, although neither of the two groups of countries can accurately predict when it will occur, its potential impact will depend on a set of factors, such as 'its magnitude, depth (focus or hypocentre), epicentral distance (from the epicentre to the affected areas), local conditions of terrestrial materials (site conditions) and the way infrastructure is built: houses, buildings, roads, railways, service lines and pipelines, that is, the construction typology' (Omaña et al. 2017, p. 259). If infrastructure is inadequate for a building to resist seismic movements from noncompliance with the seismic norms, the damages and losses will be severe.

The lower the resilience to natural disasters, the greater the magnitude of the negative consequences, many of which occur at different times. The direct losses occur in the short term and include the lives of people (human capital) and physical capital (goods, buildings, infrastructure and other constructions). Indirect losses also arise in the social and economic sphere, but their repercussions are longer term. Indeed, a natural disaster can disrupt the normal functioning of the financial system, domestic and foreign trade, as well as the labour market. Therefore, a reliable estimate of the resilience of society must consider both negative consequences.

Natural disasters can change the characteristics and structure of the labour market. The most immediate and direct effect is the decrease in labour supply and demand. Deaths, injuries or displacement of workers outside the affected location leave a small workforce to fill job vacancies. Some employers are forced to cease economic activity. Given the loss of human and physical capital, companies cannot make changes in the factors of production. That, in turn, produces negative consequences on future income flows (Yamauchi et al. 2008a, b; Skoufias 2003) whose magnitude will depend on the scale of destruction and the degree of substitutability between capital and labour in the production process (Mueller and Quisumbing 2011).

On the contrary, while some companies may choose to substitute capital for labour, others will seek to incorporate new technologies to increase worker productivity. If in these sectors, labour is complementary to capital, labour demand is expected to increase. In these cases, a change in the composition of employment will be observed. However, if work is a substitute for capital, the natural disaster may imply a change in the dynamics of the labour market. Some workers will seek employment outside the affected area. These movements will intensify if the displacements between sectors and cities are not too costly or if the expected revenues exceed the costs. Likewise, natural disasters can produce a positive shock in the labour demand in specific sectors as a result of the influx of resources for reconstruction, which increase demand in sectors such as construction (Rodríguez-Oreggia and Olvera 2011; Belasen and Polachek 2008).

However, the third alternative for companies seeking to recover production and employment after a natural disaster is to modify the quality of employment by offering temporary, informal or shorter-term contracts. These modifications are likely to occur in developing countries that are usually characterized by a high deficit in employment quality, poor enforcement of labour laws and weak institutions. In this context, the resilience of the labour market becomes more complicated. Precarious employment contracts can favour the recovery of employment levels, but also worsen their quality. This study considers a labour market as resilient from a quality of employment view if the labour market reflects a positive or stable trajectory of jobs without a quality deficit after an external shock.

Other issue that should be considered in cases like Chile where the economy is open is that the external demand drivers should be also taken into consideration when analysing specific issues on labour market. This is quite important because, after the 2008 financial crisis and 2009 economic hiatus, the external demand for Chilean commodities arouse in 2010. Over the last four decades, this country almost fully liberalized its trade and foreign direct investment, which accelerated growth of flows in both areas and contributed to important changes in the labour market (Friedman et al. 2012). In that regard, evidence shows that the process of economic openness of the Chilean economy has positively impacted various sectors, both in jobs creation and in jobs quality (Reinecke and Posthuma 2019). However, Medina and Naudon (2012) show that the terms of trade have effects on the labour market but not always significant. In particular, the unemployment rate does not change significantly when non-mining terms of trade improve, but this rate drops significantly after an increase in mining terms of trade.

Chile is characterized by recurring seismic movements. In this region, the Nazca Plate and the South American Plate converge, causing seismic events of varying magnitude that sometimes trigger catastrophes of significant dimensions. On 27 February 2010, the country was shaken by an 8.8 M_w earthquake and subsequent tidal wave of great magnitude, which produced the greatest damage to infrastructure known in the history of the nation. Moreover, the geographical area and the percentage of the population affected by this unfortunate event exceed what was recorded in previous catastrophes (Government of Chile 2010). The Bío-Bío Region (VIII Region), one of the regions most damaged by the earthquake, has the second-highest regional GDP in Chile. Also, the affected zones comprised 20% of total national employment and 40% of national employment in the agricultural sector (ECLAC 2010). In this context, the analysis of the resilience capacity of the Chilean labour market is particularly relevant.

This type of study not only allows measuring the impacts caused by a natural catastrophe but also knowing the effectiveness and efficiency of the recovery process implemented by the state based on the magnitude of the estimated damage. Furthermore, the recovery of the labour market is an essential variable for the analysis of economic resilience because, among other reasons, it determines the ability of a family to resolve their impaired financial situation after a natural disaster occurred (Bastaminia et al. 2017).

This document aims to estimate the effects of the 2010 Bío-Bío earthquake and tsunami on the Chilean labour market. Specifically, it seeks to examine how resilient the country is regarding job opportunities and quality of employment in the face of unexpected and large-scale shocks caused by a natural catastrophe such as an earthquake and a tsunami. This analysis is developed distinguishing the short- and long-term impacts. The final effect is ambiguous. On the one hand, production and employment are likely to suffer in the regions most affected by the earthquake. Without appropriate and timely action, adverse effects will not only be significant in the short term but also will remain in the long term. On the other hand, implementation of some policies during the recovery process can mitigate, or even reverse, the negative consequences on the labour market.

2 Literature review

The relationship between economic resilience and natural disasters remains a subject of intense debate that has not yet been sufficiently investigated (Tanaka 2015). Some studies offer evidence in favour of the hypothesis of creative destruction (Leiter et al. 2009; Crespo Cuaresma et al. 2008) according to which growth, production or employment can be positively affected by natural disasters (Toya and Skidmore 2007) because they promote the updating of capital and the adoption of new technologies (Tanaka 2015). In contrast, other studies reveal that natural disasters produce negative impacts on the economy and society with short- and long-term consequences (Raddatz 2009). However, Cavallo et al. (2013) warned that only significant natural catastrophes that are followed by political instability produce adverse effects on production both in the short and long term.

Given the difficulties in identifying and isolating long-term economic effects, the literature regarding the impacts of natural disasters in the short term is more abundant. Hornbeck (2012) is one of the few that considered longer-term impacts. Hornbeck's evidence confirmed that natural disasters have persistent effects on the value and use of land. Similarly, Gignoux and Menéndez (2016) showed that households benefitted from the earthquakes in Indonesia, but in the long term. Porcelli and Trezzi (2019), on the other hand, concluded that the effects of natural disasters on economic activity are not persistent, but tend to be reabsorbed within two years after the event.

Another large set of literature focuses on the analysis of disaster repair and risk mitigation (Salem et al. 2019), but few examine the effects on the labour market. According to the Web of Science and Scopus search engines, there are 118[1] articles about effects of natural disaster on the labour market, and most of the existing evidence comes from Japan, the USA, China and Canada, while the literature for Latin America does not exceed 1% (Fig. 1). The small number of articles published in indexed journals for Latin America is striking given the recurrent seismic nature that characterizes the region. Only one study was found for Chile and Brazil. In the first case, Jiménez and Cubillos (2010) examined the effects of the 2010 Bío-Bío earthquake on perceived stress and job satisfaction in a Chilean company exposed to a successful program of intervention on risk prevention. The results indicate that even though perceived stress increased in the participants after the quake, job satisfaction remained at high levels. An article by Da Silva et al. (2017) for Brazil estimated the impacts caused by the 2008 rains and flooding in Santa Catarina on the labour market, wages and employability. The evidence shows that wages increased 4.7% on average for each standard deviation increase in rainfall in the municipalities. Nevertheless, there is not a significant effect of the rains on employability.

Regarding the potential effect of natural disasters on the labour market, a negative shock on labour supply in the damaged region is expected along with undetermined shocks to the

[1] By counting only once the studies in both databases, the final sample involved 118 articles.

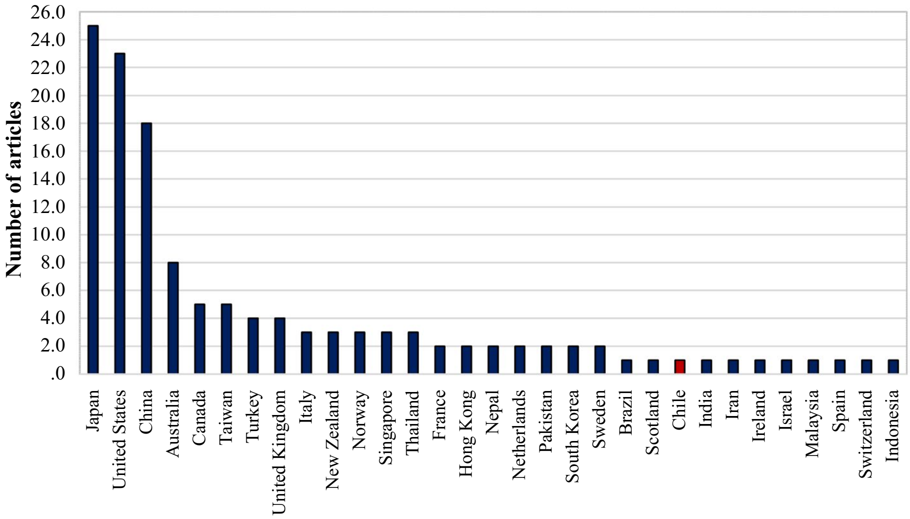

Fig. 1 Articles in indexed journals about natural disasters' effects on the labour market among countries. *Notes*: The search process comprises all studies in journals (excluding those from meetings or conferences) that have some reference to terms such as 'natural disaster', 'earthquake' or 'tsunami' and 'labour', 'employment', 'employee', 'workers', 'job', 'occupation' 'wage' or 'salary' in the title for all languages and the longest possible period that both databases allow establishing, that is, between the years 1900 and November 2019. *Source*: own elaboration based on Scopus and Web of Science

region's labour demand. On one side, some firms might attempt to fill vacancies in their workforces. On the other side, some companies might leave town because of the outflow of workers or the destruction of private property and physical capital. However, the risk of a natural disaster can reduce the expected return to physical capital causing a substitution effect towards human capital as a replacement. This last effect could raise the price of human capital, leading to an income effect that runs counter to the substitution effect (Belasen and Polachek 2009; Skidmore and Toya 2002). Therefore, the final net effect on employment, wages and the quality of jobs is unclear as it depends on the previous factors as well as other variables such as infrastructure, public policies or other determinants associated with the recovery process.

The recovery of employment is an essential variable for the analysis of economic resilience (Bastaminia et al. 2017). However, the evidence on this subject is quite scarce and controversial. While some studies found that natural disasters produce adverse but temporary effects on employment (Bondonio and Greenbaum 2018; Fabling et al. 2016; Tanaka 2015), others revealed positive effects associated with the process of post-disaster reconstruction work (Kirchberger 2017; Guo et al. 2014). In this context, the adverse effects of natural disasters on employment imply a worsening of working conditions, either by reducing the extensive margin (number of available jobs) or intensive (working hours or days of employment), while the contrary is true when the articles find a positive effect. Specifically, Guo et al. (2014) showed that the damage caused by the 2008 Wenchuan earthquake produced a surplus of labour in the construction sector, reducing the number of workers dedicated to plantation, aquaculture and non-agricultural labour. Due to the shortage of skilled labour, this surplus of labour supply remained in the long term. Skidmore and Toya (2002) warned that a natural disaster can increase employment by reducing the expected return to physical capital and producing a substitution effect on human capital.

The impact of an earthquake on employment quality is an issue not sufficiently explored in the literature. In this context, a rise of quality employment deficits would imply that earthquake produces a negative effect on working conditions by increasing the informal labour or temporary jobs, for example. In this context, Pecha Garzón (2017) examined the probability of men employed in the formal sector transitioning to informal jobs because of disruptions in the labour market from hurricanes and tropical storms in Jamaica. The findings suggest that hurricanes do not affect unemployment but raise the probability of transition to informality. Similarly, Valencia and Valencia (2019) studied the probability of being a part of informal labour markets after a natural disaster in Ecuador. The evidence indicates that the earthquake studied had a positive effect on the likelihood of being a part of the informal sector if workers were in the affected areas. In this sense, it is important to bear in mind that Jamaica and Ecuador have higher levels of informal employment than Chile. Therefore, shocks on the labour market could have more significant effects on informal employment in countries where labour informality is greater compared to those where is lower, such as Chile.

Another dimension of job quality is employee satisfaction. Baruch et al. (2016) found that earthquakes influence people's attitudes towards life and work and cause many to reflect critically on their plans and alter their intentions. Employees who are highly satisfied and committed may opt to leave their employment. Managers need to be aware of this risk and react quickly to support employees in a post-crisis situation.

Furthermore, workers' incomes and the economic gains of the companies can be affected by natural disasters. For instance, Auzzir et al. (2018) revealed that small and medium enterprises (SMEs) could not cope with natural disaster risks due to their limited financial capacity and experience as well as a lack of information. Moreover, Sardana and Dasanayaka (2013) observed that the primary damage of the tsunami in Sri Lanka occurred in physical capital (plant and machinery) and inventories. Although the evidence generally finds positive effects of natural disasters on workers' wages (Kirchberger 2017; Ewing et al. 2007), these effects occur in the short term (Mueller and Quisumbing 2011; Belasen and Polachek 2008, 2009). In particular, Ewing et al. (2007) found that although labour incomes increased immediately after the Bertha, Fran, Bonnie, Floyd and Dennis hurricanes, they then converged to levels seen before the hurricanes' arrivals. The authors maintained that even though hurricanes create a short-term economic disruption, they also can generate long-term economic gains in the presence of reconstruction and improvements. Other studies attribute the positive effects to wages (given the increase in demand for work in specific sectors) and also to the influx of resources for post-earthquake reconstruction (Rodríguez-Oreggia and Olvera 2011; Dresdner and Sehnbruch 2010; Belasen and Polachek 2008).

The literature on the impact of natural disasters in Chile is quite scarce. As mentioned earlier, with the search criteria used in the Web of Science and Scopus, only one article on the labour market and natural disasters was published in indexed journals. However, when the search criteria are extended, other studies are found. Most of them perform assessments of the damage caused to infrastructure, roads and homes (Contreras and Winckler 2013) as well as of the vulnerability and social resilience to natural disasters (Martínez Reyes 2014; Grandón et al. 2014).

On the contrary, scant articles examine the impacts of the 2010 Bío-Bío earthquake in Chile on other socio-economic and institutional variables. Polanco (2012) analyses socio-political effects in the affected communities and their implication in the construction of collective experience, changes in the legitimacy of government action and political coalitions. Sanhueza et al. (2012) used a Post-earthquake Survey prepared to monitor the effects of the 2010 Bío-Bío earthquake on the affected population. Based on a difference-in-differences approach, they found that the earthquake caused a significant increase in multidimensional poverty among the child population. Also, the health of the elderly population was negatively affected. Nevertheless, there was no negative impact on the income or monetary poverty dimension due to the earthquake.

