

Recovering from earthquakes, a synthetic control approach

The importance of institutions

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Introduction

- The number and the impact of natural disasters is increasing, as a result of increased vulnerability, since more people are living in dangerous places, and climate change (World Disasters Report, 2016)
- Immediate impact of disasters include deaths, destruction of infrastructure, displacement, and several other political, economic, and social effects.
- Chile is a highly seismic country that has experienced several high intensity earthquakes (1960, 1985, 2010).
- What are the short and long term effects in economic growth?
- What does growth theory say about the impact on the economy?
- What influences the recovery process after a natural disaster?
- Several factors have been reported: Institutions, trade openness, income level, corruption, state capacity, etc.

- ① Purpose of our paper: Analyze the impact of two earthquakes in Chile (1985, 2010) and compare the effects on economic growth on the affected regions, and then compare with the earthquakes in New Zealand and Japan during 2010-2011.
- ② Methodology: The Synthetic Control Method (SCM)
- ③ What explains the differences? Institutions, fiscal balance, other factors.

Literature review

- Empirical growth studies using standard tools often come up with unintuitive results. Skidmore & Toya (2002) and Loayza et al. (2012) found positive effects of certain types of natural disasters on economic growth (Climatic disasters and floods).
- On earthquakes, Loayza et al. (2012) found no effect on aggregate GDP growth, but positive in the industrial sector for developed countries.
- Main argument for explaining positive effects is the accelerated replacement of the capital stock (Skidmore & Toya, 2002).
- Entrepreneurial intention increases after a natural disaster because they generate necessity-driven opportunities. Monllor & Altay (2016), Patzelt & Shepherd (2011).
- Felbermayr & Gröschl (2014). Disasters, and earthquakes are always negative, but institutions help.
- Barone & Mocetti (2014). Case study using the Synthetic Control Method for two Italian regions. North region improves after earthquake, South declines. Differences explained by institutions.
- Other factors that affect the economic recovery after a disaster include effective leadership (Useem, 2015) and social capital (Putnam, 1993), which has been shown to increase after an earthquake (Dussaillant & Guzman, 2014).

Historic comparison

Chile earthquakes of 1985 and 2010

Table: A comparison of the earthquakes' direct damage. Source: EM-DAT. GDP from World Bank.

Variable	1985	2010
Magnitude of earthquake (Richter)	7,7	8,8
Most affected region in earthquake	Valparaíso	Maule
Total deaths	180	562
Total Affected*	1.482.275	2.671.556
Total losses (billions US\$)	1,5	30
Total losses (as % of GDP)	8,47%	13,73%

Historic comparison

Chile earthquakes of 1985 and 2010

Table: Chile before each earthquake

Variables	Chile 1984	Chile 2009	Source
GDP per capita - (current US\$)	\$1,637	\$10,243	World Bank
Public spending change - year of earthquake	27,64%	10,44%	World Bank
Internal conflict	6,58	9,75	ICRG
Government stability	3,25	8,42	ICRG
Law and Order	4	5	ICRG
Bureocracy Quality	2,58	3	ICRG
Trade Openness	50,58%	66,30%	World Bank
Inflation	19,86%	0,35%	OECD

The earthquakes in Chile, New Zealand and Japan

How do they compare?

Table: A comparison of the earthquakes' direct damage between countries.

Source: EM-DAT. GDP from World Bank.

Characteristics	Maule 2010	Tohoku 2011	Canterbury 2011
Magnitude (Richter)	8.8	9	6.1
Total deaths	562	19.846	181
Total affected	2.671.556	368.820	301.500
Total damage (billion US\$)	30	210	15
Losses as % of national GDP	13,73%	3.4%	10%
Reconstruction government spending (billion US\$)	8,41	250	10,14

Growth rates in Chile, New Zealand and Japan

Table: A comparison of GDP growth rates at national and regional level (year of earthquake). Sources: World Bank for national level, local government statistics agency for regional level.

