Pontifícia Universidade Católica
do Rio de Janeiro

Gustavo Ribeiro Soares Pinto

Essays on the impact of extreme events on culture: the case of Japan

Tese de Doutorado

Thesis presented to the Programa de Pós–graduação em Economia, do Departamento de Economia da PUC-Rio in partial fulfillment of the requirements for the degree of Doutor em Economia.

Advisor : Prof. Thierry Verdier
Co-advisor: Prof. Juliano Assunção

Rio de Janeiro
February 2023

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Bibliographic data

Ribeiro Soares Pinto, Gustavo

Essays on the impact of extreme events on culture: the case of Japan / Gustavo Ribeiro Soares Pinto; advisor: Thierry Verdier; co-advisor: Juliano Assunção. – 2023.

170 f: il. color. ; 30 cm

Tese (doutorado) - Pontifícia Universidade Católica do Rio de Janeiro, Departamento de Economia, 2023.

Inclui bibliografia

1. Economia – Teses. 2. Economia do Desenvolvimento. 3. Economia da Cultura. 4. Desastres Naturais. 5. Japão. 6. Economia Política. 7. Capital Social. I. Verdier, Thierry. II. Assunção, Juliano. III. Pontifícia Universidade Católica do Rio de Janeiro. Departamento de Economia. IV. Título.

CDD: 620.11

To my grandparents, Glorita and Sotero.

Acknowledgments

The development of a PhD thesis certainly requires a good deal of individual effort. Nevertheless, it involves the participation of many others besides its author. Therefore, while I run the grave risk of not mentioning some very important people, I would like to express my full gratitude to all those who have contributed to the dissertation either directly or by "just" providing personal support.

I would like to thank PUC-Rio, CAPES, CNPq and Campus France/ Ministère de l'Europe et des Affaires étrangères for funding this research. Without their support, it would not have been possible to undertake this project. I would like to especially thank Campus France for their support during my stay in France. It was of the highest value.

First of all, I would like to thank my family. My parents Mario and Rosi and my sisters Mariana and Sophia are the most precious thing I could ask for. Their unconditional support during this period (and others) has been absolutely fundamental. Although it is certainly a cliché, it is entirely true: as hard as I can try, no words can describe my love and gratitude. Thank you!

I would like to thank my grandparents, Sotero and Glorita. The love and support you have given me is the most beautiful thing there is. It is no coincidence that this work is dedicated to you. If this can represent just a tiny fraction of my gratitude, I have achieved my goal. Also, I would like to thank Maria José (*in memoriam*) and Mario (*in memoriam*). Although we did not have much time together, you are certainly part of this.

To Bruno, Giu, Luara and Pedro, thank you for all your friendship and support! All my love to you! I promise to return to our Trupe immediately. To tia Magda, Rapha, Andrea, Lucas, Luísa, Camila, tio Ricardo, Valéria, Rafa, Ana Clara, João, and Gabi. Thank you all!

To Paula, who arrived in the final stages of the work and provided all the support (including some research assistance!). You have been amazing! Thank you very much!

To my beloved friends: Luiza, Dani, Lê, Moura, Munk, Cris, João, Tati, Fafá, Maiara, Bruno, Lê, Bruninho, Luna, Clarinha, Leo, Amaral, Laurinha, Camila. Thank you very much for the companionship and support! Many thanks to Teresinha and Maíra for their support throughout the process!

I would like to express my full gratitude and admiration for my advisors prof. Thierry Verdier and prof. Juliano Assunção. They are not only exceptional researchers and advisors, but also true leaders from whom I had the pleasure to learn. Thank you very much!

To the members of the thesis committee, prof. Tomás Guanziroli, prof. Claudio Ferraz, prof. Francisco Costa, and prof. Akiko Suwa-Eisenmann, for their availability, their attentive analysis of this work, and their invaluable suggestions! Thank you very much!

I would like to thank professors Gustavo Gonzaga and Claudio Ferraz. They were the first people I talked to when I decided to change careers. Their support was very important. Yvan Bécard, for all the support. Thank you very much!

To the staff of the Department of Economics at PUC-Rio, Bianca, Priscilla, Bruna and Roseli. Thank you very much for all the support and kindness.

To my friends from PUC, Iúri, Yuri, Dani, Giba, Marcão, Henrique, Luiz, Luiza, Claudio, Matheus, Pablo. You were fundamental in making this time much easier! A special thank to Amanda for the incredible partnership and support along the way. This was certainly just the beginning.

To my office colleagues and friends at PSE, Christian Abele, Anna Barbeta, Louise de Gaudemaris, Julius Goedde, Thiago Scarelli, Eric Teschke, Guillermo Mora, Alvaro Zuniga-Cordero, and Rodrigue Dossou-Cadja. Thank you for the warm welcome in Paris.

** This research was financed by: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001; CNPq - taxa de bancada; Bourse d'Excellence Eiffel/Campus France/Ministère de l'Europe et des Affaires étrangères*

Abstract

Ribeiro Soares Pinto, Gustavo; Verdier, Thierry (Advisor); Assunção, Juliano (Co-Advisor). **Essays on the impact of extreme events on culture: the case of Japan**. Rio de Janeiro, 2023. 170p. Tese de Doutorado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

This thesis consists of 3 chapters in development economics that relate natural disasters and environmental quality to political engagement and social capital. In the first chapter, we show that natural disasters can lead to punishment of incumbents. Interestingly, such punishment is the result of some heterogeneity in political participation. In local elections, turnout was lower in regions where the incumbent belonged to the party in power at the country level (DPJ), while turnout was higher in regions where the incumbent belonged to the main rival (LDP). As a result, the ruling party suffered a loss in these elections. The possible reason for this heterogeneity lies in the population's disappointment with the DPJ. In addition, it shows a further heterogeneity in regards to the level of social capital. Whereas it is related to higher political participation, the associated higher community resilience possibly led to different voting behavior. The second chapter proposes a theoretical framework to link the empirical and theoretical literatures on the influence of environmental quality and risk on the emergence of cooperative behavior. Consistent with the empirical literature, it is shown that depending on the relationship between the environment and the club good and individuals' beliefs about the cooperative behavior of others, the higher the probability of bad times, the greater the propensity of individuals to engage in collective action within a community. Finally, the third chapter examines the impact of natural disasters on the formation of social capital and its long-term persistence. Using data on ancient earthquakes in Japan, it is shown that people living in rural Japanese cities that were strongly hit in the past currently exhibit higher levels of trust and political engagement.

Keywords

Development Economics; Culture Economics; Natural Disasters; Japan; Political Economy; Social Capital.

Resumo

Ribeiro Soares Pinto, Gustavo; Verdier, Thierry; Assunção, Juliano. **Ensaios sobre o impacto de eventos extremos em cultura: o caso do Japão**. Rio de Janeiro, 2023. 170p. Tese de Doutorado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Esta tese é composta por 3 capítulos em Economia do Desenvolvimento, relacionando desastres naturais e a qualidade do ambiente com engajamento político e capital social. No primeiro capítulo, mostramos que desastres naturais podem levar à punição de incumbentes. De forma interessante, tal punição é consequência da heterogeneidade na participação política. Em eleições locais, eleitores em regiões onde o incumbente era do partido no poder a nível nacional (DPJ) compareceram menos às urnas, enquanto eleitores em regiões onde o incumbente era do principal partido concorrente (LDP) compareceram mais. Como consequência, o partido no poder perdeu mais assentos. A potencial razão para a heterogeneidade observada está na decepção na população em relação ao DPJ. Ainda, é também mostrada a heterogeneidade em relação ao nível de capital social. Enquanto é mais associado à maior participação política, a maior resiliência potencialmente levou a uma diferença no padrão de votos. O segundo capítulo sugere um arcabouço teórico para conectar as literaturas empírica e teórica sobre a influência da qualidade e dos riscos ambientais na formação de comportamento cooperativo. Em linha com a literatura empírica, mostra que, a depender das relações entre o ambiente e um bem público e das crenças dos indivíduos sobre o comportamento cooperativo dos demais, quanto maior for a probabilidade de ocorrência de tempos ruins, maior será a propensão de indivíduos em uma comunidade de agirem coletivamente. Finalmente, o terceiro capítulo investiga os efeitos de desastres naturais na formação de capital social e em sua persistência no longo prazo. Se valendo se dados em terremotos passados no Japão, mostra que indivíduos vivendo em cidades rurais Japonesas que foram atingidas no passado exibem hoje em dia níveis mais altos de confiança e engajamento político.

Palavras-chave

Economia do Desenvolvimento; Economia da Cultura; Desastres Naturais; Japão; Economia Política; Capital Social.

Table of contents

List of figures

List of tables

"Disciplina é liberdade."

Dado Villa-Lobos, Marcelo Bonfá, e Renato Russo, *Há Tempos*.

1
Introduction

This thesis is composed of 3 essays in development economics, seeking to provide a better understanding of how natural disasters can affect people's preferences and impact the formation of social capital and the level of political participation.

The first essay shows that natural disasters affect political participation. Moreover, it points out that if such events unveil political and governance issues, their sociopolitical consequences are not limited to the location where they occur, but can spill over to other regions. Moreover, the paper provides suggestive evidence that individuals' responses may be influenced by local levels of social capital. The higher the level of social capital, the more likely people are to engage in political activity. The recent literature on the effects of natural disasters on political participation has reached mixed results. In terms of turnout, instances of both higher and lower participation have been observed. Regarding the punishment or reward of politicians, the consequences depend on the local political setting. As for the influence of social capital, it was observed that higher levels of social capital lead to higher political participation.

In our analysis, using high quality data on both earthquakes and election results for the House of Representatives in Japan, we find that voter turnout declined at both the local and national levels. By focusing our analysis on the 2011 Great East Japan Earthquake (GEJE) that led to the meltdown at the Fukushima Daiichi nuclear power plant, we find that not only was turnout lower overall, but that this decline was more pronounced when the incumbent belonged to the Democrat Party of Japan (DPJ), the party in power at the national level at the time. We also find that the DPJ was the overall loser in these elections, while its main rival, the Liberal Party of Japan (LDP), was the main winner. As a possible mechanism, we identify that behind these results was a feeling of disappointment from the Japanese population towards the DPJ, possibly related to the problems it faced in its attempt to politically decentralize the country. Finally, we find that in regions where social capital was higher, political participation was also higher. In these cases, punishment to DPJ incumbent was also high, but it was not necessarily in favor of the more far-right party, LDP.

This research significantly contributes to the literature on retrospective voting by providing evidence that voters are attentive to politicians' responses to natural disasters. Moreover, not only local politicians – with a direct potential link to the event – are punished or rewarded, but politicians from the same party are also affected by such consequences. In addition, we show that the mechanism through which punishment occurs is not necessarily due to higher engagement. As discussed in the literature on political withdrawal, it may be that voters who are disappointed with the party's actions simply choose not to vote, thus reducing the political base. Finally, the paper contributes to the literature on the interaction among natural disasters, social capital, and political economy by showing that political engagement as a result of natural disasters can be heterogeneous depending on social capital. Not only can it lead to higher levels of participation, but it can also serve as a support network, reducing the actual impact of potential disasters and thus their political consequences.

In the second paper, we propose a theoretical model to describe the impact of natural disasters on the evolution of collective action within a community dealing with a common-pool resource (CPR). While the empirical literature has provided evidence that bad natural conditions and climate risks in the past are associated with current higher levels of collective behavior and trust, little has been said about this relationship from a theoretical perspective. Regarding the evolution of cooperation, the theoretical literature has suggested the existence of specific types of individuals, with established preferences. Thus, if interaction between these different types of individuals is allowed, cooperative behavior may evolve, according to the boundary conditions.

Our suggested model attempts to bridge the gap between the aforementioned empirical observations and the theoretical literature. Given that the environment and a given club good display a substitutive character, we propose a framework in which agents are of the same type, but choose whether to cooperate or act individualistically depending on their beliefs about future cooperative behavior and future environmental conditions. The difference in their actions lies in the optimization protocol they choose. While individualistic agents act according to the Nash protocol, cooperative agents act according to the Kantian protocol, by which they choose the best generalizable strategy. In our results, we show that the lower the propensity of high-quality natural environment, the higher the probability of cooperative behavior. This result depends on how many cooperative individuals are expected in the community. The lower the expected number of cooperative individuals, the lower the probability of future collectivist behavior. Based on these results, we provide some discussion in regards to public policy by suggesting that, given certain parameters, the government can lower the cost of enforcing potential defectors and thereby improve the level of cooperation.

In this paper, our main contribution is to link the observed empirical evidence on the effects of low-quality environment on the formation of social capital to the theoretical literature on the development and persistence of cooperative behavior. In essence, we advance this literature by showing under what conditions agents, who are in principle of the same type, can behave individualistically or collectively. More specifically, we show that agents can overcome the second-order free-rider problem by applying the Kantian protocol and that cooperative behavior can evolve depending on beliefs about the share of cooperators and the perceived volatility of environmental conditions.

Finally, in the third paper, we examine the long-term effects of natural disasters on trust and political engagement. Recent literature has provided evidence that natural disasters indeed exert influence on the formation of social capital. However, despite the growing theoretical literature on the persistence of preferences over time, not much has been said empirically about the long-term consequences of extreme events in culture. Moreover, to the best of our knowledge, this is the first work to document the consequences in terms of political values.

By exploiting data on earthquakes in Japan dating back to AD 684, we examine how trust and political engagement differ in rural cities in Japan that have been severely affected by natural disasters in the past. Our results show that, by our measures, people in regions that were strongly affected by natural disasters in the past (up to 1900) currently have higher levels of trust and political engagement.

With these results, we contribute to the literature on the impact of natural disasters on social capital by providing suggestive evidence of such a positive correlation. In addition, we contribute to the literature on the persistence of preferences by suggesting that such traits are persistent over time.

2
How do Extreme Events Affect Political Outcomes? The Case of Japan

Abstract

This paper studies how the impact of extreme events influences electoral outcomes in Japan. Based on rich datasets on Japanese House of Representatives elections and ground motion, we assess what impact earthquakes had on political participation and punishment of Japanese politicians. More importantly, we assess the impacts of the 2011 Fukushima triple disaster on 2012 election outcomes. We first show that although there is a general decline in turnout in the heavily affected districts, this effect is small compared to the decline in turnout in 2012 for the country as a whole. Moreover, we find that the decline in 2012 was most pronounced in districts where the incumbent belonged to the Democrat Party of Japan (DPJ), the party in power at the time. Consequently, the party suffered a major loss in 2012, while its main rival, the Liberal Democrat Party (LDP), was the main winner. We argue that behind such results lies disenchantment with the DPJ among the Japanese population. Finally, we suggest that in places with higher social capital, the a higher turnout was observed, leading to somewhat different voting behavior. These results add to the literature on retrospective voting, showing that the population's response may not only be local, but may also spill over to regions not directly affected, depending on the magnitude of the disaster.

2.1
Introduction

The extent to which relevant events, such as natural disasters or economic shocks, affect a population's political engagement is a hotly debated topic in political economy. Works on this subject have reached different conclusions depending on their specific settings. For example, when looking at engagement as measured by voter turnout after disasters, results in the literature show both increases and decreases. Similarly, when looking at the electoral outcomes of politicians, both punishments and rewards have been documented depending on the context. In addition, much of the studies on the subject have focused on the USA or developing countries[1]. In addition,

[1] To give a few examples, whereas Fair et al. (2017) find no differential effect on incumbents in regions impacted by floods in Pakistan, Cole et al. (2012), on the other hand, find that the incumbent party was punished for events beyond its control due to monsoons in

no consensus has been reached in respect to both how political participation is shaped and how it influences the electoral outcomes[2].

This article contributes to this literature by examining the impact of a natural disaster on the political outcomes of elections to the Japanese House of Representatives, the lower chamber of the national legislature. More specifically, it studies both the political participation of the Japanese population and the electoral outcomes of politicians in the aftermath of the nuclear disaster that followed the 2011 Great East Japan Earthquake (GEJE) and subsequent tsunami. This event not only triggered popular unrest due to the country's nuclear power generation policies and regulations (Kingston, 2013), but also highlighted the government's weaknesses in managing the reconstruction process (Cho, 2014).

To better understand the mechanisms behind the observed results, we examine how turnout in each electoral district was related to the incumbent candidate's party. In addition to documenting the electoral outcomes, we rely on a survey undertaken with voters to assess the possible reasons behind their decisions. Finally, we investigate the influence of social capital both in both voter turnout and in politicians' outcomes.

Throughout our analysis, we adopt several empirical strategies. Firstly, we consider the impact of strong earthquakes in turnout in the elections from 2000 to 2014. To identify the impact of strong earthquakes, we use the ground motion index developed by the Japanese Meteorological Agency (JMA). A district where ground motion measurements are high in the election year or in the year before is considered to be treated. In a two-way fixed effects regression, such districts are compared to those where ground motion was low or inexistent. In this case, identification comes from the fact that once controlling for district and year fixed effects, earthquakes are exogenous events. When specifically accounting for the Fukushima disaster, we drop the time fixed effects and include a linear time trend. In such case, we want to observe how the specific behavior of electoral variables in 2012 compares to the remaining years, while accounting for the outcome variables' potential evolution in time. Whereas the identification in this case is jeopardized – i.e., it is not possible to claim that the observed effects are solely due to the Fukushima event – we undertake a heterogeneity analysis of the population sentiment in topics related both to the catastrophe and to

India. Moreover, in Gasper and Reeves (2011)'s results, voters responded negatively to the perception of severe damage, but positively to incumbents' reactions.

[2]While Fair et al. (2017)'s results point to an increase in turnout in elections following a natural disaster, for instance, Sinclair et al. (2011) and Rudolph and Kuhn (2018) find a decrease.

political issues to better understand their political behavior in that year. By means of a survey undertaken with a nationally representative sample of voters, we can compare their attitudes in in the elections from 2009 to 2014 and observe how different it was in 2012.

We find that in 2012 – the first elections to the House of Representatives after the Fukushima event – turnout was 1.8 percentage points lower. This is not specifically related to the severely affected regions (in the sense of strong ground motion), but can be observed for the whole country. Moreover, the most affected prefectures in terms of fatalities experienced an additional 3 percentage point drop in turnout. It is interesting to note that while the triple disaster was physically a local event, it had a national political impact. Concerning the turnout cross-sectional heterogeneity in 2012, we find that in districts where the incumbent's party was the Democrat Party of Japan (DPJ), the turnout was lower by around 4 percentage points. In contrast, in districts where the incumbent candidate was from the Liberal Democratic Party (LDP), voter turnout was higher by around 3 percentage points. Indeed, by analyzing surveys undertaken with voters, evidence suggests that those who had voted for the DPJ (LDP) in the previous elections for the Proportional Representative section were less (more) likely to vote in the 2012 elections. We also test the political impact of strong earthquakes before elections in other years. While these are also associated with lower local turnout, the effect of the Fukushima event is substantially stronger.

In terms of party results, the impact of the GEJE is also quite clear. In 2012, the DPJ – the ruling party at the national level – was a loser, while the LDP – the main rival and the historically dominant party (Scheiner, 2005) – was a winner, both in terms of the candidates' overall position and their probability of winning. This result holds even when the sample is restricted to incumbents only. Moreover, the LDP benefited even more in the same year in places where a strong ground movement was felt.

Based on the voter survey, we find that some reasons are likely responsible for this result. On the one hand, the reconstruction process was highly criticized (Cho, 2014), as the severely affected regions went through hard times to restore normal life. It was noted that this problem was related to the process of political decentralization, an important motto of the DPJ, which did not produce the desired results. Accounting for the fact that the disaster led to a worse economic scenario for the country, the results show that those who valued decentralization reduced their feelings toward the DPJ and voted more for the LDP. In this case, the disaster had a signaling effect that revealed structural problems in the Japanese political scenario and caused those who were closer to the ruling party to turn away politically, leading to its poorer results. On the other hand, the results suggest that those who had voted for the DPJ and attributed importance to either the environment or the nuclear issue showed lower attachment to the party. In fact, the number of votes for the DPJ declined among those who placed value on the environment, a result that was not repeated when nuclear concerns were assessed. This pattern may be related to the fact that the LDP, the DPJ's main competitor, is strongly linked to the nuclear industry in Japan (Kingston, 2013) and therefore did not attract votes from people who cared about this issue.

We also assess the impact of local social capital on political outcomes. We find that in 2012 turnout was slightly higher in regions where "bridging" social capital was higher, consistent with the literature on social capital and political participation. Moreover, DPJ incumbents performed worse in these regions, while DPJ challengers were more likely to be elected. While it is not straightforward to assert causality or pinpoint mechanisms at this point, such correlations provide interesting suggestions. If the more socially connected communities were generally more effective at removing incumbents out of office in the face of political turmoil, they continued to vote for the more centrist (less extremist) party. Another possibility is that, apart from punishing incumbents, places with higher social capital tend to be more resilient and less demanding of the potential LDP advantage of promoting a better flow of resources. Furthermore, when looking at per capita income, it was observed that poorer localities tended to punish DPJ more, suggesting stronger punishment in more vulnerable localities.

The paper is structured as follows. After this introduction, Sec. 2.2 provides a brief literature review and Sec. 2.3 briefly introduces the Japanese political context and sec. 2.4 describes the Fukushima disaster. Next, in Sec. 2.5, the utilized data is presented, including the data on earthquake impacts, for the Japanese House of Representatives elections, and for social capital. In Sec. 2.6, the empirical strategies adopted throughout this work are discussed and the results are presented. Finally, Sec. 2.7 provides the conclusions.

2.2 Literature Review

This work interacts with three branches of literature. More broadly, it relates to the literature on retrospective voting, which has attempted to understand how voters respond to the behavior of politicians. With respect to natural disasters, Cole et al. (2012), studying monsoon rains in India, find that voters punish the incumbent party for events beyond its control, but find some rewarding when the government takes strong relief action. For county-level elections from 1970 to 2006 in the United States, Gasper and Reeves (2011) conclude that voters respond negatively to perceptions of severe damage, but positively to incumbent responses. In another case study, Bodet et al. (2016) observed political outcomes following flooding in the City of Calgary. The authors find mixed results depending on their empirical strategy. When they assume that the natural event was exogenous, they find that the incumbent had less support, but when the event was considered endogenous, the authors found no effect. In the case of floods in Pakistan, Fair et al. (2017) conclude that political engagement increased when the government and civil society adequately managed the consequences of the disaster, a result that could be due to a learning mechanism due to citizens' better level of information. Arceneaux and Stein (2006) examine the aftermath of Storm Allison in Houston, asking who is held responsible for natural disasters and why. Using surveys, they find that punishment depends on citizens' level of political knowledge and how much their lives were affected. In turn, Achen and Bartels (2004) find that voters tend to punish incumbent politicians after events such as droughts, floods, and shark attacks, even when they are not responsible. More recently, however, Fowler and Hall (2018) conducted a review of the results of Achen and Bartels (2004) and found that the authors' results become significantly weaker under alternative specifications. Finally, Busby et al. (2017) find that irrelevant events such as soccer match results can alter a politician's perceived performance.

Also related to political participation, but from a different standpoint, the political economy literature has sought to understand the determinants of political participation. Sinclair et al. (2011), examining the impact of Hurricane Katrina on mayoral elections in 2006, found that flooding led to a decline in voter turnout, but this was not necessarily related to voter characteristics or the depth of flooding. Finally, Rudolph and Kuhn (2018) find a modest decline in turnout following floods in German communities. In addition to the effects of natural disasters, the impact of other factors on the political engagement of the population has also been studied. As Lynge and Martinez i Coma (2022) comment, individuals' reactions to boundary conditions may be in terms of "mobilization" or by means of "withdrawal". While in the former participation increases, in the latter participation is reduced. For example, Rosenstone (1982) finds that unemployment, poverty, and declines in financial well-being reduce participation. The author notes that when individuals are in a difficult situation, they are more concerned with "closer" issues. As a result, political participation is lower. In more recent works, Aytaç et al. (2020) and Schafer et al. (2022), respectively, find that unemployment and income changes lower turnout. In addition, Solt (2008)'s findings suggest that higher levels of income inequality reduce political interest. Providing other examples, Cox (2003) and Ojeda (2015) provide evidences of lower participation due to lack of trust in government and depression, respectively. In these cases, the absence in polls are instances of the withdrawal mechanism, according to which individuals do not turnout to vote due to either a higher concern with more pressing issues or to punish politicians (Lynge and Martinez i Coma, 2022).

In general, results are mixed, with punishment and political participation varying across works. In this paper, then, we contribute to this literature by taking advantage of high-quality data on natural disasters and electoral processes in Japan to show that earthquakes did not significantly affect political outcomes in a developed country, with affected regions differing moderately from others. However, when the disaster interacted with an identified weakness in government, the scenario changed. Incumbents were generally punished, especially those who belonged to the ruling party. This result is related to the literature on retrospective voting and suggests that voters are able to appropriately distinguish between cases in which incumbents should or should not be held responsible. It also suggests mechanisms for understanding the observed punishment. While turnout was generally lower, it was even lower in places where the incumbent belonged to the ruling party, but relatively higher in localities where the main rival party was in power. Given the disappointment with the ruling party, those who had voted for them in the previous elections, indeed turned out less. As such, the we add to literature by providing another instance of the withdrawal hypothesis.

Moreover, this work is in dialog with the literature on the Japanese political context and the specific consequences of the Fukushima disaster. To date, studies have examined how the political involvement occurred. Novikova (2016) and Kingston (2013) shed light on the consequences of the nuclear issue by discussing the rise of anti-nuclear activism and its relationship with the Japanese government. Interestingly, as Huang et al. (2013) and Goebel et al. (2015) discuss, the Fukushima disaster has had an impact on the nuclear issue not only in Japan, but also in other countries such as China and Germany. In addition, in his analysis of the Fukushima event, Jenkins (2019) finds higher political participation, with higher voter turnout in affected regions. The difference in our results most likely stems from the fact that we looked at the most directly affected regions, whereas Jenkins (2019) also considered indirectly affected ones. Cho (2014), in turn, not only documents the increase in civic participation, but also argues that the government did not focus on building social capital and citizen participation in decision making. Moreover, the author argues that the event exposed certain weaknesses related to the problem of political decentralization. In a paper on a related topic, Scheiner (2005) discusses the clientelistic nature of the Japanese political scene. As the author describes, public funds in Japan are heavily controlled by the central government, which has helped the LDP establish a "near-monopoly" on local power. Moreover, both Hommerich (2012) and Hasegawa (2014) associate the disaster with lower levels of trust in government. The results obtained here add to this literature by showing that voters were attentive to decentralization as well as the nuclear and the environmental issues, leading to disappointment with the Democrat Party of Japan and its loss in the post-disaster elections.

Finally, this work finds an overlap with the literature on the effects of social capital which to a large extent resonates the work of Bourdieu (1986); Coleman (1988); Putnam et al. (1993); Putnam (1995), most of which describe the concept and discuss its relevance. On the one hand, social capital is seen as closely related to community resilience. It provides insurance to individuals when they are affected by catastrophic events by enabling and strengthening the flow of resources (physical, psychological, informational, etc.) within the group. Studies have assessed the impact of social capital in its various manifestations both theoretically (Norris et al., 2008; Aldrich and Meyer, 2015) and in catastrophic events such as Hurricane Katrina (Hawkins and Maurer, 2009), floods in Pakistan (Akbar and Aldrich, 2018), the Kobe earthquake (Yamamura, 2010), the Fukushima triple disaster (Aldrich, 2016; Ueda and Shaw, 2016; Ye and Aldrich, 2019; Goryoda et al., 2019), or when considering an aggregate of events (Shimada, 2015). On the other hand, social capital is also associated with social and political engagement, promoting collective action. From a more theoretical perspective, one can refer to the work of Szreter and Woolcock (2004); Stubager (2008); Woolcock (2010); Nannicini et al. (2013); Enke (2020), while empirically one can find cases for India Krishna (2002), the US (Knack, 2000; Chong and Rogers, 2005; Helliwell and Putnam, 2007; Enke, 2020; Giuliano and Wacziarg, 2020), Italy (Nannicini et al., 2013; Putnam et al., 1993), Mexico (Atkinson and Fowler, 2014), South Africa (Gibson and Gouws, 2000), Japan (Nishide and Yamauchi, 2005), Denmark (Stubager, 2008), or across countries (Gethin et al., 2022). In such a branch, this work contributes to the literature by showing that social capital can function both as a source of resilience, by reducing the degree of vulnerability of communities, and as a source of civic engagement, by promoting individuals' participation in the electoral process and influencing their voting decisions.

2.3
The Japanese political context

The Japanese political scene has been characterized by a lack of changes in power. As Catalinac et al. (2020) argue, the LDP has been able to win 19 out of 21 elections to the House of Representatives since its establishment in 1955. In fact, the literature on post-war Japanese political scene mentions the existence and the persistence of an "Iron Triangle", comprised by the LDP-led government, the bureaucratic, and the corporate elites (Cho, 2014; Matanle, 2011). This hegemony has been strongly influenced by the flow of resources from LDP candidates to districts with higher political support (Catalinac et al., 2020). This flow has been organized by the central government, which would reward local politicians and leaders by mobilizing votes. In return, regions with more votes for the LDP would receive more resources (Catalinac et al., 2020). Consistent with this description, Scheiner (2005) argues that the Japanese political system is highly clientelistic. Given the heavy dependence of local governments on the national government for funding, local politicians and voters would have incentives to align with parties that are more closely linked to the state budget. The author contends that such centralization has helped the LDP establish a "near-monopoly" (Scheiner, 2005).

As Foljanty-Jost and Schmidt (2006) discuss, the continued hegemony of the LDP, as well as the country's political elite involvement in corruption and the weakness of opposition parties, are some reasons for the decline in the political engagement of the population. Indeed, as the authors show, the early 1990s saw a decline in voter turnout for the House of Representatives, from 73.3 % in 1990 to 59.6% in 1996. In 1994, in response to corruption scandals and distrust in the government, a reform was passed that aimed to promote more alternation in power, thereby curbing corruption and money politics. As a result, the electoral system was changed from a Multi-Member District (MMD) to a mixed system combining Single-Member Districts (SMD) and Proportional Representative (PR) systems (Sakamoto, 1999). As Foljanty-Jost and Schmidt (2006) show, by the late 1990s and early 2000s, the turnout trend presented a (mild) recovery.

During this process of change, there were a number of realignments in the parties. As a result, new parties emerged to challenge the dominance of the LDP, with the DPJ being the most important (Miura et al., 2005). As the authors describe, the DPJ attempted to distinguish itself ideologically from the LDP but, after successive losses, moved closer and closer to the hegemonic party. On two relevant issues, for instance, the DPJ was more in favor of administrative reform leading to political decentralization and more in favor of political reform to fight corruption. In 2009, the DPJ rose to power and instituted relevant reforms with the objective to increase local governments' discretion. However, it faced the central government bureaucratic resistance.