A report of the Economic Commission for Latin America and the Caribbean (ECLAC) (2010) evaluates, preliminarily, the 2010 Bío-Bío earthquake damage for the macroeconomic, housing, educational and transportation categories. The evidence shows that the most affected population inhabited adobe and light material homes closer to the coast or the river mouth and who suffered the direct impact of the earthquake and tidal wave. The impact on health and educational infrastructure affected the population with lower resources, increasing their socio-economic vulnerability due to the loss of their physical capital, employment and productive capacity.

To the authors' knowledge, the research of Jiménez and Cubillos (2010) and that of Dresdner and Sehnbruch (2010) are the only studies that analyse the effect of the 2010 Bío-Bío earthquake on the labour market. The latter article, using the National Employment Survey of 1997–2010, estimated a series of indicators associated with the functioning of the labour market (employment and unemployment rate) as well as the job quality (labour informality, contract duration and occupational category). The results indicate that the earthquake had a greater effect on self-employed workers, women and less qualified workers (except for workers with higher education), that is, the most vulnerable workers. Nevertheless, this evidence is preliminary because it compares the levels of various labour indicators before and after the natural disaster without controlling for potential confounders that could explain the differences observed. Another source of possible bias in the findings provided by Dresdner and Sehnbruch (2010) is the methodological changes introduced from March 2010, just after the earthquake, in the National Employment Survey that they use as a source of information for their analysis. These changes could be problematic if the data are not appropriately adjusted by constructing harmonized variables when the impacts of the Bío-Bío earthquake on the labour market are analysed.

The main contribution of this article to the existing literature consists on the one hand of estimating, for the first time, the effects of the 2010 Bío-Bío earthquake on Chilean labour market resilience. With this objective, this study analyses the impact of the natural disaster on the quantity and quality of jobs. Since the notion of quality of employment is a multidimensional concept, the analysis considers different variables related to jobs. On the other hand, this work considers the short term as well as the long term. Likewise, different econometric techniques are used, exploiting their distinct advantages and instantly observing the robustness of the results obtained.

3 Data

This article combines three different groups of data. The first comes from the 2009–2010 Post-earthquake Survey carried out by the Ministry of National Planning and Economic Policy (MIDEPLAN), and the second comes from *Caracterización Socioeconómica Nacional* [National Socioeconomic Characterization] (CASEN) surveys of 2009, 2011, 2013, 2015 and 2017 (the latest available) carried out by the Ministry of Social Development (Ministry of Social Development 2019).

The third group of data comes from the United States Geological Survey (USGS). The USGS seismic hazard database includes instrumental intensity values and peak ground acceleration values (U.S. Geological Survey 2019). Peak ground acceleration values are directly measured at seismic stations. Instrumental intensity values are derived from empirical relations between peak ground acceleration values and modified Mercalli intensity (Wald et al. 1999). Therefore, the estimated intensities are not related to the effects of an earthquake on people or structures. Both data are measured only at the location of the stations and then interpolated for the rest of the territory. The ground motion and instrumental intensity values have been spatially associated with each community. In the future, we would like to extend the proposed methodology with a detailed seismic hazard assessment of the area of interest.

To estimate the effects of natural disasters on the Chilean labour market in the short term, the Post-earthquake Survey was carried out by MIDEPLAN in the months immediately following these events (between May and June of 2010). This survey's purpose was to collect information about the affected population due to the earthquake and the tsunami. The regions of Valparaíso, Metropolitana, Libertador Bernardo, O'Higgins, Maule, Bío-Bío and Araucanía were identified as damaged areas by Government of Chile (2010) (Fig. 2). The survey collected data from 22,456 households, which corresponds to a subset of the population interviewed in the 2009 CASEN Survey. The Post-earthquake Survey is a panel database, which means that the sample was followed up two times. The survey has national representativeness, but with a higher number of observations as a percentage of the population in the affected regions to enable more detailed analysis (Government of Chile 2010).

The CASEN household survey has been conducted by the Ministry of Social Development every two years since 1985, every three years since 2003 and every two years again since 2011. The information allows for the diagnosis of the socio-economic reality of different social sectors of the country (including various topics such as education, work, income, poverty and health) and the evaluation of social programs that represent a high component of public social spending. The CASEN survey is organized into six modules (residents, education, employment and income, health and housing). The sampling is conducted in two stages stratified by conglomerates and is nationally representative (Government of Chile 2010).

With both surveys, different interest variables are defined to assess the effect of the earthquake on the labour market. In particular, the employment, unemployment and participation status, as well as variables associated with the quality of employment, are considered. The notion of quality of employment includes different aspects of work, not only those related to social protection but also labour rights, employment opportunities and social dialogue (ILO 2002). This definition corresponds to the concept of decent work introduced by the International Labour Organization (ILO). Given the data available to carry out the objectives of this study, the dimensions used to characterize the quality of jobs in Chile are working time, labour contract duration, social security and labour income. Part-time employees are considered as those who work less than 35 h per week. Those who have a contract with a fixed period are employed in temporary work.

The analysis of labour informality is also relevant in Chile because it is one of the problems in the labour market. From an empirical point of view, the definition of informal employment generally follows either a productive approach (which includes unskilled self-employed workers, small business workers and non-income workers) or a legalistic approach, based on compliance with social security regulations or even a combination of both. Given the information available in the databases used for this study, informal work is

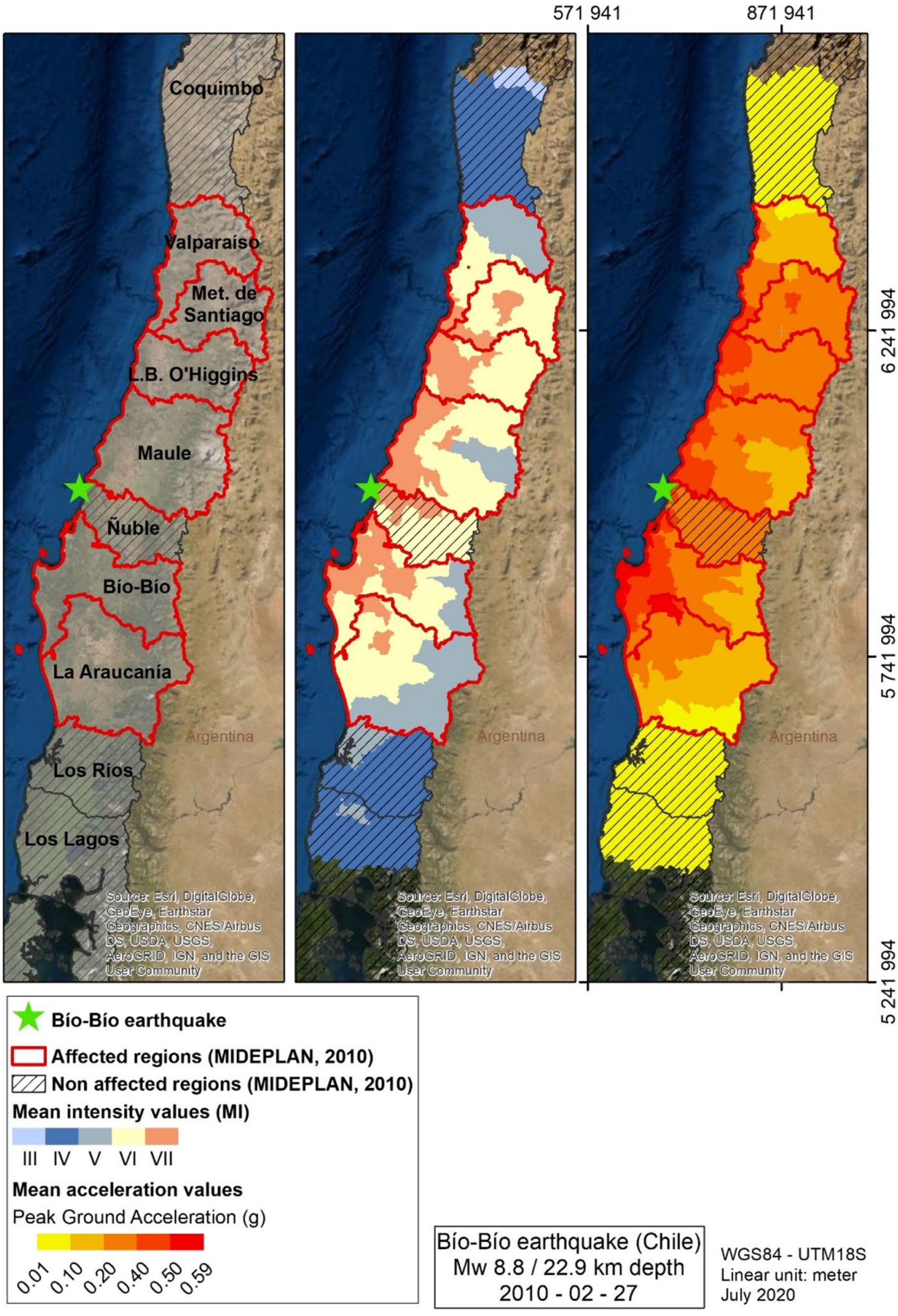

Fig. 2 Affected region by mean acceleration values (PGA) and instrumental intensity values (mean intensity values) of the 2010 Bío-Bío earthquake. *Source*: Own elaboration based on USGS Shakemap data

defined as workers who are not contributing to the pension system. This criterion is consistent with the regulations in force in Chile that establishes as obligatory, in the Labour Contract Law 19,759, to notify the start and the end of the employee hiring and other labour relations before the Labour Inspection or Social Security. Also, the legal definition of informality is more in line with the term 'informal economy' defined by ILO (2002), which recognizes that informality is a multidimensional phenomenon; therefore, it is necessary to broaden its definition to incorporate workers who are not subject to labour legislation beyond the sector (formal or informal) in which they develop their activities. Employees who do not sign an employment contract are also considered as informal workers.

Other variables included in the estimations are the hours worked and monthly wages adjusted for inflation. These variables permit exploration of channels of adjustment used by employers after a natural disaster. For example, firms might substitute technology for hours worked. Moreover, salaries can change when an employee decides to move within or into other sectors.

There is no information about employment hours either labour contract duration for all workers in the 2009–2010 MIDEPLAN Post-earthquake Survey. Therefore, it is not possible to differentiate between part-time and full-time or between temporary and permanent workers. Thus, these result variables are only analysed for the 2011–2017 period using CASEN survey data.

For the analysis of the effect of natural disaster on all previous variables, the population was restricted to 15–65 years old.

4 An overview of the 2010 Bío-Bío earthquake and the labour market of Chile

To investigate the effects of natural disasters on the labour market, this study focuses on one of the most seismic regions in the world. Chile has a risk of earthquakes from seismologically active regions (Silva and Mena 2020) and is in the so-called Pacific Ring of Fire. Under Chile's territory, the Nazca Plate and the South American Plate converge, causing recurring seismic events of varying magnitude that sometimes trigger gigantic catastrophes.

Seismic hazard is classified as high in the Chilean region (Petersen et al. 2018). This means that there is more than a 20% chance that a potentially dangerous earthquake will occur in the area in the next 50 years. From 1960 to 2016, Chile was one of the top three countries with the highest percentage of the population affected by earthquakes. Over time, earthquakes have become part of the collective identity of Chileans (Government of Chile 2010).

The 'Bío-Bío' earthquake occurring on 27 February 2010 (M_w 8.8) is considered one of the eight strongest earthquakes recorded in the world and the second strongest in the history of Chile after the Valdivia earthquake of 1960.[2] The seismic event affected Chile from Santiago to Temuco, a distance of approximately 700 kilometres. The regions that experienced the most considerable destructive force on the instrumental intensity values were those of Valparaíso, the Metropolitan Region of Santiago, O'Higgins, Maule, Bío-Bío and Araucanía (Fig. 3).

[2] Although other earthquakes occurred between 2011 and 2017 in Chile, these did not produce severe damage to housing and infrastructure or loss of life, such as the 2010 Bío-Bío earthquake.

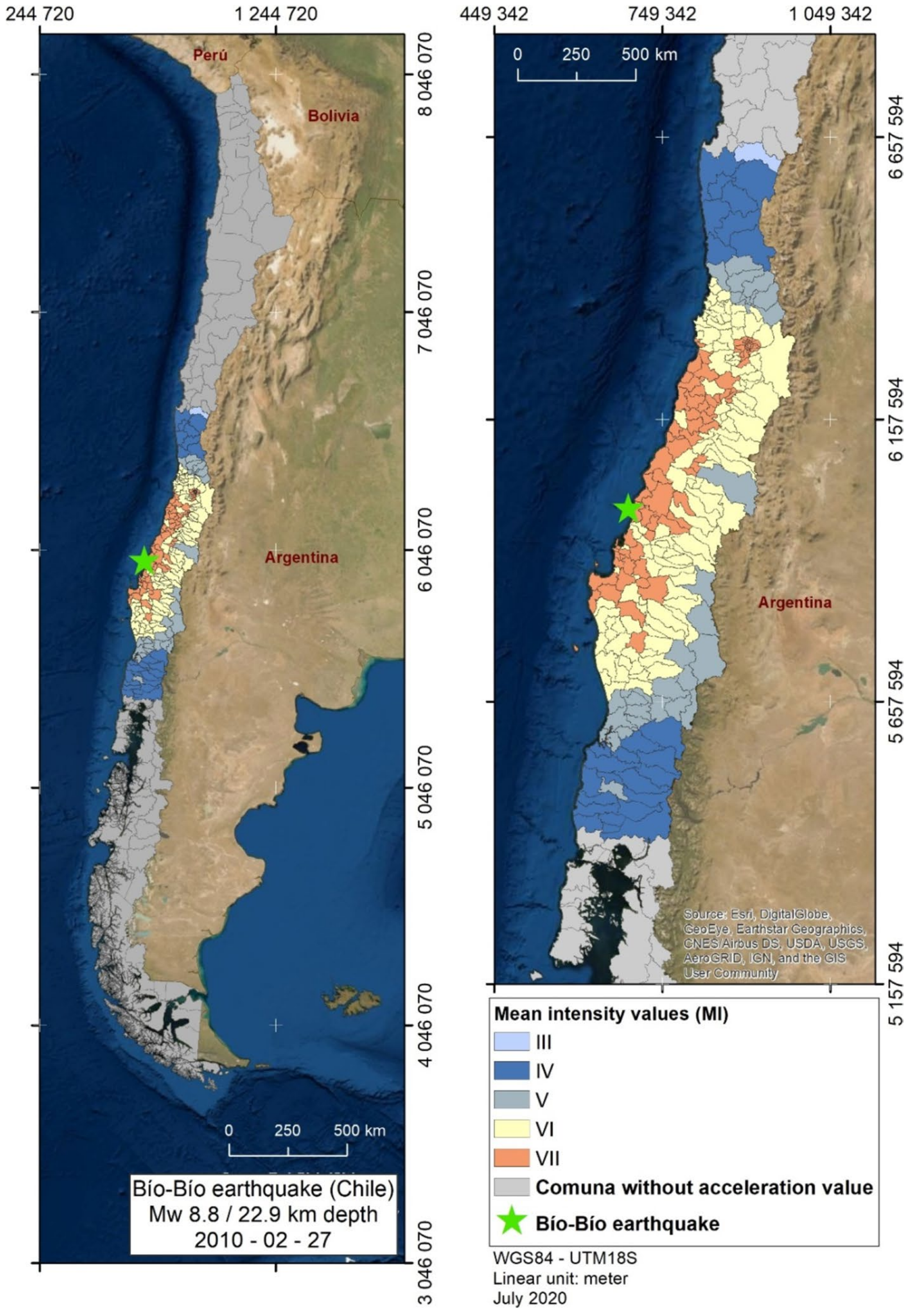

Fig. 3 Instrumental intensity values (mean intensity values) of the 2010 Bío-Bío earthquake. *Source*: Own elaboration based on USGS Shakemap data

Therefore, the earthquake affected a geographical area where more than 13 million people live: about 80% of the country's population. In the regions of O'Higgins (VI), Maule (VII) and Bío-Bío (VIII), the earthquake reached its highest intensity. These three most affected regions have 4 million residents (23% of the national population), of which almost half were injured. The number of fatalities totalled 521 (ECLAC 2010). It is estimated that around 440,000 homes were damaged (Contreras and Winckler 2013; ECLAC 2010).

