

Income Taxation and State Capacities in Chile: measuring institutional development using historical earthquake data

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Abstract

Building on the fiscal sociology paradigm, this paper argues that the development of the modern fiscal apparatus in Chile was product of a sectoral conflict around in the 1920's between the industrial and agricultural political elites. Particularly, this paper identifies the importance of the income tax, explaining and measuring how the tax contributed to the expansion of state capacities at the subnational level. Exploiting the quasi-randomness of earthquake shocks, I leverage a novel historical earthquake death tolls dataset and a Bayesian multilevel Poisson model to measure state capacities at the local level between 1900 and 2010. The results suggest that the implementation of the income tax has historically decreased the proportion of local deaths, and that the effect has been stronger in industrial localities. These two findings combined point out to the positive effects the emergence of a political challenger had on state-building.

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Students of the Latin American states have several *theories* to explain the causes and consequences of state capacities. Scholars also have countless alternatives to *measure* state capacities. However, there exists a huge deficit. Most state formation theories (just to name a few) are situated during precolonial times,¹ or during early² or late³ independent Latin America. Yet, we lack of a measurement that corresponds *temporally* with the theories we have. While our explanations of state-making are *historical* in nature, in practice, most available measurements capture *contemporary* levels of stateness. In this paper I try to bridge this gap by providing an explanation on the origins of state capacities in Latin America and a corresponding indicator able to capture *historical* levels of state capacities. This paper then seeks to contribute to the state formation literature in general, both from a theoretical and methodological perspectives.

Figure 1: Causal Mechanism



Building on the fiscal sociology paradigm,⁴ I argue that the implementation of the income tax contributed to form the Latin American state. And that the income tax was product of an inter-sectoral conflict between agricultural and industrial elites (see Figure 1). Analytically, I consider sectoral conflicts the spring of both fiscal expansion and state development. Economic sectors not only shape the economic landscape. Given that each sector has a corresponding political arm, the *sectoral economic* conflict is also a *political* conflict.⁵ Sectoral conflicts find their origins in the economic structural transformation characterized by “a secular decline of agriculture and substantial expansion of manufacturing.”⁶ These gradual long-term changes imposed tight constraints on the way politics was run by the incumbent landowning class, who had inherited its institutional privileges since colonial times.⁷ Exploiting the quasi-randomness of earthquake shocks, I leverage a novel historical dataset on Chilean earthquake death tolls and a Bayesian multilevel Poisson model to measure state capacities at the local level between 1900 and 2010. The capacity the Chilean state has had of enforcing and monitoring building codes throughout the territory has been a *reflexion* of the Chilean *overall* state capacities. I capture these state efforts (and the *outcomes* of these efforts) throughout time at the subnational level. The results suggest that the implementation of the income

¹ Mahoney [2010].

² See Kurtz [2013] and Soifer [2015].

³ Bahamonde [2017b].

⁴ For an excellent overview of both classic and new fiscal sociology refer to Martin et al. [2009, Ch. 1].

⁵ Bahamonde [2017a].

⁶ Johnston and Mellor [1961, 567].

⁷ Bahamonde [2017b].

tax has historically decreased the count of local deaths. This effect has been stronger in industrial localities, suggesting that the predominance of an institutional order that benefits the economic and political challenger (i.e. the industrial sector), increases overall state capacities. The rest of the paper proceeds as follows

pending.

I. FISCAL SOCIOLOGY, SECTORAL CONFLICTS AND STATE CONSOLIDATION

The expansion of the fiscal system has a long tradition of being associated with sectoral conflicts. For example, Schumpeter sees “taxation in terms of group conflicts,”⁸ while others see taxation as “an outcome of economic relations.”⁹ Following this tradition, I sketch the theory around the sectoral conflict that existed between the industrial and agricultural elites in Latin America. Class conflicts are more likely to resolve in favor of direct taxation when income inequality *among the elite* is low.¹⁰ Given that similar degrees of sectoral economic development can be converted into armies of similar capabilities,¹¹ elites will have incentives to reach agreements rather than engaging in conflict when their economic/military capacities are similar. This is because when levels of inter-elite inequality are low, war is more likely to exhaust all existent assets without producing positive outcomes for either sector,¹² putting then pressures to reach agreements instead of engaging in armed conflicts. In the Latin American context, considering the initial institutional and economical advantages the agricultural sector enjoyed since colonial times, reducing inter-elite inequality meant a rapid expansion of the industrial sector. Elsewhere, I have argued that the emergence of a strong industrial elite altered not only the structure of the economy but also the inter-sectoral balance of political power, making unsustainable the political monopoly run by the landed elites.¹³

A theory focused on sectoral conflicts offers also a theory of state consolidation. As others have argued, “state formation will be more likely to the degree that powerful individual actors form two groups on the basis of divergent economic and political interests.”¹⁴ State centralization affects landowners and industrialists in different ways. Consequently, every sector will have different preferences towards taxation and state centralization.¹⁵ On the one hand, as land fixity increases the risk premium of the landed elite’s main asset,¹⁶ they systematically resisted taxation. On the other hand, as capital could be reinvested in nontaxable sectors, industrialists’ preferences toward taxation were more elastic.¹⁷ Going beyond the conflictive nature of the implementation of the

⁸Monson and Scheidel [2015, 14].

⁹Seligman (1895). In Martin et al. [2009, 7].

¹⁰Tani [1966, 157] explains that the absence of “wealth groups” makes passing an income tax law easier.

¹¹Boix [2015].

¹²Richard Salvucci in Uribe-Uran [2001, 48].

¹³Bahamonde [2017b].

¹⁴Hechter and Brustein [1980, 1085].

¹⁵See Acemoglu and Robinson [2009, 289] and Best [1976, 50].

¹⁶Robinson [2006, 512].