2.4
The Fukushima Disaster and the recovery process

Although the triple disaster was due to a natural event, it had a rather human character. At the center of the chain of events was the meltdown at the Fukushima Daiichi nuclear power plant. As described by Aldrich (2019), on the afternoon of March 11, a 13-m-high wave overtopped the protective walls and flooded the entire site. In addition, the seawater destroyed the diesel engines that were supposed to act as a secondary safety system and would have prevented the reactors from overheating. Adding to the already overwhelming scenario, engineers were not adequately trained to deal with the situation, and by March 14, reactors 1, 2, and 3 had melted down (Aldrich, 2019). As Kingston (2013) reports, by 2012 three major investigations of the accident claimed that the disaster could have been avoided, leading not only to TEPCO's admission that it had been overly optimistic about the potential risks, but also that it had lied to the government and the public from the beginning of the crisis. Moreover, such investigations pointed to collusive relationships between nuclear companies and nuclear regulators that jeopardized the safety of nuclear power plant (Kingston, 2013).

After the disaster, the government took several measures for the recovery process. These included the deployment of 100,000 Japan Self-Defense Force (JSDF) troops for rescue operations, the establishment of the Reconstruction Design Council, and the creation of an office to deal with the economic impact of the disaster (Matanle, 2011; Jenkins, 2019). Despite some effective responses to the disaster[3] (Aldrich, 2019; Jenkins, 2019), the gov-

[3]Nuclear energy experts classified the event as level 7 - equivalent to the Chernobyl disaster

ernment and TEPCO struggled to establish consistent emergency management system. To illustrate this assertion, one can cite the "lack of a central emergency management agency, lack of emergency plans, and limited interagency communication."(Jenkins, 2019; Samuels, 2013). In another example, the U.S. government recommended evacuating residents within 80 km of the power plant, while the Japanese government issued a 10 km evacuation order on March 11 that was later expanded to 20 km. On March 23, the Japanese government asked residents within 30 km of the power plant to leave (Aldrich, 2019). In addition, as the author describes, the government withheld information about the extent of radiation, fueling mistrust (Mizohata, 2011).

Moreover, the country's highly centralized financial structure had a negative impact on the recovery process. While the decentralization process was an important political motto for the Democratic Party of Japan (DPJ) (Cho, 2014), the slow recovery showed how much the country was still too centralized. As (Aldrich, 2016) cites, despite the implementation of reforms and the changes in the electoral system, the LDP concentrates the redistribution of wealth to peripherical regions to gain support.

As Noy et al. (2022) explain, following changes in the law, municipalities estimate the costs in the event of a disaster and report to the central government, which provides assistance and resources as needed. Thus, although the mayor and the municipality are responsible for the spending plan, resources are controlled by the central government. Despite some success in physical reconstruction, the combined disaster exceeded the capacity of the municipalities, leading to a halt in reconstruction plans (Cho, 2014). Consistent with this structure, Cho (2014) notes that although municipalities made reconstruction plans, they could not execute them independently. For example, they had to obtain approval from the Ministry of Land, Infrastructure, Transport and Tourism (MLITT). Even the program created to transfer authority from the central government to local governments (the Special Zones for Reconstruction) did not work properly. It failed because of the bureaucratic walls of the central government. As Cho (2014) notes, this lack of decentralization led to a slower recovery process.

2.5 The Data

This section describes the data used. Since our goal is to understand whether and how politicians are adequately monitored by citizens, we first present the data used to describe the Japanese House of Representatives elections in Sec. 2.5.1. Essentially, the relevant variables are those related to voter turnout and candidate performance. In addition, this section also presents the survey data that were used to better understand voters' preferences in terms of political attitudes in Japan. Furthermore, relevant to our analysis is whether the fact that a candidate is running in a highly affected region has an impact on voters' political behavior and politicians' outcomes. In this regard, we describe in Sec. 2.5.2 the metrics used in the study to identify such highly affected regions.

2.5.1
Elections data

Concerning the outcomes of interest, we focus on voter turnout and the performance of politicians in elections to the House of Representatives, the national legislative lower house. The House of Representatives consists of 480 seats, 300 of which are reserved for Single Member Districts (SMDs). The remaining 180 seats are distributed among Japan's 11 regions according to the proportional representation system (PR). Thus, when Japanese voters are called to vote for the House of Representatives, they have two ballots: one on which they choose their candidate for the Single Member District candidate, and another on the other they choose a party for their region PR. In this last case, the party allocates its candidates for that region according to their vote share (Krauss and Pekkanen, 2004; Local Governance , Policy Making and Civil Society). Elections to the House of Representatives are held every 4 years, but can be dissolved before the deadline. In this case, new elections are called. In this study, we focus on the 300 SMD seats because with such a granular division, we are able to more accurately relate the districts that were severely affected by the earthquakes to the results of each election. Most importantly, for each observed election, we are able to compare political outcomes in these districts with those in districts that were not directly affected by the disaster.

Regarding election data, we draw on the Reed-Smith Japanese House of Representatives Elections Dataset (Smith and Reed, 2018), which consists of a repeated cross-section containing all candidates who contested the general election for the Japanese House of Representatives between 1947 and 2014. Most importantly for our purposes, it contains for each election whether the candidate was an incumbent, his/her party, his/her result-whether he/she was elected and his/her rank-and the turnout in a particular district. In addition, it also contains the ideological orientation of the candidates, indicated in the database by their 'camp." More specifically, each candidate is classified as "conservative," "socialist," "Kōmeitō," "NFP/DPJ/Ozawa Liberals/TPJ," "communist," "right-wing," or "independent/unknown." With this information, the variable RL was created. If a candidate belongs to the "left" spectrum, $RL = -1$, if he/she belongs to the "right" spectrum, $RL = 1$. Otherwise, $RL = 0$[4]. As indicated in section 2.5.2, our detailed data on seismic events begin in 1996, so we trimmed the election data to be compatible with information on severely affected regions. As a result, our analysis is based on a pooled cross-section in which each observation consists of a candidate c in district d who contested elections in year e, from 2000 to 2014[5]. There were 6 major elections for the House of Representatives during this period.

Given the information on Japanese elections, it is of utmost importance for the purposes of this study to understand how individuals make political decisions and how these can be related to the events observed in our period of study. To this end, we rely on the survey conducted jointly by the Taniguchi Laboratory (University of Tokyo) and the Asahi Shimbun, one of Japan's largest newspapers (Taniguchi Lab., 2003). While the survey for the House of Representatives elections has been conducted since 2003, the codebooks were only readily available since 2009. Since the interest is in the 2012 elections, the 2009, 2012, and 2014 polls are considered. Each survey targeted a nationally representative sample (with 2085, 1900, and 1813 valid responses for 2009, 2012, and 2014, respectively) and was conducted near election days. The questionnaires provide information about respondents' characteristics, such as age range, education, sex, and prefecture of origin, as well as their attitudes toward political issues: whether they voted in the current and previous elections, which party they voted for, what they think about certain political figures, and what political ideologies they hold. These data are very important for this study because they help to build a picture of the political scenario for each election.

Naturally, not all the questions asked were of interest. Therefore, the questions relevant for our purposes are presented here according to the analysis performed. However, Table 2.1 provides a brief description of the variables that are most relevant to this work. The variables "Feel DPJ" and "Feel LDP," described in more detail in Sec 2.6.2.1, indicate how respondents feel about the party, on a scale from 0 (worst possible) to 100 (best possible).

[4]Leftist candidates belong to the "socialist", "NFP/DPJ/Ozawa Liberals/TPJ", or "communist" camps; rightist candidates belong to the "conservative", "Kōmeitō", and "right-wing" camps

[5]There were elections for the House of Representatives in 1996, but as clarified in Sec. 2.5.2, we would need to have earthquake data from 1995 to include them in our analysis, which is not the case

The "Vote" variables represent the average value for the dummy variable indicating whether the respondent voted for the specified party in the SMD or PR section of the elections.

Table 2.1: Summary of most relevant variables, according to the electoral survey (Taniguchi Lab., 2003).

Year	Feel DPJ	Vote DPJ - SMD	Vote DPJ - PR	Feel LDP	Vote LDP - SMD	Vote LDP - PR
2009	57.34	0.53	0.47	46.02	0.38	0.29
2012	36.00	0.23	0.16	50.20	0.45	0.33
2014	39.28	0.22	0.19	50.95	0.49	0.36

Notes: This table presents the average values in each year for the feeling in regards the DPJ and the LDP, as well as for the dummy variables indicating whether the respondent votes for the parties in the SMD and in the PR sections.

2.5.2
Earthquake data

In order to assess the impact of natural disasters on political outcomes, we must first adequately measure the impact of earthquakes across the country. This is possible thanks to the network of more than 1,700 measuring stations uniformly distributed across the country established by the Japanese Meteorological Agency (JMA) (National Research Institute for Earth Science and Disaster Resilience, 2019; Hanaoka et al., 2018). As Doi (2014) explains, this monitoring network has only been in operation since 1996. To detect ground motion, each station has three accelerometers whose data are processed and used to create an objective intensity index I_{JMA} (Shabestari and Yamazaki, 2001). As Doi (2014) describes, the index aims to adequately capture human perception and behavior of furniture and buildings due to seismic activity.

The index ranges from 0 to 7 and is divided into categories, which can be seen in Table 2.2, according to the consequences of the earthquake. Given such a scale, we focus here on events that resulted in at least "many people finding it hard to move" and "holding to something stable" and furniture falling. Objectively, we focus on scenarios in which $I_{JMA} \geq 5$. Ideally, we would like to narrow our index to the highest values, but as can be seen in Figure 2.1, for the available time frame, not many observations satisfy $I_{JMA} \geq 6$. The events that were actually selected for treatment are those to the right of the dashed line.

Fundamentally, in addition to the geolocation of the ground motion and its intensity, the exact time of its occurrence is known. This information makes it possible to establish the link between events of high intensity and the closest elections in time, and thus to observe their relationship. To better

Table 2.2: JMA index scale description, adapted from Hanaoka et al. (2018).

Seismic intensity	Human perception/reaction	Indoor
0	Imperceptible to people	–
1	Felt slightly by some people	–
2	Felt by many people keeping quiet in buildings. Some people may be awoken.	Hanging objects such as lamps swing slightly.
3	Felt by most people in buildings. Felt by some people walking. Many people are awoken.	Dishes in cupboards may rattle.
4	Most people are startled. Felt by most people walking. Most people are awoken.	Hanging objects such as lamps swing significantly, and dishes in cupboards rattle. Unstable ornaments may fall.
4.5-5	Many people are frightened and feel the need to hold onto something stable.	Hanging objects such as lamps swing violently. Dishes in cupboards and items on bookshelves may fall. Many unstable ornaments fall. Unsecured furniture may move, and unstable furniture may topple over.
5-5.5	Many people find it hard to move; walking is difficult withing holding to something stable.	Dishes in cupboards and items on bookshelves are more likely to fall. TVs may fall from their stands, and unsecured furniture may topple over.
5.5-6	It is difficult to remain standing.	Many items of unsecured furniture move and may topple over. Doors may become wedged shut.
6-6.5	It is impossible to remain standing or move without crawling. People may be thrown through the air	Most items of unsecured furniture move and are more likely to topple over
7		Most items of unsecured furniture move and topple over or may even be thrown through the air.

understand the temporal distribution of seismic events, Figure 4.1 shows the number of sensors activated (Fig. 2.2a) and the number of districts affected per year (Fig. 2.2b) [6] over time, considering the studied election period. It can be seen that the most important year is 2011, when the country was hit by the so-called Great East Japan Earthquake (GEJE) in March. Moreover, the number of events where the impact index is higher than 6 is much lower than when it is higher than 5.

With these data, we are able to establish a link between an extreme event (intensity, location, and time) to an election. We hypothesize that extreme events occurring in an election year or the year before should have some impact on political participation and/or candidate performance, taking into account whether the candidate is an incumbent and his or her party. Therefore, in Figure 2.3, we can observe the districts affected by earthquakes in an election year (up to Election Day) or the year before according to the impact index. In our empirical strategy, we take advantage of the fact that such events are random, while controlling for district and year fixed effects, which allows for a proper comparison between districts that were severely affected (orange/red) and those that were not directly affected (yellow).

2.6 Empirical strategy and results

In this section two lines of analysis are followed. Sec. 2.6.1 describes the local effects of natural disasters on political outcomes. Importantly, we compare the impact of being in a district heavily affected by earthquakes-

[6] Note that each earthquake can be felt by more than one sensor, which means that there can be more than one sensor activation per earthquake.

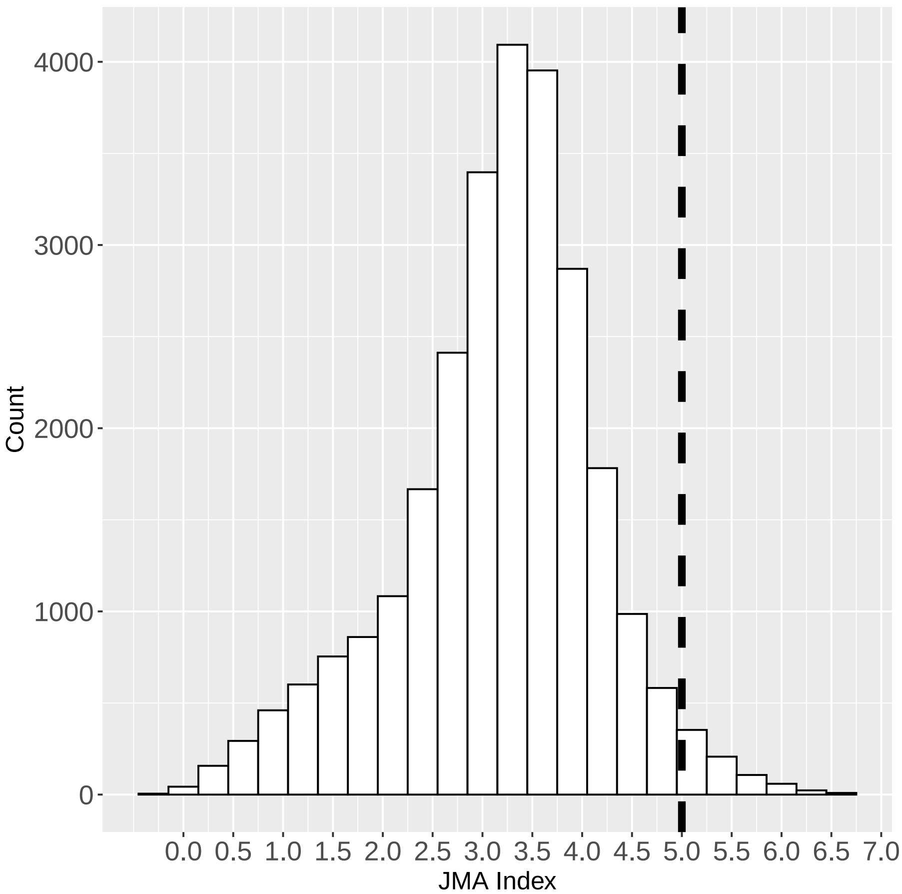
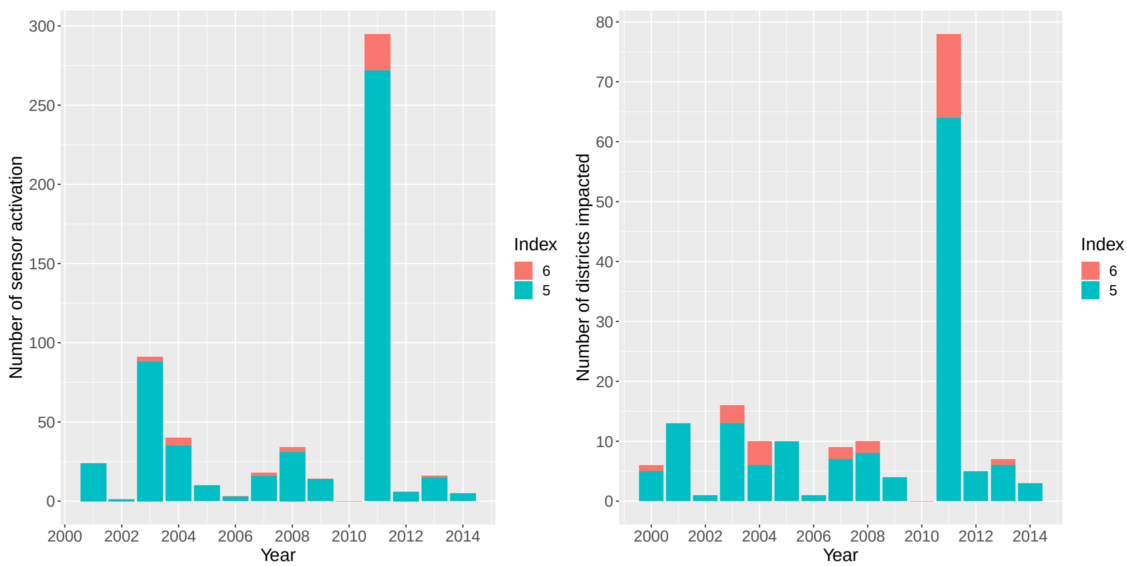


Figure 2.1: Histogram of seismic events according to their respective indices, conditional on having been observed. The chosen events for the present analysis are those to the right of the dashed line, i.e., for which $I_{JMA} \geq 5$.



(a) Number of sensors activated.

(b) Number of districts impacted.

Figure 2.2: Earthquakes felt per year according to the number of sensors and districts.

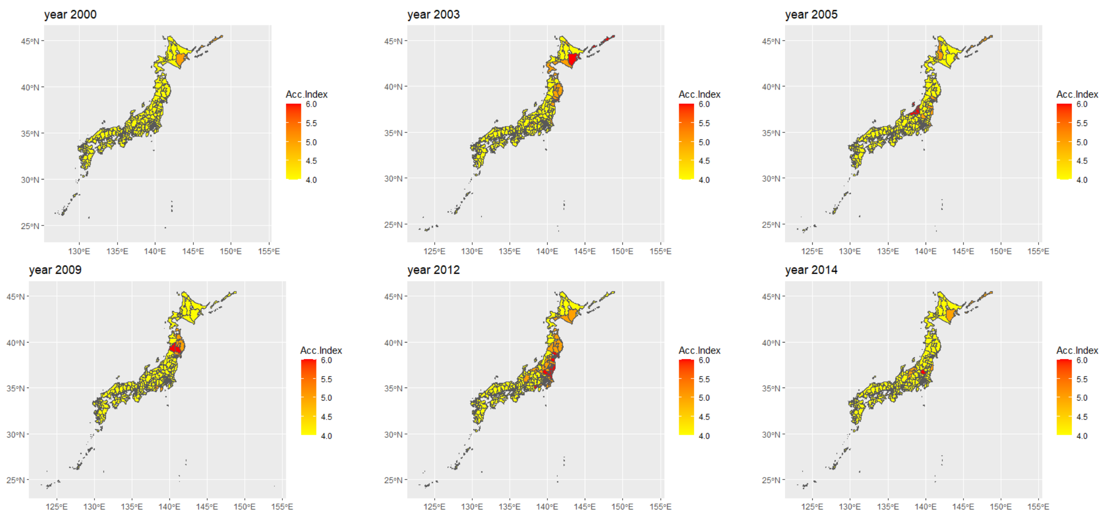


Figure 2.3: Impact distribution for the main election years in the analyzed period. Red districts were those for which $I_{JMA} \geq 6$; Orange districts were those for which $I_{JMA} \geq 5$. The remaining are those considered as controls ($I_{JMA} < 5$).

regardless of the year-to the specific impact of the Fukushima event on the 2012 elections-the first for the House of Representatives after the disaster. First, I assess the impact on political participation, as measured by voter turnout. In addition, I examine the impact of the party of the district's incumbent candidate on turnout. Next, I examine the performance of candidates from Japan's two largest parties, the Democrat Japanese Party (DPJ) and the Liberal Democrat Party (LDP). Finally, special attention is paid to the impact on the results of the incumbent candidates. Next, given the magnitude of the Fukushima event, subsection 2.6.2 assesses voter behavior specifically for the 2012 elections using the survey conducted by Taniguchi Lab. (2003). In this case, the most important factors in voters' decisions are examined.

2.6.1
The influence of catastrophic events

As discussed in Section 2.5.2, given the calculated impact index, according to the JMA methodology, it is possible to establish a link between an electoral district and its ground motion. As such, whenever an electoral district d is subject to a ground motion recorded as $I_{JMA} \geq x$, in an electoral year[7] e or in the year before, it is represented by a dummy $\mathbb{1}_{d,t,x}$, where $x \in \{5, 6\}$. With such variable, one can thus observe the political outcomes in hardly hit places in the elections following the impact.

[7]Up to the election day.

In the creation of the impact dummy variable, the choice regarding the length of the period before the elections is undoubtedly arbitrary. On the one hand, to include only the year when the election takes place would leave aside important events that could potentially affect the political outcomes of interest. On the other hand, to include more years would increase the possible interference of events other than the natural disasters under assessment, including other elections.

An important issue to be addressed is whether the dummy $\mathbb{1}_{d,t,x}$ is endogenous in regards to our outcomes of interest, i.e., the turnout and the performance of incumbents and parties. Earthquakes are known for their random character, but surely enough, within broad regions, these events are more likely to happen[8]. Nevertheless, if given that, within a certain area, an instance of an earthquake presents a random character, so there should be nothing simultaneously correlated between such events our outcomes of interest. Indeed, as Matsu'ura (2017) and Hao et al. (2018) describe, much research is still required to allow adequate prediction and there is still disputes in regards to the events' characteristics. Moreover, corroborates with such events' random character the fact that until today they produce a high number of victims. Even if some region is highly prepared against earthquakes, recent events have shown that they have unfortunately resulted in negative surprises. In any case, in order to lay on the safe side and allow for appropriate comparisons, the fixed effect of unit–the electoral district– is used.

2.6.1.1
The effect on turnout

First, we analyze turnout in elections to the House of Representatives in Single Member Districts. The relationship between turnout in a given district and the fact that it was affected at most in the year before the election is expressed in equation 2-1. Each observation consists of precinct d in election year t,

$$TO_{d,t} = \beta \mathbb{1}_{d,t,x} + \delta_d + \gamma_t + \mathbf{X_{d,t}}'\boldsymbol{\alpha} + \varepsilon_{d,t}. \tag{2-1}$$

Thus, turnout in district d for elections in year t, $TO_{d,t}$[9], is regressed against the impact dummy, $\mathbb{1}_{d,t,x}$, while controlling for the vector $\mathbf{X}'_{d,t}$, which is composed of the size of the electorate, the number of candidates, and the

[8]Having chosen Japan for these study, for instance, was not random, as it is the country most hit by earthquakes (Noy et al., 2022).

[9]Calculated as the ratio between the total number of votes and the electorate in that district

proportion of right-leaning candidates in the district, that is, the average value of the variable RL for that district. Also included are the fixed effects of district, δ_d, and year, γ_t. As our intention is to capture the effect of being in a heavily affected district on turnout, our coefficient of interest is β.

In this case, the identification stems from the fact that by adding the above controls, nothing should be simultaneously correlated between the impact in district d in year t and turnout in subsequent elections. At this point, it should be recalled that the date of elections may not be exogenous, as the House of Representatives may be dissolved before the regular 4-year period. As Smith (1996) and Palmer and Whitten (2000) comment, it can be the case that governments choose to call for elections according to some economic or social criteria, for example. However, given the use of both district and year fixed effects, and that the elections are held at the national level, such issue should not play a role in this case. Another important point is that, given the available data, our strategy is based on the intention to treat (ITT). This is the case because our impact metrics capture the extent to which a particular region was affected by a disaster. By basing our impact measurement on an entire district, individuals who were severely affected by the disaster are put together with those who were not as severely affected.

To account for the fact that the Fukushima event was a potential outlier, some changes are made to the empirical specification. First, a second impact index is considered, $\mathbb{1}_{t,MIP}$, to capture the effect of belonging to a district in one of the most affected prefectures in terms of fatalities[10]. Also, the interaction between the impact dummy variable and the 2012 dummy variable, $\mathbb{1}_{t=2012}$, is included to account for the specific impact in that year. Moreover, since we observe the impact in a specific year whose corresponding dummy variable is already included, we no longer use the year fixed effect γ_t, but instead include a year trend t to account for the potential time variation in turnout. The resulting specification is shown in equation 2-2,

$$TO_{d,t} = \gamma \mathbb{1}_{t=2012} + \eta Imp_{d,t} + \beta \mathbb{1}_{t=2012} * Imp_{d,t} + \delta_d + \theta t + \mathbf{X_{d,t}}' \boldsymbol{\alpha} + \varepsilon_{d,t}, \tag{2-2}$$

where $Imp_{d,t} \in \{\mathbb{1}_{d,t,x}, \mathbb{1}_{t,MIP}\}$ captures both impact metrics. In this case, both γ and β are of interest. While γ captures the specific effect of 2012, β indicates how different turnout was in the hard-hit regions that

[10]According to Kazama and Noda (2012), almost all the deaths related to the disaster were in the prefectures of Iwate, Fukushima, and Miyagi prefectures.

year. It is important to comment on the identification strategy. While the control group associated with β is quite clear since we compare severely affected regions with unaffected ones, the same cannot be said for γ. In this case, the entire 2012 effect is captured and we do not have a suitable counterfactual for the event itself. The relevant comparison made at this point is between the outcome in 2012 and the time trend in turnout. While this is true, we assess below the heterogeneity of turnout, which helps to understand the patterns behind the result observed here. Regarding the possible endogenous nature of the 2012 election timing, this would be more significant if the election results were more favorable to the incumbent party, DPJ. As the results below show, this is not the case.

According to Eqs. 2-1 and 2-2, Table 2.3 shows turnout in severely impacted regions (i.e., where the impact index was above 5 or 6), both in isolation (columns (1) and (2), to the left of the vertical bar, and relative to Eq. 2-1) and taking into account the Fukushima event (columns (4), (5), and (6), on the right side of the vertical bar and relative to Eq. 2-2). In addition, it also shows the behavior in 2012 alone (column (3)). Importantly, the errors are clustered at the district level. As it can be seen in columns (1) and (2), turnout is generally lower in the most impacted areas. Column (3) also shows that turnout in 2012 is lower than the trend. Looking at the results in columns (4) and (5), it is clear that the lower turnout in the most affected areas found in columns (1) and (2) is overshadowed by the overall effect of the Fukushima year. In fact, as it can inferred from Foljanty-Jost and Schmidt (2006) and is commented by Pekkanen (2002), the turnout in 2012 was lowest after the World War II, which is a rather interesting result, given the previous upward trend.

From a different perspective, column (6) looks at the behavior in the most affected prefectures. As can be observed, turnout was lower in these regions in 2012, but this does not explain the overall decline, as can be seen in the third row. One possible mechanism for the lower turnout in most impacted prefectures is the internal migration from strongly affected regions to neighboring regions. Besides the casualities, those registered to vote in these regions might have had to move, being unable to vote. However, as we show, the decrease in turnout was not a local phenomenon. Interestingly, Jenkins (2019) finds an increase in turnout in the affected regions, but in his analysis, the author selects prefectures other than those indicated by Kazama and Noda (2012) as those where there were the greater number of casualties. While we focus here on the areas directly affected by the event, Jenkins (2019) also includes indirectly affected regions in his analysis. By looking only at the directly affected prefectures, we want to avoid capturing other effects besides the impact of the disaster itself.

As the results in columns (1) and (2) show, it is interesting to note that severely affected regions tend to have lower turnout. Given the use of year fixed effects, this result is not unique to the 2012 elections, but when compared to the post-Fukushima elections, this effect becomes irrelevant, highlighting the magnitude of the 2011 disaster and its aftermath. The most important finding at this point concerns the magnitude of the Fukushima event. Not only did it have a negative impact on local turnout in regions with high physical damage, but it is also associated with lower turnout across the country. In fact, in Fig. 2.4, one can observe the average turnout in districts in the main elections over time. It can be clearly seen that turnout in the 2012 elections deviated from an upward trend.

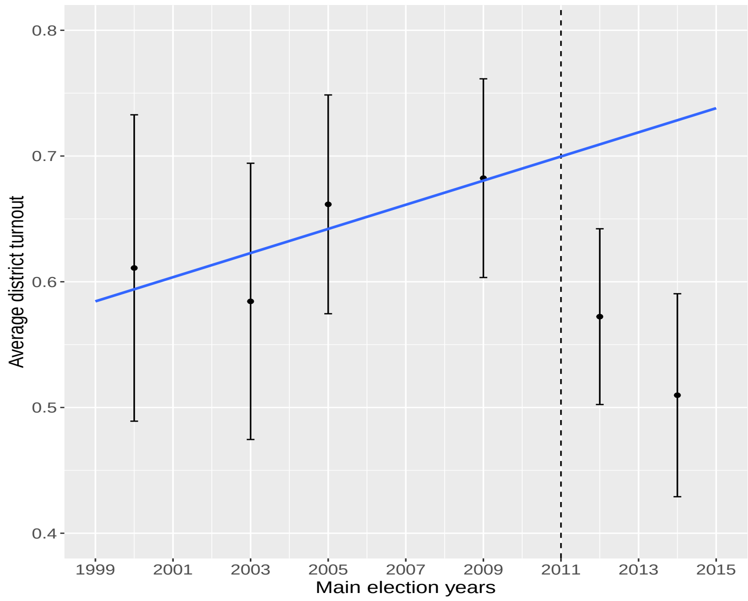


Figure 2.4: Average turnout for the House of Representatives and corresponding 95% confidence interval. The dashed line represents the year of the Fukushima catastrophe and the trend concerns the years before 2011.