After the occurrence of any earthquake in the subduction zone, aftershocks are expected. Aftershocks occurred mainly in the area which had been fractured as well as at the edges of the rupture zone, in this case both the north end (V Region) and the south end (VIII Region) (Seismological Centre of Chile 2010). One of these aftershocks produced a strong tsunami on the Chilean coast that devastated several villages in the same regions where the earthquake hit (i.e. Constitución, Iloca, Duao and Pelluhue in Maule as well as Talcahuano and Dichato in Bío-Bío). The Juan Fernandez archipelago, despite not having suffered the earthquake, was hit by the tsunami, which devastated its only population centre, San Juan Bautista. The tsunami caused 156 deaths and 25 people missing (ECLAC 2010).

De la Llera et al. (2017) presented an overview of some of the critical processes of data collection and analysis that took place during and after the emergency caused by the 2010 Bío-Bío earthquake. According to government estimates, the direct and indirect losses due to the earthquake and tsunami amount to $30 billion USD, or about 18% of Chile's GDP. The economic sectors suffering the greatest impacts included industrials, fishing, tourism, housing and education (De la Llera et al. 2017; Government of Chile 2010).

After the 2010 Bío-Bío earthquake, MIDEPLAN conducted its Post-earthquake Survey on the affected areas. Based on this survey, it is possible to make some direct estimates of the damage in the affected regions. Table 1 shows that O'Higgins and Maule are the regions with the highest proportions of people affected by a level of severe damage to their homes caused by the earthquake or tsunami (18.8% and 19.9%, respectively). Damages faced by the residents of the O'Higgins Region, particularly, were more visible in rural areas where several communities were isolated (ECLAC 2010).

These natural disasters also modified the labour activity of the population. In Valparaíso, O'Higgins, Maule and Bío-Bío, 2.4–4.8% of the population did not look for work due to the earthquake and tsunami. However, a small percentage left their occupation as a result of these natural disasters.

The regions of Bío-Bío, O'Higgins and Maule were the most affected in terms of disruption of the normal functioning of productive activity. Specifically, from 11.9 to 19.9% of the workers reported significant damages to the workplace that affected the normal development of their work. The sectors worst affected by the natural disaster are usually associated with low-quality jobs that are less prepared to deal with it. Notably, when the damage assessment is broken down by sector, it is revealed that agricultural activities in all regions were the primary recipients of damage from the earthquake and tsunami.

In the rest of the sectors, the magnitude of the damage differs between regions. Thus, in Bío-Bío, the construction sector had the highest damage rates. In Valparaíso, however, 8.9% of the manufacturing industry altered normal functioning from the damage. Likewise, the working conditions related to the contract, social contributions, working hours or income were also modified after the disaster for 6.5% of the population in Maule and 12.9% in Bío-Bío.

From 2.4 to 41.6% of the independent workers in the damaged regions reported that their productive activity was affected by the earthquake and tsunami. Also, 7.2% to almost 13% of self-employed and employers in Valparaíso, Maule and O'Higgins had completely stopped their productive activity up to the survey date. However, there were no significant

Table 1 Damages and losses caused by the 2010 Bío-Bío earthquake and tsunami. *Source*: own elaboration based on Post-earthquake Survey

	All (%)	Valparaíso (%)	O'Higgins (%)	Maule (%)	Bío-Bío (%)	La Araucanía (%)	Santiago (%)	Rest of the country (%)
Damage in the main dwelling (total population)								
Destroyed or with severe damage	6.90	7.07	11.88	19.94	17.05	4.89	4.80	0.67
Minor damage	20.98	22.16	28.31	32.16	44.54	19.72	20.68	2.10
No damage	72.12	70.78	59.82	47.91	38.41	75.39	74.52	97.23
Geographic area of the population with damage in the main dwelling								
Urban	77.76	94.43	48.45	48.77	83.73	54.13	94.01	81.74
Rural	22.24	5.57	51.55	51.23	16.27	45.87	5.99	18.26
Reasons for not looking for work (inactive population)								
Associated with the earthquake or tsunami	2.33	2.40	3.89	4.80	4.22	1.69	1.91	0.85
Not associated with the earthquake or tsunami	97.67	97.60	96.11	95.20	95.78	98.31	98.09	99.15
Reasons for termination, quitting or changing jobs (inactive population)								
Destroyed their source of work	0.20	0.18	0.16	0.65	0.83	0.20	0.07	0.00
Disabled (accident/illness)	0.01	0.00	0.06	0.00	0.04	0.00	0.00	0.00
Dismissal for company needs	0.11	0.19	0.03	0.14	0.26	0.24	0.07	0.02
Other	99.68	99.63	99.75	99.20	98.87	99.57	99.86	99.98
Workplace with major damage that affected normal operations (employees)								
Agriculture	8.82	6.06	12.60	25.86	16.98	8.70	5.35	0.88
Manufacturing industry	6.41	8.66	11.75	18.25	17.35	3.62	4.40	0.09
Construction	6.21	5.86	10.79	15.95	20.25	2.84	4.22	0.26
Commerce, transport and hotel	5.25	8.01	9.33	14.09	12.20	3.95	4.00	0.42
Insurance and financial establishments	3.59	1.51	7.69	8.54	21.37	1.56	2.51	0.22
Social communal services	6.12	5.75	11.06	15.85	14.75	3.00	4.91	0.56
All	6.90	7.07	11.88	19.94	17.05	4.89	4.80	0.67
Reasons for change in their working conditions (contract, social contribution, working day or income) (employees)								
Earthquake or tsunami	3.20	2.88	2.87	6.46	12.87	2.90	2.05	0.24
Unrelated to the earthquake or tsunami	2.04	3.38	2.38	1.67	1.71	1.85	1.90	1.91

Table 1 (continued)

	All (%)	Valparaíso (%)	O'Higgins (%)	Maule (%)	Bío-Bío (%)	La Araucanía (%)	Santiago (%)	Rest of the country (%)
No change	94.76	93.75	94.75	91.87	85.42	95.25	96.05	97.85
Productive activity affected by the earthquake or tsunami (housing, industry, workshop or other premises) (independent workers)								
Yes	18.02	18.96	33.30	41.62	22.02	12.82	2.38	14.26
No	81.98	81.04	66.70	58.38	77.98	87.18	97.62	85.74
Period of main business or activity stopped (independent workers)								
Less than 1 month	27.13	31.54	35.70	47.01	54.34	19.11	24.57	10.84
More than 1 month	7.13	4.30	4.93	10.95	21.94	3.92	7.08	0.75
Till the date	3.69	3.04	7.08	8.83	7.85	2.08	3.41	0.72
Did not stop	62.06	61.12	52.28	33.22	15.87	74.90	64.95	87.69

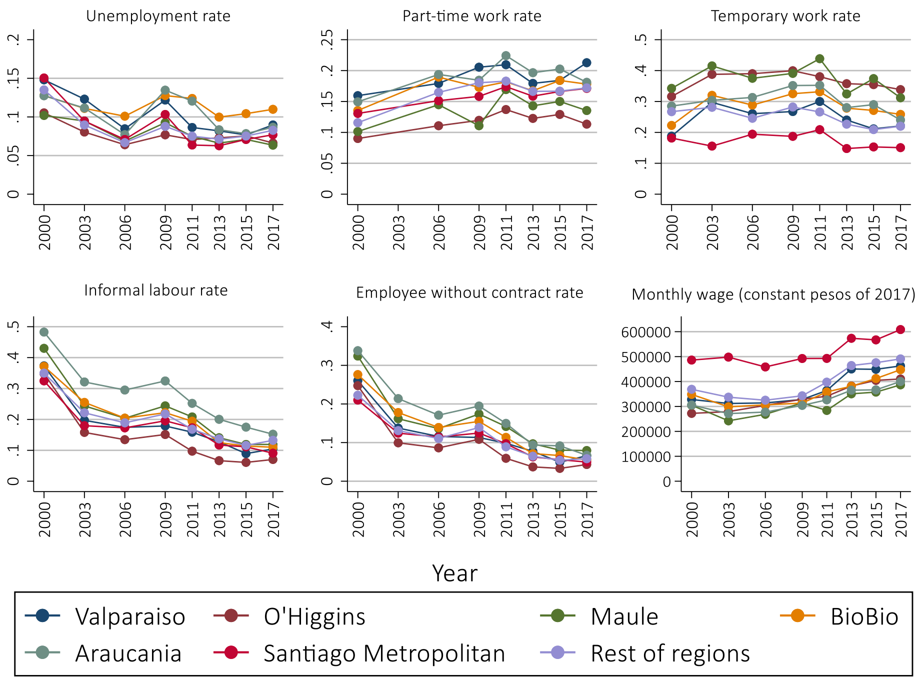

Fig. 4 Indicators of the labour market, Chile 2000–2017. *Source*: own elaboration based on CASEN

losses in inputs, products, machinery, office equipment and other components of productive activity.

Given the consequences on the agriculture, construction and manufacturing sectors caused by the earthquake and tsunami, significant changes in the labour market are expected due in these labour-intensive sectors.

In theoretical terms, the existence of a negative effect on the labour market is assumed mainly in the short term, not only because of the direct damage observed in regions affected by natural disasters but also by lower-income (higher losses) resulting from the interruption of economic activity in general. In the medium and long term, however, the effects on the labour market could be positive or negative depending on the reconstruction efforts, the levels of public and private investment and the government's efforts to restore order.

The resilience of the Chilean labour market will also depend on its characteristics and operation before the occurrence of natural disasters. According to ILO (2018), economic and labour dynamics in Chile are highly dependent on the price cycles of the raw materials exported by it. In 1999, mainly as a result of the impact of the Asian Crisis, the Chilean economy entered a recession, and the unemployment rate rose above 10% (Fig. 4). At the beginning of the 2000s and during the following years, the economy grew again, and the unemployment rate dropped (Medina and Naudon 2012). After the financial crisis of 2008, a worsening of the labour market performance can be observed from the indicators in Fig. 4. However, as several primary export commodities prices started growth, the economy quickly recovered. In this context, the labour demand increased (ILO 2018), and the unemployment rate dropped in 2011. Although this evidence could be a little conflictive with the earthquake effects expected, two observations must be considered. First, in some affected regions, like Bío-Bío and O´Higgins, the unemployment rate reduction in 2011 is smaller than in other regions. Second, the government, as well as private aids during the recovery process, could have smoothed, in damaged regions, the earthquake impact on the labour market. This issue is analysed in more detail in Sect. 6.

Figure 4 also reveals that Chile has significant deficits of job quality mainly associated with a lack of social protection. These deficits are also heterogeneous between the different regions of the country. Precisely, Bío-Bío, Araucanía and Maule show higher rates of unemployment and informal employment than the rest of the regions. The lack of social security coverage, either because workers do not have a signed contract or do not make contributions to the pension system, is the most worrying considering that this coverage is activated against unexpected shocks. Nonetheless, Fig. 4 shows that access to social security increased continuously since 2011.

The Chilean labour market is also characterized by a high percentage of temporary contracts. Companies use these types of contracts to avoid the legal stipulations of the Labour Code, in particular, the dismissal costs associated with indefinite contracts (Dresdner and Sehnbruch 2010). Although the incidence of jobs with a limited-term contract among employees is high in all regions, the highest percentages are observed in the Maule and O'Higgins regions. The latter is worrying considering that these regions were the most affected by natural disasters (along with Bío-Bío) and that only workers with permanent contracts are entitled to receive unemployment insurance from the Solidarity Fund (Dresdner and Sehnbruch 2010). After the 2010 Bío-Bío earthquake and tsunami, the proportion of temporary jobs increased in affected regions but reduced in rest of regions. The Chilean government's recovery plan included time-bounded hiring subsidies and other similar instruments in the affected regions. According to the Government of Chile (2014), about 65% of the jobs created in 2010 were emergency jobs to overcome the catastrophe that arose in a context of negative economic growth in the affected regions.

Given that the Chilean labour market has a high percentage of workers with precarious contracts, the 2010 Bío-Bío earthquake and tsunami are expected to have significant impacts on some variables associated with the quantity and quality of employment.

5 Empirical strategy to estimate the effects of natural disaster on the labour market

To estimate the impact of the 2010 Bío-Bío earthquake and tsunami in Chile on the labour market, different methods were implemented according to the type of data available. These techniques include: (1). a difference-in-differences approach (DiD), (2). instrumental variables method (IV) and (3). propensity score weighting regression (PSWR). The implementation of these estimation techniques permits exploiting the advantages that one method has over the others and also to check the robustness of the results.

The main identification strategy underlying the methods implemented is exploitation of the exogenous nature of the natural disaster. The earthquake and tsunami are unexpected events for companies and workers. Therefore, after the occurrence of a natural catastrophe, it is possible to 'naturally' identify the group that directly suffers the impact of this shock (treatment group) and one that does not suffer any impact (control group).

To identify the control and treatment groups, information from the 2010 Post-earthquake Survey about damage to the main dwelling was used. However, as Kirchberger

(2017) warns, this variable might be correlated with unobserved determinants of change in the variables related to the quantity and quality of employment through housing quality. To solve this problem, an exogenous measure of the earthquake, highly correlated with the damage but not with other socio-economic characteristics of the population, was also used as a treatment and instrumental variable. This measure is the seismic acceleration or peak ground acceleration (PGA) obtained from the USGS.[3] An average of the PGA values per community was calculated by combining the USGS Shakemaps with the cartography of the country (Fig. 5).

The peak ground acceleration values are a better instrument than other measures such as the Mercalli intensity. Indeed, the lower numbers of the instrumental intensity value generally reflect the way the earthquake is felt by people. Furthermore, the higher PGA values are based on observed structural damage. Thus, this variable could be correlated with the potential results through housing quality. Instead, the PGA influences the treatment but not the potential outcomes.