¹⁷Hirschman [1970] and Ronald Rogowski in Drake and McCubbins [1998, ch. 4]. However, see Bates and Lien [1985, 15].

income tax, its very implementation produced a secular accumulation of know-how, particularly, of technologies able to monitor individual incomes. Observing individual economies and transforming private income into public property is what *causes* state consolidation.¹⁸ In fact, Musgrave [1992, 99] argues that since taxation (specially on incomes) requires such a high degree of state penetration, public finances offer the key for a theory of state-building.¹⁹ And while some situate the relevant state-building critical juncture at the end of the colonial period, before the class compromises I identify in this paper,²⁰ the implementation of the income tax was an important building block in this process.

In all Latin American economies during and right after the colonial period, agriculture was the most important sector.²¹ And by extension, agricultural political elites were the most powerful elite.²² Particularly for the Chilean case, Collier and Collier [2002, 106] have argued that initially the “national government was dominated by the central part of the country, with owners of large agricultural holdings playing a predominant role.”²³ There existed an important asymmetry, however. While both the agricultural and industrial sectors were growing at the same pace (see Figure 2), the latter were kept from participating in politics under fair conditions. This asymmetry led these two ‘antagonistic elites’²⁴ to two bloody civil wars. Zeitlin [1984, 23] argues that the civil wars challenged a “large landed property [elite against a] productive capital [elite].” However, war was not sustainable over time. Given their relative similar degrees of economic development and military capacities, the two elites opted for a political compromise.²⁵ In 1924, industrial elites accepted to be income taxed by agriculturalist incumbents in exchange of having a more open political system. The non-agricultural sector “(reluctantly) accepted taxation, *while demanding state services and expecting to influence how tax revenues were spent.*”²⁶ In this paper I measure the extent these services actually helped the Chilean state to consolidate further, boosting its overall state capacities.

¹⁸Musgrave [1992, 98] and Moore [2004b, 298].

¹⁹Indirect taxes are, *ceteris paribus*, easier to levy, and hence this kind of revenue is generally considered “unearned income” (Moore [2004b, 304]) or “easy-to-collect source of revenues” (Coatsworth and Williamson [2002, 10]). Given the relatively lower costs states have to incur to collect them, indirect taxes have a very low impact on state-building (Moore [2004a, 14]). Krasner [1985, 46] explains that “tariffs and export taxes are easier to obtain than direct taxes, which require high levels of bureaucratic skill and voluntary compliance.” In fact, when early Latin American states depended heavily on the taxation of international trade, the state apparatus tended to be less developed (Campbell [1993, 177]). Since customs administrations in the region have always been concentrated in a few critical locations, especially ports, tariffs and customs duties did not require an elaborate fiscal structure (Bertola and Ocampo [2012, 132]).

²⁰Kurtz [2009, 2013], Soifer [2015]

²¹Keller [1931, 13].

²²Wright [1975, 45-46].

²³Similarly, McBride [1936, 15] explains that “Chile’s people live on the soil. Her life is agricultural to the core. *Her government has always been of farm owners. Her Congress is made up chiefly of rich landlords.* Social life is dominated by families whose proudest possession is the ancestral estate.” Emphases are mine.

²⁴Keller [1931, 37-38].

²⁵Geddes [1991] argues that competition between two rival parties of about the same size creates clearer incentives to invest in political institutions.

²⁶Carmenza Gallo, in Brautigam et al. [2008, 165]. Emphases are mine. She refers specifically to nitrate producers.

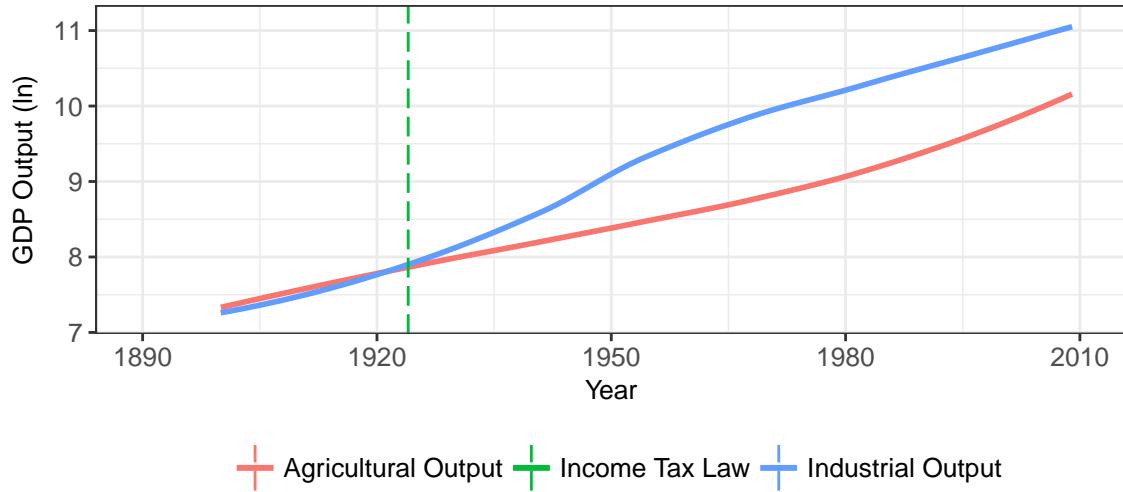


Figure 2: *Industrial and Agricultural Outputs, and The Passage of the Income Tax Law in Chile*