In order to better understand turnout in 2012, we analyze how it varied by party of incumbent in each district'. In doing so, we aim to determine whether political engagement changed in places where a particular party had been previously elected. To capture such behavior, we resort to Eq. 2-3,

$$TO_{d,t} = \gamma \mathbb{1}_{t=2012} + \eta \mathbb{1}_{d,t,IncParty} + \beta \mathbb{1}_{t=2012} * \mathbb{1}_{d,t,IncParty} + \theta t + \kappa t * \mathbb{1}_{d,t,IncParty} + \mathbf{X_{d,t}}' \boldsymbol{\alpha} + \delta_d + \varepsilon_{d,t}, \tag{2-3}$$

This follows an empirical strategy quite similar to the one proposed earlier, except that the "treatment variable" is now a dummy variable indi-

Table 2.3: Earthquake effect on turnout

	Dependent variable:					
	Turnout					
	(1)	(2)	(3)	(4)	(5)	(6)
$(I > 5)$	-0.005^{*}			0.010		
	(0.003)			(0.012)		
$(I > 6)$		-0.013^{**}			0.015	
		(0.005)			(0.022)	
2012			-0.018^{***}	-0.015^{***}	-0.016^{***}	-0.017^{***}
			(0.003)	(0.003)	(0.003)	(0.003)
2012:$(I > 5)$				-0.015		
				(0.012)		
2012:$(I > 6)$					-0.030	
					(0.023)	
2012:MIP						-0.030^{***}
						(0.010)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	No	No	No
Year trend	No	No	Yes	Yes	Yes	Yes
Observations	1,745	1,745	1,826	1,745	1,745	1,826
R^2	0.881	0.882	0.413	0.409	0.409	0.415

Notes: This table presents turnout according to the impact level, including the most hit prefectures in terms of deaths. Standard errors are clustered at the district level. *p<0.1; **p<0.05; ***p<0.01

cating the party of the district' incumbent[11] $\mathbb{1}_{d,t,IncParty}$, where $IncParty \in \{DPJ, LDP\}$. In addition, an interaction between this specific party dummy and the election year is included to control for a possible different trend across parties. The coefficient of interest here is β, indicating the interaction between the 2012 dummy, $\mathbb{1}_{t=2012}$, and the incumbent party dummy, $\mathbb{1}_{d,t,IncParty}$. The idea behind this specification is to understand how politically engaged the population was from a district where the incumbent belonged to a particular party, especially in the year after the Fukushima event. The results are shown in Table 2.4. As it can be seen in column (1), in 2012, in districts where the incumbent belonged to the DPJ turnout reduced by about 4 percentage points from the already reduced turnout in that year. In contrast, when the incumbent belonged to the LDP, turnout was about 3 percentage points higher, as column (2) shows. These results suggest that in localities where the population had been more closely aligned with the

[11]The electoral structure for the House of Representatives specifies that there is only one incumbent per district,

DPJ, political engagement was lower. In contrast, turnout was higher in localities that were more connected to the LDP. Comparing these values with the previous average turnout can be misleading, as Fig. 2.4 clearly shows an upward trend in this variable. However, it is important to note that this value was around 65%. Thus, the observed decrease was about 5%.

Table 2.4: Effect of incumbent's party on turnout

	Dependent variable:	
	Turnout	
	(1)	(2)
2012	−0.017***	−0.052***
	(0.004)	(0.010)
2012:Inc DPJ	−0.039***	
	(0.008)	
2012:Inc LDP		0.033***
		(0.011)
District FE	Yes	Yes
Year-party trend	Yes	Yes
Controls	Yes	Yes
Observations	1,833	1,833
R^2	0.447	0.432

Notes: This table presents turnout in 2012 according to the party of the incumbent candidate. Standard errors are clustered at the district level. *p<0.1; **p<0.05; ***p<0.01

To better understand voter behavior in the 2012 elections, this paper draws on surveys conducted by Taniguchi Lab. (2003). As described in Sec. 2.5.1, such surveys provide information on voters' perceptions and attitudes regarding Japanese electoral outlook. Thus, based on these surveys, a repeated cross structure was constructed in which each observation consists of a respondent r from prefecture p in election year t.

For each election year, respondents not only indicated whether they voted in the current election, but they were also asked which party they had voted for in previous elections for the Proportional Representative section (Taniguchi Lab., 2003). While the focus of this work is on the Single Member District section, primarily because of the granularity allowed, the PR election is also interesting because the corresponding voting decision must be made with respect to a party. It is therefore interesting to observe whether the propensity to vote in a particular election is influenced by the party that had been chosen in the previous election. Therefore, in Eq. 2-4, which is run both as a linear probability model and according to a Logit model, the dummy variable indicating whether respondent r from prefecture p voted in a given election t, $\mathbb{1}_{r,t,p,Voted}$, is regressed against a dummy variable indicating which party he/she had voted for in the previous election, $\mathbb{1}_{r,t,p-LastParty}$, interacted with the dummy variable for the 2012 elections, $\mathbb{1}_{t=2012}$. In addition, we also include the demographic data, $X_{r,t,p}$, the year trend, and the prefecture fixed effect,

$$\mathbb{1}_{r,t,p,Voted} = \gamma \mathbb{1}_{t=2012} + \eta \mathbb{1}_{r,t,p-LastParty} + \beta \mathbb{1}_{r,t,p-LastParty} * \mathbb{1}_{t=2012} + \theta t + \mathbf{X_{r,t,p}}' \boldsymbol{\alpha} + \kappa_p + \varepsilon_{r,t,p}. \tag{2-4}$$

where $X_{r,t,p}$ includes the respondents' gender, age, education level, and their opinion of the country's economic conditions. To provide such an outlook, the authors asked what respondents thought about Japan's current economic situation. Responses were on a Likert scale of 1 (very good) to 5 (very bad). To positively correlate responses with thoughts about the economic situation, the scale was flipped to -5 (very bad) to -1 (very good). Of interest in this analysis is the coefficient associated with the interaction term indicating the effect on turnout of having voted for a particular party in the election prior to 2012, β. The comparison we seek to conduct in this approach is between the behavior in 2012 and in other years of voters who had voted for a specific party in the previous elections.

To account for the possibility that our results are due to some heterogeneity in respondents' characteristics, a second specification is also proposed. In this case, respondents' education level and their opinion about the country's economic status are interacted with the dummy parameter for the elections after the Fukushima event. The results shown in Table 2.5 are consistent with those shown previously[12] and are robust across specifications. In 2012, the probability of turnout decreased (increased) if one had voted for DPJ (LDP) in the previous election. Looking at the linear probability model (on the left-hand side), the variations were of approximately -4% and 4% for the DPJ and the LDP, respectively. For comparison, the average turnout considering all respondents is 79%.

In summary, in addition to the national nature of the lower voter turnout after the Fukushima disaster, there was also a rather selective pattern. Districts more associated with the DPJ showed lower turnout, while

[12] An interesting byproduct of this table is the positive correlation between education and voter turnout, a result previously discussed in the literature (Brady et al., 1995; Glaeser et al., 2007),

Table 2.5: Probability of voting, given the party voted for in the previous PR elections.

	Dependent variable:							
	Voted							
	Linear probability model				Logit model			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2012	0.01	0.07	-0.02^{*}	0.03	0.05	0.62	-0.31^{**}	0.14
	(0.02)	(0.07)	(0.01)	(0.06)	(0.13)	(0.58)	(0.13)	(0.60)
$VoteLast_{DPJ}$	0.03^{**}	0.03^{*}			0.27^{*}	0.26^{*}		
	(0.01)	(0.01)			(0.14)	(0.14)		
Education	0.01^{***}	0.01^{***}	0.01^{***}	0.01^{***}	0.13^{***}	0.14^{***}	0.14^{***}	0.14^{***}
	(0.00)	(0.01)	(0.00)	(0.00)	(0.04)	(0.04)	(0.04)	(0.04)
Econ	0.01^{**}	0.01	0.01^{**}	0.01^{*}	0.11^{*}	0.07	0.13^{**}	0.11
	(0.01)	(0.01)	(0.01)	(0.01)	(0.06)	(0.07)	(0.06)	(0.07)
2012:$VoteLast_{DPJ}$	-0.04^{*}	-0.04^{*}			-0.41^{**}	-0.40^{*}		
	(0.02)	(0.02)			(0.21)	(0.21)		
2012:Educ		-0.00		-0.00		-0.02		-0.02
		(0.01)		(0.01)		(0.07)		(0.07)
2012:Econ		0.01		0.01		0.12		0.09
		(0.02)		(0.01)		(0.13)		(0.13)
$VoteLast_{LDP}$			-0.05^{***}	-0.05^{***}			-0.49^{***}	-0.49^{***}
			(0.01)	(0.01)			(0.12)	(0.12)
2012:$VoteLast_{LDP}$			0.04^{*}	0.04			0.42^{**}	0.41^{**}
			(0.03)	(0.03)			(0.21)	(0.21)
Num. obs.	4417	4417	4417	4417	4393	4393	4393	4393
Year trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the relationship for the dummy variable indicating that the respondent voted in a given election and the fact that he/she had voted for a given party in a given election, with a focus in the 2012 elections. The four columns to the left, (1)-(4), consider a linear probability model, and the four columns to the right (5)-(8), consider a logit model. Columns (1), (2), (5) and (6) focus on whether the respondent had voted for the DPJ on the previous elections. Columns (3), (4), (7) and (8) focus on whether the respondent had voted for the LDP on the previous elections Standard errors are clustered at the prefecture level. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

districts more associated with the LDP showed higher turnout. Given these results, the next section examines the impact of natural disasters on political parties.

2.6.1.2
The effect on political parties

To understand how political parties in Japan were affected, we consider the major parties in Japan, namely the Liberal Democrat Party (LDP) and the Democrat Party of Japan (DPJ), as well as the ′ ideological orientation of candidates, RL, as defined in Sec. 2.5.1. For this analysis, based on the Reed-Smith dataset (Smith and Reed, 2018), we have a repeated cross-section structure in which each observation corresponds to a candidate c belonging to an electoral district d in election year t. The candidates' outcomes, $y_{c,d,t} \in \{rank_{c,d,t}, result_{c,d,t}\}$, are evaluated according to two measures: the candidate's rank, $rank_{c,d,t}$, and a dummy variable indicating whether he/she won the election for SMD, $result_{c,d,t}$. The goal is to understand whether the fact that the candidate is from a region heavily affected by the disasters and belongs to a particular party affected his/her result. For such, as Eq. 2-5 indicates, the aforementioned dependent variables are basically regressed against the interaction $Imp_{d,t} * Party_{c,d,t}$, where $Imp_{d,t}\ in\{\mathbb{1}_{d,t,x}, \mathbb{1}_{t,MIP}\}$ accounts for the impact metrics and $Party_{c,d,t}\ in\{DPJ, LDP, RL\}$ indicates the party or ideological orientation of the candidates,

$$y_{c,d,t} = \gamma Imp_{d,t} + \eta Party_{c,d,t} + \beta Imp_{d,t} * Party_{c,d,t} + \mathbf{X_{d,t}}'\boldsymbol{\alpha} + \delta_d + \gamma_t + \varepsilon_{c,d,t}, \tag{2-5}$$

where $X_{d,t}$ are the usual controls for the districts, δ_d are district fixed effects and γ_t are year fixed effects. The main idea is to capture the extent to which party affiliation had an effect on the candidate's outcome if his/her district was recently hit by a natural disaster. An extension of this analysis is to assess specific outcomes in 2012. In this case, the triple interaction $Imp_{d,t} * Party_{c,d,t} * \mathbb{1}_{t=2012}$ is adopted, as Eq. 2-6 indicates,

$$y_{c,d,t} = \beta \mathbb{1}_{t=2012} * Imp_{d,t} * Party_{c,d,t} + \mathbf{X_{d,t}}'\boldsymbol{\alpha} + \gamma t * Party_{c,d,t} + \delta_d + \varepsilon_{c,d,t}. \tag{2-6}$$

As in Sec. 2.6.1.2, due to the fact that an assessment is being done specifically for the 2012 elections, the year fixed effects have been replaced by the interaction between year and party in order to capture any party-specific trends[13]. The idea is to capture whether a candidate belonging to an affected region and affiliated with a particular party had higher or lower chances of being successful in the 2012 election. Such triple interaction is captured by the coefficient β. In equation in Eq. 2-6 all terms from the interactions are included, but are omitted here for clarity.

Table 2.6 shows the results for the case in which the outcome is the probability that DPJ candidates' win the election. On the left-hand side are the results in terms of Eq. 2-5, while on the right side are the results for Eq. 2-6. The most important result is that while the DPJ had an advantage in heavily impacted districts (as columns (1) and (2) show), the party was punished in 2012 regardless of whether the region was affected or not (row

[13] For robustness check, the results based on the specification with year fixed effects are presented in 2.8, as captured by γ. For our purposes, the two approaches should not make much difference, since the goal here is to capture the heterogeneous effect of party affiliation within a given election. As the results show, this is indeed the case.

"DPJ : 2012" from columns (4), (5), and (6))[14]. In Appendix 2.8, it can be seen that the result is robust to the analysis in which the outcome of interest is the ranking of the candidates (Table 2.18) and to the case in which the specification takes into account the year fixed effect (Table 2.24).

As for the LDP's results, Table 2.7 describes the chances of the party's candidates to win the elections[15]. As it can be observed, column (1) shows that LDP's candidates generally have a moderately higher chance of winning elections when they run in highly affected districts ($I_{JMA} > 5$). In addition, columns (4), (5), and (6) show that, in 2012, LDP's candidates had a higher chance of winning the elections, just as opposed from those from the Democrat Party. Column (5) also shows that LDP candidates had an even greater advantage in hard-hit areas in 2012, while their chances were lower in hard-hit areas in other years. In general, these results are reported in Tables2.27 and 2.28, in Appendix 2.8, with the ideological spectrum coded in the variable RL.

In summary, the LDP's results contrast interestingly with those of the DPJ. While the Liberal Party performed better in 2012, both in general and specifically in the hard-hit regions, quite the opposite can be observed for the Democrat Party. This suggests that the aftermath of disasters in "normal years" may have disadvantaged the right-wing party in favor of the center-left, but the Fukushima disaster reversed this pattern not only locally but nationwide. This result is closely related to the results in Sec. 2.6.1.2, where it is shown that in this year not only turnout was lower (higher) in districts where the incumbent belonged to the DPJ (LDP), but also voters who had voted for the DPJ (LDP) in previous elections tended to vote less (more). Interestingly

While we have so far examined the results in terms of both turnout and party performance, nothing has been said about the results of incumbents. Such an analysis is undertaken in the next section.

2.6.1.3 The effect on incumbents

Another relevant analysis is to consider how (un)successful incumbents were given that natural disasters occurred in their district. To capture such a pattern, we use a strategy quite similar to that assumed in Eqs. 2-5 and 2-6 is considered. The key difference is that the focus is no longer on the

[14] In column (5), where the year 2012 is highlighted, one can observe that the DPJ actually had an advantage in heavily impacted regions in other years

[15] Table 2.20, in the Appendix 2.8, lists the results for ranking the candidates

Table 2.6: Earthquake impact effect on DPJ candidates' likelihood of winning.

	Dependent variable:					
	Won the election					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	0.020			−0.013		
	(0.016)			(0.029)		
(I>6)		−0.020			−0.109*	
		(0.035)			(0.062)	
DPJ	0.103***	0.097***	0.075***	−19.368***	−19.342***	−19.838***
	(0.024)	(0.023)	(0.023)	(6.980)	(6.970)	(6.757)
2012				0.074***	0.072***	0.070***
				(0.006)	(0.005)	(0.005)
(I>5):DPJ	−0.069			0.055		
	(0.067)			(0.107)		
(I>6):DPJ		0.077			0.423**	
		(0.137)			(0.207)	
Most Imp.:DPJ			0.226*			0.211*
			(0.119)			(0.118)
(I>5):2012				0.002		
				(0.028)		
(I>6):2012					0.092	
					(0.068)	
Most Imp.:2012						0.002
						(0.022)
DPJ:2012				−0.399***	−0.388***	−0.376***
				(0.028)	(0.025)	(0.025)
(I>5):DPJ:2012				0.019		
				(0.104)		
(I>6):DPJ:2012					−0.302	
					(0.241)	
Most Imp.:DPJ:2012						0.067
						(0.111)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
Year trend	No	No	No	Yes	Yes	Yes
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.029	0.029	0.030	0.044	0.045	0.043

Notes: This table presents the relationship between a candidate result in the House of Representatives elections, his/her party (DPJ) and the fact that his/her district was hit by an earthquake or belonged to a most hit prefecture in the Fukushima catastrophe, in 2011. The dependent variable is a dummy indicating whether he/she won the election. Columns (1)-(3) do not explicit the 2012 elections and consider year fixed effects. Columns (4)-(6) make explicit the 2012 year and do not use year fixed effect, but include a time trend. Standard errors are clustered at the district level. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 2.7: Earthquake impact effect on LDP candidates' likelihood of winning.

	Dependent variable:					
	Won the election					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	−0.026			0.019		
	(0.017)			(0.032)		
(I>6)		0.018			0.150**	
		(0.038)			(0.066)	
LDP	0.476***	0.486***	0.506***	6.662	6.739	6.877
	(0.023)	(0.023)	(0.022)	(6.345)	(6.327)	(6.171)
2012				−0.081***	−0.082***	−0.080***
				(0.008)	(0.007)	(0.007)
(I>5):LDP	0.123*			−0.048		
	(0.068)			(0.113)		
(I>6):LDP		−0.068			−0.466**	
		(0.141)			(0.210)	
Most Imp.:LDP			−0.246*			−0.253*
			(0.138)			(0.138)
(I>5):2012				−0.019		
				(0.032)		
(I>6):2012					−0.145**	
					(0.073)	
Most Imp.:2012						−0.023
						(0.023)
LDP:2012				0.338***	0.343***	0.333***
				(0.031)	(0.027)	(0.026)
(I>5):LDP:2012				0.067		
				(0.117)		
(I>6):LDP:2012					0.417*	
					(0.252)	
Most Imp.:LDP:2012						0.044
						(0.094)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
Year trend	No	No	No	Yes	Yes	Yes
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.241	0.240	0.251	0.255	0.256	0.265

Notes: This table presents the relationship between a candidate result in the House of Representatives elections, his/her party (LDP) and the fact that his/her district was hit by an earthquake or belonged to a most hit prefecture in the Fukushima catastrophe, in 2011. The dependent variable is a dummy indicating whether he/she won the election. Columns (1)-(3) do not explicit the 2012 elections and consider year fixed effects. Columns (4)-(6) make explicit the 2012 year and do not use year fixed effect, but include a time trend. Standard errors are clustered at the district level. *p<0.1; **p<0.05; ***p<0.01

candidate's party affiliation, but on whether he/she was an incumbent in that election. More specifically, the term $Party_{c,d,t}$ is replaced by the dummy $Inc_{c,d,t}$, which takes the value 1 whenever candidate c in district d was an incumbent in the election in year t for the SMD[16].

As before, the most important coefficients are those associated with the interaction terms, capturing the effect of incumbency in a highly impacted region on the outcomes of interest (analogous to Eq. 2-5). To account for the specific impact of 2012, the analogous to Eq. 2-6 is assumed. Table 2.8 brings the results for incumbent party win probabilities. In the Appendix 2.8, Table 2.22 shows the results for the ranking of the incumbent parties.

As one can see from columns (1), (2), and (3), incumbents generally had a higher probability of achieving better results, as row 3 shows. Row 4 that they had a harder time winning if their district was affected by a ground motion in which $I_{JMA} > 5$. Moreover, looking specifically at the results in 2012, incumbents were generally penalized regardless of whether they were in a heavily affected district (row "Inc : 2012"). Looking at column (4) of the Table 2.8, we can see that the effect of being in a heavily affected region becomes less relevant compared to the 2012 effect.

From these results, it is clear that while being in a severely affected areas generally mattered, the Fukushima event stood out. It is therefore interesting to summarize the above results by excluding the impact variables and looking at the overall performance of incumbents and parties in a more general way. To this end, Eq. 2-7 considers the electoral outlook in 2012 in terms of incumbency, the candidates' parties, and their ideological orientation (RL),

$$y_{c,d,t} = \gamma \mathbb{1}_{t=2012} + \eta \mathbb{1}_{c,t,int} + \beta \mathbb{1}_{t=2012} * \mathbb{1}_{c,t,int} + \delta_d + \theta t * \mathbb{1}_{c,t,int} + \mathbf{X_{d,t}}' \boldsymbol{\alpha} + \varepsilon_{c,d,t}, \tag{2-7}$$

where $\mathbb{1}_{t=2012}$, δ_d, $X_{d,t}$, and t are defined according to the previous equations. The dependent variable, $y_{c,d,t} \in \{rank_{c,d,t}, result_{c,d,t}\}$ represents either the rank or the result of candidate c from district d in election year t, and $\mathbb{1}_{c,t,int} \in \{Inc_{c,d,t}, Party_{c,d,t}\}$ indicates whether the candidate is an incumbent and whether he/she belongs to the DPJ or to the LDP, as well as his/her ideological orientation RL. When $y_{c,d,t} = rank_{c,d,t}$, a simple linear model is run and when $y_{c,d,t} = result_{c,d,t}$, a logit model is run. The relevant coefficient is the one related to the interaction between the Fukushima year dummy and the candidate information, β. Its goal is to capture how

[16]It is important to note that a candidate is considered an incumbent here if he/she won the previous election in the SMDs.

Table 2.8: Earthquake impact effect on incumbents' winning probability.

	Dependent variable:					
	Won the election					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	0.049***			−0.001		
	(0.015)			(0.022)		
(I>6)		0.009			−0.065	
		(0.036)			(0.061)	
Inc	0.508***	0.495***	0.501***	−4.818	−4.879	−4.977
	(0.020)	(0.019)	(0.019)	(5.601)	(5.615)	(5.438)
2012				0.116***	0.118***	0.116***
				(0.009)	(0.008)	(0.008)
(I>5):Inc	−0.217***			0.073		
	(0.066)			(0.077)		
(I>6):Inc		−0.130			0.124	
		(0.145)			(0.189)	
Most Imp.:Inc			0.110			0.110**
			(0.072)			(0.054)
(I>5):2012				0.003		
				(0.026)		
(I>6):2012					0.027	
					(0.067)	
Most Imp.:2012						−0.029
						(0.032)
Inc:2012				−0.490***	−0.507***	−0.491***
				(0.037)	(0.032)	(0.032)
(I>5):Inc:2012				−0.124		
				(0.101)		
(I>6):Inc:2012					−0.064	
					(0.224)	
Most Imp.:Inc:2012						0.029
						(0.139)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
Year trend	No	No	No	Yes	Yes	Yes
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.241	0.238	0.250	0.269	0.269	0.280

Notes: This table presents the relationship between a candidate result in the House of Representatives elections, if he/she was an incumbent and the fact that his/her district was hit by an earthquake or belonged to a most hit prefecture in the Fukushima catastrophe, in 2011. The dependent variable is a dummy indicating whether he/she won the election. Columns (1)-(3) do not explicit the 2012 elections and consider year fixed effects. Columns (4)-(6) make explicit the 2012 year and do not use year fixed effect, but include a time trend. Standard errors are clustered at the district level. *p<0.1; **p<0.05; ***p<0.01

Table 2.9: Party and ideology leaning after Fukushima, for all candidates, considering a logit model.

	Dependent variable: Won the election			
	Incumbents	DPJ	RL	LDP
2012:Inc	-2.38^{***}			
	(0.19)			
2012:DPJ		-2.13^{***}		
		(0.25)		
2012:RL			1.00^{***}	
			(0.13)	
2012:LDP				2.31^{***}
				(0.23)
Num. obs.	6724	6724	6724	6724
Dist. FE	Yes	Yes	Yes	Yes
Year-Var trend	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: By means of a logit model, this table presents the relationship between a candidate result in the House of Representatives elections, if he/she was an incumbent (column (1)), his/her party (columns (2) and (4)), his/her ideological leaning (column (3)), considering the specific result in 2012. The dependent variable is a dummy indicating whether he/she won the election. Standard errors are clustered at the district level. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

different being an incumbent or affiliated to a certain party (according to $y_{c,d,t}$) was in 2012 as compared to the time trend for these variables. The electoral consequence of such a scenario is quite clear in Table 2.9, which presents the results of the logit model: incumbents were generally removed from office in 2012 (column 1), the DPJ lost substantial seats (column 2), and right-wing parties (column 3), especially the LDP (column 4), benefited.

Restricting the sample to incumbent candidates in all elections, as shown in Table 2.10, confirms that 2012 was particularly negative for incumbents (column 1), and even more so if the incumbent belonged to DPJ (column 2). However, this trend was favorable for incumbents from right-wing parties' (column 3), especially for LDP candidates (column 4). Thus, it becomes quite clear that there was indeed an overall punishment to the Democrat Party, which is consistent with the scenario presented by citetKingston2013, and that, as discussed in section2.6.1.3, this was not related to the localities most affected[17].

These findings suggest that the social phenomena following the

[17] Tables 2.29 and 2.30, in Appendix 2.8, provide a similar picture, but using the ranking of candidates rather than the result in a particular election as the dependent variable. The result largely mirrors that observed here. In general, the ranking of incumbents and DPJ candidates' is lower, while that of right wing and LDP candidates is higher.

Table 2.10: Party and ideology leaning after Fukushima, for incumbents only, considering a logit model.

	Dependent variable: Won the election			
	All	DPJ	RL	LDP
2012	-2.61^{***}	-1.69^{***}	-2.03^{***}	-3.04^{***}
	(0.26)	(0.36)	(0.37)	(0.42)
2012:DPJ		-1.56^{*}		
		(0.65)		
2012:RL			1.65^{***}	
			(0.37)	
2012:LDP				4.70^{***}
				(1.05)
Num. obs.	1249	1249	1249	1249
Dist. FE	Yes	Yes	Yes	Yes
Year-Var trend	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: By means of a logit model and restricting the sample to only incumbents, this table presents the relationship between a candidate result in the House of Representatives elections his/her party (columns (2) and (4)), his/her ideological leaning (column (3)), considering the specific result in 2012. The dependent variable is a dummy indicating whether he/she won the election. Standard errors are clustered at the district level. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Fukushima triple disaster were a national event and not specific to particular localities. Incumbent politicians had a harder time than usual getting re-elected, and this was especially true for DPJ candidates. The picture that the disaster indeed had a national character is strengthened by Novikova (2016)'s report that movements motivated by the nuclear issue emerged in various parts of the country in 2012. From a different perspective, Carvalho et al. (2021) finds that the Fukushima disaster had an overall negative impact on Japan's GDP, and Kawashima and Takeda (2012) find that the stock value of companies owning nuclear power plants in Japan declined, suggesting that investors beliefs about the regulatory environment after the event. These facts help to illustrate the far-reaching consequences of the disaster. In some dimensions, the impact was felt even outside Japan. For example, Huang et al. (2013) document that the risk perception of Chinese living near nuclear power plants changed significantly, and Goebel et al. (2015) report an increased environmental awareness among Germans. Given such a scenario, the following section attempts to provide a better perspective on the Japanese public's response to the 2011 disaster.

2.6.2
What is behind the 2012 elections?

Given the high relevance of the Fukushima event, it is interesting to understand what was behind the election results in the post-disaster elections. What was it that kept DPJ voters away from the polls and led to better results for the LDP? To this end, we first examine how the Japanese public evaluated the DPJ in 2012. Then, we analyze the individuals' potential motivations for the observed results.

2.6.2.1
The population view about DPJ

First, it is important to observe how perceptions and attitudes toward DPJ changed in 2012. To gain such a general understanding, we again rely on the survey conducted by Taniguchi Lab. (2003) and observe how respondents thought about the Democrat Party and whether they voted for it in the Single Member District and in the Proportional Representative portions of the electoral process. The last two variables are dummies indicating whether or not the respondent voted for the party $Vote^{SMD}_{r,t,p,DPJ} \in \{0,1\}$ represents the vote for DPJ in the SMD and $Vote^{PR}_{r,t,p,DPJ} \in \{0,1\}$ indicates this vote in the PR part. As for the feeling towards the DPJ, it is codified in the variable $Feelig_{r,t,p,DPJ} \in [0,100]$, which is a numerical "emotional thermometer" indicating whether respondents have a positive feeling or antipathy towards the party. In this case, $Feelig_{r,t,p,DPJ} = 0$ represents total antipathy and $Feelig_{r,t,p,DPJ} = 100$ represents the highest positive feeling[18]. These variables are summarized in Table 2.1.

Recalling that the survey dataset consists of a repeated cross-section in which each observation represents, for each election year t, respondent r, living in prefecture p, Eq. 2-8 relates the aforementioned outcomes to the 2012 dummy, $\mathbb{1}_{t=2012}$. We also include controls for year trend, t, and respondent characteristics, $X_{r,t,p}$, which include gender, education level, age, and his/her perception of the country's economic status.

$$y_{r,t,p,DPJ} = \beta \mathbb{1}_{t=2012} + \theta t + \mathbf{X_{r,t,p}}'\boldsymbol{\alpha} + \kappa_p + \varepsilon_{r,t,p}, \tag{2-8}$$

where $y_{r,t,p,DPJ} \in \{Feelig_{r,t,p,DPJ}, Vote^{SMD}_{r,t,p,DPJ}, Vote^{PR}_{r,t,p,DPJ}\}$ is the desired outcome and κ_p is the fixed effect of prefecture. Our coefficient of interest is β, which captures how different 2012 was from the time trend. As in the previous regressions, in terms of identification, we would ideally like to have a counterfactual to the Fukushima event and observe DPJ's perfor-

[18] The question makes clear that the value 50 should mean indifference.

mance in both cases. However, since we found that the event had a national character, such an approach is not possible. Therefore, a comparison is made here between DPJ's performance in 2012 and its time trend.

Table 2.11 thus shows the 2012 effect on sentiment toward the DPJ and votes for the party in both the SMD and the PR elections, controlling for year trend and individuals' gender, age, education, and assessment of the country's economic situation. Column (1) shows that the public's sentiment toward the party decreased significantly in 2012. Considering that the scale for feeling toward the party ranges from 0 to 100, indicating the worst and the best scores respectively, this value decreased by about 10 points in 2012 compared to the already decreasing annual trend. If one compares the 10-point decrease with the 57 points attained in 2009, showed in Table 2.1, the result is quite relevant. Pre-2009 data would make the result more reliable, but the fact that the DPJ was on the rise makes this hard decline quite relevant.

Moreover, this decline is reflected in votes for DPJ in both SMD (column 2) and PR elections (column 3). The interpretation of these results is quite straightforward, as the dependent variables are dummies that equal 1 if the person voted for the DPJ in the SMD (PR) portion in column 2 (column 3) and zero otherwise. The decreases of 0.139 and 0.162 for the SMD and PR sections, respectively, are quite relevant when compared to the 2009 values. In that year, Table 2.1 shows that our dummy variable "Vote for DPJ" had a value of 0.53 and 0.47 for the SMD and PR sections, respectively. Consistent with this evidence, Hommerich (2012) found lower trust in government among those more affected by the disaster, which, according to the author, was not necessarily related to individuals' regions.

