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Abstract

I exploit the exogenous characteristic of a natural disaster occurred in Chile in order to explain its effects on general unemployment over affected and unaffected regions of the country in a mid-run timespan of 5 measured years. By using a fixed effect panel data regression model, I find that regions closer to the epicentre of the 27F earthquake showed significantly deeper reductions of unemployment over the time in comparison to those regions which are further from the epicentre. This effect was not observed in a significant way when using a short-run subsample of two years. I also perform diverse robustness checks over the estimates, all of which strongly support these findings. Thus, I conclude that more affected regions received a prime on unemployment reduction in the mid-run lapse of these four years after the earthquake.

Keywords: earthquake, unemployment, exogenous variation.

JEL Classification: J640, O540, Q540, R110 and R150.

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1 Introduction

Measuring the effects of a natural disaster, is very important, as it encourages the application of well informed public policies that allow optimal decisions to be taken when facing such extreme situations. In a highly seismic country like Chile, earthquakes receive a broad discussion in different topics. In the present document, I will focus in a particular large-scale recent event: the earthquake that affected the central and southern regions of Chile on February 27, 2010 (hereby 27F). Several studies exist regarding the topic of disasters in general and their effects, but the literature related to the 27F earthquake is scarce.

In this sense, I precisely focus this paper on analysing the 27F earthquake, exploiting the exogenous characteristic of this natural phenomena. My research establishes a mid-run temporal approach, tracking different variables from one year before the earthquake till four years after it. Having this dimension set, my hypothesis is that the 27F earthquake had a causal positive effect in reducing the mid-run unemployment of the most affected regions in Chile. Theoretical and empirical backgrounds may sustain this hypothesis. For instance, unemployment may have fallen due to the fact that the construction sector was highly boosted on those regions that were closer to the epicentre. Also, the loss of net capital had to be patched with higher investment rates, which create a dynamic environment that promotes employment. This fact may also be backed-up with Rybczynski's Theorem, as labor endowment would be relatively higher compared to the pre-earthquake situation of capital, which would lead to a higher use of labor, that is, more employment.

To contrast this hypothesis, this document is structurally defined in 7 parts. The second section of this document (2) revises some relevant existing literature about the topic, exposing different approaches used in various fields of investigation. A theoretical background is also exposed in this section. The third section (3) explains the data that was used in order to test the general hypothesis, the sources and the way this data was used. Section 4 presents and comments the model that was used to compute the estimates. In section 5, the results are discussed and contrasted with the initial hypothesis, showing the outputs computed by the model. Additional robustness checks are performed and explained in section 6. Finally, section 7 concludes and proposes extensions to this investigation.

2 Literature Review

As anticipated in the last section, economic literature regarding the 27F is scarce. Therefore, this section aims to expose a short review of different natural-disasters-related studies in order to contrast and discuss conclusions obtained by other authors.

Revising the existing literature, studies such as the one developed by Moreno and Cardona (2010) may be found. The authors argue through a general framework that these kind of disasters generate in the short and even in the long term an increase on unemployment. They determine the following sequence: 1) Earthquake 2) Destruction of productive capacity 3) Reduction of labor productivity and demand of this factor 4) Reduction of the aggregate supply 5) Increase in prices, which given that wages are fixed in the short term, necessarily imply and increase in unemployment. This work stands for an opposite position, broadening the discussion.

Other study was developed in Mexico by the ECLAC (2007), revising various disasters that have occurred in this country since 1990. They state that there are three types of effects in a disaster. The direct effects, which directly affect capital, people or institutions. The indirect effects that are related to the flow of goods and services affected by the disaster. Finally the macroeconomic effects measure the aggregated impact of the phenomena. This document is based on the latter effects, particularly on unemployment. Nevertheless, a lot of these effects are left apart in this paper, such as economic growth, imbalances in current account payments, increased government payment, inflation, decreased international reserves, worsening of income inequality in families and the costs of isolation of certain agricultural regions. Clearly there is a lot to study about the macroeconomic effects of the 27F earthquake.