II. FROM EARTHQUAKE DEATH TOLLS TO STATE CAPACITIES

More than being blessed, the literature is in fact cursed with the over abundance of poor indicators of state capacities.²⁷ Soifer [2012, 589] explains that there exists a “veritable industry of indices measuring state weakness, state failure, and state fragility [which] has cropped up in recent years.” Yet, as Fukuyama [2013, 347] explains, its abundance “points to the poor state of empirical measures of the quality of states.”²⁸ The literature points out to two main concerns. First, ‘most fragility indices barely satisfy scientific standards.’²⁹ And second, most indices are conflated with analytical and conceptual problems. For example, often times analyst measure state capacities looking at the capacity of the state of protecting the rule of law or the independence of the judiciary.³⁰ However, as Kurtz and Schrank [2007, 543] correctly explain, these measures are confounded “with policy preferences over the structure of private property rights.” This is problematic since the sources of these data are elite interviews. To “the extent that public bureaucracies *are* effective in imposing taxes or regulatory demands [...] they are likely to be judged ‘burdensome’ and ‘growth-inhibiting’ by many businesspersons,”³¹ introducing in this way systematic measurement error.³² Expert surveys suffer from the same problem.³³ Beyond measurement, the problem is conceptual as well. As Soifer [2008, 247] puts it, there is a widely spread “problem of misalignment between dimension and indicator.” For example, the U.S.S.R. did have a strong state, however it did not protect property rights.³⁴ Furthermore, the World Bank offers a series of widely used indicators. These series are “[c]learly, the most comprehensive source for cross-national measures of governance.”³⁵ One of the dimensions is the absence of violence. However, “there isn’t much byway of street crime or military

coup attempts in North Korea,”³⁶ a state that can barely provide basic services to its population. Others have focused on tax rates.³⁷ However, in late imperial China, “the high taxes on peasants [...] were the result of rulers’ lack of power. Chinese rulers consistently attempted to limit official’s excessive extractions from the masses, but were unable to do so.”³⁸

This paper identifies a third limitation. Besides of their conceptual and analytical problems, most measurements provide a rough approximation of *contemporary* state capacities. Just to name a few examples, Soifer [2012, 585] “builds a new measure of state capacity for [...] contemporary Latin America [combining] multiple dimensions (extraction, security, and the administration of basic services).” Kurtz and Schrank [2012, 618-619] propose an experimental design based on list-experiments³⁹ to study (in an unbiased way) bureaucrat’s opinion on whether “the bureaucracy was really based on a competitive, meritocratic process; whether tenure protections are effective; whether extralegal payments or extortion take place,” among others. Finally, Soifer and Luna [2016] employ a survey-based design to measure sub-national state capacities. While these measurements overcome the problems mentioned above, they do not help us to study state capacities in a historical setup. Economic historians and students of political development have offered other measures that seek (or could potentially be used) to capture historical levels of state capacities, such as the opening of postal offices,⁴⁰ the administration of national censuses,⁴¹ vaccination,⁴² the investment in public goods such as infrastructure, roads,⁴³ electrification (measured as light intensity per pixel),⁴⁴ and railroads.⁴⁵ Others have used economic growth,⁴⁶ which is also problematic.

To solve these limitations, I propose earthquake death tolls as an alternative measurement of

Mahoney?

explain why

²⁷Hanson and Sigman [2013, 10] compiled 24 different types of measurements of state-capacities, while Mata and Ziaja constructed a combined measurement of 12 other indicators.

²⁸I agree with Soifer [2012, 586] in that most “scholarship on state capacity [...] lack[s] a satisfying conceptualization and measurement scheme for this concept.”

²⁹Mata and Ziaja, 35.

³⁰See for example Besley and Persson [2009, 1237].

³¹Kurtz and Schrank [2007, 542]. Emphasis in original.

³²See also Kurtz and Schrank [2012, 618].

³³Fukuyama [2013, 349].

³⁴Hence, it is advisable to “explicitly avoid an emphasis on outputs that are at the center of political or policy debates, such as property rights” (Kurtz and Schrank [2012, 619]).

³⁵Kurtz and Schrank [2007, 543].

³⁶Fukuyama [2013, 348].

³⁷Besley and Persson [2014].

³⁸Kiser and Tong [1992, 301].

³⁹Refer to Aronow et al. [2014], Blair and Imai [2012], Blair et al. [2014], Corstange [2008, 2010], Glynn [2013], Imai [2011], Imai et al. [2015], Kane et al. [2004], Kiewiet de Jonge [2015].

⁴⁰See for example Acemoglu et al. [2016].

⁴¹See for example Soifer [2013] and Centeno [2002].

⁴²Soifer [2012].

⁴³See for example Mann [1984, 2008], Acemoglu [2005], Saylor [2012], Thies [2009], Besley and Persson [2010]. However see Soifer and vom Hau [2008, 226].

⁴⁴Huntington and Wibbels [2014].

⁴⁵Saylor [2012, 302] and Coatsworth [1974]. However, this measurement is debatable since “railroads were often constructed by private actors” (Soifer [2012, 593], footnote #11).

⁴⁶Fearon and Laitin [2003].

historical state capacities. While “[e]arthquakes alone claim thousands of lives a year,”⁴⁷ “[d]isasters are not as well studied [...] in the field of political science.”⁴⁸ Building on Mann [1984, 113], the proposed measurement captures state’s ‘infrastructural’ power.⁴⁹ “Natural hazards can be seen as a function of a specific natural process and human [...] activity.”⁵⁰ Since disasters happen at random, the only part that is left unexplained is the systematic human component, which is what the measurement captures. Earthquakes, in particular, happen at random, and hence they represent a completely exogenous shock to the affected locality.⁵¹ Earthquakes are orthogonal to levels of state and economic development development too,⁵² and by extension, they happen at any level of state capacity. Consequently, keeping earthquake magnitudes constant, (weighted) death counts should be attributed to the (in)capacity of the states of investing in preparedness and mitigation institutions.⁵³ I focus on earthquakes and not on other natural disasters such as ‘extreme temperature events, floods, landslides, and windstorms’⁵⁴ because earthquakes cannot be foreseen, and such, they put to a test the capacity of the states to have their preventive institutions *already* in place and in good shape. State capacities consist of sustained *proactive* efforts of enforcing institutions throughout the territory, and hence quick *reactions* to particular events should *not* be considered state-*making*.⁵⁵ Moreover, unlike other natural disasters, earthquakes do not allow actors to adapt their behavior while the quake is happening. In fact, Brancati [2007, 716] explains that “[e]arthquakes may provoke conflict more than any other type of natural disaster *because* they have rapid onsets [and] are not predictable.”⁵⁶ For example, in the case of famines, the institutions of “calamity relief in India [...] emphasize[s] the need for local administrators to look for *signs*, such as large drops in food production and increases in food prices, which *signal* an impending crisis.”⁵⁷