2.6.2.2
Potential motivations

From the previous results, it is clear that the Japanese population mostly punished DPJ incumbents mainly by not voting in the House of Representatives elections, and that people showed their disappointment with the party in 2012. Nevertheless, the motivation behind this behavior is still not understood. The following is an attempt to explain why the Democrat Party was unsuccessful.

Therefore, we once again resort to the survey conducted by Taniguchi Lab. (2003), which is also revealing as to the reasons for the above-mentioned absence. First, it is useful to understand how the population views the economic situation of the country. In 2-9 we observe whether 2012

Table 2.11: Survey results on the sentiment towards the DPJ

	Dependent variable:		
	Feel DPJ	Vote DPJ - SMD	Vote DPJ - PR
	(1)	(2)	(3)
2012	-10.551^{***}	-0.139^{***}	-0.162^{***}
	(0.722)	(0.017)	(0.015)
Educ	0.589^{***}	0.023^{***}	0.014^{**}
	(0.214)	(0.006)	(0.005)
Econ	-0.298	-0.061^{***}	-0.038^{***}
	(0.438)	(0.007)	(0.006)
Year	-3.639^{***}	-0.051^{***}	-0.050^{***}
	(0.166)	(0.005)	(0.005)
Observations	4,839	4,273	4,344
R^2	0.194	0.139	0.122

Notes: This table presents the DPJ's performance considering the dataset build based on the survey undertaken by Taniguchi Lab. (2003). In column (1), the dependent variable is feeling in regards to the DPJ, which is coded in a variable between 0 (worst feeling) and 100 (best feeling). The dependent variables in columns (2) and (3) are dummies equal to 1 if the respondent voted for the DPJ in the SMD and in the PR sections of the elections. Standard errors are clustered at the prefecture level. *p<0.1; **p<0.05; ***p<0.01

was any different in terms of such assessment,

$$Econ_{r,t,p} = \beta \mathbb{1}_{t=2012} + \mathbf{X_{r,t,p}}'\boldsymbol{\alpha} + \theta t + \kappa_p + \varepsilon_{r,t,p}. \quad (2\text{-}9)$$

$Econ_{r,t,p}$ refers to the response given by respondent r from prefecture p in election year t, $\mathbb{1}_{t=2012}$ is our dummy for 2012, $X_{r,t,p}$ is the vector of demographic characteristics– age, education level, and gender–, t is the year trend, and κ_p is the prefecture fixed effect. Table 2.12 shows how the responses changed in 2012, as captured by β. In that year, the economic situation of the country was considered worse compared to the positive trend. Indeed, this result is consistent with the literature on the economic impact of the GEJE. Carvalho et al. (2021), for example, notes that the disaster was responsible for a 0.47 percentage point decline in Japan's GDP in 2012[19]. Interestingly, this perception played an important role in the sentiment towards the DPJ. Extending the results of Table 2.11 further to understand how education and perceptions of the economy affected DPJ's

[19] As the authors note, the country's average growth rate in the decade before the disaster was 0.6%.

performance, we arrive at Table 2.13. As can be readily seen, perceptions of the state of the economy are positively correlated with DPJ' performance in 2012. However, as Table 2.12 shows, popular sentiment toward the economy is declining, leading to a deterioration in the party's results.

Table 2.12: Evaluation of the country's economic situation.

	Dependent variable:
	Japan Econ. condition
2012	-0.375^{***}
	(0.022)
Age	0.044^{***}
	(0.008)
Educ	0.019^{*}
	(0.009)
Gender	0.001
	(0.023)
Year trend	0.144^{***}
	(0.006)
Pref FE	Yes
Controls	Yes
Observations	5,569
R^2	0.156

Notes: This table presents the regression of individuals' perception on the country's economic condition. Each individual answers the question "What do you think is the current economic situation of Japan?". Whereas the answers were from 1 (Very good) to 5 (very bad), I inverted the scale to -5 (Very bad) to -1 (Very good) so that it is positively correlated with positive thoughts on the economy. Standard errors are clustered at the prefecture level. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

In addition, Taniguchi Lab. (2003) data can also be used to try to capture what is behind voters' feelings and choices about parties. Given the nature of the Fukushima disaster, it is important to understand whether respondents' thoughts about the environment and nuclear energy were related to their political choices. On the one hand, the 2012 survey asked whether respondents thought the environment was an important issue among a list of about a dozen other issues. Let $\mathbb{1}_{r,t,p,Env.1st}$ be a dummy variable that takes the value 1 if a person considers the environment to be the most important issue. On the other hand, to assess the relevance

Table 2.13: DPJ performance in 2012.

	Dependent variable:		
	Feel DPJ	Vote DPJ - SMD	Vote DPJ - PR
	(1)	(2)	(3)
2012	13.929***	0.322***	0.283***
	(3.527)	(0.071)	(0.065)
Econ	−1.967***	−0.090***	−0.069***
	(0.398)	(0.008)	(0.008)
Educ	0.326	0.022***	0.010
	(0.225)	(0.006)	(0.006)
Year	−3.387***	−0.046***	−0.045***
	(0.171)	(0.005)	(0.005)
2012:Econ	6.369***	0.111***	0.116***
	(0.808)	(0.016)	(0.017)
2012:Educ	0.809	0.001	0.014
	(0.528)	(0.009)	(0.011)
Observations	4,839	4,273	4,344
R^2	0.204	0.146	0.130

Notes: This table presents the DPJ's performance considering the dataset build based on the survey undertaken by Taniguchi Lab. (2003). In column (1), the dependent variable is feeling in regards to the DPJ, which is coded in a variable between 0 (worst feeling) and 100 (best feeling). The dependent variables in columns (2) and (3) are dummies equal to 1 if the respondent voted for the DPJ in the SMD and in the PR sections of the elections. The only difference to Table 2.11 is that it is now considered the interaction with 2012 for the thoughts on the country's economic condition and the respondents' educational level. Standard errors are clustered at the prefecture level. *p<0.1; **p<0.05; ***p<0.01

of the nuclear issue, the survey asked whether it would be "unavoidable to restart operations of nuclear power plants that have been shut down due to periodic inspection"[20]. Responses were on a Likert scale from 1 (agree) to 5 (disagree). Let $NoNP_{r,t,p}$ store respondents' answers to the above question, with high values indicating that respondents disagreed that restarting nuclear power plants was unavoidable.

To understand the relationship between these variables and respondents' behavior toward DPJ, both the feeling toward the party, $Feelig_{r,t,p,DPJ}$, and having voted for the party in the PR section, $Vote^{PR}_{r,t,p,DPJ}$, are regressed against the interaction between the aforementioned variables of interest and the variable indicating having voted for the party in previous elections for the House of Representatives. The PR section was chosen because the survey does not ask which party was voted for in the previous SMD election. Therefore, Eq. 2-10 represents four possible regressions in which the independent variables are represented by $IndVar_{r,2012,p} \in \{\mathbb{1}_{r,t,p,Env.1st}, NoNP_{r,t,p}\}$ and the two dependent variables are represented in $y_{r,2012,p} \in \{Feelig_{r,t,p,DPJ}, Vote^{PR}_{r,t,p,DPJ}\}$,

$$
\begin{aligned}
y_{r,2012,p} =& \gamma IndVar_{r,2012,p} + \eta VoteLast_{DPJ} + \beta IndVar_{r,2012,p} * VoteLast_{DPJ} + \\
&+ \mathbf{X_{r,2012,p}}'\boldsymbol{\alpha} + \kappa_p + \varepsilon_{r,2012,p}.
\end{aligned}
\tag{2-10}
$$

Table 2.14 describes the cross-sectional behavior in 2012 of those who had voted for the DPJ in the previous election, taking into account the Conley correction for standard errors for proximity among the prefectures. It can be observed that for those who considered the environment relevant and among those who were less favorable to nuclear power plants, having voted for the DPJ in 2009 decreased the sentiment toward the party in 2012 (columns (1) and (2))[21]. In other words, those who had previously trusted the DPJ to adequately address such issues experienced a decline in their regard for the party, which is consistent with Novikova (2016)'s and Kingston (2013)'s descriptions of an increase in antinuclear activism. The result in terms of actual voting for DPJ in 2012, in columns (3) and (4), is no less revealing. While the importance placed on the environment induced less voting for the DPJ in 2012, this was not true for voters who were less favorable toward nuclear power plants. The Democrat Party's main rival,

[20] As translated from Japanese using Google Translate tool.

[21] It is important to note that in the survey for the election before the Fukushima disaster, there was no question on the dimension of nuclear power, which in itself is an indication of how much this issue gained importance in that year.

Table 2.14: Cross-section assessment of voter behavior regarding environment and nuclear issues.

	Dep. variable:			
	Feel.DPJ		Vote current DPJ	
	(1)	(2)	(3)	(4)
Env. important	6.13***		−0.11***	
	(1.75)		(0.02)	
$VoteLast_{DPJ}$	14.35***	18.10***	0.26***	0.27***
	(1.04)	(2.24)	(0.02)	(0.05)
Age	1.20***	1.39***	0.02***	0.02***
	(0.33)	(0.27)	(0.00)	(0.00)
Educ	1.08***	1.16***	0.03***	0.02***
	(0.39)	(0.32)	(0.01)	(0.01)
Econ	3.59**	4.09***	0.03***	0.04***
	(1.42)	(1.33)	(0.01)	(0.01)
Env. important:$VoteLast_{DPJ}$	−10.83**		−0.21***	
	(4.54)		(0.03)	
No Nuclear		1.75***		−0.00
		(0.55)		(0.01)
No Nuclear:$VoteLast_{DPJ}$		−1.79**		−0.00
		(0.71)		(0.01)

Notes: This table presents the DPJ's performance considering the dataset build based on the survey undertaken by Taniguchi Lab. (2003). In columns (1) and (2), the dependent variable is feeling in regards to the DPJ (which is coded in a variable between 0 (worst feeling) and 100 (best feeling)), whereas in columns (3) and (4), dummies equal to 1 if the respondent voted for the DPJ in the PR sections of the elections are considered. The relevant rows are those in which the importance attributed to the environment and to the nuclear issue are interacted with the fact that the respondent had voted for the party in the previous elections. In this cross-section analysis, standard errors are clustered according to the Conley standard errors for spatial correlation, with a cut-off distance of 400 km. *p<0.1; **p<0.05; ***p<0.01

the LDP, was a pronuclear party in 2012 ((Kingston, 2013)[22]. Thus, despite the turmoil caused by the nuclear disaster, there was not much difference between the parties on this dimension. Indeed, consistent with our findings, the author argues that the 2012 elections were not really about the nuclear issue, but about the DPJ's mismanagement.

Since Taniguchi Lab. (2003) asked respondents to select from a list of various possible issues those they consider most important for this election, it is worth having a horse race among them. Since we want to capture the relevant issues among DPJ voters, it is important that each of these variables

[22]In fact, Kingston (2013) points out that the LDP is one of the pillars of the so-called nuclear village, which consists of "pronuclear advocates in the bureaucracy, Diet, business community, utilities, vendors, and lenders" (p.502).

is interacted with the fact that individuals had voted for DPJ in the previous elections. The idea is to observe the preferences of DPJ voters and relate them to the variables in the 2012 election.

More specifically, voters in 2012 were asked to select from such a list the three most relevant issues from fifteen (the 16^{th} is "others"), in order of importance. Thus, to take advantage of all the information in the 2012 data, an index is created for the cumulative importance assigned to each item. Thus, if a person identified an issue as most important, 3 points are assigned. If an attribute was second most important to a respondent, 2 points are assigned, and finally, if the topic was third most important, 1 point is assigned[23][24]. Let $Ind_{r,2012,p,i}$ be the index for a given issue i according to respondent r from prefecture p in 2012. In Eq. 2-11, the feeling towards the DPJ and having voted for the LDP are the dependent variables of interest,

$$y_{r,2012,p} = \gamma VoteLast_{DPJ} + \sum_{i=1}^{15} \beta_i VoteLast_{DPJ} * Ind_{r,2012,p,i} + \\ + \sum_{i=1}^{15} \eta_i * Ind_{r,2012,p,i} + \mathbf{X_{r,2012,p}}'\boldsymbol{\alpha} + \kappa_p + \varepsilon_{r,2012,p}, \tag{2-11}$$

where $y_{r,2012,p} \in \{Feelig_{r,t,p,DPJ}, Vote^{PR}_{r,t,p,LDP}\}$, and the remaining variables are defined as in the previous equations. This choice for the dependent variables was made because of the potential relationship between disappointment with the DPJ and LDP's performance[25]. Naturally, the coefficients of interest are those from the interaction terms, β_i, which indicate what was relevant for those who had voted for the DPJ in the previous elections to build sentiment for the party and to have voted for its main competitor. In Table 2.15, according to Eq. 2-11, both sympathy for the DPJ and votes for the LDP in 2012 are regressed against all potentially relevant policy areas[26] in interaction with the dummy variable indicating having voted

[23]Despite the arbitrariness, such an index is a fairly straightforward way to account for differences in importance attributed by respondents to the issues

[24]At this point, the main goal is to understand what is behind the consequences of the Fukushima event, and since other events may have occurred between 2012 and 2014, this last year was excluded from the sample for this analysis.

[25]Interestingly, the impact on voting for the DPJ is distributed across the index created, results not shown

[26]The relevant policy areas are: "diplomacy and security; public finance; industrial policy; agriculture, forestry and fisheries; education/childcare; pensions/medical care; employment; security; environment; political/administrative reform; decentralization; constitution (protection/revision); earthquake reconstruction/disaster prevention; social capital (infrastructure development); and nuclear power/energy policy. In the regression, the omitted variable is "other." In addition, since respondents in 2012 were asked to indicate

for the DPJ in the previous House of Representatives elections. As one can see, the variable that becomes statistically significant in the interaction is the one related to the decentralization of government, in addition to the environmental aspect.

As Cho (2014) discusses, the DPJ came to power in 2009 strongly advocating political decentralization and proclaiming 'local sovereignty reform' as its slogan. Faced with the catastrophic scenario, as described by the author, the central government was supposed to support local governments in managing the reconstruction. In fact, however, local autonomy was threatened because bureaucrats were unwilling to empower local authorities, claiming they were not prepared for the situation (Cho, 2014). Indeed, the author argues that the lack of decentralization "prevented rapid recovery". Matching such a scenario with the results from Table 2.15, it does seem plausible that the punishment could be related to the government's inability to deal with the disaster. Moreover, it does not seem unreasonable to associate negative feelings toward the DPJ with a higher vote share for the LDP. Greater concern about decentralization and voting for the DPJ in 2009 are both associated with worse feelings toward the party in 2012 (columns (1) and (2)) and a higher likelihood of voting for the LDP (columns (3) and (4)). While results from columns (1) and (2) should be compared to the feelings for DPJ in Table 2.1, those from columns (3) and (4) should be compared to the Vote for LDP variables in the same table. While the score for the feelings toward the DPJ was of 57.34 in 2009, voting for the LDP in the PR section was of 0.38 in that same year. These values indicate that the results in Table 2.15 are rather relevant. Curiously, this tendency to decentralize does not seem to be a feature of the LDP in general, as the variable "Dec" in columns (3) and (4) in the 3^{rd} row is actually associated with fewer votes for the party.

Interestingly, such a scenario fits well with the picture that Scheiner (2005)' paints of the Japanese political structure. In trying to find an explanation for the long-term dominance of the Liberal Party, the author describes the country's politics as highly centralized and clientelistic. According to his analysis, the LDP's strength was nurtured by the links between local and national governments. Indeed, the author argues that even if voters disagreed ideologically with the party, they had an incentive to vote for the party's candidates to allow a flow of resources to their communities. Given Cho (2014)'s observations regarding the suboptimal recovery process as a result of the highly centralized tax structure, the hypothesis that voter disenchant-

the three most important policy areas in order of relevance, I assign a value of 3 to the most important area, a value of 2 to the second most important, and a value of 1 to the third most important, and use the overall index.

Table 2.15: Horse race of potential explanations

	Dependent variable:			
	Feel DPJ	Feel DPJ	Vote LDP	Vote LDP
	(1)	(2)	(3)	(4)
$VoteLast_{DPJ}$	19.540	15.195	−0.138	−0.263
	(17.217)	(30.787)	(0.283)	(0.254)
Env.	5.832***	6.569***	0.096	0.085
	(2.232)	(2.187)	(0.074)	(0.070)
Dec	0.483	0.658	−0.100***	−0.106***
	(2.068)	(2.111)	(0.023)	(0.024)
Age	1.137**	0.224	0.011	0.019
	(0.560)	(0.763)	(0.012)	(0.016)
Educ	1.161**	0.641	−0.003	−0.008
	(0.454)	(0.400)	(0.007)	(0.008)
Econ	4.548***	3.840**	0.017	0.029
	(1.432)	(1.739)	(0.011)	(0.033)
$VoteLast_{DPJ}$:Env.	−4.527	−5.638*	−0.062	−0.047
	(3.330)	(3.299)	(0.076)	(0.073)
$VoteLast_{DPJ}$:Dec	−7.736**	−8.053**	0.134***	0.141***
	(3.364)	(3.539)	(0.047)	(0.046)
$VoteLast_{DPJ}$:Age		1.956		−0.018
		(1.559)		(0.016)
$VoteLast_{DPJ}$:Educ		1.108		0.012*
		(0.733)		(0.007)
$VoteLast_{DPJ}$:Econ		1.305		−0.026
		(2.657)		(0.055)
Pref FE	Yes	Yes	Yes	Yes

Notes: This table presents the result of a horse race among all the issues asked to respondents in the electoral survey (Taniguchi Lab., 2003) so as to explain the feeling towards the DPJ and votes for the LDP. Whereas all the variables are considered, only those whose interaction with having voted for DPJ in the previous elections are statistically significant are shown. In columns (1) and (2), the dependent variable is feeling in regards to the DPJ (which is coded in a variable between 0 (worst feeling) and 100 (best feeling)), whereas in columns (3) and (4), dummies equal to 1 if the respondent voted for the LDP in the PR sections of the elections are considered. In the rows, "Dec" corresponds to the importance attributed to the decentralization" and "Env" to the environment. In this cross-section analysis, standard errors are clustered according to the Conley standard errors for spatial correlation, with a cut-off distance of 400 km. *p<0.1; **p<0.05; ***p<0.01

ment with the Democratic Party was motivated by the issue of decentralization is rather strengthened.

These results become even clearer when considering the relationships identified in Table 2.16, which regresses sympathy for the DPJ and voting for the LDP against the importance attributed to decentralization, considering the 2012 and 2014 elections. More specifically, both dependent variables, $y_{r,t,p} \in \{Feelig_{r,t,p,DPJ}, Vote^{PR}_{r,t,p,LDP}\}$, are related to the importance attributed to decentralization – according to the cumulative index – taking into account the interaction effects of education and economic perception, as Eq. 2-12 describes,

Such results are further highlighted when one observes the relationships established in Table 2.16, where, considering the elections of 2012 and 2014[27], the feeling towards DPJ and voting for LDP are regressed against the pledge for decentralization. More specifically, both dependent variables, $y_{r,t,p} \in \{Feelig_{r,t,p,DPJ}, Vote^{PR}_{r,t,p,LDP}\}$, are related to importance attributed to decentralization – according to the accumulated index – considering the interaction effects of education and economic perception, as Eq. 2-12 describes,

$$y_{r,t,p} = \gamma \mathbb{1}_{t=2012} + \eta Dec_{r,t,p} + \beta Dec_{r,t,p} * \mathbb{1}_{t=2012} + \mathbf{X_{r,t,p}}'\boldsymbol{\alpha} + \varepsilon_{r,t,p} \qquad (2\text{-}12)$$

where, in addition to the usual variables, $Dec_{r,t,p}$ is the cumulative index for decentralization. Columns (1) and (2) show that considering decentralization as an important issue in 2012 reduced sentiment for the DPJ regardless of economic considerations– which nevertheless played an important role. Looking at votes for the Liberal Party, the issue of decentralization does not appear to have played a relevant role in its performance. Curiously, however, pure concerns about decentralization (first row) are not related to the Liberal Party's propensity to win. In fact, according to Scheiner (2005) and as described above, the party was known for its centralization strategy. Certainly, this analysis loses strength since we are looking at two years and do not have enough data from the period before the Fukushima event, but its connection to the political structure of the country is quite interesting.

[27]Data for the 2009 elections are not used here for two main reasons: First, the set of issues asked in the 2009 survey differs from those asked in the 2012 and 2014 elections, making the comparison not entirely fair. Also, in 2009 there is only the option to indicate the most important issue, which provides less information and variation in voter preferences. When looking at 2009 (and considering 'decentralization' as the most important issue), the coefficients were in the same direction, but were not statistically significant

Table 2.16: Relevance of decentralization for voting behavior.

	Dependent variable:			
	Feel DPJ	Feel DPJ	Vote LDP	Vote LDP
	(1)	(2)	(3)	(4)
Dec	0.637	0.538	−0.088*	−0.086*
	(0.539)	(0.545)	(0.013)	(0.011)
2012	−1.823	24.647***	0.033	−0.336
	(2.407)	(0.241)	(0.040)	(0.059)
Educ	1.067	0.880	−0.014	−0.013
	(0.222)	(0.233)	(0.007)	(0.008)
Econ	0.479	−2.050	0.086	0.121**
	(3.021)	(0.634)	(0.044)	(0.009)
Dec:2012	−3.434*	−3.167*	−0.019	−0.023
	(0.484)	(0.358)	(0.017)	(0.016)
2012:Educ		0.389		−0.003
		(0.560)		(0.003)
2012:Econ		6.838**		−0.094*
		(0.424)		(0.014)
Pref FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	2,125	2,125	2,312	2,312
R^2	0.053	0.068	0.065	0.072

Notes: This table presents the result of regressions based on the electoral survey (Taniguchi Lab., 2003) so as to explain the feeling towards the DPJ and votes for the LDP. In columns (1) and (2), the dependent variable is feeling in regards to the DPJ (which is coded in a variable between 0 (worst feeling) and 100 (best feeling)), whereas in columns (3) and (4), dummies equal to 1 if the respondent voted for the LDP in the PR sections of the elections are considered. In the rows, "Dec" corresponds to the importance attributed to the decentralization". In this analysis, the years of 2012 and 2014 are considered, with standard errors clustered at the prefecture level. *p<0.1; **p<0.05; ***p<0.01

2.6.3 Discussion

At this point, a connection can be made to the literature on retrospective voting mentioned earlier (Cole et al., 2012; Gasper and Reeves, 2011; Bodet et al., 2016; Fair et al., 2017). Regarding the natural disaster itself, the results obtained here establish a weak link between physical impacts and local political impacts. While we observed some local outcomes, such as lower voter turnout in the most affected regions and the disadvantage (advantage) of the LDP (DPJ) in hard-hit localities, the most striking results are at the national level. Thus, the evidence collected suggests that the Fukushima disaster had a signaling effect and provided information about the quality of government.

Indeed, as Cho (2014) points out, the disaster served to expose the country's political vulnerabilities. Since the DPJ had come to power claiming to address these weaknesses but ultimately failed to do so, the consequences were the disappointment we find in the data, followed by the party's punishment by voters. These findings are also related to the literature on political "withdrawal" which states that the population does not go to the polls on Election Day, either because of more pressing concerns or to punish the incumbent (Lynge and Martinez i Coma, 2022). Research on this topic has suggested some reasons for this absence, such as unemployment (Aytaç et al., 2020), depression (Ojeda, 2015) , lack of trust in government (Cox, 2003), low income (Schafer et al., 2022) , and poor economic conditions (Lynge and Martinez i Coma, 2022).

This potential mechanism seems to be quite related to the Japanese context. As Foljanty-Jost and Schmidt (2006) shows, after a consistent decline in turnout until the mid-1990s, there was an increase in participation in polls after the electoral reform and until 2009 – as Fig. 2.4 confirms. However, in the context of the scenario triggered by the Fukushima disaster, the results shown here suggest that sentiment toward the government has deteriorated, which is consistent with the distrust observed by Hommerich (2012), and its possible link to lower turnout and punishment of parties.

2.6.4 The role of social capital

So far, it has become apparent that the elections to the House of Representatives following the Fukushima triple disaster had a very clear pattern: incumbents were punished, more specifically DPJ's incumbents. Moreover, the analysis conducted shows that the worse performance of

Democrat Party politicians was related to lower voter turnout in the districts where they were incumbents. Moreover, the heterogeneity analysis revealed two possible causes of disenchantment with these politicians: (i) concerns about the country's environment and nuclear development or, more likely, (ii) concerns about the government's ability to promote the decentralization agenda and the flow of resources to enable the country's recovery.

Further analysis can be conducted. The literature argues that social capital has a strong influence on the development of a society (e.g. Bourdieu (1986); Coleman (1988); Putnam et al. (1993); Putnam (1995) are examples of early work on this topic). Consistent with the goals of this work, two potential areas where social capital can play an important role are disaster recovery (Norris et al., 2008; Hawkins and Maurer, 2009; Aldrich and Meyer, 2015; Shimada, 2015; Aldrich, 2016; Akbar and Aldrich, 2018; Fraser, 2021) and political engagement (Krishna, 2002; Helliwell and Putnam, 2007; Nannicini et al., 2013; Atkinson and Fowler, 2014; Enke, 2020; Giuliano and Wacziarg, 2020; Gethin et al., 2022).

While the definition of social capital lacks precision and consensus (Woolcock, 2010), I follow Woolcock in considering that social capital is related to the "networks embedded in social structures that enable people to act collectively" (p. 471)[28]. In considering the instances of social capital, it has been argued that it can be divided into three categories: bonding, bridging, and linking (Aldrich and Meyer, 2015). According to the authors description, bonding refers to the connections made with close individuals, such as family, friends, or people with similar demographic characteristics that lead to close ties. Bridging is more associated with looser ties, spanning social groups such as civic and political institutions, sport associations, educational and religious groups. Finally, linking describes the connection between citizens and their government and represents their interaction in "explicit, formal, or institutionalized" ways (p. 259). Although all forms of social capital can be important for post-disaster recovery (Hawkins and Maurer, 2009), this paper is concerned with the impact of bridging variables on the political consequences of disasters. As discussed in Szreter and Woolcock (2004), Putnam argues that social capital plays an important role by giving people access to resources such as "ideas, information, money, services, favours" through participation in networks (p. 654), and that bridging

[28]Different authors tend to follow somewhat different but strongly related definitions. Atkinson and Fowler (2014), for example, define social capital as "the connectedness and trust within a community, which are built in varying degrees through interaction between community members" (p. 41). Similarly, Nannicini et al. (2013) define social capital as "those persistent and shared beliefs and values that help a group overcome the freerider problem in the pursuit of socially valuable activities" (p.223)

social capital would be more relevant at this point. Along these lines, Toya and Skidmore (2014) agree and assert that bridging is critical to understanding the relationship between disasters and social trust. When viewed as the network that connects those who are very similar, bonding can even compromise collective action, as closed groups may have exclusionary interests, which actually makes social articulation more difficult (Gibson and Gouws, 2000; Szreter and Woolcock, 2004).

2.6.5
Social capital data

To examine the role of social capital in Japanese elections, this paper draws on data developed by Fraser (2021), who, based on Kyne and Aldrich (2020), collected relevant information from publicly available data to measure social capital levels at the municipality and prefecture levels in Japan. While the author creates a time-series for each variable collected, this paper uses only the first available data in the series. First, it would not be possible to synchronize the data once they are made available at different frequencies, and one would have to resort to filling strategies that could introduce noise into the known information. Moreover, as Fraser (2021) shows, there is not much temporal variation in the indices that summarize social capital, so little, if any, information is lost by using the first instances of each variable.

More specifically, information on income per capita, libraries per capita, public halls per capita, volunteer participation rate, religious organizations per capita, and unions per capita are used to represent social capital. To allow for more consistent analysis, each variable is normalized so that one unit of its variation corresponds to one standard deviation. As discussed in section 2.6.4, these data represent the *bridging* part of social capital, which is closely related to the "weak" links among individuals in a community (Hawkins and Maurer, 2009). While the first three variables are known at the community level, the last four are known only at the prefecture level. Since part of the analysis conducted here is at the electoral district level– which includes more than one municipality– the values of the variables are averaged at the electoral district level. Figures 2.5 and 2.6 show the data variations for the variables at the district and prefecture levels, respectively. As it can be observed, they have different levels of dispersion, with public halls per capita tending to be more centralized near Tokyo, while libraries and religious orgs. per capita tend to be more dispersed throughout the country. However, this problem is mitigated by our empirical strategy, which uses regional fixed effects.

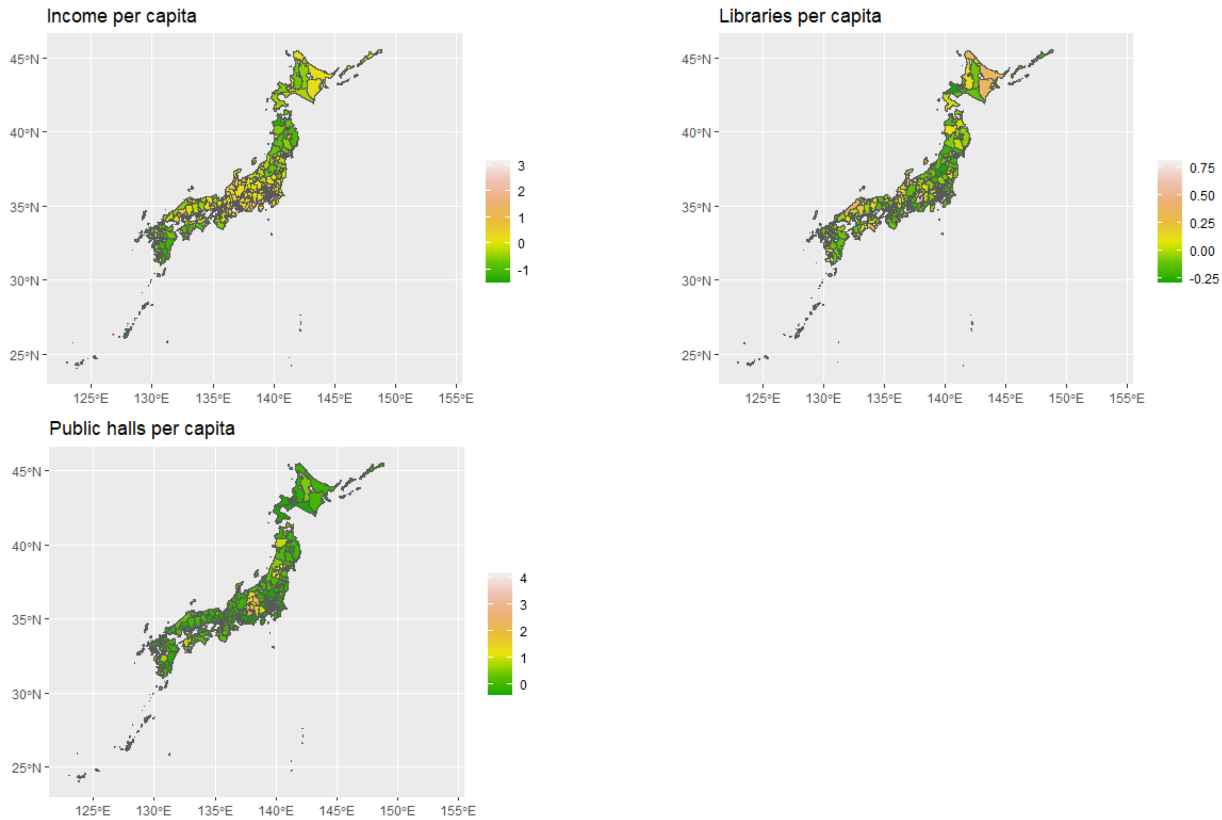


Figure 2.5: Social capital variables at the level of the district: income per capita, libraries per capita and public halls per capita.