Another interesting piece of literature is the counterfactual exercise conducted by Eduardo Cavallo et. al. (2010). These authors show that apparently major disasters have no significant permanent effects on per capita income. For this, they project the paths of GDP per capita after the the catastrophic event, showing that the economic performance deteriorates, if and only if, it has been accompanied by radical political changes, but when these effects are isolated, major disasters are neutral in the long term. The message is clear: the central problem of authorities is not the natural disaster itself, but maintaining the social and political control.

Moving on, Loayza (2009) indicates that the effect of a natural disaster on economic growth depends on the type of disaster, as the productive sector to be analysed, which shows the difficulty of measuring an overall effect of a disaster on economic growth or other macroeconomic indicators.

Landing up to the 27F event, Contreras, Sepúlveda and Morales (2012) did a research based on this same earthquake. By using a matching propensity score strategy and a difference-in-difference regression, they measure the effect of this disaster in educational achievement, contributing to the literature focused on this event.

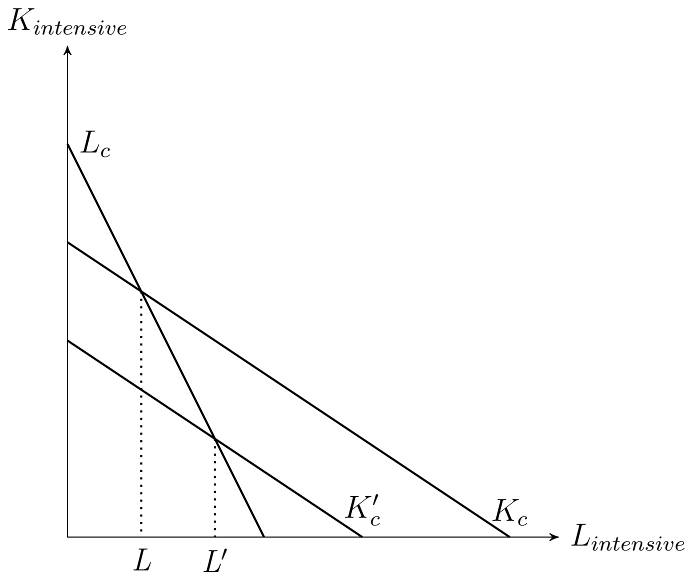
A qualitative approach applied to 27F is given by Cova and Rincón (2010) who study the effects of this disaster in the mental health of Chileans. They propose a mid and long-run effect of the phenomena over people's life wherein social and political variables are of particular relevance.

Finally, a theoretical background is supplied by Rybczynski (1955). Simplifying the situation by assuming the existence of two basic inputs, labor and capital, we can interpret the earthquake shock as an exogenous reduction of the total capital endowment of the affected regions. According to Rybczynski's Theorem, a reduction in the constrain of capital will rise the output of the goods that are labor-intensive (ceteris paribus). Figure 1 on page 4 shows how a reduction in the capital constrain from K_c to K_c' increases the production of labor-intensive goods from L to L'.

3 The Data

To contrast this hypothesis I designed a panel database, where I include information for the 15 regions of Chile on a monthly basis, going from March 2009 till February 2014 (5 years). In this way, the database includes 180 observations before the earthquake took place and 720 observations after the earthquake occurred.

Figure 1: Rybczynski's Theorem



The regional unemployment data was obtained from the Central Bank of Chile. The inflation proxy used in the estimation corresponds to the Consumer Price Index, obtained monthly and transversally (no feasible regional index exists) from the Internal Revenue Service. These two variables were obtained from trustful entities of the Chilean institutions, therefore data is expected to be reasonably well measured.

As a proxy of impact of the disaster for each region, I measure the distance from the epicentre of the earthquake till the gravity center of each region (figure 4 on page 11). A season dummy variable was also created, which is 0 for months that go from May to October and 1 for months that go from November to April. The idea of this variable is to control by seasonal effects, so it contemplates the hottest period of the year and the coldest period of the year. Along with the season dummy, a zone dummy was created, which takes value 0 for the northern zones and the far-most southern zone of the country (Norte Grande, Norte Chico and Zona Austral) and takes value 1 for the central and southern zone of the country (Zona Central and Zona Sur). Finally, the temporal instantaneous but long-lasting shock of the earthquake is stated in a binary variable that takes value 0 for the first 12 observations of each region and value 1 for the rest (before and after the earthquake). These variables were created in such a way they do not affect the exogenous characteristic of the shock that's being measured.