The capacity states have of deploying inspectors throughout the territory to enforce quake-sensitive zoning and building codes is a reflexion of the overall levels of a country’s state capacity. Since “[e]arthquake-resistant construction depends on responsible governance,”⁵⁸ state capacities

⁴⁷Anbarci et al. [2005, 1908].

⁴⁸Brancati [2007, 719].

⁴⁹He defines infrastructural power as “the capacity of the state [to] actually [...] penetrate civil society, and to implement logically political decisions throughout the realm.”

⁵⁰Raschky [2008, 627].

⁵¹Brancati [2007, 728] explains that “earthquakes constitute a natural experiment.” Gignoux and Menéndez [2016, 27] also point out “that the occurrence of earthquakes can be viewed as quasi-random [allowing the analyses of] these events as a set of repeated social experiments.” Caruso [2017, 32, unpublished] also “[exploits] the exogenous variation in the location and timing of natural disasters, as well as the exposure of different cohorts to the shock.”

⁵²Kahn [2005, 271] and Brancati [2007].

⁵³To make sure, while “earthquakes may not be preventable, it is possible to prevent the disasters they cause” (Escaleras et al. [2007, 209]). Similarly, Anbarci et al. [2005, 1911] explain that “the potentially devastating effects of major earthquakes are, if not preventable, at least subject to significant mitigation.” For a similar approach, see Noji [1996, 130].

⁵⁴Kahn [2005, 280].

⁵⁵In other words, other “natural disasters can be foreseen (or predicted with some probability) and thus measures can be taken to limit their severity” (Anbarci et al. [2005, 1908]).

⁵⁶Emphasis is mine.

⁵⁷Besley and Burgess [2002, 1423]. Emphases are mine. In fact, as Kahn [2005, 273] points out to the very non-significant low correlation between predictable and unpredictable natural disasters.

⁵⁸Ambraseys and Bilham [2011, 153].

act as a scope condition, particularly, undermining or permitting the *implementation* of these norms. For example, [Bilham \[2013, 169\]](#) explains that “although engineering codes may *exist* [,] mechanisms to *implement* these codes are largely unavailable”⁵⁹ in low-capacity states. And such, this type of measurement captures state outcomes.⁶⁰ The literature on construction agrees on that “[e]arthquake-resistant features are costly to verify after construction is complete [...] Steel reinforcement bars make a well-known contribution to earthquake resistance in concrete buildings[,] not only is the steel itself invisible [...] but the durability of the steel depends on the quality and quantity of concrete around it.”⁶¹ This is the so called ‘cover-up’ concept: “inappropriate foundations can be hidden beneath walls, shoddily assembled steel work can be hidden beneath concrete [and] poorly mixed concrete can be hidden behind paint.”⁶² Only states with higher capacities overcome their logistic limitations and successfully enforce these regulations at the local level. As others argue, “the effects of natural hazards [do] not solely depend on a region’s topographic or climatic exposure to natural processes [...] but [on] the region’s *institutional* vulnerability.”⁶³

Properly enforced and implemented building codes, among other mitigation measures, not only save lives. These kinds of institutions embody the most basic form of social contract that exists between the state and its subjects. The collapse of commerce buildings and private houses trigger higher levels of looting and social unrest. States are interested in preventing looting and social unrest because elected officials, as the visible faces *the state*, care not only about their electoral survival (or just ‘survival’ in the case of unelected officials), but also about the legitimacy of whole apparatus. That is, in the event of social unrest, not only the essential social Hobbesian-like contract is broken but also the expectations for social peace and the ability of the state to monopolize physical violence are questioned.⁶⁴ The physical presence of the state literally crumbles when institutions of social coercion and discipline such as state schools, prisons and police stations, collapse. For example, when the 7.0 earthquake hit Hati in 2010, the *Prison Civile de Port-au-Prince* had a population of 4,500 inmates. During the quake, five inmates died. As a prison guard describes, *everyone escaped. Everyone. Except the dead.* This natural disaster exacerbated the already existent chaos, freeing “gang bosses, kidnappers, gunmen,” among others.⁶⁵ Critically, under these circumstances, the

⁵⁹Emphases are mine.

⁶⁰Fukuyama [2013] is very critical of ‘outcome-oriented’ measurements. However, this outcome is different. Unlike the proportion of tax over GDP which could end up being wasted (p. 353), or “educational outcomes [which depend] much more strongly on factors like friends and family” (p. 355), death tolls associated to earthquakes are *not* ‘hard to measure’ (p. 356) neither they are subject to ‘normative’ concerns. I also disagree in that ‘econometric techniques’ to control for these and other factors add ‘another layer of complexity.’ Similarly, [Kurtz and Schrank \[2012, 619\]](#) explain that the ‘problem [...] with output based measures is that they necessarily include information on policy choice.’ However, it would be hard to say that people’s lives are subject to ideological or policy ‘preferences.’

⁶¹Keefer et al. [2011, 1531].

⁶²Bilham [2013, 167].

⁶³Raschky [2008, 628]. Emphasis is mine.