5.1 Difference-in-difference (DiD) approach

One way to calculate the impact of the Bío-Bío 2010 earthquake on the labour market estimates the following difference-in-difference model:

$$R_{\mathrm{iat}} = \alpha + \beta \mathrm{Post}_{\mathrm{it}} + \gamma D_{\mathrm{ia}} + \theta \mathrm{Post}_{\mathrm{it}} D_{\mathrm{ia}} + \delta X_{\mathrm{iat}} + \varepsilon_{\mathrm{iat}} \tag{1}$$

where R_{iat} represents the different outcome variables associated with the labour market for the ith individual residing in the ath community at time t, $\mathrm{Post}_{\mathrm{it}}$ is a dummy variable that distinguishes the period after the earthquake and tsunami (2010–2017) from the period before this event (2009), D_{ia} is a variable that identifies the individual belonging to the treatment (control) group, and the interaction term between D_{ia} and $\mathrm{Post}_{\mathrm{it}}$ identifies the individuals in the treatment group after the earthquake and tsunami occurred. Therefore, θ is the interest coefficient or the DiD coefficient because it indicates the magnitude and the sign of the impact of natural disasters on the different outcome variables. The vector X includes a set of individual variables to control for any difference in observable socio-demographic and labour characteristics of the individuals of the treatment and control group. These variables are: gender, age (and its square), education levels, marital status, school attendance, illiteracy, head of household, the number of people in the household, the presence of children under 6 years of age and elderly over 65 years at home, the branch of activity, the qualification of the task, the size of the firm and the seniority in the occupation. In the case of the short-term effects model, the control variables are from the period before the earthquake and tsunami. This is possible because in the Post-earthquake Survey, the same population sample is followed at two times, 2009 and 2010.

Since some of the dependent variables in (1) are binary, the estimated model, in these cases, is a linear probability model (LPM). The drawbacks of the LPM are that it is heteroscedastic by construction. However, this can be easily resolved by implementing some of the corrections for the standard error estimation reported by Bertrand et al. (2004). One

[3] Since the tsunami-affected cities and coastal towns in the regions of Maule and Bío-Bío that were also affected by the earthquake (ECLAC 2010), the treatment and control group identified using these parameters is expected to be similar to those that would arise if similar measures related to the tsunami were available.

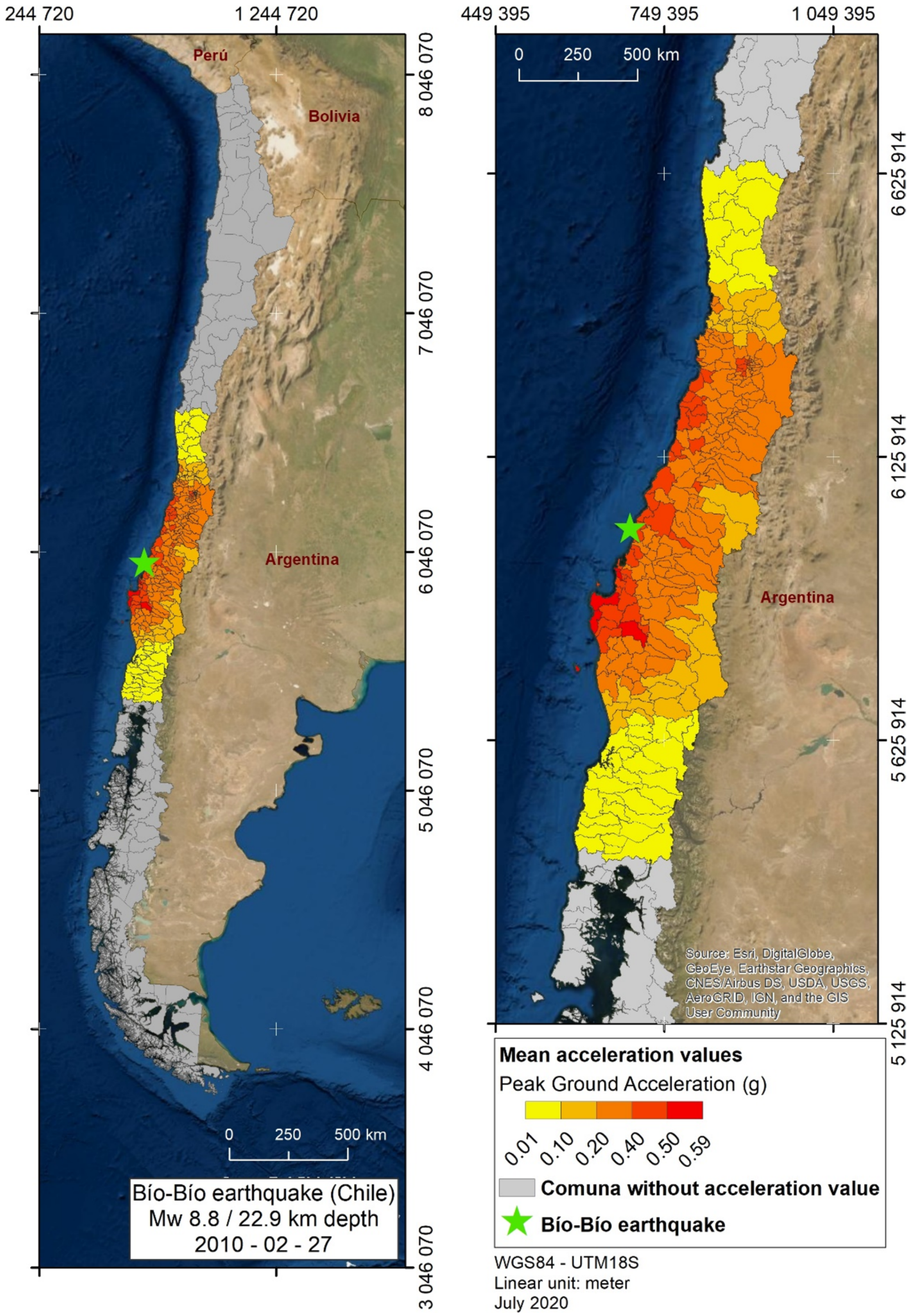

Fig. 5 Mean acceleration values (PGA) of the 2010 Bío-Bío earthquake. *Source*: own elaboration based on USGS Shakemap data

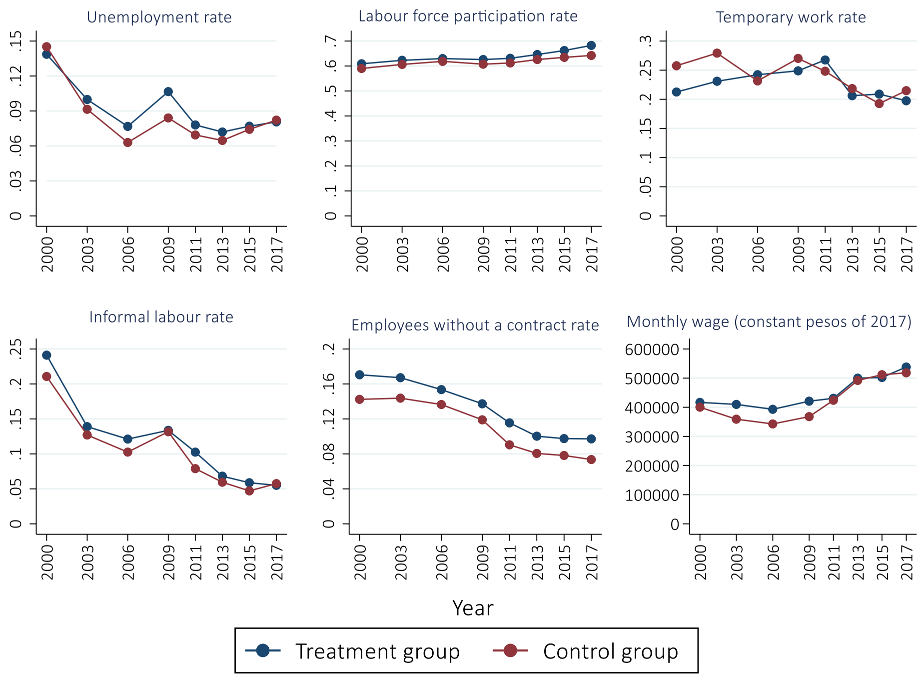

Fig. 6 Trends of result variables by group, 2000–2017. *Source*: own elaboration based on CASEN

important advantage of the LPM is that the DiD coefficient is readily interpretable, which is not necessarily valid for interaction terms in nonlinear models. Indeed, the magnitude of the interaction effect in nonlinear models does not equal the marginal effect of the interaction term and can be of the opposite sign (Ai and Norton 2003). Furthermore, DiD models in a nonlinear context (any regression with a nonlinear link function) fail to meet the common trend assumptions and therefore fail to identify treatment effects in a selection in an unobservable context (Lechner 2011).

The DiD approach is based on the assumption that the temporal trend registered in the control group allows, as a proxy variable, to know the evolution that the individuals of the treatment group would have followed if the earthquake or tsunami would not have happened (Athey and Imbens 2006). Therefore, the trends of the outcome variables in both groups should present a similar behaviour in the absence of the natural disaster. To verify this assumption, the trends of the result variables for the control and treatment group were estimated. Considering seismic acceleration as the treatment variable, the individuals who live in a community with an average seismic acceleration value higher than the first quartile[4] comprise the treatment group, while the individuals in a community with an average seismic acceleration equal to 0 are part of the control group. Figure 6 shows that in the period before the 2010 Bío-Bío earthquake and tsunami, most of the result variables' trends were approximately parallel for the control and treatment group. Some variables do not seem to fully comply with this assumption. Therefore, the IV method, as well as a different baseline period, was also considered.

[4] In the robustness check section, other quartiles were used as thresholds.

Another way to check the veracity of the identification strategy used is through the falsification test. For this, it is assumed that the occurrence of natural events occurs in a different period, but 'false' to the real one. In this exercise, 2000–2003 is the pre-episode period and 2006–2009 is the post-episode period. The estimations show that in the pre-earthquake and tsunami periods, no effects on labour market outcome variables are observed. This evidence, therefore, validates the strategy used to identify the treatment and control groups.

5.2 Instrumental variable method

The primary measure used to capture the direct effect of the earthquake and tsunami is the individuals with damage to their main dwelling. This information comes from the 2009–2010 Post-earthquake Survey. As was previously mentioned, the problem with this measure is that it might be endogenous in (1) due to its correlation with housing quality. Therefore, for example, if housing quality is lower among poorer populations (thus causing higher levels of destruction for a given earthquake magnitude), and these individuals have low performance in the labour market, then it would falsely conclude that the earthquake caused this result (Kirchberger 2017). To solve this problem, the IV technique is implemented using seismic acceleration (PGA) as an instrumental variable. Therefore, the first-stage estimation of the effect of the natural disaster in the labour market is:

$$D_{\mathrm{ia}} = \alpha + \beta Z_{\mathrm{i}} + \delta X_{\mathrm{ia}} + \varepsilon_{\mathrm{ia}} \tag{2}$$

where D_{ia} is a variable that identifies the treatment and control group, Z_{i} is the instrumental variable (the seismic acceleration), and X is a vector that includes a set of individual variables to control for any difference in observable socio-demographic and labour characteristics of the individuals who are part of the treatment and control groups. These variables are gender, age (and its square), education level, marital status, school attendance, illiteracy, the position in the household (head of household or other), the number of people in the household, the presence of children under 6 years of age or over 65 years at home, the branch of activity, the qualification of the task, the size of the firm and the seniority in the occupation. Robust standard errors are clustered at the community level.

To examine the short-term effects, the D_{ia} variable is defined as a dummy equal to 1 for individuals who reported severe destruction or damage on their main house due to the earthquake and tsunami, and equal to 0 for those who indicated they had not experienced any damage in the 2009–2010 Post-earthquake Survey. From this survey, the rate of individuals with destruction or severe damage in their main dwelling per community of residence is computed. This measure is merged with CASEN surveys data to identify the treatment and control group in the rest of the years.

5.3 Propensity score weighting regression (PSWR)

To verify that the characteristics between the treatment and control group are balanced on the baseline in 2009, Table 4 shows the *p* value of equality of means *t* test between both groups. These are defined using the seismic acceleration (PGA) and the earthquake damage as treatment variables. Both groups are largely balanced in some characteristics. However, when the earthquake damage is considered, the treatment group is slightly older, less educated and head of household in a higher proportion relative to the control group.

To solve that problem, following Kirchberger (2017) and Deryugina et al. (2018), the model (1) is estimated through a PSWR. For this, first, the propensity score (the probability of a person being assigned to the treated group) is computed using education level, age, gender, marital status, number of people in the home, the household position and the presence of children under six and elderly over 65 in the home as matching variables. Then, the observations are weighted inversely proportional to their propensity score.

6 Results and discussion

This section presents the results relative to the effects of the 2010 Bío-Bío earthquake and tsunami on the Chilean labour market. In the first place, the short-term effects, estimated using the 2009–2010 Post-earthquake Survey data, are examined. Then, the long-term impacts derived from the CASEN Surveys of the 2011–2017 period are reported and analysed. Finally, a robustness check is performed.

6.1 Short-term effects of the 2010 Bío-Bío earthquake and tsunami on the labour market

The short-term effects of 2010 Bío-Bío earthquake and tsunami on the labour market are presented in Table 2. In general, the estimations suggest this natural disaster produced a negative impact on the quantity and quality of employment in the months after these events. Also, some results are sensitive to the variables used to define the control and treatment group.

The evidence indicates that these natural disasters reduced the probability of employment among the affected population. One of the possible channels that could explain the observed negative employment effect is the reduction of jobs due to the destruction or closure of companies or the limitations in transport, communications and logistics to continue with commercial activity. In addition, labour demand could also decrease due to the destruction of private property and physical capital (Belasen and Polachek 2009). According to the data of the Post-earthquake Survey, 65.9% of the individuals in the treatment group suffered severe damage to their workplace that affected normal business operations. In addition, 48.4% of the independent workers in the treatment group declared that the earthquake and tsunami had damaged or left their place of work non-functioning and 30.6% of firms were not operational for more than a month. The probability of employment declined 4.2 percentage points (p.p.) when the damage variable was instrumented using the value of the average seismic acceleration.

An increase in the chances of being unemployed could have accompanied the reduction in employment. Nevertheless, there is no evidence in favour of this hypothesis. The DiD coefficient is not statistically significant in any of the estimated models (Table 2). This result could be explained, in part, by a fall in the labour supply as a result of the workers killed, injured, emigrated or prevented from participating in the labour market. The negative effect of the earthquake on the probability of participation in the labour force confirms that hypothesis. This probability fell between 2.7 and 5.3 p.p.