A brief summary of unemployment statistics by region, zone and period may be found on table 1 (on page 6), where it is easy to observe how affected regions reduced their unemployment rates more than unaffected regions after the earthquake. This may be complemented graphically with figure 3, located on page 7.

4 The Model

After testing the specification, I state a fixed-effect panel data regression model, described as follows:

$$U_{it} = \beta_0 + \beta_1 \cdot D_i \cdot E_t + \beta_2 \cdot E_t + \beta_3 \cdot \ln(P_t) + \beta_4 \cdot S_t \cdot Z_i + \beta_5 \cdot U_{i(t-1)} + v_i + \varepsilon_{it} \tag{1}$$

$$\forall i = 1, 2, ..., 15 \quad \forall t = 2, 4, ..., 60$$

Where U_{it} is the percentage of unemployment of region i in month t, D_i is the epicentral distance of region i, E_t is a dummy variable that is 0 if $t \leq 12$ and 1 if not, P_t is the consumer price index in month t, S_t is the season associated to month t, Z_i is the zone associated to region i, $U_{i(t-1)}$ is the monthly unemployment lag for each region over time, v_i is a fixed error component for each region and ε_{it} is a random well-behaved disturbance term over the months and regions.

The justification of the model follows the idea that regions that were less affected by the earthquake, that is, those with higher epicentral distances, will be less benefited with the mid-run reduction of unemployment that I expect due to the earthquake. Thus, β_1 is expected to be positive (more distance, more unemployment). The earthquake dummy is expected to have a negative incidence on unemployment ($\beta_2 < 0$) as there was a reductionist trend over time after 2009, but also because Chile was experiencing a general reduction of unemployment in a national level because of the international macroeconomical context (e.g. end of the sub-prime crisis short-run shock). Having said this, the main focus is on β_1, as it explains the hypothesis, but also on β_2, as it supports the core of this study. The consumer price index follows Phillips (1958), who argues that there is a negative relation between inflation and unemployment in an aggregate level. Thus, β_3 is expected to be negative (the logarithmic form introduced is to describe the elasticity of unemployment over inflation). The idea behind β_4 is the fact that employment is promoted on hotter seasons (better conditions for construction sector, youth employment, etc.), but has almost no incidence on the "tail zones" of Chile, as the weather plays a more invariant role on employment. In this sense, I expect β_4 to be negative (on hotter seasons, unemployment falls). When analysing the unemployment lag, a positive coefficient (β_5) is expected for the first lag, as unemployment is a high-frequency variable that is not likely to present a random adjustment, as it follows a tendency adjustment. The results of the estimations are explained in the following section.

5 Results

The empirical strategy includes estimating subsamples of the available data, in order to point out that the positive effects of the earthquake in terms of unemployment reduction are attributed to a mid-run time lapse (4 years, in this case). In this way, I first estimate the whole panel (5 years) for the first model (1), finding that all the coefficients are just as expected and very significant at the same time. The same happens when estimating 4 years, 3 years and 2 years, with similar impacts on unemployment, which can be noticed on the magnitude of β_1 and β_2. Therefore, this model is aligned with our expectations. An interesting result of the model is the fact that the last estimation that includes only 2 years (the year before and the year after 27F) gives a non-significant parameter for the earthquake dummy, which means that it cannot be stated that the earthquake reduced unemployment on a short-run. This is precisely what I propose.

A second estimation of the model was held in order to correct potential efficiency issues (for example, due to a low number of observations). This was done by resampling the data using 500 bootstrap repetitions. A bit of significance is lost, but the main conclusions do not vary.

The results are shown on table 2 and on table 3, located on page 8. As the measurement units for all variables were kept in their original state, the interpretation of the parameters in order to estimate effects on unemployment is simple and direct.