⁶⁴Others have studied how in some context earthquakes damage interpersonal trust. For example, [Carlin et al. \[2014, 419\]](#) argue that “state capacity plays a decisive role in determining natural disasters’ consequences for social capital.”

⁶⁵Reed [2011]. See also [Laursen \[2010\]](#).

legitimacy of the state, and particularly, the *tax state*, reduces to zero. Thus, officials (elected or unelected), care about the potentially negative outcomes the lack of building code enforcement might cause. For humanitarian or selfish reasons, it is in their best interest to make sure that these institutions are enforced throughout the territory. Should the state fail, its extractive enterprise will be the first one in being scrutinized.

This measurement has a number of advantages and disadvantages. Unlike survey-based or policy-based measures, earthquake death tolls are an *objective* measurement of earthquake preparedness,⁶⁶ an activity that *any* state *must* perform.⁶⁷ Kurtz [2013, 58] for example explains that “the best measures [of state capacities] would be of the sorts of activities that all (or nearly all) states consider to be of primary importance.” Soifer [2008, 235-236] divides the state infrastructural power in three layers, ‘national capabilities,’⁶⁸ the ‘weight of the state’⁶⁹ and a ‘subnational’ component which tracks “the ability of the state to exercise control within its territory.” Given that death tolls are a function of how building codes are *enforced* by the state *throughout the territory*, earthquake death tolls (as a measurement of state capacities) map well into the first and third components. For example, Anbarci et al. [2005, 1910] explain that “while Iran has building codes which are comparable to those existing in the United States, they tend to be enforced only in the country’s larger cities,” failing to monitor the countryside, which was where most of the deaths occurred in the 6.4 earthquake in Changureh in 2002.⁷⁰ This measurement has a number of drawbacks, however. Obviously, the country needs to have earthquakes, possibly limiting the number of potential cases. However, most “earthquakes occur at the various borders of the Pacific plate, the Western border of the Latin American plate, and the boundaries between the African, the Arabic and the Indian plates and the Eurasian plate,” allowing potential cross-country comparisons within most of the developing world.⁷¹ There are countries, like India or the United States, where earthquakes happen in certain regions only, and presumably, state earthquake mitigation policies are targeted to specific areas, possibly undermining the assumption that these kinds of policies should penetrate

⁶⁶That is, “it does not rely on an effort to measure the beliefs of citizens about the nature of the state, the legitimacy of its leaders or the institutional procedures that selected them, or even perceptions of the efficiency of public bureaucracies” (Kurtz and Schrank [2012, 616]).

⁶⁷I agree with Kurtz and Schrank [2012, 619] in that an “output-linked approach [...] should only examine public sector outputs that are not particularly politicized, and generally perceived to be essential state functions across a very broad set of states.” In fact, he mentions building codes as one possibility. Similarly, Carlin et al. [2014, 422] explain that “a basket of ‘minimal’ state functions [typically includes] primary education, public health, rule of law, public finance management, and disaster relief.”

⁶⁸This layer ‘sees state infrastructural power as a characteristic of the central state’.

⁶⁹This relates to ‘how the exercise of state power shapes the society it controls.’

⁷⁰Similarly, Bardhan [2016, 865] explains that “unlike in the case of some macroeconomic policies, [...] the effectiveness of the state varies enormously across localities and administrative levels within the same country.”

⁷¹Keefer et al. [2011, 1534]. From a population size perspective, this measurement is also convenient. A “quarter of the world’s population inhabits [...] the northern edge of the Arabian and Indian Plates that are colliding with the southern margin of the Eurasian Plate” (Bilham and Gaur [2013, 618]). Finally, other measurements also are contingent on the context. For example, Soifer [2012, 593] proposes a measurement of administrative capacities focusing on how states are able to enforce voter registration ‘where voting is mandatory.’ This strategy evidently shortens the sample to only democratic countries, introducing potential sample selection biases.

the ‘entire’ territory.⁷² Another potential concern is that the ability of counting the death might be a function of state capacities itself.⁷³ However, civic organizations, the Catholic Church, and particularly, the press (national and local) have been the main entities who willingly or not have carried out the task of enumerating casualties. Another concern has to do with the measurement of the magnitudes. Before the instrumental period, magnitudes were obtained in an estimative way. And while there are methods to approximate historical felt magnitudes to instrumental-like intensities,⁷⁴ this unfortunately adds more than one layer of complexity. All in all, this measurement offers a rough approximation of historical state capacities. And while some econometric techniques might ameliorate some of the problems, it is unlikely that they disappear completely.