Table 2 Short-term effects of the 2010 Bío-Bío earthquake and tsunami on labour market. *Source*: own creation based on 2009–2010 Post-earthquake Survey and USGS

	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employment	−0.025**	0.000	−0.038***	−0.034***	−0.041***	−0.042***
	(0.013)	(0.010)	(0.011)	(0.010)	(0.011)	(0.008)
Observations	31,184	85,388	31,184	31,184	25,630	31,184
Adjusted R^2	0.321	0.309	0.321	0.318	0.314	0.318
Unemployment	0.004	−0.011*	−0.013	0.010	0.007	−0.003
	(0.017)	(0.006)	(0.017)	(0.012)	(0.013)	(0.012)
Observations	17,642	48,714	17,642	17,642	14,611	17,642
Adjusted R^2	0.052	0.041	0.052	0.054	0.054	0.055
Participation labour	−0.027**	−0.008	−0.053***	−0.033***	−0.043***	−0.050***
	(0.013)	(0.010)	(0.011)	(0.009)	(0.011)	(0.007)
Observations	31,184	85,388	31,184	31,184	25,630	31,184
Adjusted R^2	0.345	0.340	0.345	0.344	0.340	0.344
Informal work	0.020	−0.004	0.230***	0.005	0.013	0.242***
	(0.024)	(0.019)	(0.025)	(0.018)	(0.020)	(0.013)
Observations	14,272	39,637	14,272	14,272	11,813	14,272
Adjusted R^2	0.188	0.162	0.104	0.206	0.203	0.134
Informal self-employment	0.044	0.002	0.639***	−0.014	0.006	0.574***
	(0.051)	(0.047)	(0.065)	(0.035)	(0.038)	(0.032)
Observations	3479	8151	3479	3479	2847	3479
Adjusted R^2	0.382	0.353	0.123	0.391	0.388	0.170
Informal salaried work	0.013	0.003	0.113***	0.032**	0.036**	0.138***
	(0.017)	(0.013)	(0.015)	(0.013)	(0.015)	(0.011)
Observations	10,394	30,608	10,394	10,394	8619	10,394
Adjusted R^2	0.077	0.076	0.040	0.084	0.087	0.060

Table 2 (continued)

	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Log monthly wage	−0.024	−0.064**	−0.028	−0.018	−0.016	−0.039**
	(0.027)	(0.026)	(0.022)	(0.022)	(0.022)	(0.016)
Observations	13,892	38,919	13,892	13,892	11,527	13,892
Adjusted R^2	0.378	0.372	0.379	0.336	0.347	0.336
Employee without contract	0.010	0.057	−0.009	0.033	0.045	0.059*
	(0.056)	(0.037)	(0.048)	(0.037)	(0.040)	(0.032)
Observations	6345	18,763	6345	6345	5290	6345
Adjusted R^2	0.153	0.147	0.154	0.133	0.135	0.137

Robust standard errors in parentheses, clustered at the community level

***$p<0.01$; **$p<0.05$; *$p<0.1$

Furthermore, part of this effect could be responding to an increase in the migration from the affected area. According to the estimated impact on this variable (Table 5),[5] the earthquake and tsunami increased the probability of emigration among the treated group who were economically active, particularly among the workers. The reduction of the labour supply could also be associated with the exit of the labour market due to job destruction or the cessation of job searching by people whose homes were affected by the earthquake and the tsunami. In fact, according to the Post-earthquake Survey, almost half of the treatment group who stopped looking for work due to the natural disaster did so because they had to do housework that involves repairing disaster damage and 25.2% for other reasons associated with the earthquake.

The evidence also indicates deterioration in the quality of employment, mainly associated with the lack of access to social security. In the months immediately after the natural disasters, the probability of having informal salaried work increased up to 13.8 p.p. when considering the IV estimations obtained from balancing the observable characteristics of the treatment and control group. The absence of contributions to the pension system is usually a cost-reduction strategy by companies. Likewise, tax evasion is more feasible in periods of crisis or when labour institutions are weakened. Besides, labour inspection could have been debilitated after the earthquake. Therefore, the results on informality (social security coverage) could, in part, be associated with the weakness of the legal enforcement in the treatment group.

Another adverse effect of the earthquake and tsunami was the fall in monthly wages by a magnitude that differs according to the techniques used. In particular, the largest effect suggests a decrease of 6.4% in wages when control and treatment group are defined according to seismic acceleration. This reduction in labour income could be the result of the workplace damage that most workers in the treatment group suffered, according to the Post-earthquake Survey. Therefore, to face those extra damage expenses, employers probably adjusted production costs by reducing workers' wages. Also, when victims lost their jobs or moved to other regions after the earthquake, they had to change to new careers that did not match their abilities and skills, which did not enable them to earn as much as they would have if the earthquake had not occurred.

Furthermore, given that the quality of employment and wages deteriorated jointly in the months following these natural disasters, it is possible that jobs occupied by young people or individuals with low qualifications increased. Between 2009 and 2010, jobs with low or no qualification levels increased in higher proportions for the treated group than the control group.

The government and private sector actions could have partially mitigated the estimated adverse short-term impacts of the earthquake during the reconstruction process. Among the first reactions of the Chilean government, which could affect the labour market, is the package of support measures for SMEs and artisanal fishers. They were sectors strongly damaged by the earthquake and tsunami. These measures include lines of credit and financing for reconstruction. Other actions taken by the public sector include the approval of a set of laws, with potential impact on the labour market. Among them, Law 20,440 (May 8, 2010) made access to unemployment insurance benefits more flexible. Law 20,446 (June 20, 2010) facilitated for employers the payment of pension debts in the affected regions. And, Law No. 20,454 (July 15, 2010) extended and improved the incentive to pre-contract and training of workers (Government of Chile 2010). However, some of these actions effects were probably not captured in the Post-earthquake Survey conducted between May and June 2010. Besides, in order to evaluate whether the adverse impacts could be higher when the actions and expenses made by the Chilean government are taking into account, the model

[5] To obtain these results, 2015 CASEN survey was used with information on the place of residence 5 years ago, that is, in 2010, when the earthquake and tsunami occurred.

was estimated including two additional control variables: the rate of workers with a job as part of a state emergency employment program per community (calculated from the 2010 Post-earthquake Survey) and the regional expenditure per capita (in constant pesos) of the Ministry of Public Works of Chile during 2009–2010.[6] The results of Table 6 confirm this hypothesis. Therefore, the evidence in Table 2 would show the total short-term impact of the earthquake and tsunami that includes the negative direct effect and the positive indirect effect associated with the public and private aids regarding to the reconstruction process.

6.2 Long-term effects of the 2010 Bío-Bío earthquake and tsunami on the labour market

When the effects of the 2010 Bío-Bío earthquake and tsunami on the labour market are analysed a few years after the events, the conclusions change. The Chilean labour market begins to show signs of recovery and resilience for some variables in certain years (Table 3). For example, the results indicate that the adverse effects on the probability of being employed, which had been observed in the months after the earthquake, ended in 2011. Furthermore, in 2015 and 2017 there was a positive effect on the probability of employment as well as a reduction in the likelihood of being unemployed that suggests that reconstruction actions and recovery policies produced the desired effect after several years of natural disasters. Furthermore, in a post-disaster context, governments could promote self-employment through interest-free loans or by facilitating access to productive credits (Valencia and Valencia 2019). Indeed, the Reconstruction Plan implemented by the national government included a support program for enterprises affected by the earthquake through microcredits to micro, small and medium firms (Government of Chile 2012).

From 2011–2017, there are also hints of a labour market's reactivation through the increase in the labour supply that had reduced in the months immediately after the earthquake. Furthermore, in 2015, there are positive and significant effects on the probability of participation in the labour force. This result could be associated with labour migration. That is, some people who lost their jobs due to the earthquake and tsunami may have returned to the affected areas once the labour market showed signs of regaining normal functioning.

Another indication of the resilience of the Chilean labour market is the increase observed in job quality among the affected workers in 2017, although only for some variables. Thus, for example, the probability of being in an informal employment arrangement decreased 4.3 p.p. that year. This result is robust to the different techniques and variables used. However, there is also a positive effect on the likelihood of being employed in temporary work in 2011 and 2015. This result may suggest that the recovery in employment observed during 2011–2017 could have occurred, in part, through temporary jobs. Although the observed effect on temporary work could respond to the prevalence of the use of temporary jobs in the treatment group, especially if the agricultural activities—that tend to use temporary contracts—have a higher weight in this group, this is probably not the case for several reasons. First, the estimated models include control variables regarding branches of economic activity which includes among them the agricultural sector.

[6] This expenditure is related to the reconstruction activities of public infrastructures that were carried out after the earthquake and tsunami. Indeed, the regional expenditure per capita (in constant pesos) of the Ministry of Public Works of Chile shows a significant increase in the affected regions after 2009. Although it would be convenient to have an adequate measure of the total public consolidated expenditure during the recovery process, it is not easy to collect all the necessary information per community (and even per region).

Table 3 Long-term effects of the 2010 Bío-Bío earthquake and tsunami on the labour market. *Source*: own creation based on CASEN Surveys and USGS

	2011						2013					
	DiD		IV	DiD with PSWR		IV with PSWR	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employment	0.016*	0.014*	0.015	0.021**	0.021**	0.020**	0.016**	0.014**	0.025**	0.021***	0.018**	0.018**
	(0.009)	(0.008)	(0.014)	(0.008)	(0.009)	(0.009)	(0.007)	(0.006)	(0.011)	(0.007)	(0.008)	(0.008)
Observations	284,678	296,856	284,678	284,678	246,280	284,678	250,194	258,487	250,194	250,194	217,596	250,194
Adjusted R^2	0.321	0.323	0.321	0.332	0.330	0.332	0.314	0.316	0.314	0.331	0.329	0.331
Unemployment	−0.015	−0.016**	−0.019	−0.009	−0.014**	−0.013**	−0.024*	−0.017*	−0.038**	−0.013**	−0.011*	−0.015**
	(0.010)	(0.007)	(0.015)	(0.006)	(0.006)	(0.006)	(0.012)	(0.009)	(0.016)	(0.006)	(0.006)	(0.007)
Observations	169,958	179,013	169,958	169,958	148,175	169,958	150,032	156,620	150,032	150,032	131,551	150,032
Adjusted R^2	0.061	0.058	0.061	0.058	0.055	0.058	0.059	0.057	0.059	0.057	0.055	0.057
Participation labour	0.006	0.004	0.005	0.017**	0.014*	0.014	0.001	0.004	0.003	0.015**	0.013*	0.012
	(0.010)	(0.008)	(0.016)	(0.008)	(0.008)	(0.008)	(0.009)	(0.007)	(0.012)	(0.007)	(0.008)	(0.008)
Observations	284,678	296,856	284,678	284,678	246,280	284,678	250,194	258,487	250,194	250,194	217,596	250,194
Adjusted R^2	0.343	0.346	0.343	0.353	0.351	0.353	0.337	0.340	0.337	0.355	0.354	0.356
Informal work	0.013	0.012	−0.014	0.008	0.005	0.000	−0.014	−0.014	−0.039	−0.016	−0.018	−0.023*
	(0.019)	(0.016)	(0.026)	(0.015)	(0.017)	(0.017)	(0.019)	(0.016)	(0.024)	(0.012)	(0.014)	(0.013)
Observations	148,474	157,186	148,474	148,474	129,780	148,474	132,329	138,721	132,329	132,329	116,233	132,329
Adjusted R^2	0.219	0.215	0.219	0.229	0.229	0.229	0.198	0.196	0.198	0.214	0.214	0.214

Table 3 (continued)

	2011						2013					
	DiD		IV	DiD with PSWR		IV with PSWR	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employee without contract	0.010	0.004	−0.000	0.010	0.000	0.005	−0.011	−0.018**	−0.034**	−0.009	−0.021	−0.020
	(0.010)	(0.007)	(0.015)	(0.010)	(0.011)	(0.012)	(0.009)	(0.007)	(0.016)	(0.013)	(0.014)	(0.014)
Observations	114,725	121,082	114,725	114,725	100,866	114,725	101,183	105,504	101,183	101,183	89,358	101,183
Adjusted R^2	0.182	0.181	0.182	0.169	0.167	0.169	0.167	0.164	0.167	0.162	0.161	0.162
Temporary work	0.011	0.018*	−0.007	0.019	0.027**	0.030**	−0.019	−0.017	−0.025	−0.028*	−0.012	−0.015
	(0.011)	(0.010)	(0.020)	(0.013)	(0.013)	(0.014)	(0.014)	(0.015)	(0.023)	(0.016)	(0.018)	(0.018)
Observations	150,867	159,719	150,867	150,867	131,914	150,867	132,094	138,486	132,094	132,094	116,031	132,094
Adjusted R^2	0.220	0.215	0.220	0.202	0.200	0.202	0.210	0.202	0.210	0.208	0.205	0.208
Part-time work	−0.011	0.013	−0.023	0.006	0.008	0.009	−0.007	0.013	−0.015	0.008	0.009	0.012
	(0.010)	(0.019)	(0.016)	(0.011)	(0.012)	(0.012)	(0.011)	(0.020)	(0.015)	(0.011)	(0.012)	(0.012)
Observations	153,881	162,942	153,881	153,881	134,550	153,881	135,439	141,979	135,439	135,439	118,952	135,439
Adjusted R^2	0.151	0.148	0.151	0.125	0.125	0.125	0.146	0.144	0.146	0.128	0.130	0.128
Hours worked	−0.450	−1.290*	−0.712	−0.850	−0.819	−0.941	−0.874**	−2.224***	−1.436**	−1.444***	−1.328**	−1.547***
	(0.441)	(0.717)	(0.622)	(0.585)	(0.653)	(0.618)	(0.353)	(0.753)	(0.603)	(0.544)	(0.619)	(0.586)

Table 3 (continued)

	2011						2013					
	DiD		IV	DiD with PSWR		IV with PSWR	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Observations	150,867	159,719	150,867	150,867	131,914	150,867	132,329	138,721	132,329	132,329	116,233	132,329
Adjusted R^2	0.097	0.098	0.097	0.088	0.090	0.088	0.096	0.097	0.096	0.104	0.107	0.104
Log monthly wage	−0.018	−0.037	0.036	−0.083***	−0.068**	−0.081**	−0.025	−0.032	0.002	−0.027	−0.012	−0.018
	(0.027)	(0.025)	(0.062)	(0.032)	(0.033)	(0.034)	(0.026)	(0.026)	(0.036)	(0.044)	(0.049)	(0.047)
Observations	119,951	126,355	119,951	119,951	105,057	119,951	127,376	133,762	127,376	127,376	112,124	127,376
Adjusted R^2	0.477	0.492	0.477	0.463	0.466	0.463	0.492	0.497	0.492	0.475	0.478	0.475
	2015						2017					
	DiD		IV	DiD with PSWR		IV with PSWR	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employment	0.030***	0.031***	0.032**	0.032***	0.032***	0.030***	0.037***	0.040***	0.044***	0.039***	0.041***	0.036**
	(0.011)	(0.009)	(0.015)	(0.008)	(0.009)	(0.009)	(0.014)	(0.012)	(0.017)	(0.013)	(0.015)	(0.014)
Observations	270,329	284,095	270,329	270,329	236,220	270,329	241,976	251,359	241,976	241,976	212,197	241,976
Adjusted R^2	0.314	0.316	0.315	0.327	0.324	0.327	0.310	0.312	0.310	0.320	0.318	0.320

Table 3 (continued)