2.6.6
Empirical strategy and results

Fundamentally, one of the main influences of social capital on political outcomes is by means of a higher civic engagement (Knack, 2000; Enke, 2020). Therefore, we first observe the relationship between social capital variables and voter turnout in the 2012 elections. To capture this relationship, using the social capital data described in section2.6.5 and the Reed-Smith dataset on election outcomes (Smith and Reed, 2018), we regress voter turnout in each district, $TO_{d,t}$, on the social capital of each region according to the chosen metrics. This examines whether living in a region with higher social capital had an impact on the population's turnout in 2012. More specifically, Eq. 2-13 shows the proposed empirical strategy,

$$TO_{d,t} = \gamma \mathbb{1}_{t=2012} + \eta t + \beta \mathbb{1}_{t=2012} * SC_{reg} + \theta t * SC_{reg} + \delta_{reg} + \mathbf{X_{d,t}}'\alpha + \varepsilon_{d,t}, \tag{2-13}$$

where $TO_{d,t}$ corresponds to the turnout of district d in elections in year t, $\mathbb{1}_{t=2012}$ is the dummy for 2012, SC_{reg} is the metric for social capital in region $reg \in \{d, p\}$, δ_{reg} is the fixed effect of region, and $X_{d,t}$ is the usual vector

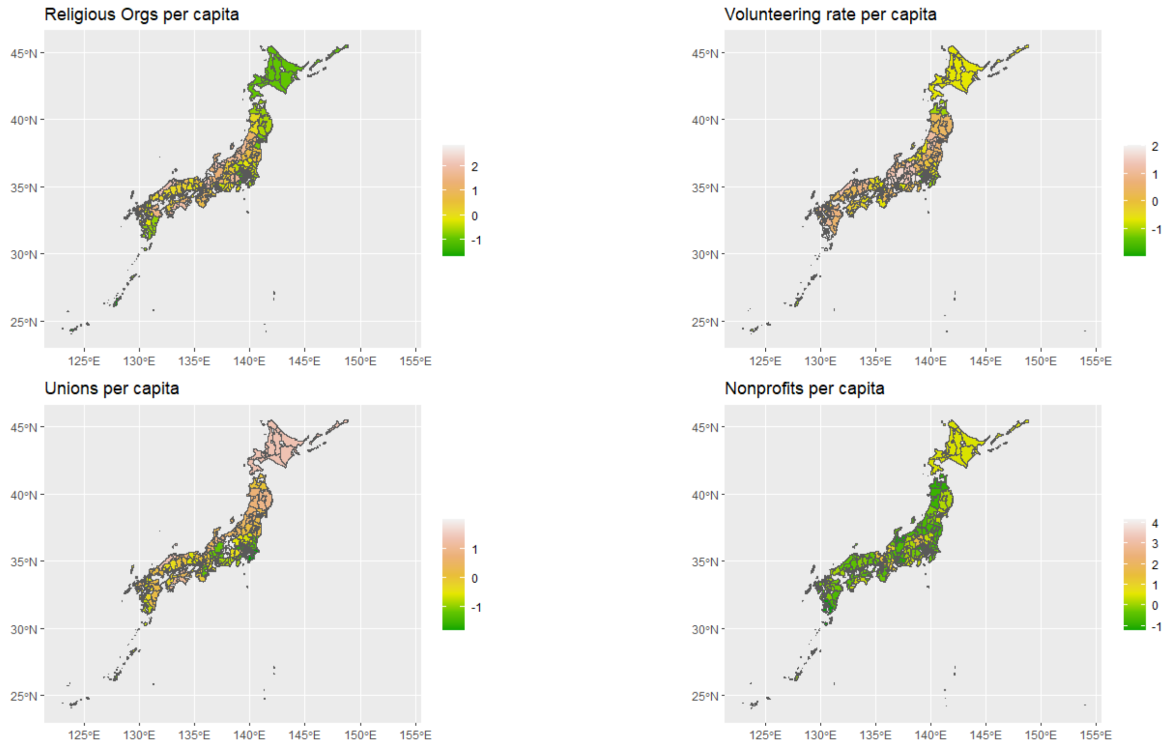


Figure 2.6: Social capital variables at the level of the prefecture: Religious orgs. per capita, volunteering rate per capita, unions per capita, and non-profit orgs. per capita.

of district-year controls. It is important to highlight that the data for income per capita, libraries per capita, and public halls per capita are available at the municipality level, and therefore it is possible to aggregate these variables to the district level so that the region under study is the district, i.e., $reg = d$. The remaining social capital variables – unions, religious organizations, volunteering participation rate, and nonprofit firms – are only available at the prefecture level. In these cases, the region analyzed is the prefecture and in these cases $reg = p$. It is also important to recall that the interaction between the time trend and social capital aims to capture how the impact of social capital on turnout has evolved over time, since the focus here is on observing differential behavior in 2012. Consequently, the coefficient of interest is the one related to the social capital-2012 interaction, β. Since we use the region fixed effect, which should capture the invariant influence of social capital on our outcome variable, β captures the specific effect of our social capital variables in the 2012 elections. The idea, then, is to consider the influence of social capital in a year when the political scenario was arguably shaken by the specifics discussed so far. The results are presented in Table 2.17.

As it can be verified, in line with the literature (Krishna, 2002; Chong and Rogers, 2005), with the exception of unions and nonprofit organizations, all other variables are positively correlated with (modestly) higher turnout, if compared to the the turnout magnitude presented in Fig. 2.4, of around 65% until 2009. If, as has been argued, social capital can be associated with higher levels of civism, Table 2.17 provides evidence that it is reflected in political participation, represented here by higher presence at the polls[29]. Relevantly, this slightly higher turnout was observed in a year when turnout was generally lower, as noted earlier.

Table 2.17: Social capital influence on turnout

	Dependent variable:												
	District turnout												
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
2012	-0.020^{***}	-0.018^{***}	-0.023^{***}	-0.018^{***}	-0.024^{***}	-0.014^{***}	-0.022^{***}	-0.013^{***}	-0.022^{***}	-0.014^{***}	-0.020^{***}	-0.013^{***}	-0.022^{***}
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
2012:$Income_{pc}$	0.006^{***}		0.018^{***}		0.018^{***}		0.019^{***}		0.018^{***}		0.016^{***}		0.019^{***}
	(0.002)		(0.002)		(0.002)		(0.003)		(0.003)		(0.003)		(0.002)
2012:$Libs_{pc}$		-0.008	0.020^{*}										
		(0.010)	(0.011)										
2012:Pub $Halls_{pc}$				-0.002	0.011^{**}								
				(0.003)	(0.006)								
2012:Unions						-0.004	0.003						
						(0.003)	(0.003)						
2012:Relig. Orgs								-0.001	0.005^{*}				
								(0.002)	(0.002)				
2012:Volunteer										-0.003	0.004^{*}		
										(0.002)	(0.002)		
2012:Nonprofits												0.003	-0.0005
												(0.002)	(0.003)
Pref FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-SC trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,653	1,653	1,653	1,653	1,653	1,653	1,653	1,653	1,653	1,653	1,653	1,653	1,653
R^2	0.434	0.417	0.422	0.417	0.423	0.281	0.295	0.289	0.303	0.297	0.308	0.283	0.296

Notes: This table presents the district turnout according to different social capital variables. Standard errors are clustered at the district level for variables income, libraries and public halls and at the prefecture level for the remaining variables. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Finally, we attempt to capture the influence of social capital on the results of the different parties in 2012. To this end, we regress both the ranking and the outcome of each candidate on the differential effect of belonging to the DPJ or the LDP in 2012 and interacted with the social capital variable. For completeness, we also include the effect of ideological orientation (RL). As Eq. 2-14 makes clear, the dependent variable of interest, $y_{c,d,t} \in \{rank_{c,d,t}, result_{c,d,t}\}$, is regressed against the triple interaction $\mathbb{1}_{t=2012} * SC_{reg} * Party_{c,d,t}$,

$$\begin{aligned} y_{c,d,t} =& \beta \mathbb{1}_{t=2012} * SC_{reg} * Party_{c,d,t} + \gamma Income_{pc,d} * Party_{c,d,t} + \delta_{reg} + \\ & + \mathbf{X_{d,t}}'\boldsymbol{\alpha} + \theta t * Party_{c,d,t} + \varepsilon_{c,d,t}. \end{aligned} \tag{2-14}$$

[29]Krishna (2002), for example, argues that voter turnout is only one of the possible instances of political engagement.

As one can note, in addition to the usual controls, the interaction between per capita income and party is also taken into account– and naturally disconsidered when income is the social capital variable being evaluated. In this way, we control for the natural influence of the districts' economic conditions, which can potentially affect social capital trends, and party outcomes. Once more, the isolated terms in the interactions are included in the regressions, but are omitted here for clarity. Our coefficient of interest is β, which captures the specific effect social capital had in 2012 in regions where the candidate was affiliated to a given party. The idea behind this approach is to understand how different electoral outcomes were for a given party, in an year in which the political scenario was rather difficult, in a region where social capital was especially high. The detailed results, from Table 2.31 to Table 2.51, can be found in Appendix 2.8. From Table 2.31 to 2.37, the entire sample is considered, with each table associated with an instance of social capital. Similarly, tables from 2.38 to 2.44 present results for incumbents only, and from Table 2.45 to 2.51 only challengers remain in the sample.

For each analysis, we evaluate whether the candidate won the election (columns (1) through (3)) and how the candidate ranks (columns (4) through (6)). For columns (1) and (4), we are interested in whether the candidate belonged to the DPJ; for columns (2) and (5), we consider whether the candidate belonged to a left-wing party (RL = -1), an independent party (RL = 0), or a right-wing party (RL = 1). Finally, columns (3) and (6) evaluate the performance of candidates who belong to the LDP. The most interesting term is the triple interaction among the year of 2012, the candidate's party affiliation, and the measure of social capital in his/her district or prefecture[30]. For clarity, all the tables with the analysis for social capital are places in Appendix 2.8.

While several results were obtained due to the variety of social capital variables analyzed, we discuss here those that showed to be the most relevant. The first result that can be derived is that none of these variables are related to the Liberal Party' results. The most relevant social capital instances in the analysis conducted here are the presence of religious organizations (Tables 2.32, 2.39, and 2.46), the rate of volunteering (Tables 2.33, 2.40, and 2.47), and public halls (Tables 2.36, 2.43, and 2.50). The main pattern that can be observed is that DPJ's incumbents in places with higher social capital (by these measures) were more penalized, implying a lower

[30]For the variables income per capita, libraries per capita, and public halls per capita, the value for each municipality is known and aggregated at the district level. For the other variables, the values are known only at the prefecture level

probability of winning. Right-wing candidates, on the other hand, did better, with mixed results for their ranking and likelihood of winning the seat. In addition, the results are interesting for challengers'. Despite the worse results for incumbents, DPJ's challengers were more likely to win in places with higher social capital. This effect was particularly strong in places with high levels of volunteering, where the effect of challengers offset the lower propensity of incumbents to do well, so that DPJ' candidates were actually more likely to win the election in general.

Although it is not easy to determine the exact mechanisms behind the results, some possibilities can be suggested. First, in the context of social capital, civic sense may indeed have played a role in pushing out of office those who were not considered competent enough during the period, which is consistent with the discussion in 2.6.2 and supported in the literature (Besley and Burgess, 2002; Knack, 2000; Helliwell and Putnam, 2007; Nannicini et al., 2013). Potentially more puzzling is the result regarding the challengers advantage. As has been argued in the literature both generally and specifically for the GEJE case (Nishide and Yamauchi, 2005; Hawkins and Maurer, 2009; Shimada, 2015; Ye and Aldrich, 2019; Goryoda et al., 2019), social capital is an essential tool for community resilience because it provides informal insurance and promotes collective action, which is potentially more important than physical structures. In such a case, social capital can act as a substitute asset for government or the market (Shimada, 2015). While punishing the incumbent parties may have been important given the scenario described above, a shift to the right-or rather, a shift to the right by the LDP– and restoring the flow of resources may not have been.

Another potential mechanism is the closer connection between the LDP and its more authoritarian character. As Dalton and Tanaka (2007) point out, the DPJ is perceived by voters as a more centrist party (to the left of the average voter), while the LDP is positioned more to the extreme right. In this sense, as Stubager (2008) suggests, the security provided by socialization would make people less susceptible to authoritarian/traditionalist/nationalist [31] leaning.

Finally, as it has been shown in literature, the Fukushima disaster led to a large number of anti-nuclear demonstrations and protests (Novikova, 2016; Hasegawa, 2014). Given the proximity between the LDP and the nuclear village, localities with higher levels of social engagement may have kept votes away from the party, and while DPJ incumbents were punished,

[31] To put it in the terms of Gethin et al. (2022).

this was not to the Liberal Party's advantage.

Another interesting result is the effect of income per capita. As shown in the Table 2.44, higher income is associated with a higher probability that DPJ's incumbents win. As noted earlier, perceptions of the country's economic situation were significantly worse in 2012 (Table 2.12), which could be associated with worse sentiment and fewer votes for the DPJ (Table 2.13), a scenario with which the picture in Table 2.44 is interestingly consistent with. In districts with higher (lower) income, incumbent punishment was lower (higher). This strengthens the mechanism of resource flow (or lack thereof). Because higher-income districts are supposedly less vulnerable, dysfunctionality in resource management is seen as less of a problem than in more vulnerable regions, so punishment is lower.

Undoubtedly, the correlations found above between Japanese elections and social capital should be taken with caution, as a more in-depth assessment of mechanisms should be considered. However, such patterns may help clarify the forces behind the punishment observed in the House of Representatives elections following the Fukushima triple disaster. As Gethin et al. (2022) show, changes in political patterns have been observed throughout the literature, and the relationship between social networks (virtual or otherwise) and political outcomes is certainly a promising avenue for future work.

2.6.7 Robustness and caveats

In this section we try to clarify and explore some issues related to the strategies used, which can be deepened. First, it is important to mention the problem of identification in assessing the political impact of the Fukushima disaster. The analysis conducted here is based on the comparison between the 2012 results and their evolution over time. One possibility would be to use time fixed effects. This approach would capture the specific effect of each year, but it would be unclear what it would provide in terms of the comparison made. Another strategy would be to adopt a more flexible specification and use a polynomial for the time effect rather than a linear time trend. However, this is a question for future work.

Regarding the analysis of partys' outcomes, while it would be too demanding in terms of data to include fixed effects of politicians, it would be interesting to consider their specific characteristics. Such an addition would potentially capture some important specific characteristics of politicians that might be related to our results. To account for the possible effects of public spending on our results, these data could also be included in our analysis. While our results are at the national level, such information could help us understand how inefficient the flow of resources to affected areas was and what impact had on the 2012 elections. In addition, when looking at partys' results, it might be beneficial to compare SMD and PR results. While there is not much cross-sectional variation in PR since there are only 11 regions, the difference between PR and SMD could yield some interesting results. While both party and candidate characteristics are relevant in the latter, only party matters in the former.

In terms of sentiment analysis, it would also be beneficial to have access to polling data for other election years, especially for the period before 2009. This information would be very important to provide a better picture of the evolution of public perception of the parties. If possible, data on the population affected by the disaster would also be interesting, as it would allow a clearer distinction between those affected and those not affected.

Finally, it is interesting to expand the commentary on social capital data. Here we fixed the social capital variables to their values at the beginning of the sample. While this was done to avoid noise in the data and a potential endogeneity problem, it is interesting for better understanding the impact of more recent information. While **?** indicates that the variation in social capital was not high, a more detailed assessment of its influence might be interesting.

2.7 Conclusion

This paper examined the impact of extreme events on political outcomes. Profiting from high-quality data on the impact of earthquakes in Japan and on the results of elections to the country's lower house, the House of Representatives, a comprehensive analysis was conducted to understand how politicians were punished or rewarded depending on election outcomes and voter preferences. In addition, the impact of the largest disaster in recent years, the Great East Japan Earthquake (GEJE), was examined in more detail. In addition, an analysis was conducted to understand the impact of social capital on political outcomes, using publicly available data for Japanese cities and prefectures.

It was found that in a country like Japan, where technology and safety regulations have dramatically mitigated the effects of earthquakes, such events have not played a major political role at the local level. In light of the literature on retrospective voting, there is little evidence that citizens blame their governors for events beyond their control. However, when an event of unusually high magnitude interacted with human-related problems, a different scenario emerged.

The results of this work suggest that the Japanese population punished incumbents and, to an even greater extent, members of the ruling party, curiously favoring the party that was allegedly involved in matters related to one of the main causes of the disaster. According to the literature, the Democrat Party of Japan (DPJ) suffered electoral losses due to inefficient management of the reconstruction process, largely favoring the Liberal Democratic Party (LDP). This result may have been related to one of the party's main campaign slogans: the political decentralization process. Indeed, the results presented here confirm such an explanation: nuclear power and decentralization were associated with a decline in the DPJ's standing among the population.

Interestingly, the evidence collected suggests that the mechanism linking the lower esteem and worse results for the DPJ and the better ones for the LDP is that turnout was lower (higher) in localities where the incumbent belonged to the DPJ (LDP). However, turnout was slightly higher in localities where social capital measured by bridging variables was higher. While DPJ incumbents were actually punished in these localities, the party's challengers fared better. Although the actual mechanism behind this pattern is not as easily explained, the results suggest that, consistent with the literature, places with higher social capital have a more engaged community that not only punished incumbents but also distanced the population from the more right-wing, pronuclear party.

Given the attempt made here to map the motivations behind political behavior in the aftermath of the Fukushima disaster, a promising avenue for future research would be to examine more closely the actual mechanisms behind the punishment process. It would also be important to link them to the different levels of social capital and promote the disentanglement of the proposed motivations. Furthermore, this work focused on the bridging part of social capital, but it would also be interesting to understand whether the linking and bonding variables play a role.

2.8 Appendix

Table 2.18: Earthquake impact effect on candidates' ranking.

	Dependent variable:					
	Candidate Ranking					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	0.015			−0.033		
	(0.024)			(0.037)		
(I>6)		−0.016			−0.055	
		(0.047)			(0.080)	
DPJ	0.814***	0.809***	0.790***	−5.482	−5.592	−7.283
	(0.036)	(0.035)	(0.036)	(10.272)	(10.325)	(10.005)
2012				0.059***	0.057***	0.056***
				(0.016)	(0.014)	(0.014)
(I>5):DPJ	−0.050			0.078		
	(0.106)			(0.135)		
(I>6):DPJ		0.113			0.252	
		(0.193)			(0.239)	
Most Imp.:DPJ			0.121			0.061
			(0.138)			(0.137)
(I>5):2012				0.008		
				(0.047)		
(I>6):2012					−0.004	
					(0.095)	
Most Imp.:2012						−0.044
						(0.062)
DPJ:2012				−0.419***	−0.405***	−0.394***
				(0.077)	(0.070)	(0.068)
(I>5):DPJ:2012				0.065		
				(0.201)		
(I>6):DPJ:2012					0.068	
					(0.335)	
Most Imp.:DPJ:2012						0.339
						(0.338)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
Year trend	No	No	No	Yes	Yes	Yes
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.241	0.241	0.240	0.243	0.243	0.242

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.19: Earthquake impact effect on candidates' ranking, with alternative specifications.

	Dependent variable:					
	Candidate Ranking					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	−0.008			−0.022		
	(0.023)			(0.037)		
(I>6)		−0.040			−0.039	
		(0.047)			(0.082)	
DPJ	25.378***	26.210***	23.001**	0.875***	0.877***	0.857***
	(9.494)	(9.627)	(9.402)	(0.037)	(0.036)	(0.036)
(I>5):DPJ	−0.012			0.078		
	(0.105)			(0.136)		
(I>6):DPJ		0.157			0.250	
		(0.192)			(0.241)	
Most Imp.:DPJ			0.122			0.061
			(0.138)			(0.137)
(I>5):2012				−0.001		
				(0.047)		
(I>6):2012					−0.018	
					(0.096)	
Most Imp.:2012						−0.043
						(0.061)
DPJ:2012				−0.402***	−0.388***	−0.372***
				(0.072)	(0.065)	(0.063)
(I>5):DPJ:2012				0.065		
				(0.201)		
(I>6):DPJ:2012					0.070	
					(0.337)	
Most Imp.:DPJ:2012						0.340
						(0.338)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	No	No	No
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.241	0.241	0.240	0.243	0.243	0.242

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.20: Earthquake impact effect on candidates' ranking.

	Dependent variable:					
	Candidate Ranking					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	−0.074***			0.038		
	(0.026)			(0.044)		
(I>6)		0.006			0.222***	
		(0.058)			(0.067)	
LDP	1.319***	1.341***	1.357***	32.285***	32.458***	32.039***
	(0.027)	(0.027)	(0.026)	(8.835)	(8.811)	(8.540)
2012				−0.184***	−0.192***	−0.188***
				(0.013)	(0.012)	(0.011)
(I>5):LDP	0.303***			−0.130		
	(0.104)			(0.148)		
(I>6):LDP		−0.004			−0.694***	
		(0.205)			(0.204)	
Most Imp.:LDP			−0.273*			−0.278*
			(0.164)			(0.156)
(I>5):2012				−0.066		
				(0.047)		
(I>6):2012					−0.204**	
					(0.084)	
Most Imp.:2012						−0.024
						(0.048)
LDP:2012				0.800***	0.833***	0.807***
				(0.050)	(0.046)	(0.044)
(I>5):LDP:2012				0.249		
				(0.174)		
(I>6):LDP:2012					0.596*	
					(0.312)	
Most Imp.:LDP:2012						0.042
						(0.209)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
Year trend	No	No	No	Yes	Yes	Yes
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.382	0.382	0.385	0.392	0.392	0.395

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.21: Earthquake impact effect on candidates' ranking, with alternative specifications.

	Dependent variable:					
	Candidate Ranking					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	−0.064**			0.044		
	(0.027)			(0.044)		
(I>6)		0.017			0.226***	
		(0.056)			(0.070)	
LDP	−21.540**	−25.607***	−24.617***	1.214***	1.214***	1.230***
	(8.665)	(8.524)	(8.196)	(0.027)	(0.028)	(0.027)
(I>5):LDP	0.274***			−0.138		
	(0.105)			(0.148)		
(I>6):LDP		−0.038			−0.694***	
		(0.202)			(0.209)	
Most Imp.:LDP			−0.270			−0.277*
			(0.164)			(0.157)
(I>5):2012				−0.071		
				(0.047)		
(I>6):2012					−0.208**	
					(0.086)	
Most Imp.:2012						−0.022
						(0.049)
LDP:2012				0.709***	0.742***	0.717***
				(0.051)	(0.047)	(0.045)
(I>5):LDP:2012				0.256		
				(0.174)		
(I>6):LDP:2012					0.595*	
					(0.317)	
Most Imp.:LDP:2012						0.040
						(0.210)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	No	No	No
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.383	0.382	0.386	0.392	0.392	0.394
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 2.22: Earthquake impact effect on incumbents' ranking.

	Dependent variable:					
	Candidate Ranking					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	0.034			0.040		
	(0.024)			(0.030)		
(I>6)		−0.024			−0.032	
		(0.050)			(0.050)	
Inc	1.264***	1.253***	1.259***	10.443	10.539	11.027
	(0.024)	(0.023)	(0.023)	(7.854)	(7.862)	(7.627)
2012				0.092***	0.087***	0.086***
				(0.017)	(0.016)	(0.015)
(I>5):Inc	−0.190**			−0.056		
	(0.085)			(0.091)		
(I>6):Inc		−0.139			−0.055	
		(0.162)			(0.155)	
Most Imp.:Inc			0.094			0.062
			(0.096)			(0.086)
(I>5):2012				−0.073*		
				(0.042)		
(I>6):2012					−0.052	
					(0.083)	
Most Imp.:2012						−0.093
						(0.074)
Inc:2012				−0.319***	−0.323***	−0.318***
				(0.069)	(0.062)	(0.060)
(I>5):Inc:2012				0.044		
				(0.152)		
(I>6):Inc:2012					0.112	
					(0.256)	
Most Imp.:Inc:2012						0.178
						(0.263)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
Year trend	No	No	No	Yes	Yes	Yes
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.347	0.347	0.352	0.348	0.348	0.354

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.23: Earthquake impact effect on candidates' ranking, with alternative specifications.

	Dependent variable:					
	Candidate Ranking					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	0.026			0.043		
	(0.024)			(0.032)		
(I>6)		−0.035			−0.025	
		(0.050)			(0.048)	
Inc	30.357***	32.216***	32.286***	1.317***	1.315***	1.322***
	(7.934)	(7.906)	(7.675)	(0.023)	(0.023)	(0.023)
(I>5):Inc	−0.146*			−0.062		
	(0.085)			(0.092)		
(I>6):Inc		−0.100			−0.058	
		(0.157)			(0.158)	
Most Imp.:Inc			0.092			0.065
			(0.094)			(0.087)
(I>5):2012				−0.076*		
				(0.044)		
(I>6):2012					−0.057	
					(0.082)	
Most Imp.:2012						−0.087
						(0.073)
Inc:2012				−0.350***	−0.354***	−0.350***
				(0.068)	(0.061)	(0.059)
(I>5):Inc:2012				0.049		
				(0.153)		
(I>6):Inc:2012					0.115	
					(0.257)	
Most Imp.:Inc:2012						0.175
						(0.262)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	No	No	No
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.347	0.347	0.353	0.349	0.349	0.354
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 2.24: Earthquake impact effect on candidates' propensity to win, with alternative specifications.

	Dependent variable:					
	Won the elections					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	0.013			−0.014		
	(0.015)			(0.029)		
(I>6)		−0.026			−0.107*	
		(0.035)			(0.064)	
DPJ	10.379	11.711*	10.072	0.154***	0.154***	0.131***
	(6.342)	(6.398)	(6.197)	(0.026)	(0.025)	(0.025)
(I>5):DPJ	−0.054			0.063		
	(0.067)			(0.107)		
(I>6):DPJ		0.096			0.429**	
		(0.136)			(0.213)	
Most Imp.:DPJ			0.226*			0.212*
			(0.120)			(0.118)
(I>5):2012				0.002		
				(0.028)		
(I>6):2012					0.089	
					(0.069)	
Most Imp.:2012						0.001
						(0.022)
DPJ:2012				−0.339***	−0.328***	−0.314***
				(0.028)	(0.026)	(0.026)
(I>5):DPJ:2012				0.011		
				(0.105)		
(I>6):DPJ:2012					−0.308	
					(0.248)	
Most Imp.:DPJ:2012						0.066
						(0.110)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	No	No	No
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.030	0.030	0.030	0.043	0.044	0.042
Note:				*p<0.1; **p<0.05; ***p<0.01		

Table 2.25: Earthquake impact effect on LDP's candidates' propensity to win the election, with alternative specifications.

	Dependent variable:					
	Won the election					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	−0.021			0.020		
	(0.017)			(0.033)		
(I>6)		0.024			0.152^{**}	
		(0.037)			(0.067)	
LDP	-15.792^{**}	-17.515^{***}	-16.642^{***}	0.430^{***}	0.431^{***}	0.451^{***}
	(6.293)	(6.264)	(6.028)	(0.025)	(0.024)	(0.024)
(I>5):LDP	0.102			−0.049		
	(0.069)			(0.113)		
(I>6):LDP		−0.090			-0.466^{**}	
		(0.140)			(0.212)	
Most Imp.:LDP			-0.245^{*}			-0.252^{*}
			(0.138)			(0.138)
(I>5):2012				−0.020		
				(0.033)		
(I>6):2012					-0.147^{**}	
					(0.074)	
Most Imp.:2012						−0.022
						(0.023)
LDP:2012				0.320^{***}	0.325^{***}	0.314^{***}
				(0.034)	(0.030)	(0.029)
(I>5):LDP:2012				0.068		
				(0.117)		
(I>6):LDP:2012					0.417	
					(0.254)	
Most Imp.:LDP:2012						0.044
						(0.094)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	No	No	No
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.243	0.242	0.252	0.255	0.256	0.265
Note:				*p<0.1; **p<0.05; ***p<0.01		

Table 2.26: Earthquake impact effect on incumbents' winning probability, with alternative specifications.