III. MULTILEVEL ANALYSES

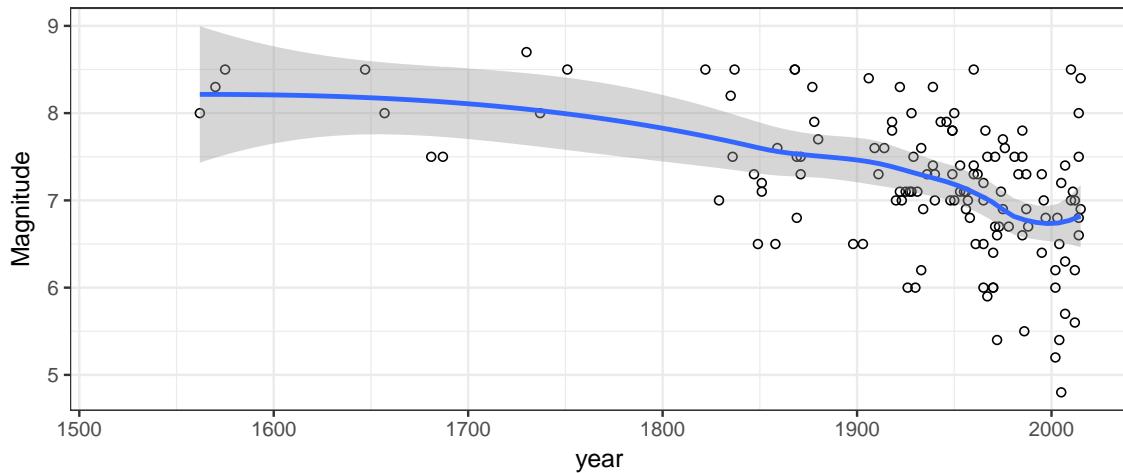


Figure 3: Time Cross-Sectional Earthquakes in Chile 1500-2010

I constructed a novel dataset using the *Significant Earthquake Database* compiled by the National Centers for Environmental Information (NOAA) as a starting point.⁷⁵ The dataset ‘contains information on destructive earthquakes from 2150 B.C. to the present,’ and records the number of deaths,⁷⁶ the magnitude and year, and the latitude and longitude of every quake. Using archival census data from 1907 to 2012,⁷⁷ I complemented the NOAA dataset with local population at the

⁷²Dunbar et al. [2003, 164] explains that the Indian state implements targeted policies (that might not necessarily correspond to the administrative areas) based on isoseismal maps that define different zones of seismic hazard.

⁷³If this were true, states with higher capacities would have higher death tolls, while states with lower capacities, due to their incapacity to count, lower death tolls.

⁷⁴Szeliga et al. [2010].

⁷⁵[NGDC/WDS].

⁷⁶Importantly, the NOAA distinguishes earthquake deaths from total deaths (which includes tsunami casualties). I use just the former variable.

⁷⁷Particularly, censuses of 1907, 1920, 1930, 1940, 1952, 1960, 1970, 1982, 1992, 2002 and 2012. Some of them were kept at the *Biblioteca Nacional* and others at the *National Statistic Institute* historical library.

municipality level at the moment and place of each earthquake. That way I am able to weight the death toll by local population. Using archival census data as well, I also considered the main economic activity of the affected municipality,⁷⁸ and also whether the affected locality was urban or rural.⁷⁹ The death tolls proportionated by the NOAA dataset were contrasted case by case with historical press archival information,⁸⁰ while magnitudes were compared to the **International Seismological Centre**. All these are subnational-level variables. Next, I included national-level indicators that aim to proxy sectoral conflicts. Following [Bahamonde \[2017b\]](#) and [Bahamonde \[2017a\]](#), I proxy sectoral competition and specifically, the degree in which the industrial elites challenged incumbent landowners, using industrial and agricultural sectoral growth rates as presented in the **MOxLAD** data (see [Figure 2](#)).⁸¹ The dataset spans from 1900 to 2010. According to [Astorga et al. \[2005, 790\]](#), these data provide extended comparable sectoral value-added series in constant purchasing power parity prices.

Chile is a good case since it has considerable variance regarding magnitudes and locations of the earthquakes. [Figure 3](#) plots the earthquakes, the years and the magnitudes, while [Figure 4](#) plots the geographical distribution and magnitudes of the quakes. Both plots consider the full sample starting in 1500 and ending in 2015. The northern part of Chile has historically been an industrial region, while the southern part of Chile has traditionally been an agricultural region. Relatedly, both regions vary according to their climate as well. Chile is arid in the north, limiting agricultural activity, and has a temperate oceanic climate in the south, a more appropriated climate for agriculture. Distance from Santiago, the capital city located at the center (around latitude 33°), might impose some degree of difficulty for the central government to reach out the farthest northern/southern parts of the territory. However, given that earthquakes happen at various latitudes and in different magnitudes, both regions have been exposed indistinctly to a wide range of shocks. There is also variance considering longitude. Closeness to the Andean mountains (around longitude 70°) determines the ruggedness of the terrain, presumably making it harder for the state to penetrate these areas.⁸² However shocks have affected the territory from coast to mountain.⁸³ In sum, quakes have shocked the country regardless of longitude and latitude, distance from the center, type of climate and main economic activity.

⁷⁸Agricultural, industrial, or mixed (i.e., both agricultural and industrial).

⁷⁹If more than 50% of the population lives in an urban setting, I assigned a 1 to that municipality, 0 otherwise.

⁸⁰*El Mercurio* and *La Nación* newspapers, both kept at the *Archivo de la Biblioteca Nacional de Chile*.

⁸¹“These data build on the studies and statistical abstracts of the Economic Commission for Latin America, but also rely on Mitchell’s International Historical Statistics, International Monetary Fund’s International Financial Statistics, the World Bank’s World Development Indicators and a variety of national sources.” I used the *agriculture value-added* and *manufacturing value-added* variables. The former measures “the output of the sector net of intermediate inputs and includes the cultivation of crops, livestock production, hunting, forestry and fishing.” The later “[r]eports the output of the sector net of intermediate inputs.” Both of them are expressed in local currency at 1970 constant prices.

⁸²Moreover, [Brancati \[2007, 729\]](#) explains that “[e]arthquakes often occur in mountainous areas.”

⁸³Since “most of the damage in major earthquakes occurs within 30 km of the epicenter,” ([Dunbar et al. \[2003, 172\]](#)) I don’t necessarily drop quakes that didn’t happen on land. While the epicenter might have happened a few miles away from the shore, the consequences certainly reached the land.