Table 1: Mean unemployment (standard deviation in *italics*)

		Unemployment		
Zone	Region	Before	After	Total
Unaffected	I	6.70	5.29	5.57
		0.50	*0.95*	*1.05*
	II	8.82	6.00	6.56
		0.33	*1.10*	*1.51*
	III	10.02	5.92	6.74
		2.53	*1.31*	*2.30*
	IV	9.57	6.99	7.50
		0.82	*1.14*	*1.50*
	X	7.63	4.52	5.14
		1.15	*1.72*	*2.04*
	XI	4.50	4.57	4.55
		1.15	*0.96*	*0.99*
	XII	7.27	4.26	4.86
		1.50	*0.97*	*1.62*
	XIV	10.48	6.84	7.57
		2.01	*1.45*	*2.14*
	XV	8.07	6.58	6.87
		1.35	*1.28*	*1.41*
		8.11	5.66	6.15
		2.23	*1.57*	*1.98*
Affected	V	12.97	7.99	8.99
		1.61	*1.19*	*2.37*
	VI	8.77	5.88	6.45
		1.13	*1.08*	*1.59*
	VII	10.35	6.27	7.09
		2.41	*1.01*	*2.14*
	VIII	12.35	8.29	9.10
		1.35	*0.89*	*1.91*
	IX	11.98	7.56	8.45
		1.25	*1.11*	*2.11*
	RM	10.93	6.85	7.66
		0.72	*0.94*	*1.87*
		11.23	7.14	7.96
		2.02	*1.36*	*2.23*

Figure 2: Affected regions

Figure 3: Unemployment over time by region (unaffected and affected, respectively).