Country	Growth rate
Japan	-0,10%
Tohoku	-0,05%
New Zealand	1,80%
Canterbury	5,14%
Chile-2010	5,80%
Maule-2010	0,68%
Chile-1985	3,87%
Valparaíso-1985	-0,41%

Chile, New Zealand and Japan

Comparison between countries

Table: Cross country comparison between Chile, New Zealand and Japan. Average institutions is the mean value between all the ICRG indexes, Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption.

Variable	Chile	New Zealand	Japan	Source
GDP per capita - 2009 (current US\$)	\$10,243	\$28,200	\$40,855	World Bank
Public spending change - year of earthquake	10.44%	6.24%	19.00%	World Bank
Government debt as % of GDP - 2011	11.10%	62.60%	177.50%	World Bank
Government deficit as % of GDP - year of earthquake	-3.45%	-4.01%	-9.10%	OECD
Average Institutions - 2009	0,80	0,93	0,82	ICRG
Trade Openness - 2009	66.30%	55.20%	24.50%	OECD
Inflation Rate - 2009	0,35%	2.10%	1.40%	OECD

Empirical methodology

The synthetic control method

- The synthetic control method (SCM) developed by Abadie & Gardeazabal (2003) provides a natural approach for evaluating the effects of an exogenous treatment that affects some areas.
- A counter-factual unit is created for the treated region from the pool of unaffected regions in the same country.
- Weights are chosen so that the synthetic control approaches the behavior of the treated unit before the treatment.
- With X being a matrix of the outcome variable values, and Z a matrix of covariates. A nested minimization problem is solved for estimating the weights.

$$(1) : \text{minimize}(X_1 - X_0 w)' V (X_1 - X_0 w)$$

$$(2) : \text{argmin}(Z_1 - Z_0 w^*(V))' (Z_1 - Z_0 w^*(V))$$

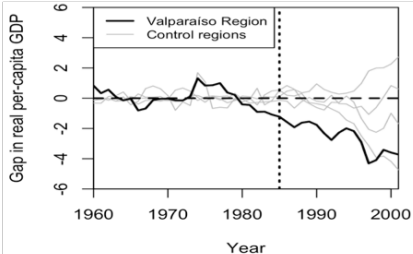
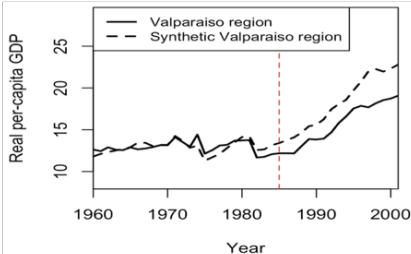
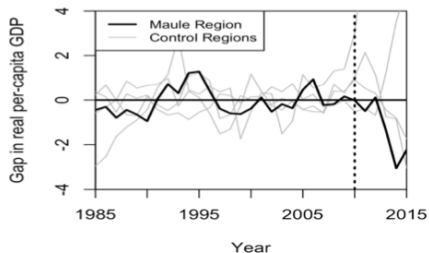
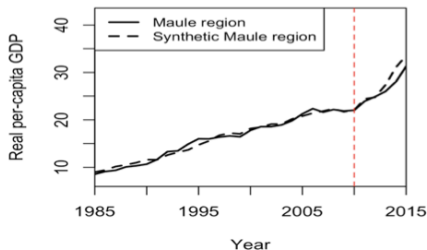
Empirical methodology

Data

- In the case of Chile, we use the following variables at a regional level: GDP per capita, share of population with tertiary education, and the following sectoral shares of GDP: agriculture, fishing, mining, manufacturing, energy, construction, retail, transport, financial, immobiliary, personal, and public sector. Central Bank and Mineduc (Education Ministry of Chile).
- For New Zealand. Besides GDP per capita, the following sectoral GDP shares were used: agriculture, administration, construction, education, financial, food, health, information, manufacturing, occupation, professional, public services, rental, retail, transport, wholesale, and others. As a measure of human capital, the percentage of the population with a tertiary educational level. Stats NZ and Education Counts NZ.
- For Japan, besides GDP per capita, sectoral shares of GDP on industry level were used (Primary, Secondary, and Tertiary industry). Data on employment was also available and used, as well as the number of universities. Statistics Japan.