	Dependent variable:					
	Won the election					
	(1)	(2)	(3)	(4)	(5)	(6)
(I>5)	0.039**			−0.001		
	(0.015)			(0.023)		
(I>6)		−0.004			−0.061	
		(0.035)			(0.059)	
Inc	26.914***	29.260***	28.558***	0.579***	0.581***	0.586***
	(5.709)	(5.616)	(5.492)	(0.019)	(0.019)	(0.019)
(I>5):Inc	−0.180***			0.073		
	(0.064)			(0.077)		
(I>6):Inc		−0.095			0.122	
		(0.138)			(0.187)	
Most Imp.:Inc			0.110			0.112**
			(0.071)			(0.055)
(I>5):2012				0.003		
				(0.027)		
(I>6):2012					0.023	
					(0.066)	
Most Imp.:2012						−0.027
						(0.032)
Inc:2012				−0.477***	−0.494***	−0.478***
				(0.038)	(0.034)	(0.033)
(I>5):Inc:2012				−0.124		
				(0.101)		
(I>6):Inc:2012					−0.061	
					(0.222)	
Most Imp.:Inc:2012						0.028
						(0.139)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	No	No	No
Observations	6,447	6,447	6,724	6,447	6,447	6,724
R^2	0.244	0.242	0.254	0.270	0.270	0.281

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.27: Earthquake impact effect on RL candidates' ranking

	Dependent variable:							
	Ranking							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(I>5)	0.043***	0.034**	−0.021	−0.014				
	(0.012)	(0.014)	(0.021)	(0.017)				
(I>6)					0.019	0.010	−0.058*	−0.050*
					(0.027)	(0.020)	(0.034)	(0.025)
RL	−32.741***	0.427***	−5.215	0.359***	−35.101***	0.440***	−5.181	0.359***
	(4.363)	(0.112)	(4.582)	(0.107)	(4.324)	(0.115)	(4.590)	(0.107)
2012			0.095***				0.098***	
			(0.008)	(0.000)			(0.008)	(0.000)
(I>5):RL	0.133***	0.183*	−0.029	−0.026				
	(0.046)	(0.094)	(0.066)	(0.059)				
(I>5):2012			0.034	0.028				
			(0.027)	(0.020)				
RL:2012			0.386***	0.401***			0.396***	0.411***
			(0.025)	(0.103)			(0.023)	(0.103)
(I>6):RL					−0.033	0.020	−0.223	−0.218*
					(0.090)	(0.090)	(0.139)	(0.113)
(I>6):2012							0.065	0.058**
							(0.041)	(0.023)
(I>5):RL:2012			0.041	0.038				
			(0.079)	(0.051)				
(I>6):RL:2012							0.070	0.064
							(0.164)	(0.110)
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	No	Yes	No	Yes	No
Year trend	Yes	No	Yes	No	No	Yes	No	Yes
Observations	6,447	6,447	6,447	6,447	6,447	6,447	6,447	6,447
R^2	0.279	0.276	0.289	0.290	0.279	0.275	0.290	0.290
Note:						*p<0.1; **p<0.05; ***p<0.01		

Table 2.28: Earthquake impact effect on RL candidates' winning probability

	Dependent variable:							
	Result							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(I>5)	0.012*	0.007	−0.006	−0.005				
	(0.006)	(0.006)	(0.014)	(0.007)				
(I>6)					−0.006	−0.011	−0.050**	−0.048*
					(0.016)	(0.017)	(0.025)	(0.023)
RL	−3.385	0.174**	3.682	0.159**	−3.671	0.176***	3.725	0.159**
	(2.289)	(0.060)	(2.388)	(0.069)	(2.285)	(0.059)	(2.387)	(0.070)
2012			0.026***				0.027***	
			(0.003)	(0.000)			(0.003)	(0.000)
(I>5):RL	0.005	0.010	−0.031	−0.032				
	(0.027)	(0.033)	(0.055)	(0.032)				
(I>5):2012			0.011	0.010*				
			(0.015)	(0.006)				
RL:2012			0.100***	0.089			0.095***	0.083
			(0.011)	(0.066)			(0.010)	(0.067)
(I>6):RL					−0.061	−0.055	−0.215*	−0.213*
					(0.057)	(0.072)	(0.114)	(0.102)
(I>6):2012							0.050*	0.048**
							(0.027)	(0.018)
(I>5):RL:2012			0.002	0.002				
			(0.054)	(0.022)				
(I>6):RL:2012							0.179	0.177*
							(0.123)	(0.100)
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	No	Yes	No	Yes	No
Year trend	Yes	No	Yes	No	No	Yes	No	Yes
Observations	6,447	6,447	6,447	6,447	6,447	6,447	6,447	6,447
R^2	0.151	0.152	0.156	0.157	0.151	0.152	0.157	0.158
Note:						*p<0.1; **p<0.05; ***p<0.01		

Table 2.29: Party and ideology leaning after Fukushima, for all candidates, considering a simple linear model model.

	Dependent variable:			
	Ranking			
	(1)	(2)	(3)	(4)
2012:Inc	-0.308^{***}			
	(0.059)			
2012:DPJ		-0.377^{***}		
		(0.067)		
2012:RL			0.382^{***}	
			(0.022)	
2012:LDP				0.809^{***}
				(0.043)
Observations	6,724	6,724	6,724	6,724
R^2	0.354	0.425	0.437	0.476
Dist. FE	Yes	Yes	Yes	Yes
Year-Var trend	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 2.30: Party and ideology leaning after Fukushima, for incumbents only.

	Dependent variable:			
	Ranking			
	(1)	(2)	(3)	(4)
2012	-0.487^{***}	-0.440^{***}	-0.330^{***}	-0.572^{***}
	(0.046)	(0.079)	(0.044)	(0.070)
2012:DPJ		-0.050		
		(0.109)		
2012:RL			0.299^{***}	
			(0.044)	
2012:LDP				0.659^{***}
				(0.081)
Observations	1,620	1,620	1,620	1,620
R^2	0.429	0.431	0.460	0.470
Dist. FE	Yes	Yes	Yes	Yes
Year-Var trend	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 2.31: Union effect on propensity to win in the year after Fukushima

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.07^{***}	0.03^{***}	-0.08^{***}	$0.04^{\cdot}$	0.09^{***}	-0.18^{***}
	(0.01)	(0.00)	(0.02)	(0.03)	(0.01)	(0.02)
DPJ	-19.44^{*}			-1.63		
	(8.73)			(14.54)		
$Income_{pc}$	-0.04^{***}	-0.01^{**}	0.02^{*}	-0.09^{***}	$-0.01^{\cdot}$	-0.01
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
2012:Unions	0.01	0.00	0.00	-0.01	-0.01	0.03
	(0.01)	(0.00)	(0.02)	(0.02)	(0.01)	(0.02)
2012:DPJ	-0.39^{***}			-0.35^{*}		
	(0.04)			(0.14)		
Unions:DPJ	0.06^{*}			0.10^{*}		
	(0.03)			(0.04)		
DPJ:$Income_{pc}$	0.17^{***}			0.35^{***}		
	(0.04)			(0.05)		
2012:Unions:DPJ	-0.02			0.06		
	(0.04)			(0.11)		
RL		3.53			-7.12	
		(2.90)			(6.89)	
2012:RL		0.10^{***}			0.35^{***}	
		(0.02)			(0.03)	
Unions:RL		-0.02			-0.01	
		(0.02)			(0.02)	
RL:$Income_{pc}$		-0.07^{***}			-0.10^{***}	
		(0.02)			(0.03)	
2012:Unions:RL		0.01			-0.07^{*}	
		(0.02)			(0.03)	
LDP			8.86			36.96^{***}
			(7.04)			(7.37)
2012:LDP			0.34^{***}			0.79^{***}
			(0.06)			(0.09)
Unions:LDP			-0.04			-0.01
			(0.03)			(0.04)
LDP:$Income_{pc}$			-0.11^{**}			0.01
			(0.03)			(0.04)
2012:Unions:LDP			-0.03			-0.13
			(0.06)			(0.09)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6022	6022	6022	6022	6022	6022
R^2 (full model)	0.06	0.17	0.26	0.24	0.29	0.38
R^2 (proj model)	0.06	0.17	0.26	0.23	0.28	0.38
Adj. R^2 (full model)	0.05	0.16	0.25	0.24	0.28	0.38
Adj. R^2 (proj model)	0.05	0.16	0.25	0.23	0.27	0.37
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the level of prefectures prefecture.

Table 2.32: Religion effect on propensity to win in the year after Fukushima

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.07^{***}	0.03^{***}	-0.09^{***}	0.04^{*}	0.09^{***}	-0.19^{***}
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)
DPJ	-20.26^{*}			-3.05		
	(8.69)			(14.56)		
$Income_{pc}$	-0.03^{**}	-0.01^{*}	$0.02^{\cdot}$	-0.08^{***}	-0.01	-0.01
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)
2012:Relig. Orgs	-0.01	-0.00	-0.01	-0.03	-0.01	0.01
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)
2012:DPJ	-0.38^{***}			-0.35^{**}		
	(0.04)			(0.11)		
Relig. Orgs:DPJ	-0.01			-0.03		
	(0.04)			(0.06)		
DPJ:$Income_{pc}$	0.14^{**}			0.30^{***}		
	(0.04)			(0.06)		
2012:Relig. Orgs:DPJ	0.04			0.14		
	(0.04)			(0.10)		
RL		3.65			-7.05	
		(2.90)			(6.92)	
2012:RL		0.09^{***}			0.35^{***}	
		(0.02)			(0.02)	
Relig. Orgs:RL		0.02			0.04	
		(0.02)			(0.03)	
RL:$Income_{pc}$		-0.06^{**}			-0.08^{**}	
		(0.02)			(0.03)	
2012:Relig. Orgs:RL		-0.01			-0.09^{**}	
		(0.02)			(0.03)	
LDP			8.77			36.92^{***}
			(7.01)			(7.37)
2012:LDP			0.35^{***}			0.82^{***}
			(0.05)			(0.07)
Relig. Orgs:LDP			0.04			0.02
			(0.04)			(0.04)
LDP:$Income_{pc}$			-0.08^{*}			0.02
			(0.03)			(0.04)
2012:Relig. Orgs:LDP			0.01			-0.07
			(0.06)			(0.08)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6022	6022	6022	6022	6022	6022
R^2 (full model)	0.06	0.17	0.26	0.24	0.29	0.38
R^2 (proj model)	0.06	0.17	0.26	0.23	0.28	0.38
Adj. R^2 (full model)	0.05	0.16	0.25	0.24	0.28	0.38
Adj. R^2 (proj model)	0.05	0.16	0.25	0.22	0.27	0.37
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture level.

Table 2.33: Volunteering effect on propensity to win in the year after Fukushima

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.07^{***}	0.02^{***}	-0.09^{***}	$0.03^{\cdot}$	0.09^{***}	-0.19^{***}
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)
DPJ	-20.13^{*}			-2.85		
	(8.73)			(14.58)		
$Income_{pc}$	-0.04^{**}	-0.01^{*}	0.02	-0.08^{***}	-0.01	-0.01
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)
2012:Volunt. Rate	-0.01^{*}	$-0.01^{\cdot}$	-0.01	$-0.04^{\cdot}$	-0.01	-0.00
	(0.01)	(0.00)	(0.02)	(0.02)	(0.01)	(0.02)
2012:DPJ	-0.37^{***}			-0.31^{**}		
	(0.03)			(0.09)		
Volunt. Rate:DPJ	-0.01			-0.02		
	(0.04)			(0.05)		
DPJ:$Income_{pc}$	0.15^{**}			0.32^{***}		
	(0.04)			(0.06)		
2012:Volunt. Rate:DPJ	0.06^{*}			$0.20^{\cdot}$		
	(0.03)			(0.11)		
RL		3.65			-7.03	
		(2.91)			(6.94)	
2012:RL		0.09^{***}			0.34^{***}	
		(0.01)			(0.02)	
Volunt. Rate:RL		0.01			0.04	
		(0.02)			(0.02)	
RL:$Income_{pc}$		-0.06^{**}			-0.08^{*}	
		(0.02)			(0.03)	
2012:Volunt. Rate:RL		-0.02			-0.09^{***}	
		(0.01)			(0.02)	
LDP			8.83			36.97^{***}
			(7.04)			(7.40)
2012:LDP			0.36^{***}			0.82^{***}
			(0.04)			(0.06)
Volunt. Rate:LDP			0.02			-0.00
			(0.04)			(0.04)
LDP:$Income_{pc}$			$-0.08^{\cdot}$			0.02
			(0.04)			(0.04)
2012:Volunt. Rate:LDP			0.02			-0.01
			(0.07)			(0.10)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6022	6022	6022	6022	6022	6022
R^2 (full model)	0.06	0.17	0.26	0.24	0.29	0.38
R^2 (proj model)	0.06	0.17	0.26	0.23	0.28	0.38
Adj. R^2 (full model)	0.05	0.16	0.25	0.24	0.28	0.38
Adj. R^2 (proj model)	0.05	0.16	0.25	0.23	0.27	0.37
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.34: Nonprofits effect on propensity to win in the year after Fukushima

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.07^{***}	0.03^{***}	-0.08^{***}	0.05^{*}	0.09^{***}	-0.19^{***}
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)
Nonprofits						
DPJ	-20.04^{*}			-2.62		
	(8.67)			(14.45)		
$Income_{pc}$	-0.04^{***}	-0.01^{**}	0.02^{*}	-0.08^{***}	-0.01	-0.01
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)
2012:Nonprofits	0.00	0.00	0.01	-0.02	-0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
2012:DPJ	-0.38^{***}			-0.37^{**}		
	(0.04)			(0.12)		
Nonprofits:DPJ	-0.00			-0.01		
	(0.02)			(0.03)		
DPJ:$Income_{pc}$	0.14^{***}			0.31^{***}		
	(0.04)			(0.05)		
2012:Nonprofits:DPJ	0.00			0.07		
	(0.03)			(0.09)		
RL		3.65			-7.05	
		(2.90)			(6.88)	
2012:RL		0.10^{***}			0.37^{***}	
		(0.01)			(0.02)	
Nonprofits:RL		0.00			-0.02	
		(0.01)			(0.02)	
RL:$Income_{pc}$		-0.06^{***}			-0.08^{**}	
		(0.02)			(0.03)	
2012:Nonprofits:RL		-0.01			0.01	
		(0.02)			(0.03)	
LDP			8.82			36.96^{***}
			(7.08)			(7.40)
2012:LDP			0.35^{***}			0.83^{***}
			(0.05)			(0.07)
Nonprofits:LDP			0.01			0.00
			(0.02)			(0.03)
LDP:$Income_{pc}$			-0.09^{**}			0.02
			(0.03)			(0.04)
2012:Nonprofits:LDP			-0.03			0.02
			(0.06)			(0.08)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6022	6022	6022	6022	6022	6022
R^2 (full model)	0.06	0.17	0.26	0.24	0.29	0.38
R^2 (proj model)	0.06	0.17	0.26	0.23	0.28	0.38
Adj. R^2 (full model)	0.05	0.16	0.25	0.24	0.28	0.38
Adj. R^2 (proj model)	0.05	0.16	0.25	0.22	0.27	0.37
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.35: Libraries per capita effect on propensity to win in the year after Fukushima

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.06^{***}	0.03^{***}	-0.09^{***}	0.05^{**}	0.09^{***}	-0.19^{***}
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)
Libs_{pc}						
DPJ	-20.09^{**}			-2.89		
	(7.22)			(10.62)		
$Income_{pc}$						
2012:Libs_{pc}	-0.09^{***}	-0.01	-0.01	-0.07	-0.02	0.00
	(0.03)	(0.02)	(0.04)	(0.09)	(0.04)	(0.06)
2012:DPJ	-0.35^{***}			-0.34^{***}		
	(0.03)			(0.09)		
$\text{Libs}_{pc} : DPJ$	-0.38^{**}			-0.55^{**}		
	(0.12)			(0.17)		
$\text{DPJ:}Income_{pc}$	0.13^{***}			0.28^{***}		
	(0.02)			(0.03)		
$\text{2012:Libs}_{pc} : DPJ$	0.38^{***}			0.33		
	(0.11)			(0.47)		
RL		3.64			-7.19	
		(2.52)			(4.69)	
2012:RL		0.09^{***}			0.34^{***}	
		(0.01)			(0.03)	
$\text{Libs}_{pc} : RL$		$0.12^{\cdot}$			$0.17^{\cdot}$	
		(0.07)			(0.09)	
$\text{RL:}Income_{pc}$		-0.06^{***}			-0.08^{***}	
		(0.01)			(0.02)	
$\text{2012:Libs}_{pc} : RL$		-0.07			-0.31^{*}	
		(0.05)			(0.13)	
LDP			9.04			37.37^{***}
			(6.60)			(9.09)
2012:LDP			0.35^{***}			0.81^{***}
			(0.03)			(0.05)
$\text{Libs}_{pc} : LDP$			0.24			0.14
			(0.15)			(0.17)
$\text{LDP:}Income_{pc}$			-0.08^{**}			0.03
			(0.03)			(0.03)
$\text{2012:Libs}_{pc} : LDP$			-0.03			-0.18
			(0.14)			(0.23)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6022	6022	6022	6022	6022	6022
R^2 (full model)	0.06	0.17	0.26	0.24	0.29	0.39
R^2 (proj model)	0.06	0.17	0.26	0.21	0.25	0.35
Adj. R^2 (full model)	0.02	0.13	0.22	0.21	0.26	0.36
Adj. R^2 (proj model)	0.01	0.13	0.22	0.17	0.22	0.32
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the district level.

Table 2.36: Public Halls per capita effect on propensity to win in the year after Fukushima

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.07***	0.03***	−0.09***	0.05**	0.09***	−0.19***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Pub Halls$_{pc}$						
DPJ	−20.24**			−2.80		
	(7.25)			(10.64)		
$Income_{pc}$						
2012:Pub Halls$_{pc}$	−0.02·	−0.01·	0.00	−0.03	−0.01	0.03
	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.02)
2012:DPJ	−0.37***			−0.35***		
	(0.03)			(0.07)		
Pub Halls$_{pc}$: DPJ	0.02			0.09		
	(0.05)			(0.07)		
DPJ:$Income_{pc}$	0.15***			0.33***		
	(0.03)			(0.04)		
2012:Pub Halls$_{pc}$: DPJ	0.09			0.13		
	(0.06)			(0.12)		
RL		3.69			−7.00	
		(2.52)			(4.69)	
2012:RL		0.09***			0.35***	
		(0.01)			(0.03)	
Pub Halls$_{pc}$: RL		0.00			0.04	
		(0.02)			(0.03)	
RL:$Income_{pc}$		−0.06***			−0.09***	
		(0.01)			(0.02)	
2012:Pub Halls$_{pc}$: RL		−0.04·			−0.11*	
		(0.02)			(0.05)	
LDP			8.94			37.33***
			(6.58)			(9.07)
2012:LDP			0.35***			0.81***
			(0.03)			(0.05)
Pub Halls$_{pc}$: LDP			−0.00			0.02
			(0.06)			(0.08)
LDP:$Income_{pc}$			−0.10***			0.02
			(0.03)			(0.03)
2012:Pub Halls$_{pc}$: LDP			−0.03			−0.11
			(0.06)			(0.09)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6022	6022	6022	6022	6022	6022
R^2 (full model)	0.06	0.17	0.26	0.24	0.29	0.39
R^2 (proj model)	0.05	0.17	0.25	0.20	0.25	0.35
Adj. R^2 (full model)	0.01	0.13	0.22	0.21	0.26	0.36
Adj. R^2 (proj model)	0.01	0.13	0.22	0.17	0.22	0.32
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the district level.

Table 2.37: Income per capita effect on propensity to win in the year after Fukushima

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.05^{***}	0.02^{***}	-0.08^{***}	0.04	0.08^{***}	-0.18^{***}
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)
$Income_{pc}$	-0.04^{***}	-0.01^{**}	0.02^{*}	-0.08^{***}	$-0.01^{\cdot}$	-0.01
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
DPJ	-20.04^{*}			-2.64		
	(8.67)			(14.45)		
2012:$Income_{pc}$	0.03^{***}	0.01^{*}	-0.01	0.02	0.02^{*}	-0.03
	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)
2012:DPJ	-0.32^{***}			-0.32^{**}		
	(0.04)			(0.11)		
$Income_{pc}$:DPJ	0.16^{***}			0.32^{***}		
	(0.04)			(0.04)		
2012:$Income_{pc}$:DPJ	-0.11^{**}			-0.08		
	(0.03)			(0.11)		
RL		3.62			-7.16	
		(2.91)			(6.93)	
2012:RL		0.08^{***}			0.30^{***}	
		(0.02)			(0.03)	
$Income_{pc}$:RL		-0.07^{***}			-0.11^{***}	
		(0.02)			(0.03)	
2012:$Income_{pc}$:RL		0.03			0.13^{***}	
		(0.02)			(0.03)	
LDP			8.81			36.91^{***}
			(7.07)			(7.41)
2012:LDP			0.32^{***}			0.76^{***}
			(0.05)			(0.07)
$Income_{pc}$:LDP			-0.11^{**}			-0.00
			(0.04)			(0.04)
2012:$Income_{pc}$:LDP			0.06			0.13
			(0.04)			(0.08)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6022	6022	6022	6022	6022	6022
R^2 (full model)	0.06	0.17	0.26	0.24	0.29	0.38
R^2 (proj model)	0.06	0.17	0.26	0.23	0.28	0.38
Adj. R^2 (full model)	0.05	0.16	0.25	0.24	0.28	0.38
Adj. R^2 (proj model)	0.05	0.16	0.25	0.22	0.27	0.37
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.38: Union effect on propensity to win in the year after Fukushima, considering incumbents only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	-0.14^{**}	-0.30^{***}	-0.55^{***}	-0.36^{**}	-0.38^{***}	-0.74^{***}
	(0.04)	(0.04)	(0.07)	(0.10)	(0.05)	(0.06)
Unions						
DPJ	-25.00^{*}			$-24.86^{\cdot}$		
	(11.77)			(14.39)		
$Income_{pc}$	-0.07	-0.04	-0.02	-0.06	-0.01	-0.01
	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)	(0.05)
2012:Unions	-0.06	-0.10^{**}	-0.10^{**}	0.01	-0.07	-0.04
	(0.04)	(0.04)	(0.04)	(0.11)	(0.05)	(0.08)
2012:DPJ	-0.45^{***}			-0.29^{*}		
	(0.08)			(0.13)		
Unions:DPJ	0.09^{*}			0.11^{*}		
	(0.04)			(0.05)		
DPJ:$Income_{pc}$	0.06			0.09		
	(0.06)			(0.08)		
2012:Unions:DPJ	-0.04			-0.05		
	(0.06)			(0.13)		
RL		17.72^{**}			21.75^{**}	
		(6.24)			(7.50)	
2012:RL		0.33^{***}			0.44^{***}	
		(0.03)			(0.05)	
Unions:RL		-0.04^{*}			-0.05^{**}	
		(0.02)			(0.02)	
RL:$Income_{pc}$		-0.02			-0.02	
		(0.02)			(0.03)	
2012:Unions:RL		-0.00			-0.05	
		(0.02)			(0.05)	
LDP			27.42^{*}			43.07^{**}
			(12.72)			(13.47)
2012:LDP			0.71^{***}			0.96^{***}
			(0.08)			(0.07)
Unions:LDP			-0.05			-0.06^{*}
			(0.04)			(0.03)
LDP:$Income_{pc}$			-0.02			0.02
			(0.04)			(0.05)
2012:Unions:LDP			0.01			-0.05
			(0.06)			(0.08)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1460	1460	1460	1460	1460	1460
R^2 (full model)	0.26	0.28	0.28	0.30	0.34	0.34
R^2 (proj model)	0.20	0.22	0.22	0.25	0.29	0.29
Adj. R^2 (full model)	0.23	0.25	0.25	0.27	0.31	0.31
Adj. R^2 (proj model)	0.17	0.19	0.19	0.22	0.26	0.26
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.39: Religion effect on propensity to win in the year after Fukushima, considering incumbents only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	-0.11^{**}	-0.29^{***}	-0.54^{***}	-0.33^{***}	-0.37^{***}	-0.73^{***}
	(0.04)	(0.04)	(0.06)	(0.07)	(0.04)	(0.06)
Relig. Orgs						
DPJ	-18.74			-18.03		
	(12.12)			(14.01)		
$Income_{pc}$	$-0.07^{\cdot}$	-0.05	-0.03	-0.07	-0.02	-0.02
	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)	(0.05)
2012:Relig. Orgs	0.06	-0.06	$-0.08^{\cdot}$	0.22^{*}	-0.00	0.02
	(0.04)	(0.04)	(0.04)	(0.08)	(0.05)	(0.08)
2012:DPJ	-0.46^{***}			-0.32^{**}		
	(0.06)			(0.11)		
Relig. Orgs:DPJ	$0.10^{\cdot}$			0.14^{*}		
	(0.05)			(0.06)		
DPJ:$Income_{pc}$	0.05			0.07		
	(0.06)			(0.08)		
2012:Relig. Orgs:DPJ	-0.19^{***}			-0.32^{***}		
	(0.05)			(0.08)		
RL		15.47^{*}			19.56^{*}	
		(6.43)			(7.48)	
2012:RL		0.34^{***}			0.45^{***}	
		(0.03)			(0.05)	
Relig. Orgs:RL		-0.03			-0.05^{*}	
		(0.02)			(0.02)	
RL:$Income_{pc}$		-0.02			-0.01	
		(0.02)			(0.04)	
2012:Relig. Orgs:RL		0.05^{*}			-0.00	
		(0.02)			(0.05)	
LDP			27.26^{*}			43.40^{**}
			(12.56)			(13.19)
2012:LDP			0.72^{***}			0.96^{***}
			(0.07)			(0.07)
Relig. Orgs:LDP			-0.01			-0.03
			(0.05)			(0.05)
LDP:$Income_{pc}$			-0.00			0.03
			(0.04)			(0.05)
2012:Relig. Orgs:LDP			0.04			-0.05
			(0.05)			(0.08)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1460	1460	1460	1460	1460	1460
R^2 (full model)	0.26	0.28	0.28	0.31	0.34	0.34
R^2 (proj model)	0.20	0.22	0.22	0.26	0.29	0.29
Adj. R^2 (full model)	0.23	0.25	0.25	0.28	0.31	0.31
Adj. R^2 (proj model)	0.17	0.19	0.19	0.22	0.26	0.26
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.40: Volunteering effect on propensity to win in the year after Fukushima, considering incumbents only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	-0.11^{*}	-0.29^{***}	-0.54^{***}	-0.31^{***}	-0.37^{***}	-0.71^{***}
	(0.04)	(0.04)	(0.06)	(0.07)	(0.04)	(0.06)
Volunt. Rate						
DPJ	-20.48			-21.04		
	(12.80)			(14.80)		
$Income_{pc}$	$-0.07^{\cdot}$	-0.04	-0.03	-0.07	-0.01	-0.01
	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)	(0.05)
2012:Volunt. Rate	0.07	-0.04	-0.05^{*}	0.27^{**}	0.03	0.07
	(0.04)	(0.04)	(0.03)	(0.09)	(0.06)	(0.08)
2012:DPJ	-0.49^{***}			-0.35^{**}		
	(0.07)			(0.11)		
Volunt. Rate:DPJ	$0.09^{\cdot}$			0.12^{*}		
	(0.04)			(0.06)		
DPJ:$Income_{pc}$	0.06			0.08		
	(0.06)			(0.09)		
2012:Volunt. Rate:DPJ	-0.17^{***}			-0.31^{***}		
	(0.04)			(0.07)		
RL		15.75^{*}			20.13^{*}	
		(6.64)			(7.78)	
2012:RL		0.34^{***}			0.45^{***}	
		(0.03)			(0.05)	
Volunt. Rate:RL		$-0.03^{\cdot}$			-0.05^{**}	
		(0.02)			(0.02)	
RL:$Income_{pc}$		-0.02			-0.03	
		(0.03)			(0.04)	
2012:Volunt. Rate:RL		0.05^{*}			0.01	
		(0.02)			(0.05)	
LDP			27.42^{*}			43.77^{**}
			(12.44)			(13.25)
2012:LDP			0.72^{***}			0.94^{***}
			(0.08)			(0.08)
Volunt. Rate:LDP			-0.01			-0.03
			(0.04)			(0.04)
LDP:$Income_{pc}$			-0.01			0.01
			(0.04)			(0.05)
2012:Volunt. Rate:LDP			0.04			-0.07
			(0.04)			(0.07)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1460	1460	1460	1460	1460	1460
R^2 (full model)	0.26	0.28	0.28	0.31	0.34	0.34
R^2 (proj model)	0.20	0.22	0.22	0.26	0.29	0.29
Adj. R^2 (full model)	0.23	0.25	0.25	0.28	0.32	0.31
Adj. R^2 (proj model)	0.17	0.19	0.19	0.23	0.26	0.26
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.41: Nonprofits effect on propensity to win in the year after Fukushima, considering incumbents only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	-0.12^{**}	-0.28^{***}	-0.52^{***}	-0.37^{***}	-0.37^{***}	-0.73^{***}
	(0.04)	(0.04)	(0.06)	(0.10)	(0.04)	(0.05)
Nonprofits						
DPJ	$-23.29^{\cdot}$			-22.67		
	(12.91)			(15.76)		
$Income_{pc}$	-0.07	-0.05	-0.03	-0.06	-0.02	-0.02
	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)	(0.05)
2012:Nonprofits	0.03	0.02	0.05^{*}	-0.06	0.01	0.04
	(0.06)	(0.03)	(0.02)	(0.15)	(0.07)	(0.07)
2012:DPJ	-0.46^{***}			-0.29^{*}		
	(0.07)			(0.13)		
Nonprofits:DPJ	-0.03			$-0.04^{\cdot}$		
	(0.02)			(0.02)		
DPJ:$Income_{pc}$	0.03			0.04		
	(0.06)			(0.09)		
2012:Nonprofits:DPJ	0.02			0.13		
	(0.06)			(0.13)		
RL		16.61^{*}			20.40^{*}	
		(6.62)			(7.83)	
2012:RL		0.33^{***}			0.45^{***}	
		(0.03)			(0.05)	
Nonprofits:RL		0.01			0.02	
		(0.01)			(0.01)	
RL:$Income_{pc}$		-0.01			0.00	
		(0.03)			(0.04)	
2012:Nonprofits:RL		-0.03			-0.05	
		(0.03)			(0.05)	
LDP			27.53^{*}			42.76^{**}
			(12.82)			(13.41)
2012:LDP			0.70^{***}			0.96^{***}
			(0.07)			(0.07)
Nonprofits:LDP			0.04^{*}			0.03
			(0.02)			(0.02)
LDP:$Income_{pc}$			-0.01			0.03
			(0.04)			(0.05)
2012:Nonprofits:LDP			-0.01			0.03
			(0.03)			(0.06)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1460	1460	1460	1460	1460	1460
R^2 (full model)	0.26	0.28	0.28	0.30	0.34	0.34
R^2 (proj model)	0.20	0.22	0.22	0.25	0.29	0.29
Adj. R^2 (full model)	0.23	0.24	0.25	0.27	0.31	0.31
Adj. R^2 (proj model)	0.16	0.18	0.19	0.21	0.26	0.26
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.42: Libraries per capita effect on propensity to win in the year after Fukushima, considering incumbents only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	-0.18^{***}	-0.26^{***}	-0.43^{***}	-0.40^{***}	-0.28^{***}	-0.52^{***}
	(0.04)	(0.05)	(0.06)	(0.08)	(0.06)	(0.09)
Libs_{pc}						
DPJ	8.53			14.17		
	(13.62)			(16.31)		
$Income_{pc}$						
2012:Libs_{pc}	0.10	-0.15	-0.22	0.76^{**}	0.39	0.41
	(0.17)	(0.20)	(0.25)	(0.29)	(0.32)	(0.42)
2012:DPJ	-0.31^{***}			-0.02		
	(0.09)			(0.13)		
$\text{Libs}_{pc} : DPJ$	0.10			-0.43		
	(0.29)			(0.60)		
$\text{DPJ:}Income_{pc}$	0.02			0.00		
	(0.04)			(0.06)		
$\text{2012:Libs}_{pc} : DPJ$	-0.55			-0.22		
	(0.40)			(0.62)		
RL		1.23			1.32	
		(6.60)			(8.31)	
2012:RL		0.23^{***}			0.26^{***}	
		(0.04)			(0.06)	
$\text{Libs}_{pc} : RL$		-0.03			0.17	
		(0.15)			(0.26)	
$\text{RL:}Income_{pc}$		-0.02			0.00	
		(0.02)			(0.03)	
$\text{2012:Libs}_{pc} : RL$		0.04			-0.38	
		(0.21)			(0.32)	
LDP			1.75			8.17
			(11.47)			(16.22)
2012:LDP			0.51^{***}			0.64^{***}
			(0.07)			(0.10)
$\text{Libs}_{pc} : LDP$			-0.18			-0.09
			(0.28)			(0.41)
$\text{LDP:}Income_{pc}$			-0.02			0.03
			(0.03)			(0.05)
$\text{2012:Libs}_{pc} : LDP$			0.32			-0.28
			(0.28)			(0.45)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1460	1460	1460	1460	1460	1460
R^2 (full model)	0.40	0.41	0.42	0.44	0.47	0.48
R^2 (proj model)	0.19	0.21	0.21	0.25	0.28	0.29
Adj. R^2 (full model)	0.26	0.27	0.28	0.31	0.34	0.35
Adj. R^2 (proj model)	-0.00	0.02	0.03	0.07	0.11	0.12
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the district level.