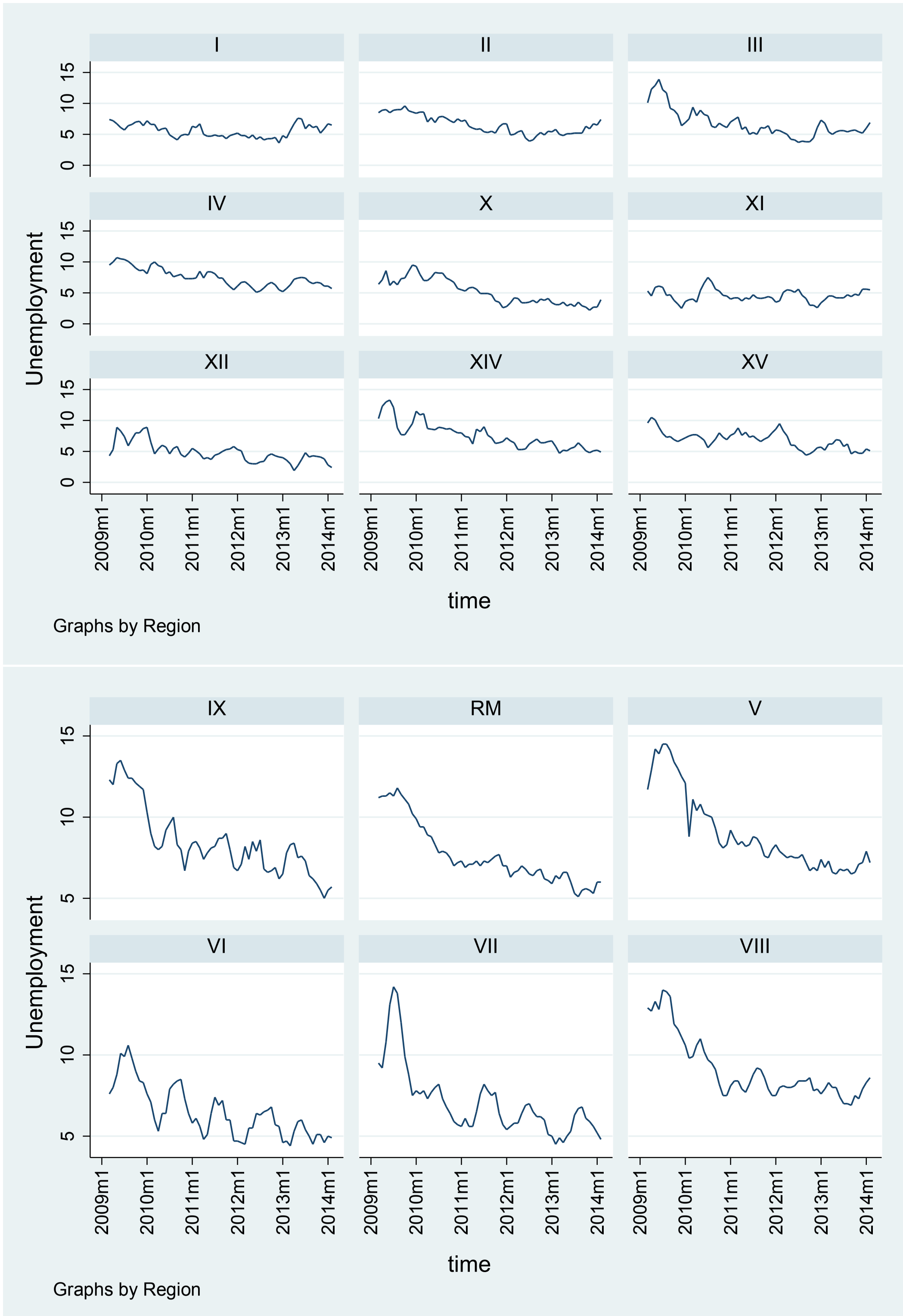


Table 2: Model on different subsamples (with no resampling)

	(1) Unemployment		(2) Unemployment		(3) Unemployment		(4) Unemployment	
Epicentral Distance	0.000230*	(2.56)	0.000240*	(2.68)	0.000295**	(3.03)	0.000275*	(2.96)
Earthquake	-0.550***	(-6.61)	-0.540***	(-5.75)	-0.591***	(-4.82)	-0.352	(-1.81)
Consumer Price Index (ln)	-3.664**	(-3.04)	-6.369***	(-5.50)	-6.744**	(-3.12)	-16.62	(-2.06)
Season Interaction	-0.308*	(-2.56)	-0.445**	(-3.40)	-0.538**	(-3.65)	-0.552**	(-3.63)
Unemployment Lag	0.790***	(26.97)	0.748***	(21.99)	0.738***	(21.35)	0.720***	(17.08)
Constant	18.80**	(3.23)	31.65***	(5.65)	33.49**	(3.31)	79.05	(2.12)
R^2	0.866		0.859		0.830		0.782	
Observations	885		705		525		345	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Model on different subsamples (with resampling)

	(1) Unemployment		(2) Unemployment		(3) Unemployment		(4) Unemployment	
Epicentral Distance	0.000230*	(2.00)	0.000240*	(2.01)	0.000295*	(2.32)	0.000275	(1.92)
Earthquake	-0.550***	(-3.82)	-0.540***	(-3.44)	-0.591***	(-3.43)	-0.352	(-1.48)
Consumer Price Index (ln)	-3.664***	(-3.73)	-6.369***	(-4.53)	-6.744**	(-3.28)	-16.62*	(-2.18)
Season Interaction	-0.308***	(-5.10)	-0.445***	(-6.06)	-0.538***	(-5.92)	-0.552***	(-4.11)
Unemployment Lag	0.790***	(31.35)	0.748***	(25.57)	0.738***	(21.99)	0.720***	(16.13)
Constant	18.80***	(4.03)	31.65***	(4.76)	33.49***	(3.48)	79.05*	(2.25)
R^2	0.866		0.859		0.830		0.782	
Observations	885		705		525		345	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6 Robustness Check

In this section, different robustness checks are performed in order to support (or contrast) the results shown in the last section. It is important to mention that the intention of these exercises are not to avail precise estimates, but to test their general meaning. That is, this section won't corroborate point estimates, but will judge the capacity of these estimates to stay consistent upon different intuitive tests.