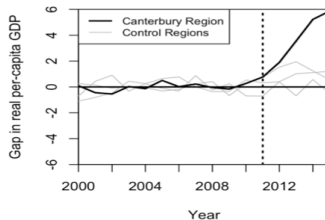
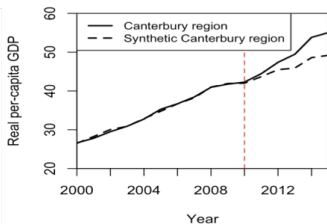
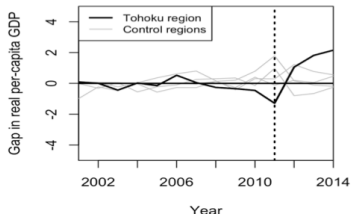
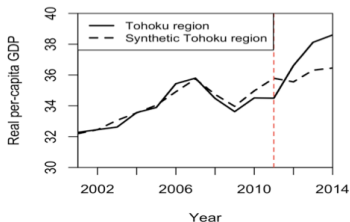
The synthetic control method

Synthetic control and placebo test for the earthquake of Maule (2010) and Valparaíso (1985)



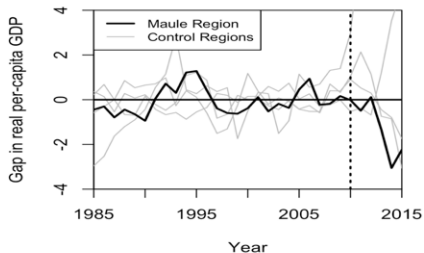
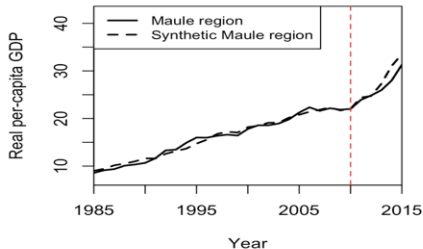
The synthetic control method

Synthetic control and placebo test for the earthquakes of Tohoku (2011) and Canterbury (2011)



The synthetic control method

Synthetic control and placebo test for the earthquake of Maule (2010)