	2015						2017					
	DiD		IV	DiD with PSWR		IV with PSWR	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Unemployment	−0.020	−0.024**	−0.032**	−0.016*	−0.018**	−0.020**	−0.033**	−0.027***	−0.041***	−0.026***	−0.028***	−0.027***
	(0.014)	(0.011)	(0.016)	(0.008)	(0.009)	(0.009)	(0.013)	(0.010)	(0.015)	(0.009)	(0.010)	(0.010)
Observations	164,850	175,194	164,850	164,850	145,458	164,850	148,668	155,802	148,668	148,668	131,413	148,668
Adjusted R^2	0.060	0.058	0.060	0.054	0.052	0.054	0.058	0.056	0.058	0.055	0.053	0.055
Participation labour	0.020*	0.019**	0.015	0.025***	0.024***	0.020**	0.018	0.026**	0.021	0.026**	0.026**	0.022*
	(0.011)	(0.008)	(0.015)	(0.007)	(0.009)	(0.008)	(0.012)	(0.011)	(0.015)	(0.011)	(0.012)	(0.011)
Observations	270,329	284,095	270,329	270,329	236,220	270,329	241,976	251,359	241,976	241,976	212,197	241,976
Adjusted R^2	0.339	0.341	0.339	0.355	0.354	0.355	0.338	0.341	0.338	0.349	0.348	0.349
Informal work	−0.002	0.002	0.004	−0.003	0.003	0.000	−0.037*	−0.041***	−0.043**	−0.031**	−0.037**	−0.034**
	(0.015)	(0.014)	(0.019)	(0.014)	(0.016)	(0.015)	(0.019)	(0.014)	(0.021)	(0.014)	(0.015)	(0.015)
Observations	149,266	159,099	149,266	149,266	131,869	149,266	133,301	140,078	133,301	133,301	118,005	133,301
Adjusted R^2	0.191	0.188	0.191	0.201	0.202	0.201	0.183	0.181	0.183	0.201	0.202	0.202

Table 3 (continued)

	2015						2017					
	DiD		IV	DiD with PSWR		IV with PSWR	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employee without contract	−0.003	−0.007	−0.020	−0.003	−0.012	−0.011	0.001	0.000	−0.020	−0.001	−0.015**	−0.013
	(0.009)	(0.008)	(0.014)	(0.008)	(0.009)	(0.009)	(0.007)	(0.007)	(0.012)	(0.008)	(0.007)	(0.008)
Observations	149,266	159,099	149,266	149,266	131,869	149,266	133,301	140,078	133,301	133,301	118,005	133,301
Adjusted R^2	0.114	0.109	0.114	0.113	0.110	0.114	0.108	0.106	0.108	0.111	0.108	0.111
Temporary work	0.020*	0.020**	0.029*	0.011	0.027**	0.023*	−0.013	−0.008	−0.013	−0.032*	−0.025	−0.021
	(0.011)	(0.010)	(0.015)	(0.012)	(0.012)	(0.013)	(0.011)	(0.010)	(0.018)	(0.016)	(0.017)	(0.017)
Observations	149,258	159,087	149,258	149,258	131,861	149,258	133,032	139,764	133,032	133,032	117,762	133,032
Adjusted R^2	0.197	0.192	0.197	0.188	0.187	0.188	0.195	0.192	0.195	0.194	0.192	0.194
Part-time work	0.006	0.028	0.002	0.017	0.019	0.019	0.001	0.016	−0.001	0.004	0.004	0.007
	(0.010)	(0.018)	(0.014)	(0.012)	(0.013)	(0.013)	(0.009)	(0.020)	(0.015)	(0.012)	(0.013)	(0.012)
Observations	149,287	159,122	149,287	149,287	131,888	149,287	133,360	140,150	133,360	133,360	118,055	133,360
Adjusted R^2	0.157	0.156	0.157	0.132	0.134	0.132	0.160	0.157	0.160	0.133	0.134	0.133

Table 3 (continued)

	2015						2017					
	DiD		IV	DiD with PSWR		IV with PSWR	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Hours worked	− 1.311	− 11.020**	− 2.936	− 1.825	− 7.246	− 7.021	− 1.186	− 10.854**	− 2.678	− 2.016	− 6.926*	− 6.590
	(6.141)	(5.316)	(6.764)	(4.240)	(4.512)	(4.882)	(6.038)	(5.224)	(6.771)	(4.068)	(4.065)	(4.384)
Observations	149,266	159,099	149,266	149,266	131,869	149,266	133,301	140,078	133,301	133,301	118,005	133,301
Adjusted R^2	0.022	0.023	0.023	0.019	0.019	0.019	0.022	0.023	0.022	0.017	0.018	0.017
Log monthly wage	− 0.006	− 0.045**	− 0.002	− 0.003	− 0.007	− 0.004	0.010	− 0.028	0.015	0.003	0.020	0.006
	(0.023)	(0.022)	(0.030)	(0.026)	(0.028)	(0.027)	(0.017)	(0.021)	(0.031)	(0.026)	(0.028)	(0.028)
Observations	143,699	153,387	143,699	143,699	127,163	143,699	128,665	135,420	128,665	128,665	114,078	128,665
Adjusted R^2	0.452	0.465	0.452	0.439	0.447	0.440	0.456	0.468	0.456	0.459	0.463	0.459

	2011–2017					
	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employment	0.025***	0.025***	0.029**	0.028***	0.029***	0.027***

Table 3 (continued)

	2011–2017					
	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
	(0.009)	(0.008)	(0.012)	(0.007)	(0.008)	(0.008)
Observations	640,992	685,020	640,992	640,992	562,932	640,992
Adjusted R^2	0.312	0.314	0.312	0.324	0.323	0.324
Unemployment	−0.023**	−0.021**	−0.032**	−0.016**	−0.018**	−0.018***
	(0.012)	(0.009)	(0.014)	(0.006)	(0.007)	(0.007)
Observations	396,698	427,492	396,698	396,698	351,120	396,698
Adjusted R^2	0.053	0.051	0.053	0.054	0.051	0.054
Participation labour	0.012	0.013**	0.011	0.021***	0.020***	0.018**
	(0.009)	(0.007)	(0.012)	(0.007)	(0.007)	(0.007)
Observations	640,992	685,020	640,992	640,992	562,932	640,992
Adjusted R^2	0.336	0.339	0.336	0.349	0.348	0.349
Informal work	−0.003	−0.003	−0.027	−0.009	−0.013	−0.018
	(0.018)	(0.015)	(0.023)	(0.012)	(0.014)	(0.014)

Table 3 (continued)

	2011–2017					
	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Observations	214,854	229,242	214,854	214,854	188,958	214,854
Adjusted R^2	0.202	0.200	0.202	0.213	0.213	0.213
Employee without contract	−0.001	−0.008	−0.017	−0.003	−0.014	−0.012
	(0.008)	(0.006)	(0.014)	(0.010)	(0.011)	(0.012)
Observations	164,246	174,749	164,246	164,246	145,254	164,246
Adjusted R^2	0.168	0.167	0.168	0.162	0.161	0.162
Temporary work	−0.004	−0.000	−0.015	−0.007	0.003	0.003
	(0.011)	(0.010)	(0.020)	(0.013)	(0.013)	(0.014)
Observations	214,619	229,007	214,619	214,619	188,756	214,619
Adjusted R^2	0.206	0.201	0.206	0.195	0.193	0.195
Part-time work	−0.009	0.013	−0.019	0.005	0.007	0.008
	(0.010)	(0.019)	(0.014)	(0.010)	(0.012)	(0.011)

Table 3 (continued)

	2011–2017					
	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Observations	219,307	234,101	219,307	219,307	192,888	219,307
Adjusted R^2	0.150	0.148	0.150	0.128	0.130	0.129
Hours worked	−0.659*	−1.763**	−1.068**	−1.004*	−0.941	−1.103*
	(0.345)	(0.689)	(0.537)	(0.544)	(0.617)	(0.582)
Observations	214,854	229,242	214,854	214,854	188,958	214,854
Adjusted R^2	0.100	0.102	0.100	0.101	0.103	0.101
Log monthly wage	−0.024	−0.036	0.013	−0.043	−0.027	−0.033
	(0.023)	(0.023)	(0.037)	(0.034)	(0.036)	(0.036)
Observations	181,817	193,704	181,817	181,817	160,279	181,817
Adjusted R^2	0.486	0.496	0.485	0.473	0.476	0.473

Note: Robust standard errors in parentheses, clustered at the community level

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Secondly, the incidence of workers in the agricultural sector is not higher in the treatment group compared to the control group (see Table 4). Finally, when the model is estimated excluding the agricultural sector, the effect on temporary work is similar.[7]

At the same time, there are no significant effects of the earthquake and tsunami on the probability of having part-time employment during 2011–2017. Nevertheless, there is a negative impact on the hours worked per week among the treatment group, especially in 2013. Therefore, the employers changed the workday by reducing working hours, though less than 3 h per week. This result is compatible with the lack of effect on part-time employment. One possible explanation for the decrease of hours worked could be the need to adapt production system to the increasing external demand for agricultural commodities between the mid-2000s and the beginning of the last decade (ILO 2018). Nevertheless, when the model is estimated, with the exports value of agricultural sectors per region as an additional control variable, the negative effect on hours worked remains (Table 7). Besides, the estimations for professional versus less-skilled workers showed a negative effect on hours worked for the unskilled group but not among the skilled group.[8] Therefore, the reduction of hours worked seems to be associated with a change in the workforce composition and, probably, in the production process. However, this hypothesis requires a more detailed analysis that escapes the central objective of this article.

Monthly salary is a variable associated with the macroeconomic recovery process after a crisis or catastrophic event such as the 2010 Bío-Bío earthquake and tsunami in Chile. Indeed, there is a negative impact on labour income between workers of the treatment group in 2011 that ranges from 6.8 to 8.3 p.p. In the recovery period, labour demand reactivates, and the supply of workers increases in damaged areas due to, among other things, the return of emigrated employees to the affected areas where they resided. If the labour supply effect exceeds the demand effect, the relative salary will fall. However, there was not a significant effect on wages from 2013–2017. Once more, the results suggest that although some programs and policies might play a fundamental role in the recovery process, when these are not accompanied by a favourable macroeconomic and labour context, the desired positive effects on some variables may be lost over time. Since labour income is one of the primary means of getting out of poverty, this result can have important implications for economic and social policy considering that in some of the affected regions, there is a high incidence of poverty and job insecurity.

As it was previously mentioned, the recovery process after a natural disaster could be associated with the effects observed in some variables. Thus, to preliminarily explore this hypothesis, a term of interaction between the period, treatment and the number of rebuilt houses[9] is included in the estimations (Table 8). In this manner, it is possible to examine whether the DiD coefficient is modified for the treatment group that resides in communities with a more significant number of rebuilt homes. In general, the evidence suggests that public activity in the affected area of reconstruction of houses damaged by the earthquake and tsunami does not explain the recovery effects observed in the labour market through the increase in the probability of employment and the reduction in the probability of being unemployed.

[7] This estimation is available upon request.

[8] This estimation is available upon request.

[9] This information came from Ministry of Housing and Urbanism (2019).

Moreover, most of the effects remain similar when the model includes other control variables associated with the exports value of agricultural sectors per region[10] and regional expenditure per capita (in constant pesos) of the Ministry of Public Works of Chile during 2009–2017[11] (Table 7). Nevertheless, it should be noted that it has not been possible to capture all the mechanisms underlying government aid, such as those associated with economic opportunities (productive chains, new temporary businesses) in the most affected areas. For this reason, government intervention and recovery activities, as well as, private aids could have attenuated or even countered the negative effect of the natural disaster on labour market outcomes. Indeed, the Chilean public sector implemented a broad set of policies and actions to counteract the adverse effects of the 2010 Bío-Bío earthquake and tsunami. In terms of employment, state aid was expressed in three lines of action included in the Reconstruction Plan: support programs for SMEs affected by the earthquake, the creation of 60,000 jobs focused on areas affected by the disaster and the 'Volver a la Mar' [Let's Go Back to the Sea] program to funding, through bonuses and credits, the purchase and repair of boats and vessels (Government of Chile 2014). To recover the productive capacity of the SMEs, a set of financial instruments was available for a total amount of $408 million USD. During 2010–2013, $77 million USD had been executed in the Support Program for Investment in Productive Infrastructure managed by the Cooperation for the Promotion of Production (CORFO) and the special reconstruction program developed by the Service of Technical Cooperation (SERCOTEC) that benefited a total of 8945 companies. The 'Volver a la Mar' program ends in March 2011 with 1100 beneficiaries who received subsidies for $7.2 million USD. Besides to this, in the specific case of the Coastal Border, a broader set of investment support programs was developed that had as main beneficiaries sites on the Maule Coast and with an amount of $459,497 USD (Government of Chile 2014). To the programs and strategies for the recovery of employment, policies and expenditures executed in other areas must be added, especially those related to the repair of damaged homes and public and private infrastructures. To February 2016, the Ministry of Housing and Urbanism (MINVU) has assigned 225 thousand subsidies after the earthquake (De la Llera et al. 2017). For its part, the Ministry of Public Works, as a result of the earthquake and subsequent tsunami, immediately launched an Emergency and Reconstruction Program for 2010–2014. As of 2014, connectivity had been restored in 717 roadworks and bridges, 8 aerodromes and airports were recovered, 99 repairs of hydraulic works and 53 of port works were executed, 422 drinking water systems were repaired, among other works. Furthermore, concerning the private sector transfers associated with the insured losses, these total an estimated $8 billion USD. However, as regards with earthquake's impact on the insurance and reinsurance market, the final total may well exceed the range from $8 to 10 billion USD, on account of coverage for losses due to business interruption cover and its interpretation. Besides, just $11 million USD of the total insured losses were covered by local insurance companies (De la Llera et al. 2017).

[10] This variable allows controlling for regional differences in the level and temporal change of the value of exports from the agricultural sector during the period of analysis. Although the variable does not capture what happened to the exports of the rest of the sectors, in the affected regions, the share of the agricultural sector in exports is considerably higher than in the control group regions. Moreover, the affected zones comprised 40% of national employment in the agricultural sector (ECLAC 2010).

[11] As mentioned previously, although it would be convenient to have an adequate measure of the total public consolidated expenditure executed by the government during the recovery process, it is very difficult to collect all the necessary information per community (and even per region) throughout all period of analysis.

6.3 Robustness check

The previous estimates, for the period 2011–2017, obtained from the DiD approach were derived from a threshold determined in the treatment variables considered (the first quartile—Q25—of the damage rate per commune and the seismic acceleration) to define the treatment and control group. To examine the sensitivity of these results, other cut-off points of the exogenous treatment variable were used. To this end, all individuals in communities with an average value of seismic acceleration higher than the second (Q50) and third quartile (Q75) of this variable were identified as treated. The positive effects on the probability of employment as well as the negative effects on the likelihood of being unemployed remain (Table 9). The same happens with the negative impact on hours worked.