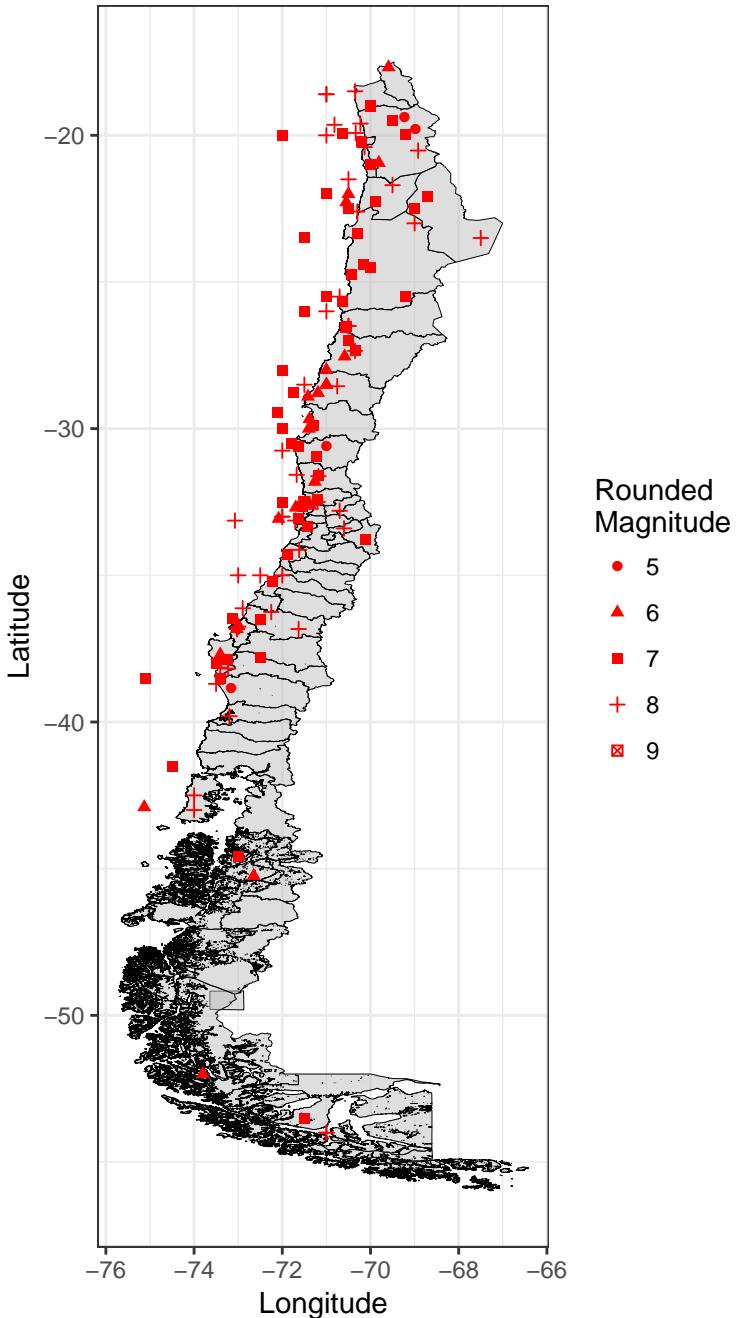


Figure 4: Geographical Distribution of Earthquakes in Chile 1500-2015

The unit of analysis is the earthquake.⁸⁴ As an event, each earthquake has a death toll, a subnational location (a municipality) identified by its latitude and longitude, a magnitude, a local economic activity, a municipal population, and an urban/rural setting. All these factors are subnational. At the national level, the design considers sectoral outputs, year, and a dummy variable

indicating whether in a given year the income tax was adopted. Specifically, using a Bayesian Poisson regression,⁸⁵ I model the number of dead individuals caused by earthquakes, controlling for a number of relevant factors.⁸⁶ The main independent variables are the proportion of national agriculture output relative to industrial output, and a dummy variable which indicates whether by year t the income tax law has been implemented. I expect death tolls to be lower when the national proportion of agricultural output decreases. Given that the historical powerful sector and its corresponding political elites has been the agricultural economy, a lower agriculture/industry proportion would indicate a contested political economy. Thus, when the relative sectoral leverage of the landowning (industrial) elites decreases (increases), elites would have incentives to invest in state-making institutions that would translate into lower death tolls. Secondly, the implementation and *praxis* (or ‘learning by doing’) of the income tax gave the state the necessary know-how to penetrate individual economies. In turn, it gave the *tax state* the capacity to monitor and enforce building codes/practices at the local level.

Since the ‘treatment’ (the proportion of agricultural output relative to industrial output, and the implementation of the income tax) takes place at the national level but the outcome (death tolls associated to earthquakes) is measured at the local level, I implement a multilevel model.⁸⁷ Additionally, I include year fixed-effects to account for unobservable/unmeasured yearly factors such as the evolution of the political system, demographic, climate and cultural changes and economic shocks (both national and international).⁸⁸ In concrete, the multilevel component of Equation 1 allows the slopes of the national proportion of agriculture relative to industry ($\beta_{1,j}$) and the earthquake’s magnitude ($\beta_{2,j}$) to vary by subnational sectoral predominance indexed by j . Subnational sectoral predominance serves as a rough proxy for the institutional setting established at the local level. Given that initial institutional, economic and political conditions were oriented to give unfair advantage to agricultural incumbents,⁸⁹ industrial sectoral predominance at the local level denotes a situation where there was high sectoral contestation, causing then more institutional investments. As explained above, the latitude where the earthquake occurred was included to

⁸⁴Kahn [2005, 273] also considers that “the unit of analysis is a disaster.”

⁸⁵Anbarci et al. [2005, 1907] use “a Negative Binomial estimation strategy with both random and fixed estimators” to estimate death tolls, Kahn [2005, 276] estimates a Zero Inflated Negative Binomial model, Brancati [2007, 729] uses “a negative binomial model with robust standard errors clustered by country,” and Escaleras et al. [2007] uses “a Negative Binomial specification.” Yet, no study tests for over dispersion. In my dataset I do not find evidence for that, hence I employ a Poisson model.