Table 2.43: Public Halls per capita effect on propensity to win in the year after Fukushima, considering incumbents only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	-0.18^{***}	-0.28^{***}	-0.46^{***}	-0.38^{***}	-0.35^{***}	-0.62^{***}
	(0.04)	(0.04)	(0.05)	(0.08)	(0.05)	(0.07)
Pub Halls_{pc}						
DPJ	10.64			14.92		
	(13.65)			(17.05)		
$Income_{pc}$						
2012:Pub Halls_{pc}	0.00	-0.20^{*}	-0.29^{***}	0.35	-0.10	$-0.23^{\cdot}$
	(0.10)	(0.08)	(0.09)	(0.22)	(0.11)	(0.13)
2012:DPJ	-0.34^{***}			$-0.19^{\cdot}$		
	(0.08)			(0.11)		
Pub $\text{Halls}_{pc} : DPJ$	0.27^{*}			$0.25^{\cdot}$		
	(0.11)			(0.14)		
DPJ:$Income_{pc}$	0.03			0.02		
	(0.04)			(0.07)		
2012:Pub $\text{Halls}_{pc} : DPJ$	-0.36^{*}			-0.64^{*}		
	(0.15)			(0.27)		
RL		0.28			0.90	
		(6.63)			(8.51)	
2012:RL		0.26^{***}			0.34^{***}	
		(0.04)			(0.05)	
Pub $\text{Halls}_{pc} : RL$		-0.13^{*}			-0.12	
		(0.06)			(0.07)	
RL:$Income_{pc}$		-0.02			-0.00	
		(0.02)			(0.03)	
2012:Pub $\text{Halls}_{pc} : RL$		$0.14^{\cdot}$			0.11	
		(0.08)			(0.11)	
LDP			0.24			7.18
			(11.51)			(16.29)
2012:LDP			0.53^{***}			0.73^{***}
			(0.07)			(0.09)
Pub $\text{Halls}_{pc} : LDP$			-0.24^{*}			-0.31^{**}
			(0.09)			(0.12)
LDP:$Income_{pc}$			-0.03			0.02
			(0.03)			(0.05)
2012:Pub $\text{Halls}_{pc} : LDP$			0.14			0.08
			(0.20)			(0.23)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1460	1460	1460	1460	1460	1460
R^2 (full model)	0.40	0.42	0.42	0.44	0.47	0.48
R^2 (proj model)	0.19	0.21	0.22	0.25	0.28	0.29
Adj. R^2 (full model)	0.26	0.28	0.28	0.31	0.34	0.35
Adj. R^2 (proj model)	0.00	0.02	0.03	0.07	0.11	0.12
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the district level.

Table 2.44: Income per capita effect on propensity to win in the year after Fukushima, considering incumbents only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	-0.17^{***}	-0.26^{***}	-0.44^{***}	-0.40^{***}	-0.33^{***}	-0.55^{***}
	(0.04)	(0.04)	(0.06)	(0.08)	(0.05)	(0.08)
$Income_{pc}$						
DPJ	11.56	14.97		14.45		
	(13.62)	(12.82)		(17.13)		
2012:$Income_{pc}$	-0.07	0.04	$0.08^{\cdot}$	-0.32^{**}	-0.02	-0.02
	(0.04)	(0.04)	(0.04)	(0.12)	(0.05)	(0.07)
2012:DPJ	-0.37^{***}			-0.15		
	(0.08)			(0.11)		
$Income_{pc}$:DPJ	-0.05			-0.03		
	(0.05)			(0.08)		
2012:$Income_{pc}$:DPJ	0.22^{***}			0.39^{**}		
	(0.06)			(0.14)		
RL		0.05			1.47	
		(0.04)			(8.66)	
2012:RL		0.23^{***}			0.31^{***}	
		(0.04)			(0.05)	
$Income_{pc}$:RL		0.01			0.01	
		(0.02)			(0.03)	
2012:$Income_{pc}$:RL		-0.07^{*}			-0.02	
		(0.03)			(0.05)	
LDP			-0.22			8.62
			(11.54)			(16.50)
2012:LDP			0.53^{***}			0.67^{***}
			(0.07)			(0.09)
$Income_{pc}$:LDP			0.02			0.04
			(0.04)			(0.05)
2012:$Income_{pc}$:LDP			-0.07			0.05
			(0.07)			(0.10)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1460	1460	1460	1460	1460	1460
R^2 (full model)	0.40	0.42	0.42	0.45	0.47	0.47
R^2 (proj model)	0.20	0.21	0.22	0.26	0.28	0.29
Adj. R^2 (full model)	0.26	0.28	0.28	0.32	0.34	0.35
Adj. R^2 (proj model)	0.00	0.02	0.03	0.08	0.11	0.12
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the prefecture levels.

Table 2.45: Union effect on propensity to win in the year after Fukushima, considering challengers only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.17***	0.13***	−0.03·	0.42***	0.24***	−0.23***
	(0.01)	(0.01)	(0.02)	(0.04)	(0.03)	(0.05)
Unions						
DPJ	−24.05**			−22.09		
	(7.74)			(16.23)		
$Income_{pc}$	0.01	−0.00	−0.00	−0.00	−0.07*	−0.13***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)
2012:Unions	0.01	0.03**	0.03·	−0.01	0.04	0.07
	(0.01)	(0.01)	(0.02)	(0.04)	(0.03)	(0.05)
2012:DPJ	−0.41***			−1.15***		
	(0.06)			(0.24)		
Unions:DPJ	0.00			0.01		
	(0.02)			(0.03)		
DPJ:$Income_{pc}$	0.14***			0.34***		
	(0.02)			(0.03)		
2012:Unions:DPJ	0.10*			0.30·		
	(0.04)			(0.17)		
RL		11.91***			8.02	
		(2.55)			(10.55)	
2012:RL		0.19***			0.87***	
		(0.02)			(0.05)	
Unions:RL		0.00			0.05·	
		(0.01)			(0.03)	
RL:$Income_{pc}$		−0.02**			−0.03·	
		(0.01)			(0.02)	
2012:Unions:RL		0.00			−0.14**	
		(0.01)			(0.04)	
LDP			23.35·			50.95**
			(13.79)			(18.70)
2012:LDP			0.52***			1.12***
			(0.10)			(0.14)
Unions:LDP			−0.03			0.01
			(0.03)			(0.04)
LDP:$Income_{pc}$			−0.04·			0.09*
			(0.02)			(0.04)
2012:Unions:LDP			−0.02			−0.14
			(0.08)			(0.13)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	3880	3880	3880	3880	3880	3880
R^2 (full model)	0.11	0.12	0.25	0.31	0.31	0.38
R^2 (proj model)	0.10	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (full model)	0.09	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (proj model)	0.08	0.10	0.23	0.29	0.29	0.36
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.46: Religion effect on propensity to win in the year after Fukushima, considering challengers only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.16^{***}	0.12^{***}	-0.04^{**}	0.41^{***}	0.23^{***}	-0.25^{***}
	(0.01)	(0.02)	(0.01)	(0.04)	(0.04)	(0.04)
Relig. Orgs						
DPJ	-24.11^{**}			-22.15		
	(7.71)			(16.05)		
$Income_{pc}$	0.01	-0.00	-0.01	-0.00	-0.07^{*}	-0.13^{***}
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)
2012:Relig. Orgs	-0.01	-0.00	0.00	$-0.07^{\cdot}$	-0.00	-0.01
	(0.02)	(0.02)	(0.02)	(0.04)	(0.03)	(0.05)
2012:DPJ	-0.42^{***}			-1.15^{***}		
	(0.04)			(0.15)		
Relig. Orgs:DPJ	-0.04			-0.05		
	(0.02)			(0.03)		
DPJ:$Income_{pc}$	0.13^{***}			0.32^{***}		
	(0.03)			(0.04)		
2012:Relig. Orgs:DPJ	0.10^{**}			0.44^{**}		
	(0.03)			(0.13)		
RL		11.77^{***}			7.33	
		(2.55)			(10.67)	
2012:RL		0.18^{***}			0.87^{***}	
		(0.02)			(0.04)	
Relig. Orgs:RL		0.02^{*}			0.06^{*}	
		(0.01)			(0.02)	
RL:$Income_{pc}$		-0.02^{*}			$-0.03^{\cdot}$	
		(0.01)			(0.02)	
2012:Relig. Orgs:RL		-0.02			-0.16^{***}	
		(0.02)			(0.03)	
LDP			$23.28^{\cdot}$			50.33^{**}
			(13.60)			(17.90)
2012:LDP			0.53^{***}			1.14^{***}
			(0.09)			(0.12)
Relig. Orgs:LDP			0.06			0.04
			(0.04)			(0.05)
LDP:$Income_{pc}$			-0.01			0.10^{**}
			(0.02)			(0.03)
2012:Relig. Orgs:LDP			-0.01			-0.07
			(0.09)			(0.13)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	3880	3880	3880	3880	3880	3880
R^2 (full model)	0.11	0.12	0.25	0.31	0.31	0.38
R^2 (proj model)	0.10	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (full model)	0.09	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (proj model)	0.08	0.10	0.23	0.29	0.29	0.36
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.47: Volunteering effect on propensity to win in the year after Fukushima, considering challengers only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.16^{***}	0.12^{***}	-0.05^{***}	0.40^{***}	0.22^{***}	-0.26^{***}
	(0.01)	(0.02)	(0.01)	(0.03)	(0.04)	(0.04)
Volunt. Rate						
DPJ	-24.12^{**}			-22.17		
	(7.76)			(16.07)		
$Income_{pc}$	0.01	0.00	-0.01	0.00	-0.06^{*}	-0.13^{***}
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)
2012:Volunt. Rate	-0.02	-0.00	-0.01	-0.09^{*}	-0.02	-0.04
	(0.01)	(0.01)	(0.03)	(0.04)	(0.03)	(0.06)
2012:DPJ	-0.41^{***}			-1.09^{***}		
	(0.04)			(0.12)		
Volunt. Rate:DPJ	$-0.03^{\cdot}$			$-0.05^{\cdot}$		
	(0.02)			(0.03)		
DPJ:$Income_{pc}$	0.13^{***}			0.32^{***}		
	(0.03)			(0.04)		
2012:Volunt. Rate:DPJ	0.13^{***}			0.51^{***}		
	(0.03)			(0.11)		
RL		11.81^{***}			7.33	
		(2.54)			(10.62)	
2012:RL		0.18^{***}			0.85^{***}	
		(0.02)			(0.04)	
Volunt. Rate:RL		$0.02^{\cdot}$			0.08^{***}	
		(0.01)			(0.02)	
RL:$Income_{pc}$		-0.02^{*}			-0.02	
		(0.01)			(0.02)	
2012:Volunt. Rate:RL		$-0.02^{\cdot}$			-0.16^{***}	
		(0.01)			(0.03)	
LDP			22.76			49.77^{**}
			(14.04)			(17.99)
2012:LDP			0.55^{***}			1.18^{***}
			(0.07)			(0.11)
Volunt. Rate:LDP			0.02			0.01
			(0.03)			(0.04)
LDP:$Income_{pc}$			-0.01			0.11^{**}
			(0.03)			(0.04)
2012:Volunt. Rate:LDP			0.07			0.05
			(0.10)			(0.16)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	3880	3880	3880	3880	3880	3880
R^2 (full model)	0.11	0.12	0.25	0.31	0.31	0.38
R^2 (proj model)	0.10	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (full model)	0.10	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (proj model)	0.08	0.10	0.23	0.29	0.29	0.36
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.48: Nonprofits effect on propensity to win in the year after Fukushima, considering challengers only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.17***	0.12***	−0.04**	0.43***	0.24***	−0.25***
	(0.01)	(0.02)	(0.02)	(0.04)	(0.03)	(0.05)
Nonprofits						
DPJ	−24.15**			−22.41		
	(7.73)			(16.09)		
$Income_{pc}$	0.01	−0.00	−0.00	−0.00	−0.07*	−0.13***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)
2012:Nonprofits	−0.00	−0.00	0.01	−0.01	−0.03	0.02
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.05)
2012:DPJ	−0.43***			−1.25***		
	(0.05)			(0.21)		
Nonprofits:DPJ	−0.01			−0.03		
	(0.02)			(0.03)		
DPJ:$Income_{pc}$	0.14***			0.33***		
	(0.03)			(0.03)		
2012:Nonprofits:DPJ	0.03			−0.11		
	(0.05)			(0.25)		
RL		11.86***			7.64	
		(2.58)			(10.57)	
2012:RL		0.19***			0.91***	
		(0.01)			(0.04)	
Nonprofits:RL		0.00			−0.00	
		(0.01)			(0.02)	
RL:$Income_{pc}$		−0.02**			−0.04*	
		(0.01)			(0.02)	
2012:Nonprofits:RL		−0.01			0.01	
		(0.01)			(0.04)	
LDP			23.65			50.13**
			(14.12)			(18.41)
2012:LDP			0.53***			1.16***
			(0.09)			(0.13)
Nonprofits:LDP			0.00			0.01
			(0.02)			(0.02)
LDP:$Income_{pc}$			−0.03			0.10**
			(0.02)			(0.03)
2012:Nonprofits:LDP			−0.05			−0.02
			(0.07)			(0.13)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	3880	3880	3880	3880	3880	3880
R^2 (full model)	0.11	0.12	0.25	0.31	0.31	0.38
R^2 (proj model)	0.10	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (full model)	0.09	0.11	0.24	0.30	0.30	0.37
Adj. R^2 (proj model)	0.08	0.10	0.23	0.29	0.29	0.36
Num. groups: Prefecture	47	47	47	47	47	47

Standard errors are clusterized at the prefecture levels.

Table 2.49: Libraries per capita effect on propensity to win in the year after Fukushima, considering challengers only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.16***	0.13***	-0.04^{***}	0.41***	0.25***	-0.28^{***}
	(0.01)	(0.02)	(0.01)	(0.04)	(0.04)	(0.03)
Libs$_{pc}$						
DPJ	-22.66^{***}			-20.47		
	(6.60)			(12.59)		
$Income_{pc}$						
2012:Libs$_{pc}$	-0.08	-0.02	-0.07	-0.34^{*}	-0.09	-0.33^{*}
	(0.07)	(0.06)	(0.04)	(0.17)	(0.13)	(0.13)
2012:DPJ	-0.41^{***}			-1.19^{***}		
	(0.04)			(0.16)		
Libs$_{pc}$: DPJ	-0.26^{**}			-0.36^{*}		
	(0.08)			(0.16)		
DPJ:$Income_{pc}$	0.13***			0.31***		
	(0.02)			(0.04)		
2012:Libs$_{pc}$: DPJ	0.48**			0.79		
	(0.15)			(0.85)		
RL		11.77***			6.86	
		(2.68)			(9.30)	
2012:RL		0.18***			0.86***	
		(0.02)			(0.05)	
Libs$_{pc}$: RL		0.14*			0.26$^{\cdot}$	
		(0.06)			(0.14)	
RL:$Income_{pc}$		-0.02^{**}			$-0.03^{\cdot}$	
		(0.01)			(0.02)	
2012:Libs$_{pc}$: RL		-0.08			-0.59^{*}	
		(0.08)			(0.23)	
LDP			17.01			43.17$^{\cdot}$
			(15.66)			(23.74)
2012:LDP			0.49***			1.10***
			(0.07)			(0.11)
Libs$_{pc}$: LDP			0.38*			0.31$^{\cdot}$
			(0.17)			(0.17)
LDP:$Income_{pc}$			-0.01			0.10**
			(0.03)			(0.03)
2012:Libs$_{pc}$: LDP			-0.01			0.02
			(0.20)			(0.34)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	3880	3880	3880	3880	3880	3880
R^2 (full model)	0.14	0.16	0.29	0.32	0.32	0.40
R^2 (proj model)	0.10	0.12	0.26	0.28	0.27	0.36
Adj. R^2 (full model)	0.07	0.09	0.23	0.27	0.27	0.35
Adj. R^2 (proj model)	0.03	0.05	0.20	0.22	0.22	0.30
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the district level.

Table 2.50: Public Halls per capita effect on propensity to win in the year after Fukushima, considering challengers only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.17^{***}	0.14^{***}	-0.03^{**}	0.44^{***}	0.27^{***}	-0.23^{***}
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.03)
Pub Halls$_{pc}$						
DPJ	-23.15^{***}			-20.47		
	(6.61)			(12.58)		
$Income_{pc}$						
2012:Pub Halls$_{pc}$	0.00	0.03	0.03	-0.03	0.02	0.06
	(0.02)	(0.02)	(0.02)	(0.06)	(0.05)	(0.08)
2012:DPJ	-0.40^{***}			-1.17^{***}		
	(0.05)			(0.14)		
Pub Halls$_{pc}$: DPJ	-0.00			0.07		
	(0.03)			(0.05)		
DPJ:$Income_{pc}$	0.15^{***}			0.35^{***}		
	(0.02)			(0.04)		
2012:Pub Halls$_{pc}$: DPJ	$0.27^{\cdot}$			0.64^{*}		
	(0.16)			(0.30)		
RL		11.97^{***}			7.64	
		(2.68)			(9.33)	
2012:RL		0.18^{***}			0.88^{***}	
		(0.02)			(0.05)	
Pub Halls$_{pc}$: RL		0.01			0.13^{*}	
		(0.02)			(0.06)	
RL:$Income_{pc}$		-0.02^{***}			-0.03	
		(0.01)			(0.02)	
2012:Pub Halls$_{pc}$: RL		-0.03			$-0.21^{\cdot}$	
		(0.03)			(0.12)	
LDP			18.77			$44.99^{\cdot}$
			(15.58)			(23.44)
2012:LDP			0.50^{***}			1.07^{***}
			(0.07)			(0.12)
Pub Halls$_{pc}$: LDP			-0.01			0.14
			(0.08)			(0.09)
LDP:$Income_{pc}$			-0.03			0.10^{**}
			(0.03)			(0.04)
2012:Pub Halls$_{pc}$: LDP			0.01			-0.17
			(0.08)			(0.16)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	3880	3880	3880	3880	3880	3880
R^2 (full model)	0.14	0.16	0.29	0.32	0.32	0.40
R^2 (proj model)	0.10	0.11	0.25	0.28	0.27	0.36
Adj. R^2 (full model)	0.07	0.09	0.23	0.27	0.27	0.35
Adj. R^2 (proj model)	0.03	0.05	0.19	0.22	0.22	0.30
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the district level.

Table 2.51: Income per capita effect on propensity to win in the year after Fukushima, considering challengers only

	Dep. variable: won the election			Dep. variable: ranking		
	DPJ	RL	LDP	DPJ	RL	LDP
2012	0.16^{***}	0.13^{***}	-0.03^{**}	0.40^{***}	0.25^{***}	-0.25^{***}
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.03)
$Income_{pc}$						
DPJ	-23.12^{***}	$-10.03^{\cdot}$		$-21.15^{\cdot}$		
	(6.59)	(5.81)		(12.56)		
2012:$Income_{pc}$	$0.02^{\cdot}$	−0.01	−0.01	0.08^{*}	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
2012:DPJ	-0.38^{***}			-1.16^{***}		
	(0.04)			(0.17)		
$Income_{pc}$:DPJ	0.16^{***}			0.36^{***}		
	(0.02)			(0.04)		
2012:$Income_{pc}$:DPJ	-0.16^{***}			−0.22		
	(0.03)			(0.16)		
RL		0.11^{***}			7.33	
		(0.01)			(9.29)	
2012:RL		0.12^{***}			0.80^{***}	
		(0.02)			(0.05)	
$Income_{pc}$:RL		-0.03^{***}			-0.09^{***}	
		(0.01)			(0.02)	
2012:$Income_{pc}$:RL		0.02			0.20^{***}	
		(0.01)			(0.04)	
LDP			18.38			$45.35^{\cdot}$
			(15.68)			(23.65)
2012:LDP			0.51^{***}			1.09^{***}
			(0.07)			(0.12)
$Income_{pc}$:LDP			−0.03			0.08^{*}
			(0.03)			(0.04)
2012:$Income_{pc}$:LDP			−0.01			0.03
			(0.04)			(0.08)
Pref FE	Yes	Yes	Yes	Yes	Yes	Yes
Year trend	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	3880	3880	3880	3880	3880	3880
R^2 (full model)	0.14	0.22	0.29	0.32	0.32	0.40
R^2 (proj model)	0.10	0.19	0.25	0.28	0.28	0.35
Adj. R^2 (full model)	0.07	0.16	0.23	0.27	0.27	0.35
Adj. R^2 (proj model)	0.03	0.12	0.19	0.22	0.22	0.30
Num. groups: DistFullName	271	271	271	271	271	271

Standard errors are clusterized at the district level.

3
Theoretical Model for Cultural Evolution as Consequence of Extreme Events

Abstract

This paper suggests a novel theoretical model to explain the empirically observed pattern that in places where the environment is of lower quality, cooperation flourishes. While it is usual to explain the evolution of behavior by means of tweaks in preferences, we show that by keeping the same preferences, but changing the optimization protocol, we are able to explain the empirical observations that in populations that have been exposed to harsher times in the past, a higher level of collective behavior is currently observed . In addition, we show under which conditions cooperative or individualistic populations thrive and suggest how public policy can promote cooperative behavior.

3.1
Introduction

As the recent empirical literature suggests, there is an important relationship between the level of cooperative behavior observed in a given community and the quality of the natural environment surrounding it. While not much work has addressed this issue, studies such as Litina (2016), Buggle (2020), and Buggle and Durante (2021) have documented that communities that historically faced lower agricultural productivity or higher production uncertainty now exhibit higher levels of collectivist behavior and trust. From a theoretical perspective, however, not much work has addressed the influence of natural resources on the development of a cooperative culture (Alger and Weibull, 2019). A few examples are Gintis (2000), Sethi and Somanathan (1996), and Litina (2016).

A common approach in the literature on behavioral evolution is to introduce changes in individuals' preferences (Alger and Weibull, 2019) to elicit the observed patterns. For example, one can include a taste for fairness (Fehr and Schmidt, 1999) or for the material payoff of other individuals (Sethi and Somanathan, 2001). With respect to the literature on environment and cooperation, Gintis (2000) argues that if individuals are endowed with simple reciprocal altruism preferences, threats to a community would actually lead to the breakdown of cooperation. The author attempts to solve the puzzle by introducing a tweak in preferences. As agreed by Gintis et al. (2003), evolutionary pressures would favor groups with a higher number of strong reciprocators in the face of potential threats to the population. As Roemer (2015) discusses, however, although there is empirical evidence that individuals are endowed with preferences that are not exclusively related to self-interest, the mechanism underlying cooperation may not be based on changes in preferences. For example, as the author mentions, cooperative behavior does not require altruism. Rather, altruism may be a consequence of the experiences individuals have in a cooperative environment.

This paper therefore attempts to bridge the gap between the above empirical observations and the current theoretical framework in order to explain how the perceived higher probability of bad times can cause the emergence of cooperation. To this end, we propose a novel model that accounts for the influence of the volatility of the environment on the intergenerational evolution of cooperation within a community. In our model, agents choose to play either cooperatively or individualistically depending on their initial beliefs about the population fraction of cooperators and the probability of a bad environment in the future. While individualists play according to the Nash protocol in the proposed framework, cooperators act according to the Kantian categorical imperative protocol. In such case, their actions are chosen based on the best generalizable strategy, i.e., the best possible strategy as long as it is played by everyone (Laffont, 1975; Curry and Roemer, 2012; Roemer, 2015; Daube and Ulph, 2016; Bezin and Ponthière, 2019; Long, 2019). As discussed in more detail below, in order to describe the intergenerational evolution of cooperation, we use the Replicator Dynamic approach. While there are other ways of modeling the persistence of cooperative behavior, the Replicator Dynamic approach provides a parsimonious way of modeling the vertical transmission of traits across generations. With the suggested model, we advance in literature by showing that the Kantian approach, alongside the Replicator Dynamic model, is able to explain how the variability in environmental conditions can influence the evolution of cooperative behavior, as it has been empirically observed.

By taking advantage of the evidence that natural resources and club goods can be viewed as substitutes (Ito, 2012; Litina, 2016), we find conditions under which agents who optimize according to the Kantian protocol are more likely to succeed. According to the results of the model, the higher the probability of a bad time in subsequent periods, the more likely agents are to act cooperatively. Given the substitutive nature between the environment and the club good, the worse the environment, the more valuable the club good becomes. As a result, it becomes all the more important for individuals to act cooperatively. Moreover, when optimizing according to the Kantian protocol, they "collectively decide" whether or not to punish individualists, who in turn may no longer benefit from the club good. In such case, our model can overcome the second-order free-rider problem, by which agents would not cooperatively enforce defectors. On the other hand, if the environment is of high quality, the marginal gain from the club good becomes less significant, leading to lower incentives for cooperation. Indeed, the results obtained here are consistent with the empirical results observed in literature. For example, Buggle (2020) points out that ancient societies that practiced irrigated agriculture together have stronger norms today. More connected to our framework, Buggle and Durante (2021) find that in European regions facing greater weather variability and thus higher agricultural risks, more interpersonal trust is observed today.

To describe the dynamic evolution of such communities, we use the Replicator Dynamics (Taylor and Jonker, 1978; Schuster and Sigmund, 1983; Hauert et al., 2002). As Hauert et al. (2002) describe it, such an approach is appropriate for explaining a game in which players can compare their outcomes with a "model" chosen randomly from a population, and adopt their strategy with a probability proportional to the difference between their own payoff and that of the model. Such an approach, while parsimonious, allows us to understand the evolution of various dynamic phenomena (Schuster and Sigmund, 1983), such as the one discussed here. More precisely, in such an approach, agents in our setting decide in each period which protocol to adopt. This contrasts, for example, with strict evolutionary models in which strategies are inherited by individuals and do not change over a lifetime (Ostrom, 2000). As a result, we show that population composition can evolve toward full cooperation or full individualism at different rates depending on initial conditions, i.e., the perceived proportion of cooperators and beliefs about the environment.

Finally, to address the commons' problem from a public policy perspective, we consider the possibility of a centralized approach in the punishment stage. As the literature suggests both theoretically and empirically, punishing defectors is quite important for maintaining cooperation, but it comes at a cost. We therefore seek to better understand the results of reducing these costs by adopting the "hired gun" approach proposed by Andreoni and Gee (2012). As we show, cost reduction through the "hired gun" leads to more cooperation because it makes incentive compatible for agents who would otherwise play individualistically to play cooperatively. Moreover, according to our framework, the lower the probability of good times, the more valuable it is to act cooperatively. As a result, the higher the tax rate charged by the external enforcer to ensure cooperation.

The article continues as follows. In Sec. 3.2, the literature is briefly reviewed. In Sec. 3.3, we present the model, both in its static and dynamic versions. In Sec. 3.4, we discuss the results for both approaches (static and dynamic), as well as some implications for public policy. Finally, Sec. 3.5 concludes our analysis.

3.2 Literature Review

This paper is largely related to the literature on the management of common resources. One of its most prominent results is Hardin's Tragedy of Commons, which states that agents who seek to maximize their individual welfare while ignoring the effects of their actions on others tend to overexploit resources, eventually leading to their total depletion (Hardin, 1968). However, in experiments examining the tradeoff between individual and group-oriented thinking, the results do not necessarily lead to a scenario in which pure individualism prevails (Bezin and Ponthière, 2019). Fehr and Schmidt (1999) argue, for example, that depending on the economic environment, raw individualism may be balanced by a preference for equality [1] to determine whether people act cooperatively or selfishly.

Anthropologists, sociologists, and psychologists have long sought to uncover mechanisms by which relationships within groups help promote or threaten their wealth and well-being (Hollander, 1990; Ostrom et al., 1992; Fehr and Gintis, 2007; Simpson and Willer, 2015). More recently, however, biologists have attempted to apply mathematical methods to such efforts (Gintis, 2000; Nowak, 2006). Based on this latter approach, economists have also developed theoretical models to promote a better understanding of these relationships and their consequences. In Gintis (2000), it is argued that in a repeated public goods game with n individuals, in which players are guided by self-interest, cooperation cannot be sustained if the group faces a high threat of disband or extinction. The author shows that such a fate could be avoided, both theoretically and experimentally, by using could

[1] For example, in the provision of a club good, if the environment is such that individualistic agents are punished, cooperation may be observed, whereas the outcome would be individualistic if punishment were not possible

be avoided if strong reciprocators[2] were present in the population. Indeed, Gintis et al. (2003) present empirical evidence based on several experimental settings that support strong reciprocity as a possible mechanism for the existence of cooperation and punishment of defectors. Indeed, such models and experimental studies are supported by real-life examples. As Sethi and Somanathan (1996) describe, communities in Brazil, India, and the Himalayas have succeeded in overcoming potential resource depletion through codes of conduct based on the implementation of sanctions. Therefore, the representation of such social norms seems particularly important to obtain a more accurate description of resource use.