On the contrary, estimates were also performed by changing the comparison period before the earthquake and tsunami. This sensitivity analysis is relevant, considering that in 2009, Chile had to face the international financial crisis. As a result, from the second half of 2008, the GDP growth rate contracted significantly, which resulted in 2009 in a decline in production and an increase in unemployment (ECLAC 2010). Thus, instead of 2009, 2006 was considered as well as a combination of 2006 and 2009. The results of this sensitivity analysis (Table 9) indicate that the main conclusions regarding the long-term impacts of the tsunami and earthquake remain.

Other robustness checks were also performed using other instruments to estimate the DiD model (1) with the IV technique such as the average instrumental intensity value[12] and the maximum seismic acceleration value per community instead of the average PGA value. The main conclusions do not change after this modification (Table 9).

Likewise, different specifications of the model (1) were estimated excluding among the control variables those related to labour characteristics that could capture part of the effect of the earthquake and tsunami as current individual labour market characteristics. Such characteristics might be correlated with current unobservable determinations of job quality or wages. The central results observed in both the short- and long-term remain after these changes.

7 Conclusions

This document studies how the Chilean labour market adjusts to destructive natural disasters in the short and long term. These two periods of analysis are relevant because the results can be different along time. On the one hand, according to theoretical explanations and given the heterogeneous characteristics of Chile's labour market, the a priori effects are ambiguous. On the other hand, the impacts are expected to be negative in the short term. However, in the long term, this effect could have been mitigated by the recovery policies and programs implemented.

So far, this is the first article that explores the impact of the 2010 Bío-Bío earthquake in Chile on different labour market variables regarding quantity as well as quality of employment. Another novelty is that the identification strategy does not depend on a single variable to define the treatment and control group. On the contrary, different variables are considered, which in turn allows the robustness of the results to be evaluated. Also, some estimates differ when earthquake damage is used as treatment variable instead of seismic

[12] The Mercalli intensity was used as instrumental variable by Kirchberger (2017) and treatment variable by Porcelli and Trezzi (2019). However, this measure could be potentially endogenous because it is related to the effects of an earthquake on people or structures.

acceleration, which questions the use of damage as a treatment variable as this can be endogenous, as Kirchberger (2017) warns.

The results suggest that these natural disasters affected the employment's quantity and quality but in a different way in the long term than in the short term. This indicates not only that there are different effects along the years but that the size of the impact is not stable over time. In fact, in the short term, the evidence suggests that the Chilean labour market suffered the adverse consequences of the earthquake and tsunami, reducing the quantity and quality of jobs. In particular, there are significant negative effects on the probability of employment and positive on the likelihood of being an informal salaried worker. These results may be closely associated with the characteristics of the Chilean labour market. Job quality deficits in the periods before the earthquake are particularly significant in Chile. The occurrence of the natural catastrophe seemed to deepen the pre-existing problems, not cause them. In this context, government institutions, the ability of the state to enforce the law in general and labour law in particular, the role of companies, the effectiveness of active and passive policies are also determining factors of the quality of employment.

In the long term, however, signs of recovery in the labour market were observed. Some public policies and recovery programs may have mitigated or eliminated the adverse effects in some affected areas. In this regard, the Economic Commission for Latin America and the Caribbean (ECLAC) (2010) mentions that Chile used 2% of the budget for catastrophe cases, the resources available to the Economic and Social Stabilization Fund (FEES) and external financing after the natural disasters. Furthermore, it should also be considered that some variables showing no significant effects do not necessarily imply that the 2010 Bío-Bío earthquake and Tsunami had no impact.

The Chilean labour market's resilience appears, however, only five to seven years after the adverse exogenous shock. The question which arises, therefore, is why the delay in the recovery process of the labour market occurred. Some variables such as political inefficiency, lack of sufficient resources, factors associated with labour supply (affected workers' education, age, experience) and demand (company size, taxes, infrastructure, technology, type of production process, etc.) might explain that result. Helping people get back into work as quickly as possible is vital to limiting the cost of displacement. Income support may also be required to support families during these transitions (Venn 2012). Also, it is important to stop and change the trends of some variables, such as labour informality. For example, it is known that informal workers tend to be one of the most vulnerable to shocks. Therefore, the process and speed of the labour market's recovery in Chile might not only involve solving the direct damages caused by the earthquake and tsunami but also the structural problems of that market and the overall economy, many of which are pre-existing. Nevertheless, this is an interesting field for future investigation.

Another line of pending research in a multidisciplinary context is related to studying the most efficient way to compute and include the impacts that earthquakes have on the labour market in the calculation of seismic risk, particularly in especially vulnerable countries such as Chile.

Funding Funding was provided by Comunidad de Madrid.

Appendix

See Tables 4, 5, 6, 7, 8, and 9.

Table 4 Baseline characteristics of treatment and control group, 2009. *Source*: own elaboration based on 2009 CASEN survey and USGS

Variables	Treatment variable: PGA			Treatment variable: earthquake damage		
	Treated	Control	*p* value	Treated	Control	*p* value
Control variables						
Women	0.522	0.514	0.020	0.521	0.519	0.545
Age	37.267	36.678	0.000	37.221	36.920	0.012
Education level						
Low educ. level	0.416	0.464	0.000	0.432	0.467	0.000
Middle educ. level	0.439	0.431	0.032	0.439	0.426	0.001
High educ. level	0.145	0.105	0.000	0.128	0.107	0.000
School attendance	0.173	0.164	0.001	0.171	0.159	0.000
Marital status						
Married	0.518	0.535	0.000	0.521	0.525	0.329
Single	0.402	0.391	0.002	0.400	0.397	0.448
Household-related variables						
Head of household	0.516	0.799	0.000	0.522	0.779	0.000
Number of children under 6 in the home	3.153	2.323	0.000	2.955	2.181	0.000
Number of elderly over 65 in the home	4.315	5.475	0.000	4.353	4.624	0.000
Skill group						
Professional	0.390	0.365	0.000	0.372	0.359	0.024
Technical	0.377	0.416	0.000	0.386	0.405	0.001
Unskilled	0.233	0.219	0.001	0.242	0.236	0.216
Seniority	6.295	6.326	0.719	6.295	6.082	0.030
Activity sector						
Agriculture	0.098	0.109	0.000	0.110	0.117	0.051
Mine	0.010	0.081	0.000	0.012	0.059	0.000
Industry	0.112	0.082	0.000	0.111	0.086	0.000
Electricity, gas and water	0.007	0.009	0.098	0.008	0.010	0.028
Construction	0.085	0.101	0.000	0.085	0.103	0.000
Commerce	0.210	0.202	0.045	0.211	0.206	0.225
Hotels	0.005	0.007	0.001	0.005	0.007	0.027
Transport and communications	0.080	0.086	0.025	0.080	0.083	0.318
Financial institutions	0.021	0.011	0.000	0.019	0.012	0.000
Real estate activities	0.010	0.005	0.000	0.009	0.005	0.000
Public administration	0.042	0.058	0.000	0.040	0.062	0.000
Education	0.073	0.071	0.405	0.071	0.071	0.848
Social, personal and communal services	0.180	0.127	0.000	0.173	0.126	0.000
Domestic work	0.066	0.051	0.000	0.065	0.054	0.000
Others organizations	0.001	0.000	0.014	0.001	0.000	0.035
Outcome variables						
Labour status						

Table 4 (continued)

Variables	Treatment variable: PGA			Treatment variable: earthquake damage		
	Treated	Control	*p* value	Treated	Control	*p* value
Employment rate	0.558	0.556	0.582	0.554	0.555	0.890
Unemployment rate	0.107	0.084	0.000	0.108	0.084	0.000
Participation rate	0.625	0.607	0.000	0.621	0.606	0.000
Informality						
Informal work	0.205	0.209	0.462	0.206	0.207	0.052
Informal self-employment	0.491	0.463	0.006	0.499	0.453	0.000
Informal salaried work	0.134	0.132	0.598	0.134	0.138	0.440
Employee without contract	0.137	0.119	0.000	0.141	0.133	0.043
Monthly wage (constant pesos of 2017)	419,829.700	367,926.600	0.000	384,386.900	364,175.600	0.000
Hours worked	43.16	43.17	0.98	43.212	43.924	0.000
Temporary work	0.249	0.270	0.000	0.258	0.267	0.068
Part-time work	0.162	0.183	0.000	0.162	0.161	0.816

Table 5 Effect of the 2010 Bío-Bío earthquake and tsunami on probability of migration from a community of the affected area *Source*: own elaboration based on 2015 CASEN survey

	2015					
	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Economically active population						
Migration	0.018	0.018	0.028*	0.022***	0.029***	0.026***
	(0.012)	(0.013)	(0.017)	(0.008)	(0.009)	(0.008)
Observations	164,571	174,916	164,571	164,571	145,212	164,571
Adjusted R^2	0.050	0.049	0.050	0.037	0.038	0.037
Workers						
Migration	0.018	0.019	0.028*	0.022***	0.031***	0.028***
	(0.012)	(0.013)	(0.017)	(0.008)	(0.008)	(0.008)
Observations	149,022	158,861	149,022	149,022	131,657	149,022
Adjusted R^2	0.057	0.056	0.057	0.046	0.048	0.046
Unemployed population						
Migration	0.005	0.005	0.019	0.013	0.014	0.017
	(0.023)	(0.021)	(0.035)	(0.015)	(0.017)	(0.016)
Observations	14,820	15,288	14,820	14,820	12,895	14,820
Adjusted R^2	0.037	0.040	0.038	0.028	0.027	0.029

Robust standard errors in parentheses, clustered at the community level

***$p<0.01$; **$p<0.05$; *$p<0.1$

Table 6 Short-term effects of the 2010 Bío-Bío earthquake and tsunami on labour market with additional controls *Source*: own elaboration based on 2015 CASEN survey

	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employment	−0.033**	−0.009	−0.042***	−0.040***	−0.048***	−0.048***
	(0.013)	(0.009)	(0.012)	(0.010)	(0.012)	(0.009)
Observations	31,184	85,388	31,184	31,184	25,630	31,184
Adjusted R^2	0.322	0.310	0.322	0.319	0.315	0.319
Unemployment	0.007	−0.010	−0.006	0.012	0.009	0.004
	(0.017)	(0.006)	(0.017)	(0.013)	(0.013)	(0.012)
Observations	17,642	48,714	17,642	17,642	14,611	17,642
Adjusted R^2	0.053	0.041	0.053	0.057	0.056	0.058
Participation labour	−0.035**	−0.018*	−0.053***	−0.038***	−0.049***	−0.053***
	(0.014)	(0.010)	(0.011)	(0.010)	(0.011)	(0.007)
Observations	31,184	85,388	31,184	31,184	25,630	31,184
Adjusted R^2	0.346	0.342	0.346	0.345	0.341	0.345
Informal work	0.022	−0.003	0.209***	0.005	0.014	0.237***
	(0.023)	(0.019)	(0.025)	(0.018)	(0.020)	(0.013)
Observations	14,272	39,637	14,272	14,272	11,813	14,272
Adjusted R^2	0.188	0.162	0.115	0.206	0.203	0.136
Informal self-employment	0.043	−0.001	0.581***	−0.009	0.010	0.563***
	(0.049)	(0.044)	(0.066)	(0.034)	(0.038)	(0.031)
Observations	3479	8151	3479	3479	2847	3479
Adjusted R^2	0.382	0.353	0.143	0.391	0.388	0.178
Informal salaried work	0.015	0.006	0.102***	0.032**	0.035**	0.135***
	(0.017)	(0.013)	(0.016)	(0.013)	(0.015)	(0.011)
Observations	10,394	30,608	10,394	10,394	8619	10,394
Adjusted R^2	0.077	0.077	0.047	0.084	0.086	0.061

Table 6 (continued)

	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Log monthly wage	−0.045*	−0.083***	−0.053**	−0.039*	−0.036	−0.062***
	(0.027)	(0.029)	(0.022)	(0.022)	(0.022)	(0.017)
Observations	13,892	38,919	13,892	13,892	11,527	13,892
Adjusted R^2	0.383	0.377	0.384	0.342	0.353	0.343
Employee without contract	0.009	0.060	−0.013	0.032	0.044	0.051
	(0.055)	(0.037)	(0.048)	(0.037)	(0.039)	(0.032)
Observations	6345	18,763	6345	6345	5290	6345
Adjusted R^2	0.154	0.147	0.158	0.136	0.139	0.140

Robust standard errors in parentheses, clustered at the community level

The model includes the following additional controls: the rate of workers with a job as part of a state emergency employment program per community (calculated from the 2010 Post-earthquake Survey), the regional expenditure per capita (in constant pesos) of the Ministry of Public Works of Chile during 2009–2010 and exports value of agricultural sectors per region

***$p<0.01$; **$p<0.05$; *$p<0.1$

Table 7 Long-term effects of the 2010 Bío-Bío earthquake and tsunami on the labour market with additional controls *Source*: own elaboration based on CASEN surveys and USGS

	2011–2017					
	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employment	0.025***	0.024***	0.028**	0.026***	0.027***	0.029***
	(0.009)	(0.008)	(0.013)	(0.006)	(0.007)	(0.007)
Observations	640,992	685,020	640,992	640,992	562,932	640,992
Adjusted R^2	0.316	0.318	0.316	0.327	0.325	0.327
Unemployment	−0.023*	−0.021**	−0.032**	−0.015**	−0.017***	−0.020***
	(0.012)	(0.009)	(0.014)	(0.006)	(0.007)	(0.007)
Observations	396,698	427,492	396,698	396,698	351,120	396,698
Adjusted R^2	0.054	0.053	0.054	0.055	0.053	0.055
Participation labour	0.012	0.013*	0.011	0.019***	0.019***	0.020***
	(0.009)	(0.007)	(0.012)	(0.005)	(0.006)	(0.006)
Observations	640,992	685,020	640,992	640,992	562,932	640,992
Adjusted R^2	0.339	0.341	0.339	0.351	0.350	0.351
Informal work	−0.003	−0.003	−0.027	−0.008	−0.012	−0.019
	(0.018)	(0.015)	(0.023)	(0.012)	(0.014)	(0.014)
Observations	214,854	229,242	214,854	214,854	188,958	214,854
Adjusted R^2	0.203	0.201	0.203	0.215	0.214	0.215
Employee without contract	−0.002	−0.005	−0.012	−0.005	−0.016**	−0.013
	(0.006)	(0.006)	(0.011)	(0.008)	(0.007)	(0.009)
Observations	214,854	229,242	214,854	214,854	188,958	214,854
Adjusted R^2	0.123	0.120	0.123	0.119	0.118	0.119
Temporary work	−0.005	−0.000	−0.014	0.000	0.010	0.007
	(0.011)	(0.010)	(0.020)	(0.012)	(0.013)	(0.013)

Table 7 (continued)