⁸⁶Undoubtedly, there are many more factors that might increase the death tolls. Ambraseys and Bilham [2011, 154] for example explain that the “number of fatalities depends on whether an earthquake happens at night or during the day, in the winter or in the summer, in a mountainous region or in a valley, after strong and protracted fore-shocks and with or without warning.” While in my model some of these factors are accounted for, I do not have complete data on the hour of the shock. However, Lomnitz [1970, 1309] explains that “some of the larger Chilean earthquakes which have caused deaths” between the 1900’s and the 1960’s have been afternoon quakes. See specially Table 1 in p. 1310. Other factors such as “the speed of tectonic movements [and] the degree to which the lower plate bends the upper plate” and the focal depth (Keefer et al. [2011, 1534]) could not be included due to the lack of complete historical data. However, the year fixed effects could pick up at some extent these unmeasured components.

⁸⁷Gelman and Hill [2006, 237]. I do not claim in any way this is a causal method.

⁸⁸Brancati [2007, 729] also includes in his analyses “year-fixed effects to control for trends over time.”

⁸⁹See Bahamonde [2017a].

control for the proximity to the Andean mountains. This variable also controls for a built-in tectonic predisposition of a higher propensity of earthquakes. Longitude controls for climate and other unobserved conditions that make agricultural development more difficult. In turn, both measurements serve as good proxies for terrain ruggedness and the difficulties the state had to face to centralize political power. More formally, I fit the next equation,

$$\begin{aligned} \text{Deaths} &\sim \text{Poisson}(\lambda_i) \\ \log(\lambda_i) = &\mu + \beta_{1j} \text{Proportion}_i + \beta_{2j} \text{Magnitude}_i + \beta_3 \text{Tax}_i + \\ &\beta_4 \text{Population}_i + \beta_5 \text{Urban}_i + \\ &\beta_6 \text{Latitude}_i + \beta_7 \text{Longitude}_i + \beta_{8t} \text{Year}_i \end{aligned} \quad (1)$$

where,

$$\begin{aligned} i_{1,\dots,I} &\text{ where } I = 91 \\ j_{1,\dots,J} &\text{ where } J = 3 \\ t_{1,\dots,T} &\text{ where } T = 59. \end{aligned} \quad (2)$$

The i subscript denotes the unit of analysis (i.e. earthquake),⁹⁰ the j index expresses the type of sub-national economic composition of the affected locality (agricultural, industrial, or mixed), and the t subscripts denotes the year when earthquake i happened. Finally, μ is the intercept. Since earthquakes can happen more than once per year, in my dataset $i > t$.⁹¹ The estimated parameters β_k have noninformative normally distributed priors,⁹² while precisions τ_p of β_{1j} , β_{2j} and β_{8t} have noninformative Gamma priors, of the form,

$$\begin{aligned} \beta_{k,\dots,K} &\sim \mathcal{N}(0, 0.01) \text{ where } K = 8 \\ \tau_{p,\dots,P} &\sim \mathcal{G}(0.5, 0.001) \text{ where } P = 3. \end{aligned} \quad (3)$$

Figure 5 and ?? show the posterior predictive distributions of the Poisson regression.

⁹⁰Kahn [2005, 278] follows the same strategy.

⁹¹For the years in which there is just one earthquake, the ‘group’ variable has only one observation. This does not endangers the robustness of the model. Gelman and Hill [2006, 276] explains that it “is even acceptable to have one observation in many of the groups.”

⁹²“Noninformative prior distributions are intended to allow Bayesian inference for parameters about which not much is known beyond the data included in the analysis at hand” (Gelman [2006, 520]).

	Mean	SD	Lower	Upper	Pr.
Prop. Agr/Ind (Agr.)	5.95	4.72	-0.19	11.81	0.89
Prop. Agr/Ind (Ind)	-16.73	4.63	-22.85	-10.89	1.00
Prop. Agr/Ind (Mixed)	-61.83	23.96	-85.50	-16.74	0.99
Income Tax	-7.00	3.87	-11.68	-1.97	0.95
Magnitude (Agr.)	0.66	0.18	0.43	0.89	1.00
Magnitude (Ind.)	1.83	0.24	1.52	2.13	1.00
Magnitude (Mixed)	4.27	1.21	2.03	5.41	1.00
Urban	-0.89	1.49	-3.13	0.74	0.71

Note: 200000 iterations with a burn-in period of n = 100000 iterations discarded.

80% credible intervals in parenthesis. All R-Hat statistics below critical levels.

Standard convergence diagnostics suggest good mixing and convergence.

Year fixed effects, latitude and longitude were omitted in the table.

A total of 4 chains were run.

Table 1: Poisson Regression: Simulated Posterior Predictions

IV. APPENDIX

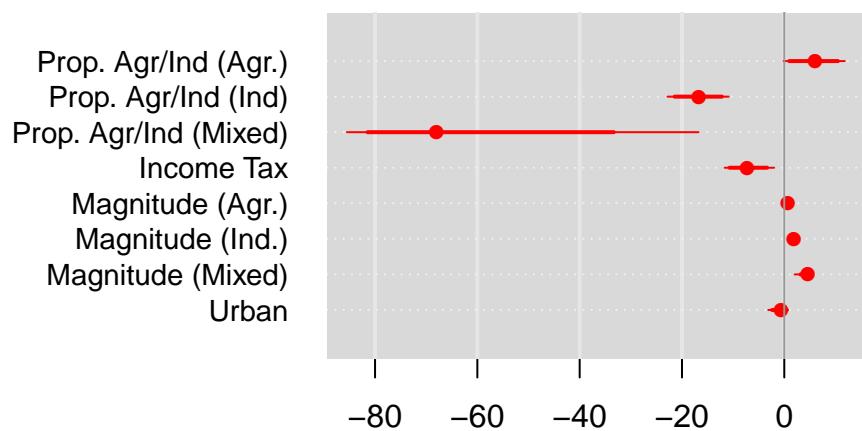


Figure 5: Posterior Predictive Distributions

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