6.1 Difference-in-Difference

As a first exercise I follow the hint given by table 1 and formally perform a Difference-in-Difference estimation. For that, I estimate the model:

$$U_{it} = \beta_0 + \beta_1 \cdot E_t + \beta_2 \cdot A_i + \beta_3 \cdot E_t \cdot A_i + \varepsilon_{it} \quad (2)$$

Where A_i is a dummy variable equal to 1 if region i was directly and substantially affected by the earthquake (i.e. the marked region on figure 2)[1]. The rest of the variables keep the same definition as of equation (1). In this case, the parameter of interest is β_3, as it is the Difference-in-Difference estimator that captures the effect over unemployment of being on an affected zone after the earthquake took place.

The results of the pooled regression of equation (2) are shown on table 4a, while table 4b shows the manual computation of this estimator using the values of table 1.

Table 4: Difference-in-Difference

(a) Regression Estimation

	(1) Unemployment	
Earthquake	-2.453***	(-13.87)
Zone	3.110***	(12.44)
Earthquake·Zone	-1.633***	(-5.84)
Constant	8.115***	(51.32)
R^2	0.474	
Observations	900	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Manual Computation

	After	Before	*Diff*
Affected	7.14	11.23	-4.09
Unaffected	5.66	8.11	-2.45
Diff	1.48	3.11	**-1.63**

As it is shown in table 4, the earthquake effectively reduced unemployment on affected regions. Nevertheless, this exercise isn't precisely a robustness check of the initial model, as it is a different specification (i.e. equation (1) and (2) are different), but it is a simple way to show the effect that is being studied.

[1]This definition may sound ambiguous (even though there is a common local understanding of these regions). A formal definition of them is the set of regions that have a locality that perceived the earthquake with at least a level of intensity of 7 in the Mercalli scale. This set of regions (the same as of table 1) is the one formed by the fifth, sixth, seventh, eighth, ninth and metropolitan region.

6.2 Temporal Placebo

A common[2] robustness check performed over regressions that estimate the impact of an event is a temporal placebo. This consist in changing the timing of the event to check if coefficients persist (i.e. they were not capturing the effect of the event, but something else) or they differ significantly (i.e. maybe they were actually accounting for the real effect).

In this case I perform a one-year-lagged earthquake placebo, in other words, re-estimate the model described by equation (1), but modifying the E_t variable so it is activated (takes value 1) when $t \leq 24$. In this way, I emulate a hypothetical (but false) earthquake taken place at the end of February of 2011. The results of this estimation are presented on table 5.

Table 5: Model on different subsamples (with temporal placebo)

	(1) Unemployment		(2) Unemployment		(3) Unemployment	
"Epicentral Distance"	0.0000953	(1.66)	0.0000795	(1.41)	0.000173	(1.84)
Placebo Earthquake	-0.159	(-1.45)	0.0559	(0.50)	0.0797	(0.45)
Consumer Price Index (ln)	-4.008*	(-2.19)	-9.676**	(-4.11)	-13.45**	(-3.43)
Season Interaction	-0.286*	(-2.46)	-0.406**	(-3.18)	-0.483**	(-3.36)
Unemployment Lag	0.826***	(35.96)	0.783***	(29.09)	0.768***	(24.64)
Constant	19.90*	(2.31)	46.43***	(4.21)	63.99**	(3.49)
R^2	0.863		0.856		0.827	
Observations	885		705		525	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notice how, after the placebo intervention, there are no significant estimates for β_1[3] nor β_2, i.e. this false one-year-lagged earthquake earthquake does not actually affect unemployment. This, at least partially, contributes to ensure that the estimates of tables 2 and 3 were capturing the effect of "something" that occurred around February of 2010.

6.3 Epicentral Placebo

A not-so-common robustness check is introduced: the epicentral placebo (from now on *fakequake*). The idea is straightforward: simulate false random epicentres of the earthquake. Just as the temporal placebo misplaced the temporal dimension of the event, fakequakes misplace the spacial dimension of the event by randomizing the latitude and longitude that characterizes the epicentre and, therefore, the epicentral distance.

For this test, 500 random epicentres were situated between latitudes -17 and -56 (in order to cover the whole length of Chile); and between longitudes -72 and -80 (to be fairly near to the actual epicentre, without entering further into the continent). The area where fakequakes were uniformly distributed is highlighted on figure 5.