	2011–2017					
	DiD		IV	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Observations	214,619	229,007	214,619	214,619	188,756	214,619
Adjusted R^2	0.211	0.207	0.211	0.197	0.197	0.197
Part-time work	−0.009	0.013	−0.019	0.005	0.007	0.007
	(0.010)	(0.019)	(0.014)	(0.010)	(0.012)	(0.011)
Observations	219,307	234,101	219,307	219,307	192,888	219,307
Adjusted R^2	0.151	0.149	0.151	0.129	0.131	0.129
Hours worked	−0.662*	−1.766**	−1.088**	−1.005*	−0.935	−1.073*
	(0.348)	(0.690)	(0.542)	(0.554)	(0.630)	(0.594)
Observations	214,854	229,242	214,854	214,854	188,958	214,854
Adjusted R^2	0.100	0.102	0.100	0.101	0.103	0.101
Log monthly wage	−0.023	−0.037	0.008	−0.054	−0.036	−0.035
	(0.023)	(0.023)	(0.037)	(0.037)	(0.038)	(0.039)
Observations	181,817	193,704	181,817	181,817	160,279	181,817
Adjusted R^2	0.494	0.504	0.494	0.478	0.482	0.478

The model includes the following additional controls: the rate of workers with a job as part of a state emergency employment program per community (calculated from the 2010 Post-earthquake Survey), the regional expenditure per capita (in constant pesos) of the Ministry of Public Works of Chile during 2009–2010 and exports value of agricultural sectors per region

Robust standard errors in parentheses, clustered at the community level

***$p<0.01$; **$p<0.05$; *$p<0.1$

Table 8 Effects of the 2010 Bío-Bío earthquake and tsunami on labour market considering the number of rebuilt houses *Source*: own elaboration based on CASEN surveys and USGS

	Number of rebuilt houses higher than Q25			Number of rebuilt houses higher than Q50			Number of rebuilt houses higher than Q75		
	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Employment									
Treat × Period	0.029***	0.032***	0.031***	0.032***	0.035***	0.028***	0.030***	0.028*	0.027**
	(0.009)	(0.010)	(0.010)	(0.009)	(0.011)	(0.010)	(0.010)	(0.015)	(0.011)
Treat × Period × Dummy variable for number of rebuilt houses	−0.002	−0.005	−0.006	−0.005	−0.010	−0.004	−0.011	−0.004	−0.007
	(0.007)	(0.007)	(0.008)	(0.007)	(0.009)	(0.009)	(0.008)	(0.014)	(0.009)
Observations	640,992	562,932	640,992	568,704	397,435	568,704	390,795	241,532	390,795
Adjusted R^2	0.324	0.323	0.324	0.325	0.325	0.325	0.328	0.329	0.328
Unemployment									
Treat × Period	−0.014**	−0.019**	−0.021***	−0.015**	−0.017*	−0.019**	−0.010	−0.010	−0.014*
	(0.007)	(0.008)	(0.007)	(0.007)	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)
Treat × Period × Dummy variable for number of rebuilt houses	−0.003	0.002	0.004	−0.001	−0.000	0.004	0.002	−0.001	0.005
	(0.005)	(0.005)	(0.004)	(0.005)	(0.007)	(0.005)	(0.006)	(0.008)	(0.006)
Observations	396,698	351,120	396,698	350,454	246,538	350,454	236,058	145,894	236,058
Adjusted R^2	0.054	0.051	0.054	0.054	0.052	0.054	0.054	0.056	0.054
Participation labour									
Treat × Period	0.023**	0.023**	0.020**	0.026***	0.027***	0.019**	0.028***	0.026*	0.022**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.014)	(0.010)
Treat × Period × Dummy variable for number of rebuilt houses	−0.004	−0.004	−0.004	−0.006	−0.011	−0.002	−0.011	−0.005	−0.005
	(0.008)	(0.007)	(0.007)	(0.007)	(0.009)	(0.007)	(0.008)	(0.013)	(0.007)

Table 8 (continued)

	Number of rebuilt houses higher than Q25			Number of rebuilt houses higher than Q50			Number of rebuilt houses higher than Q75		
	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Observations	640,992	562,932	640,992	568,704	397,435	568,704	390,795	241,532	390,795
Adjusted R^2	0.349	0.348	0.349	0.350	0.350	0.350	0.353	0.354	0.353
Informal work									
Treat × Period	−0.009	−0.013	−0.018	−0.016	−0.027	−0.016	−0.018	−0.039*	−0.019
	(0.013)	(0.016)	(0.015)	(0.014)	(0.018)	(0.015)	(0.015)	(0.021)	(0.016)
Treat × Period × Dummy variable for number of rebuilt houses	−0.001	−0.000	−0.000	0.005	0.021	0.000	−0.001	0.012	−0.009
	(0.009)	(0.010)	(0.008)	(0.009)	(0.013)	(0.009)	(0.012)	(0.018)	(0.010)
Observations	214,854	188,958	214,854	191,099	135,379	191,099	134,468	83,250	134,468
Adjusted R^2	0.213	0.213	0.213	0.214	0.215	0.214	0.210	0.226	0.210
Employee without contract									
Treat × Period	0.001	−0.010	−0.007	0.001	−0.010	−0.003	0.007	−0.008	0.004
	(0.011)	(0.012)	(0.013)	(0.011)	(0.014)	(0.013)	(0.013)	(0.017)	(0.015)
Treat × Period × Dummy variable for number of rebuilt houses	−0.006	−0.005	−0.007	−0.007	−0.007	−0.011	−0.010	−0.021	−0.021*
	(0.008)	(0.009)	(0.008)	(0.008)	(0.013)	(0.009)	(0.010)	(0.018)	(0.011)
Observations	164,246	145,254	164,246	145,890	103,591	145,890	102,870	62,428	102,870
Adjusted R^2	0.162	0.161	0.162	0.164	0.164	0.164	0.167	0.178	0.167
Temporary work									
Treat × Period	−0.008	0.005	0.009	−0.005	−0.001	0.011	0.007	0.019	0.022

Table 8 (continued)

	Number of rebuilt houses higher than Q25			Number of rebuilt houses higher than Q50			Number of rebuilt houses higher than Q75		
	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
	(0.014)	(0.015)	(0.016)	(0.015)	(0.018)	(0.016)	(0.016)	(0.023)	(0.017)
Treat × Period × Dummy variable for number of rebuilt houses	0.001	−0.004	−0.009	−0.004	−0.002	−0.015	−0.007	−0.023	−0.014
	(0.011)	(0.012)	(0.013)	(0.012)	(0.016)	(0.013)	(0.014)	(0.023)	(0.013)
Observations	214,619	188,756	214,619	190,877	135,239	190,877	134,342	83,156	134,342
Adjusted R^2	0.195	0.193	0.195	0.198	0.187	0.198	0.211	0.181	0.212
Part-time work									
Treat × Period	−0.001	0.000	0.008	0.000	−0.006	0.006	0.010	0.003	0.011
	(0.011)	(0.013)	(0.012)	(0.011)	(0.014)	(0.012)	(0.013)	(0.017)	(0.013)
Treat × Period × Dummy variable for number of rebuilt houses	0.011	0.010	−0.001	0.007	0.017*	−0.001	−0.004	0.011	−0.007
	(0.007)	(0.008)	(0.006)	(0.007)	(0.009)	(0.007)	(0.010)	(0.015)	(0.008)
Observations	219,307	192,888	219,307	195,174	138,201	195,174	137,158	84,926	137,158
Adjusted R^2	0.129	0.130	0.129	0.127	0.129	0.127	0.120	0.124	0.121
Hours worked									
Treat × Period	−0.908*	−0.838	−1.125*	−0.868	−0.706	−0.939	−1.128*	−1.035	−1.020*
	(0.545)	(0.637)	(0.591)	(0.550)	(0.654)	(0.590)	(0.576)	(0.713)	(0.615)
Treat × Period × Dummy variable for number of rebuilt houses	−0.169	−0.158	0.036	−0.170	−0.357	−0.037	0.128	−0.133	0.150
	(0.229)	(0.257)	(0.190)	(0.246)	(0.284)	(0.201)	(0.317)	(0.435)	(0.275)
Observations	214,854	188,958	214,854	191,099	135,379	191,099	134,468	83,250	134,468

Table 8 (continued)

	Number of rebuilt houses higher than Q25			Number of rebuilt houses higher than Q50			Number of rebuilt houses higher than Q75		
	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR	DiD with PSWR		IV with PSWR
	Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA		Treatment defined by damage	Treatment defined by PGA	
Adjusted R^2	0.101	0.103	0.101	0.100	0.105	0.100	0.094	0.107	0.094
Log monthly wage									
Treat × Period	−0.033	−0.017	−0.037	−0.030	−0.014	−0.039	−0.066*	−0.018	−0.053
	(0.037)	(0.038)	(0.039)	(0.037)	(0.041)	(0.040)	(0.039)	(0.046)	(0.041)
Treat × Period × Dummy variable for number of rebuilt houses	−0.017	−0.015	0.007	−0.014	−0.005	0.015	0.005	0.009	0.029
	(0.018)	(0.018)	(0.024)	(0.019)	(0.024)	(0.027)	(0.021)	(0.034)	(0.025)
Observations	181,817	160,279	181,817	161,382	114,476	161,382	112,770	69,362	112,770
Adjusted R^2	0.473	0.476	0.473	0.475	0.482	0.475	0.468	0.487	0.468

Robust standard errors in parentheses, clustered at the community level

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Table 9 Long-term effects of the 2010 Bío-Bío earthquake and tsunami on labour market by different pre-event periods. *Source*: Own elaboration based on CASEN surveys and USGS

	Pre-event period: 2009 and post-event period: 2011–2017			Pre-event period: 2006 and post-event period: 2011–2017			Pre-event period: 2006 and 2009 and post-event period: 2011–2017			Pre-event period: 2009 and post-event period: 2011–2017	
	P(25)	P(50)	P(75)	P(25)	P(50)	P(75)	P(25)	P(50)	P(75)	Treatment defined by maximum seismic acceleration value	Treatment defined by average instrumental intensity value
Employment	0.027***	0.025***	0.022**	0.039***	0.041***	0.039***	0.039***	0.044***	0.042***	0.027***	0.027***
	(0.008)	(0.008)	(0.009)	(0.011)	(0.011)	(0.011)	(0.011)	−0.009	(0.009)	(0.008)	(0.008)
Observations	640,992	568,704	390,795	641,189	571,877	390,112	390,112	692,456	473,156	640,992	640,992
Adjusted R^2	0.324	0.325	0.328	0.312	0.313	0.314	0.314	0.305	0.307	0.324	0.324
Unemployment	−0.018***	−0.016**	−0.011	−0.012*	−0.011*	−0.005	−0.005	−0.014***	−0.010*	−0.018***	−0.018***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	−0.005	(0.005)	(0.007)	(0.007)
Observations	396,698	350,454	236,058	397,754	353,421	236,135	236,135	423,161	283,208	396,698	396,698
Adjusted R^2	0.054	0.054	0.054	0.049	0.049	0.049	0.049	0.05	0.050	0.054	0.054
Participation labour	0.018**	0.017**	0.018**	0.039***	0.041***	0.043***	0.043***	0.042***	0.044***	0.018**	0.018**
	(0.007)	(0.007)	(0.008)	(0.010)	(0.010)	(0.010)	(0.010)	−0.008	(0.008)	(0.007)	(0.007)
Observations	640,992	568,704	390,795	641,189	571,877	390,112	390,112	692,456	473,156	640,992	640,992
Adjusted R^2	0.349	0.350	0.352	0.324	0.324	0.326	0.326	0.314	0.317	0.349	0.349
Informal work	−0.018	−0.016	−0.025*	−0.043***	−0.044***	−0.041***	−0.041***	−0.033***	−0.035***	−0.018	−0.018
	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)	(0.015)	(0.015)	−0.012	(0.012)	(0.014)	(0.014)
Observations	214,854	191,099	134,468	219,351	196,587	136,318	136,318	257,025	177,555	214,854	214,854
Adjusted R^2	0.213	0.214	0.210	0.206	0.206	0.203	0.203	0.205	0.201	0.213	0.213
Employee without contract	−0.012	−0.010	−0.010	−0.039***	−0.038***	−0.025*	−0.025*	−0.029**	−0.022*	−0.012	−0.012
	(0.012)	(0.012)	(0.013)	(0.014)	(0.014)	(0.015)	(0.015)	−0.011	(0.012)	(0.012)	(0.012)
Observations	164,246	145,890	102,870	184,723	165,387	114,261	114,261	210,948	145,466	164,246	164,246

Table 9 (continued)

	Pre-event period: 2009 and post-event period: 2011–2017			Pre-event period: 2006 and post-event period: 2011–2017			Pre-event period: 2006 and 2009 and post-event period: 2011–2017			Pre-event period: 2009 and post-event period: 2011–2017	
	P(25)	P(50)	P(75)	P(25)	P(50)	P(75)	P(25)	P(50)	P(75)	Treatment defined by maximum seismic acceleration value	Treatment defined by average instrumental intensity value
Adjusted R^2	0.162	0.164	0.167	0.124	0.125	0.129	0.129	0.132	0.137	0.162	0.162
Temporary work	0.003	0.002	0.012	−0.011	−0.011	0.006	0.006	−0.006	0.007	0.003	0.003
	(0.014)	(0.014)	(0.015)	(0.017)	(0.017)	(0.018)	(0.018)	−0.014	(0.015)	(0.014)	(0.014)
Observations	214,619	190,877	134,342	218,984	196,255	136,124	136,124	256,693	177,361	214,619	214,619
Adjusted R^2	0.195	0.198	0.212	0.168	0.171	0.184	0.184	0.183	0.198	0.195	0.195
Part-time work	0.008	0.005	0.007	−0.017*	−0.016	−0.017	−0.017	−0.009	−0.009	0.008	0.008
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)	(0.011)	−0.008	(0.008)	(0.011)	(0.011)
Observations	219,307	195,174	137,158	222,129	199,145	138,167	138,167	261,124	180,245	219,307	219,307
Adjusted R^2	0.129	0.127	0.121	0.130	0.129	0.123	0.123	0.121	0.115	0.129	0.129
Hours worked	−1.103*	−0.962*	−0.922	−1.783*	−1.732*	−1.229	−1.229	−1.314**	−0.945	−1.103*	−1.103*
	(0.582)	(0.579)	(0.595)	(0.932)	(0.948)	(1.026)	(1.026)	−0.626	(0.660)	(0.582)	(0.582)
Observations	214,854	191,099	134,468	219,351	196,587	136,318	136,318	257,025	177,555	214,854	214,854
Adjusted R^2	0.101	0.100	0.094	0.027	0.026	0.025	0.025	0.026	0.025	0.101	0.101
Log monthly wage	−0.033	−0.029	−0.034	−0.007	0.002	0.006	0.006	−0.012	−0.012	−0.033	−0.033
	(0.036)	(0.036)	(0.037)	(0.035)	(0.035)	(0.036)	(0.036)	−0.033	(0.034)	(0.036)	(0.036)
Observations	181,817	161,382	112,770	184,985	165,472	113,806	113,806	223,344	153,253	181,817	181,817
Adjusted R^2	0.473	0.475	0.468	0.456	0.458	0.454	0.454	0.447	0.439	0.473	0.473

Robust standard errors in parentheses, clustered at the community level

***$p<0.01$; **$p<0.05$; *$p<0.1$

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