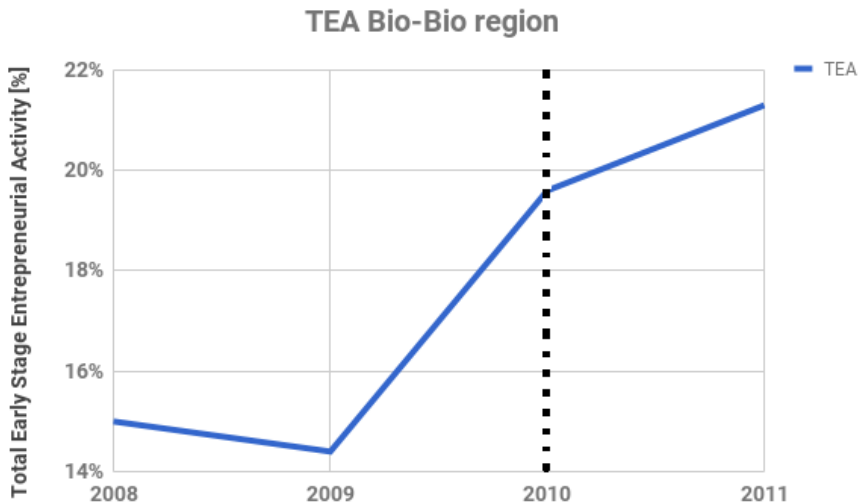
Conclusions

- We applied the SCM to estimate the impact of earthquakes in Chile, Japan, and New Zealand.
- We find that the economies of Canterbury and Tohoku achieved greater levels of GDP per capita in the years after the disaster than they would have without it. However, this says nothing about the aggregate effect in the country.
- In 2010, the Maule region experiences a slight decline in GDP (-0,59%), smaller than Tohoku's (-3,7%). We argue about the importance about fiscal capacity, which explains Tohoku's recovery. However, long term growth sustainability seems unlikely because of high deficits.
- The historic comparison in Chile provides further evidence about the importance of institutions. The impact of the earthquake of 1985, although weaker in magnitude and much less destructive than the one in 2010, produced a higher decline in Valparaíso's GDP (-10,03%), suggesting that the institutional improvements and better fiscal policies attenuate the negative effects of earthquakes.
- All our results are robust according to our placebo tests.
- Given the literature about natural disasters, other factors remain relevant for explaining the recovery process, such as leadership, social capital, and entrepreneurial intentions.
- From a public policy stand point, these are valuable lessons for a seismic country as Chile, but further research is needed.

Recovering from earthquakes, a synthetic control approach

Entrepreneurship activity after a disaster

Total Early Stage Entrepreneurial Activity for Bio-Bio region



The synthetic control method

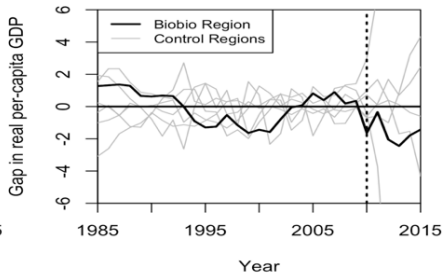
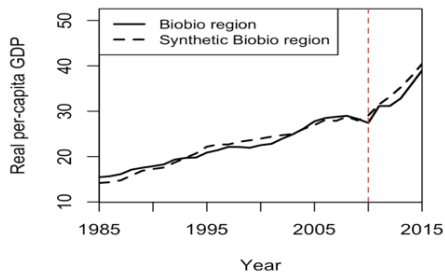
Optimization Results

Table: Synthetic control optimization results, weights and mean squared prediction error (MSPE)

	Maule 2010	Canterbury 2011	Tohoku 2011
MSPE	3.61E-01	8.50E-04	8.99E-04
MSPE ratio	7.55	186.60	29.71
Weights	Valparaíso (0.022)	Auckland (0.3)	Chugoku (0.255)
	Libertador Bernardo O'higgings (0.063)	Hawke's Bay (0.206)	Shikoku (0.001)
	Araucanía (0.25)	Manawatu-Wanganui (0.133)	Kyushu (incl. Okinawa) (0.743)
	De Los Lagos (0.66)	Tasman-Nelson (0.053)	
		Marlborough (0.09)	
		WestCoast (0.218)	

The synthetic control method

Synthetic control and placebo test for the earthquake of Biobío-Chile (2010)



The synthetic control method

Variables

Table: Variable weights from V-matrix for the Valparaíso earthquake.

Valparaíso 1985	Variables weights
GDP per capita	0.137
Sectoral shares:	
Agriculture	0.001
Fishing	0.124
Mining	0.091
Manufacturing	0.064
Energy	0.148
Construction	0.105
Retail	0.033
Transport	0.016
Other	0.281

The synthetic control method

Variables

Table: Variable weights from V-matrix for the Tohoku earthquake.

Tohoku 2011	Variable Weights
GDP per capita	0.663
Sectoral shares:	
Primary industry	0
Secondary industry	0.235
Tertiary industry	0.1
University count	0
Employed per capita	0.002

Chile, New Zealand and Japan

Comparison between countries

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Institutional variables - 2009:				
Voice and Accountability	0,79	1,00	0,83	ICRG
Political Stability and Absence of Violence	0,74	0,77	0,82	ICRG
Government Effectiveness	0,75	1,00	1,00	ICRG
Regulatory Quality	0,95	1,00	0,95	ICRG
Rule of Law	0,83	0,92	0,83	ICRG
Control of Corruption	0,75	0,92	0,50	ICRG
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