[2]For a great example of this exercise applied to a natural disaster, see Imberman et. al. (2012).

[3]The "Epicentral Distance" variable is activated after the placebo is activated, not the real earthquake.

Figure 4: Epicentral distance for all regions

Figure 5: Epicentral placebo location

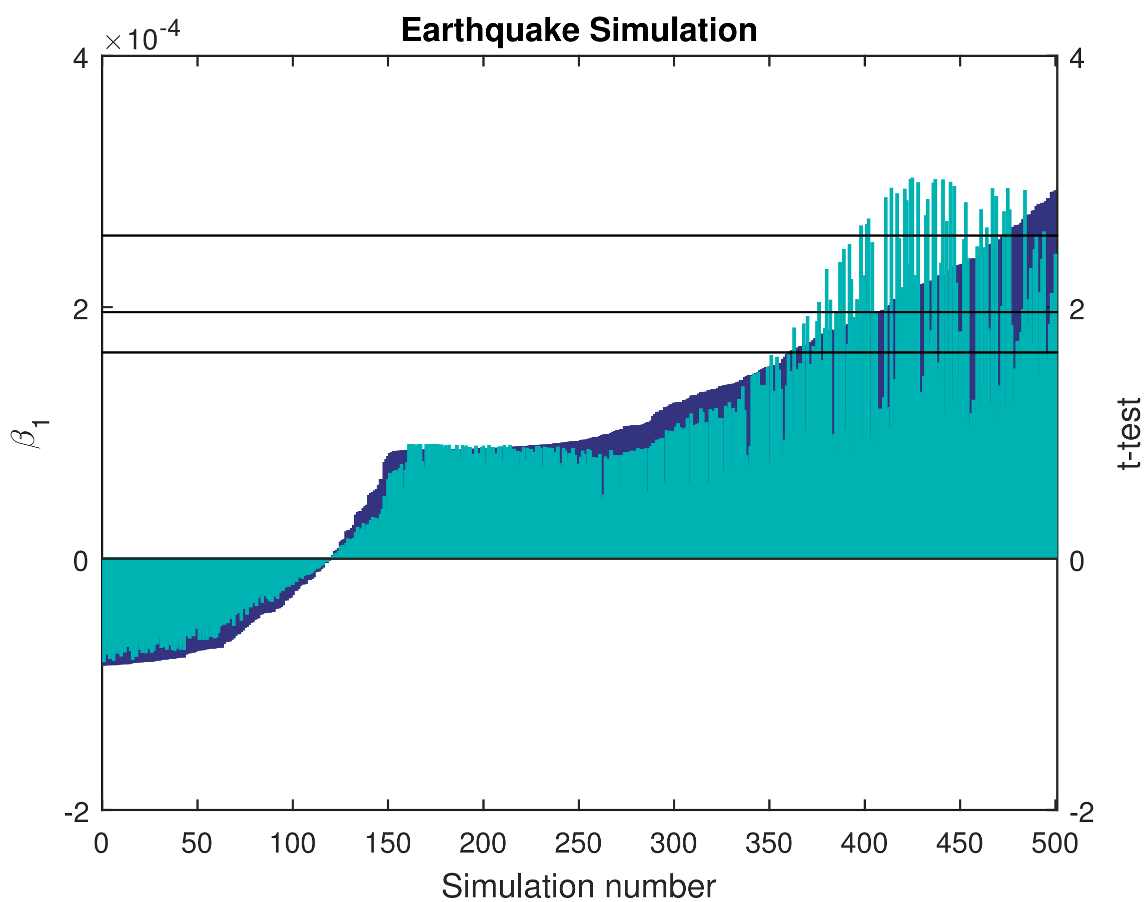
One might question the shape of the randomizing area, as it isn't very wide. The idea of this is not to introduce much variance in terms of longitude. The reason is that Chile has a particular "long and narrow" shape, so longitudinal variation of epicentres would preserve the ordinal characteristic of the epicentral distance and would not be of much use in the contrast.

After the randomization, the main model (described in equation (1)) was estimated 500 times with the same fixed effect specification, one for each fakequake. Estimates of each panel-data regression were stored and the parameter of interest (β_1) was tested over different significance levels. In this way, I state a rejection rate of the null hypothesis ($H_0 : \beta_1 = 0$) for each significance level, which can be found on table 6. Figure 6 also shows the simulated value of β_1 (dark) and its t statistic (light) for each fakequake. Significance thresholds are displayed respectively from top to bottom: 1%, 5% and 10%.

Table 6: Simulated rejection rate of H_0

	Significance		
	1%	5%	10%
Rejections	29	60	82
Rate	0.058	0.12	0.164

Figure 6: Simulated β_1 and t statistic



After looking at these results, one might that this robustness check invalidates initial conclusions, as the amount of rejections is statistically important. Nevertheless, when checking individually for those rejection cases it is easy to notice that these fakequakes' epicentres are actually pretty close to the real epicentre. The dots inside the highlighted area of figure 5 correspond to those simulated epicentres that spuriously present a significant coefficient estimate for β_1 at a 1% significance level. Indeed, they are in the neighbourhood of, and preserve the distance order of, epicentre (lat,long)=(-36.29,-73.24): the real epicentre. It is important to note that these rejections keep reducing while we narrow the randomization area, until they statistically disappear.

This exercise ensures that when displacing importantly the location of the event, no significant effect is estimated with this model. Therefore, this suggests that the results obtained in section 5 effectively account for an event occurred around the location of the real epicentre of the 27F earthquake.

As a final comment for this section, it is important to state that the model is also robust to the inclusion of other controls, such as aggregate economic activity, other measures of inflation, general performance expectations and additional unemployment lags. Estimates continue being significant and there are no mayor fluctuations from the point estimates presented in this document.

7 Conclusions

As a general conclusion, I find that the mid-run effect of the 27F earthquake on unemployment is a significant reduction on it, specially for those regions who were more affected, or were closer to the epicentre. This effect proved not to be significant in a short-run time span of 1 year after the event, maybe because of the evident level-drop of capital, which takes some time to adjust its effects on labor.

Nevertheless, I do not control for other important factors, such as other events near 27F that may affect unemployment, the government expenditure budgeted precisely because of the earthquake or labor migration issues. All of these examples may have their effects absorbed on the earthquake shock that I measure. This means I can't assure β_2 to be around 5$\sim$6% of average unemployment reduction, but probably to have a lower unemployment reduction impact (say 4%). However, the conclusions on the most relevant coefficient (β_1) stay totally intact, as they only explain a totally exogenous situation (27F impact as distance from the epicentre).

I would like to propose some extensions to my research before ending this document. First of all, the inclusion of more control variables is surely very important to assure a veridical estimation. The difficulty is to find data of these variables at a regional level on a monthly basis and from a trustworthy source. In this sense, I believe that analysing intra and interregional migration patterns would be a great extension to this study, as these kind of disasters encourage people to move on looking for a "cut of the booty" offered by the expansion of the demand of some sectors such as construction. Following this line, it would also be interesting to study the sectoral composition of unemployment for each region over the time, as it is expected that sectors such as tourism and commerce would experience an increase on unemployment, while construction and other prime necessity services shall reduce their unemployment levels.

It is in this way that the study of disasters may be very fruitful for public policies, specially in terms of resource focusing after the event. For instance, knowing that an intraregional labor migration from agriculture to construction (as these laborers may have a similar set of skills) is to be expected because of higher payments offered in the latter. As a general unemployment reduction trend is seen, this trend may be boosted, for instance, injecting subsides to the agricultural sector, so that the wages offered may be as competitive as the construction wages and in this way, other unemployed laborers may take a new job on construction or even the labor force may be incremented with fresh hands ready to get some good economical news after the shock, which would proportionally also reduce unemployment. These measures and many others (unemployment subside regulation, public technical-training courses, public and private business plan-of-action preparation, etc.) may be taken with less uncertainty after studying and measuring the impact of a natural disaster such as the 27F on the social and economical health of a country.

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