In one of the attempts to propose an explanation for the occurrence of cooperative behavior, Sethi and Somanathan (1996) promote a review of Dasgupta (1995)'s classification of previous approaches and offer their own alternative. First, they mention models based on the "recognition of rural communities as miniature states" that would enforce individuals' commitment to local social norms. However, such an approach ignores the possibility of decentralized sanctioning, since a central figure is still required for sanctioning. As a second possibility, the authors cite models in which cooperation is based on repeated games. A drawback of this type of framework is that multiple equilibria leading to cooperation are possible, including those in which cooperative behavior is abandoned and resumed shortly thereafter. Nevertheless, this type of behavior is not necessarily observed in real cases where the *status quo* is most likely persistent, whether in terms of cooperativeness or individualism. Finally, the authors comment on models in which norms are internalized through "communal living, role modeling, education, and by experiencing rewards and punishments" without explaining why certain norms are observed and others are not. To address the drawbacks of each modeling strategy mentioned above, the authors propose a Common Pool Resources (CPR) setting in which three types of agents-the defectors, the cooperators, and the enforcers-share a common resource. The composition of the population evolves over time according to evolutionary dynamics in which higher (lower) payoffs tend to lead to higher (lower) survival rates. Under the assumptions of the model, cooperators and enforcers internalize their externalities to others by exploiting the population optimum, while defectors (over)exploit according to their individual optimum. However, enforcers have the power to punish defectors, which comes

[2]Strong reciprocity is here used as opposed to weak reciprocity, associated with reciprocal altruism. As the author argues, such trait would not be able to explain situations in which cooperation and punishment are observed even when the enforcers do so at a cost.

at a cost. Consequently, population dynamics are determined by parameters such as punishment costs and the value of resources. We contribute to this literature by showing that by adopting the Kantian approach, it is possible to represent the incidence of cooperative behavior in face of the perceived probability that the environment quality will be worse. Therefore, we are able to model the increase in cooperation as a response to the volatility on the quality of natural resources[3].

In addition, we interact with research on the evolution of culture and norms. Boyd and Richerson (1985) provide an overview on models describing the evolution of preferences and cultural traits, according to a range of possible mechanisms. Furthermore, Henrich and Boyd (2001) develop a model in which the mechanisms of pay-off biased transmission (by which people copy the behavior of the successful ones) and conformist transmission (which causes people to copy the behavior of the majority) play a role in the dynamics of cultural evolution. These authors propose that cooperative behavior can be stabilized if an arbitrarily small amount of conformist transmission exists and some punishment is allowed. Moreover, they argue that groups that successfully cooperate may influence this trait in other groups because of pay-off selection forces. From a different perspective, Bisin and Verdier (2001) propose a model of intergenerational transmission of preferences in which imperfect empathy plays a fundamental role in the evolution of cultural traits. We contribute to this literature by providing an instance in which the Replicator Dynamic can be used as a mechanism that is able to parsimoniously capture the evolution of cooperative behavior.

In summary, our contribution lies in the overlap between the above branches of literature. By acknowledging that agents can choose their strategy between the individualistic (Nashian) and cooperative (Kantian) approaches, we are able to describe how the perceived variability in environment can influence the evolution of cultural traits. To illustrate this contribution, an interesting application of the model is the implementation and management of irrigation systems. As Takayama et al. (2018) argues, such systems are typically viewed as common-pool resources from which it is difficult to exclude users. Consequently, they can easily be overused and depleted if not properly managed. As Agrawal (2001), Fujiie et al. (2005), and Bardhan (1993) agree, collective participation tends to be higher when resources (in this case, water) are moderately scarce. When water is abundant (high-quality environment), cooperation is not essential and therefore

[3]While "quality" of natural resources is a rather vague term, this can be thought of as land productivity, such as in Litina (2016), or water availability, as in Ito (2012)

not fostered. On the other hand, when water is severely scarce (low-quality environment), conflicts among users may be prohibitively high to sustain cooperation.

3.3 The Model

Considering the above literature, we present a scenario in which the inhabitants of a community share a common good. For example, consider the case of a common irrigation for plantations, as described by Takayama et al. (2018) in Japanese villages, where the irrigation system is managed by the residents themselves. Following Ito (2012); Litina (2016), each household production, y_{hh}, depends on the labor allocated to agriculture, l_a, the quality of the common irrigation system, C, the technology, A, and the amount of land owned, s_{hh}. Considering the common good C, the benefits it brings to the household depend in turn on the total labor spent on its operation and maintenance, L_c, the quality of the environment e, R_e, and the household's land share, $\frac{s_{hh}}{S}$, where $S = \sum_{hh=1}^{N} s_{hh}$ and N is the number of households in the village, as shown in Eq. 3-1,

$$y_{hh} = F\left[l_a, C(L_c, \frac{s_{hh}}{S}, R_e), A, s_{hh}\right]. \tag{3-1}$$

The aggregate labor allocated to the club good, L_c, is the sum of individual household allocations, $L_c = \sum_{hh=1}^{N} l_{c,hh}$. In our context, both the labor allocated to agriculture l_a and the labor allocated to the club good, $l_{c,hh}$, are in fixed amounts. The intent behind this simplifying hypothesis is to focus on the existing trade-off each household faces between contributing to the club good - and therefore improving the quality of the common irrigation system - and free-riding - and potentially enjoying the benefits of the common resource without bearing the costs of the associated effort. For simplicity, we also assume that each household provides the same amount of labor and owns the same amount of land, so that $l_{c,hh} = l_c$ and $s_{hh} = s$. To account for this simplification in notation, equation 3-2 highlights the fact that individual production is actually a function of aggregate labor applied to the common resource and the quality of the environment, while implicitly accounting for the other variables,

$$y_{hh} = F\left[l_a, C(L_c, \frac{s}{S}, R_e), A, s\right] \equiv f\left[C(L_c \cdot \frac{s}{S}, R_e)\right]. \tag{3-2}$$

Basically, we assume that the production function is increasing and concave in the quality of the common good, $\frac{\partial f}{\partial C} > 0$ and $\frac{\partial^2 f}{\partial^2 C} < 0$. In turn, C is increasing and concave in the aggregate labor applied to the common good, $\frac{\partial C}{\partial L_c} > 0$ and $\frac{\partial^2 C}{\partial^2 L_c} < 0$. Also, for simplicity, we assume that $C(L_c, \frac{s}{S}, R_e) = C(L_c \cdot \frac{s}{S}, R_e)$.

As argued by Ito (2012) and Litina (2016), there is substitutability between the public infrastructure and the natural resources endowment. As a result, the marginal productivity of labor allocated to the common resource is lower in a higher quality environment. The rationale behind this hypothesis is that when the quality of natural resources is high, the marginal benefit of improving public infrastructure is not as large as when the quality of natural resources is lower. Thus, in the latter case, public infrastructure would potentially play a more important role. Thus[4]. Indeed, Agrawal (2001), Fujiie et al. (2005), and Bardhan (1993) also mention such behavior. Mathematically, we would have that $\frac{\partial^2 C}{\partial R \partial L_c} < 0$. Given the properties of $f(\cdot)$ and $C(\cdot)$, we have that $\frac{\partial^2 f}{\partial R \partial L_c} < 0$[5]. Given the production characteristics, it is now possible to propose a strategic interaction between agents that takes into account the environmental context.

3.3.1 The static game

In the community, households can choose whether or not to cooperate and provide their labor for the common good. If they choose to cooperate, they have a higher quality public resource, but they must also bear the cost of the labor involved. Moreover, cooperative action provides them with the opportunity to punish free-riders who do not cooperate by excluding them from the benefits of using the club good[6]. Punishment is not free, however, and cooperative households consisting of a proportion σ of the population must also bear retaliation costs, $r(\sigma)$, which are assumed to be invertible and differentiable. More specifically, the higher the proportion of cooperators,

[4]As noted earlier, however, other issues come into play when natural endowments are extremely low, such as competition for natural resources. Thus, the "bad" environment used here would be more of a "moderate" environment.

[5]This assertion is valid as long as the natural endowment affects production only through the quality of resources. As will be discussed below, the functional form used for the simulations does not follow this assumption, but the results are not compromised, i.e., it is still true that $\frac{\partial^2 f}{\partial R \partial L_c} < 0$.

[6]It is interesting to note here that in Japan, for example, villages had their own code to enforce solidarity(Satoh and Ishii, 2021). Depending on the violation, villagers were subject to sanctions such as a verbal or written apology, ostracism, or even banishment. As Befu (1965) points out, "punishment by property deprivation – monetary fine, property fine, or loss of the right of access to communal land– was meted out for theft on communal or private land, theft of farm crops, refusal to provide labor for village corvée, violation of irrigation regulation, gambling, etc.". With such a description of the enforcement of community norms, it is clear that the framework proposed here adequately reflects the actual dynamics of social sanctions

the easier it is to punish defectors, leading to $r'(\sigma) < 0$ and $r(\sigma \to 1) \to 0$.

In Eqs. 3-1 and 3-2, the impact of public infrastructure lies in the benefit it brings to the output of each household. Thus, if a household owns a large share of land, $\frac{S_{hh}}{S}$, a high-quality common resource will be of great benefit to him/her. On the other hand, households with a small share of land will benefit, but to a lesser extent. Thus, if punishment occurs, the club good will be demanded by a smaller fraction of households that own a lot of land σS, leaving those that still have access to it with a higher-value supply.

In our economy, households can choose to act as cooperators or as free-riders. In either case, they act for their own benefit, so the question of altruism does not necessarily arise. Nevertheless, the maximization protocol chosen differs for each choice. Following Roemer (2015), Bezin and Ponthière (2019), we assume that cooperators act as Kantians in the sense that they choose the best *generalizable* strategy, i.e., the one that yields the highest payoff as long as everyone else plays it as well. In contrast, when households act according to the Nash protocol, they choose the best unilateral strategy.

In the current context, an important piece of information for household decision- making is the state of nature – the quality of the environment – to which they are tied. At the time of their decision to perform work for the common good or not, this information is unknown. Agents have a prior over the future state of nature: with probability p, the state of nature will be good, in which case $R_e = R_g$, and with probability $1 - p$, the environment will be bad, $R_e = R_b < R_g$.

Thus, the game is held in four stages:

- (i), nature chooses whether the environment will be good, $R_e = R_g$, or bad, $R_e = R_b$, with probabilities p and $1 - p$, respectively;
- (ii), households choose between allocating or not labor to the public infrastructure, l_c;
- (iii), nature discloses the state of the environment and, finally;
- (iv), cooperators decide collectively whether to punish the defectors.

If cooperators choose not to punish, they will continue to share public infrastructure with free-riders, but will not incur retaliation costs. Accordingly, their payoff is

$$y^{K,np} = f\Big(C(\sigma N l_c \cdot \frac{s}{S}, R_e)\Big) - l_c, \tag{3-3}$$

which takes into account both the result of production and the costs associated with providing labor for the common good, l_c. At this point, it is important to emphasize that whenever there is a fraction σ of cooperators, the aggregate labor devoted to the common good is $L_c = \sigma \sum_{hh=1}^{N} l_c = \sigma N l_c$, provided l_c is fixed and equal for each household. If cooperators choose to punish defectors, they bear the cost of retaliation, but have less worn-out – higher quality – public infrastructure. Equation 3-4 describes the payoff for this case,

$$y^{K,p} = f\Big(C(\sigma N l_c \cdot \frac{s}{\sigma S}, R_e)\Big) - l_c - r(\sigma) = f\Big(C(N l_c \cdot \frac{s}{S}, R_e)\Big) - l_c - r(\sigma). \tag{3-4}$$

Note at this point that by adopting the Kantian protocol, agents overcome the second-order free-rider problem. By executing the best generalizable strategy, Kantians bear the retaliation cost. This is the case because as long as each individual does the same, they are better off. If the defectors are punished, in which case do not have access to the common resource, their payoff is described by Eq. 3-5,

$$y^{N,p} = f\Big(C(0, R_e)\Big). \tag{3-5}$$

However, if they are not punished, they still have access to the public infrastructure and reap its benefits, as described by Eq. 3-6,

$$y^{N,np} = f\Big(C(\sigma N l_c \cdot \frac{s}{S}, R_e)\Big). \tag{3-6}$$

A simple, simplifying assumption is that the proportion of land owned by each household is equal. Thus, if one assumes that there are N households, then $\frac{s}{S} = \frac{1}{N}$. It follows that $N l_c \frac{s}{S} = l_c$.

In solving the game, the cooperators decide in the last stage whether to punish the defectors or not. Punishment occurs if $y^{K,p} \geq y^{K,np}$, which, remembering Eqs. 3-3 and 3-4, implies that

$$y^{K,p} \geq y^{K,np} \iff r(\sigma) \leq f\Big(C(l_c, R_e)\Big) - f\Big((\sigma l_c, R_e)\Big) \equiv \Delta f_e, e \in \{b, g\}.$$

Intuitively, cooperators will choose to punish–and prohibit them from benefiting from the club good – whenever the cost of retaliation, $r(\sigma)$, is less than the production gains from having a higher quality public infrastructure, Δf_e. Note that these gains depend on the state of the environment, $e \in \{b, g\}$. Considering the substitutability between the labor allocated to the common good and the environment, $\frac{\partial^2 f}{\partial L_c \partial R_e} < 0$, one has that $\Delta f_b > \Delta f_g$[7]. Consequently, punishment is more rewarding in bad times,

[7] In fact, $\frac{\partial^2 f}{\partial L_c \partial R_e} < 0 \implies \frac{\partial f}{\partial L_c}\big|_{R_e = R_g} - \frac{\partial f}{\partial L_c}\big|_{R_e = R_b} < 0 \implies \Delta f_b > \Delta f_g$.

which means that cooperation should be valued more highly under this condition. Depending on the boundary conditions, there may even be cases where punishment occurs in a bad condition but not in a good one, i.e., $\Delta f_b > r(\sigma) > \Delta f_g$. Figure 3.1 shows the possible scenarios for a given parametrization of the production and retaliation functions. It is important to note that the production function used here for illustration is similar to that of Litina (2016) (and similar to that of Ito (2012)), as shown in Eq. 3-7 shown,

$$F\Big[l_a, C(L_c, \frac{s}{S}, R_e), A, s\Big] = \Big(R_e A + \frac{1}{R_e}(L_c)^{\beta}\Big)^{\alpha}\Big(l_a\Big)^{(1-\alpha)}, \tag{3-7}$$

where $C(L_c, R_e) = \frac{1}{R}(L_c)^{\beta}$; $\alpha, \beta \in (0,1)$; $e \in \{b, g\}$; and $A > 0$. As one can observe, such a functional form satisfies all the above requirements for $F\Big[l_a, C(L_c, \frac{s}{S}, R_e), A, s\Big]$. Basically, it shows the relevant substitutability condition between the environment and the labor supply for the common good, $\frac{\partial^2 f}{\partial L_c \partial R_e} < 0$. A functional form for the cost of punishment is also proposed, $r(\sigma) = k\frac{1-\sigma}{\sigma}$, indicating that the cost of punishment is higher when the population consists of a lower proportion of cooperators. As Ito (2012) argues, it is not always the case that the relationship between the environment and the club good has a substitutability character. According to the author, in cases where the environment is of low quality (low R_e), the relationship with the club good may be of complementarity. In this case, one would have that $\frac{\partial^2 f}{\partial L_c \partial R_e} > 0$. Therefore, in Appendix 3.6 we extend the development made here for the case where the environment and the public are complements.

As one can observe, the higher the proportion of cooperators, σ, the lower the costs of retaliation and the lower the gains from punishment. In the observed case, it is possible to verify that there can be cases where there is always punishment, $\Delta f_b > \Delta f_g > r(\sigma)$; punishment is observed only in bad times, $\Delta f_b > r(\sigma) > \Delta f_g$; and punishment does not occur under any circumstances, $r(\sigma) > \Delta f_b > \Delta f_g$.

If cooperators are indifferent to punishing in bad times or not, this is because $r(\sigma) = \Delta f_b$, in which case $\sigma = \sigma_b$. When such indifference occurs in good times, the gains from punishment are equal to its cost, $r(\sigma) = \Delta f_g$, and it is defined that $\sigma = \sigma_g$. Note that both Δf_g and Δf_b depend on σ, possibly in a nonlinear way.

In stage (ii), before nature reveals the actual state of the environment, agents must decide whether or not to cooperate – i.e., allocating labor to the common good and be able to punish defectors in the last stage – or not. The decision must be based on the probability of a "good time" in the future, p,

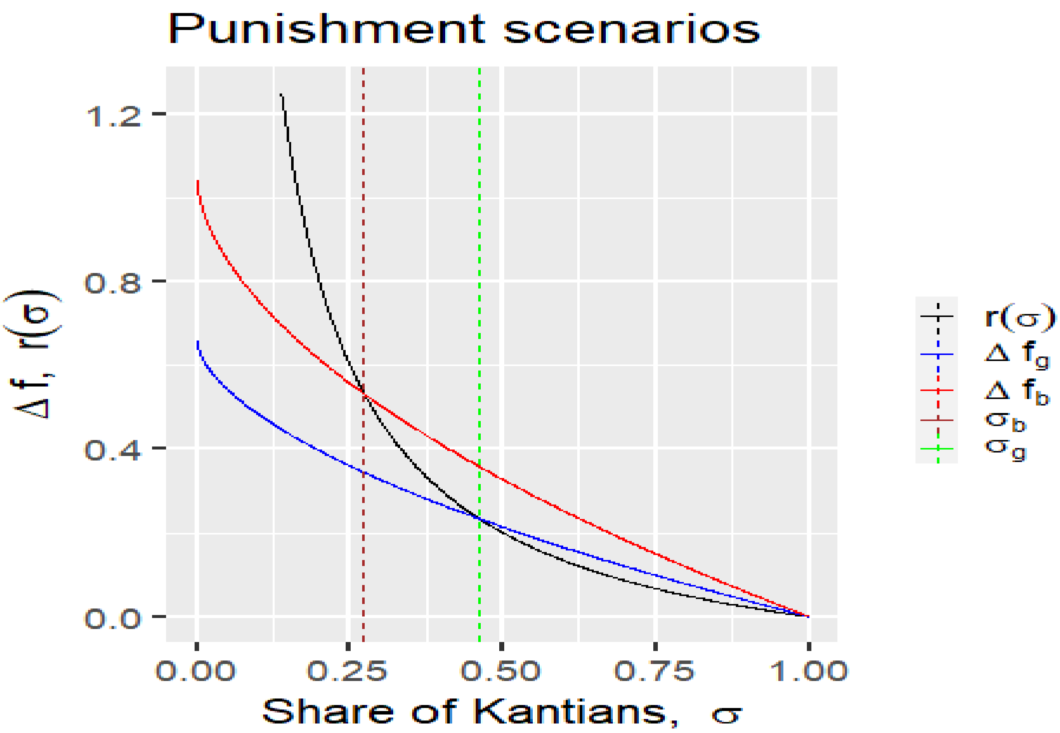


Figure 3.1: Punishment scenarios according to share of cooperators (Kantians).

leading to Eq. 3-8 for the expected gain from cooperators and Eq. 3-9 for the expected gain of defectors,

$$\mathbb{E}[y^K] = p\left[\mathbb{1}_{\{punish\}}y_g^{K,p} + (1-\mathbb{1}_{\{punish\}})y_g^{K,np}\right] + (1-p)\left[\mathbb{1}_{\{punish\}}y_b^{K,p} + (1-\mathbb{1}_{\{punish\}})y_b^{K,np}\right], \tag{3-8}$$

$$\mathbb{E}[y^N] = p\left[\mathbb{1}_{\{punish\}}y_g^{N,p} + (1-\mathbb{1}_{\{punish\}})y_g^{N,np}\right] + (1-p)\left[\mathbb{1}_{\{punish\}}y_b^{N,p} + (1-\mathbb{1}_{\{punish\}})y_b^{N,np}\right], \tag{3-9}$$

where $\mathbb{1}_{\{punish\}}$ stands for the indicator function representing the decision to punish, which is made in the final stage. $y_t^{q,u}$ represents the payoff of the agent applying the protocol $q \in \{Nash, Kant\}$ when cooperators punish ($u = p$) or do not punish ($u = np$) in an environment of quality $e \in \{b, g\}$. Simply put, agents will choose to cooperate whenever $\mathbb{E}[y^K] \geq \mathbb{E}[y^N]$. From what has been developed, it is clear that agents' decisions must be based on their prior information about the state of nature, p, and the proportion of cooperators, σ. The consequences of this information will become clear in Sec. 3.4.1 when the outcome of the game is discussed. In the next section, the dynamic evolution of the game is presented.

3.3.2 The game dynamics

As for the evolution of the population in the community, we consider the Replicator Dynamics approach (Taylor and Jonker, 1978). While the transmission of traits and the transmission of cooperative behavior can be achieved by other approaches, such as in repeated games[8], the Replicator Dynamic can parsimoniously and adequately describe the vertical transmission of traits. In such setting, the payoff of the agent can be viewed as his/her fitness in the environment, which determines the growth rate of the agent's type. However, as Hauert et al. (2002) discuss, the same dynamics can be achieved if agents compare their outcome to that of a randomly selected "model" of the population. Then, agents would switch to the model's action with a probability proportional to the difference in payoffs if this would increase their payoff. Consequently, actions yielding a higher payoff relative to the population average have a better chance of resisting evolutionary pressure because they have a higher probability of survival. Briefly, let $y_{\psi,t}$ be the payoff achieved by agents of type $\psi \in \Psi$ at time t, and let the proportion of this type in the population be $\sigma_{\psi,t}$. In discrete time, the replicator dynamics states that

$$\sigma_{\psi,t+1} = \sigma_{\psi,t} \frac{y_{\psi,t}(\sigma_{\psi,t})}{\bar{y}_t}, \tag{3-10}$$

where $\bar{y}_t = \sum_{\psi \in \Psi} \sigma_{\psi,t} y_{\psi,t}$ represents the average payoff in the population, and Ψ indicates the set of possible types. In other words, if the payoff of agents of type $\psi \in \Psi$ is above the population average ($y_{\psi,t} > \bar{y}_t$), their share in the population will increase between times t and $t+1$. In our case, a type represents the possible protocols adopted by each agent, $\Psi = \{Kant, Nash\}$. We can then assume that $\sigma_{Kant,t} = \sigma_t$ and $\sigma_{Nash,t} = 1 - \sigma_t$. Thus, the fraction of cooperators (agents playing the Kantian protocol) evolves as

$$\sigma_{t+1} = \sigma_t \frac{\mathbb{E}[y^K]}{\sigma_t \, \mathbb{E}[y^K] + (1 - \sigma_t) \, \mathbb{E}[y^N]}. \tag{3-11}$$

It is important to note at this point that there is a simplifying assumption regarding σ. It has been taken as both the actual and the perceived proportion of Kantians in the population. However, this is not necessarily the case. In a given community, the actual proportion of cooperators may differ from that believed by the population. Accounting for these differences would add flexibility to our model, but that is left for future work.

[8] Which nevertheless suffers from the problem of multiple equilibria (Sethi and Somanathan, 1996).

In view of the developed theoretical framework, the next section presents the consequences that result from establishing the equilibria and the dynamic evolution of the different types.

3.4 Results

3.4.1 Static game

In view of the game described, one should firstly establish the equilibrium conditions. As noted in Sec. 3.3.1, there are different punishment scenarios depending on the proportion of cooperators and the expectations about the environment. In the following, we describe these scenarios in more detail and establish the equilibrium conditions. To simplify notation, we assume below that $L_c = Nl_c \cdot \frac{s}{S}$, i.e., L_c represents the total labor allocated to the common good weighted by the share of land a household owns.

3.4.1.1 First scenario, $\sigma \leq \sigma_b < \sigma_g$

If the percentage of cooperators is too low – below the threshold for punishment to be held in bad times – then Eqs. 3-3 and 3-6 define the payoff for cooperators and individualists, respectively. The expected value for these protocols, based on Eqs. 3-8 and 3-9, become

$$\mathbb{E}[y^K] = pf\Big(C(\sigma L_c, R_g)\Big) + (1-p)f\Big(C(\sigma L_c, R_b)\Big) - l_c, \tag{3-12}$$

$$\mathbb{E}[y^N] = pf\Big(C(\sigma L_c, R_g)\Big) + (1-p)f\Big(C(\sigma L_c, R_b)\Big). \tag{3-13}$$

Proposition 1: *for any probability of a good time and when the share of cooperators is sufficiently low so that it never allows for punishment to be held, i.e. $\sigma \in [0, \sigma_b]$, playing individualistically is dominant and no cooperation can be sustained.*

Indeed, as one can deduce directly from Eqs. 3-12 and 3-13, the expected payoffs from cooperative or individualistic play are the same for any probability of a good time, except that cooperative players bear the cost of cooperation, $l_{c,hh}$. Thus, $\forall\, p$, and $\forall \sigma \leq \sigma_b$, $\mathbb{E}[y^N] = \mathbb{E}[y^K] + l_c \geq \mathbb{E}[y^K]$. In this scenario, playing the Nash protocol is dominant and no cooperation can be sustained, $\sigma = 0$.

3.4.1.2
Second scenario, $\sigma_b < \sigma < \sigma_g$

Under this condition, cooperators will punish defectors in bad times but not in good times. As a result, the respective payoffs will be

$$\mathbb{E}[y^K] = pf\Big(C(\sigma L_c, R_g)\Big) + (1-p)\Big[f\Big(C(L_c, R_b)\Big) - r(\sigma)\Big] - l_{c,hh}, \quad (3\text{-}14)$$

$$\mathbb{E}[y^N] = pf\Big(C(\sigma L_c, R_g)\Big) + (1-p)f\Big(C(0, R_b)\Big). \quad (3\text{-}15)$$

Proposition 2: *For all $\sigma \in (\sigma_b, \sigma_g)$, the lower the propensity of a good time, the larger the share of individuals playing with the cooperative protocol.*

To better understand strategies under this condition, we can first assume that agents are indifferent as to whether they play cooperatively or individualistically when $\mathbb{E}[y^K] = \mathbb{E}[y^N]$. Using Eqs. 3-14 and 3-15, this condition resumes to

$$(1-p)\Big[f\Big(C(L_c, R_b)\Big) - f\Big(C(0, R_b)\Big) - r(\sigma^*)\Big] = l_c, \quad (3\text{-}16)$$

which reflects the intuition that agents are always willing to play either protocol when the cost of cooperation equals the benefit. Therefore, the proportion of cooperators that yields such condition is,

$$\sigma^* = r^{-1}\Big[f\Big(C(L_c, R_b)\Big) - f\Big(C(0, R_b)\Big) - \frac{l_c}{1-p}\Big]. \quad (3\text{-}17)$$

Considering the variation of the proportion of cooperators, σ, with the perceived probability of a good time, p, it is straightforwardly verified that $\frac{d\sigma^*}{dp} = -r^{-1\prime}\frac{l_c}{(1-p)^2} > 0$. Thus, recalling that $r'(\sigma) < 0$, the higher the perceived probability of a good time, the higher the proportion of people necessary to sustain cooperation. As a result, a higher proportion of households will fall under the $\sigma > \sigma^*$ condition and play cooperatively, leading to Proposition 2.

3.4.1.3
Third scenario, $\sigma_b < \sigma_g \leq \sigma$

In the third scenario, agents believe that defectors are punished in any environment, due to the population composition. Consequently, the agents' payoffs are,

$$\mathbf{E}[y^K] = pf\Big(C(L_c, R_g)\Big) + (1-p)f\Big(C(L_c, R_b)\Big) - r(\sigma) - l_c, \quad (3\text{-}18)$$

$$\mathbf{E}[y^N] = pf\Big(C(0, R_g)\Big) + (1-p)f\Big(C(0, R_b)\Big), \quad (3\text{-}19)$$

respectively for cooperators and individualists.

Proposition 3: *For all $\sigma \in [\sigma_g, 1]$, the lower the propensity of a good time, the larger the share of individuals playing the cooperative protocol.*

To verify such statement, we start by the indifference condition, i.e., $\mathbb{E}[y^K] = \mathbb{E}[y^N]$, further detailed in Eq. 3-20[9],

$$\sigma^* = r^{-1}\Big[\Delta f_b - l_c + p\Big(\Delta f_g - \Delta f_b\Big)\Big]. \tag{3-20}$$

This condition once again illustrates the balance between the costs and benefits of cooperative play and punishment. If we examine the variation in the proportion of agents required to maintain cooperation as a function of the perceived probability of a good time, we obtain that $\frac{d\sigma^*}{dp} = r^{-1\prime}[\Delta f_g - \Delta f_b] > 0$. Analogous to the second scenario, the higher the probability of a good time, the higher the proportion of the population required to maintain cooperation. Thus, if the probability of bad times is higher– the lower isσ^* – the more likely it is that agents' beliefs about the proportion of cooperative individuals satisfy the condition $\sigma > \sigma^*$, leading to Proposition 3.

3.4.1.4
Hypothesis over l_c

So far, little has been said about the individual labor to be allocated to the common good, l_c. To address this point, one can first consider the case when $\sigma = 1$. At this point, one should expect to be in the third scenario, where $\sigma > \sigma_g$. To understand what happens then, one can consider Eq. 3-20. An intuitive assumption is that when $\sigma = 1$, punishment is costless, i.e., $r(\sigma = 1) = 0$. Thus, one has that

$$l_c = \Delta f_b + p\Big(\Delta f_g - \Delta f_b\Big). \tag{3-21}$$

Moreover, it is reasonable to assume that in good times, and under the belief that everyone would play cooperatively, agents should be at most indifferent between actually playing Kant or playing individualistically. Consequently, considering $p = 1$, one would have that

$$0 \le l_c \le \Delta f_g = f(L_c, R_g) - f(0, R_g) > 0. \tag{3-22}$$

If this is not the case (or, more precisely, if one allows $l_c > \Delta f_g$), then even with a low expectation of a bad scenario (p slightly less than 1), it might be profitable for agents to play the Nash protocol if $\sigma = 1$ is the belief, leading to an inconsistency with respect to the equilibrium condition. To be on the safe side, in what follows we assume that $l_c = \Delta f_g$, i.e., the cost of

[9] Recalling that $\Delta f_e \equiv f(L_c, R_e) - f(0, R_e)$, $e \in \{b, g\}$.

providing labor to the common good is (at most) equal to the gains of having the common good at its best condition in good times.

Based on this hypothesis, a review of the previous conditions is made for the second and third scenarios. It should be recalled at this point that the first scenario leads to a completely individualistic population ($\sigma = 0$) when $l_c > 0$. Based on Eq. 3-22 with equality, in the second scenario, where $\sigma_b < \sigma < \sigma_g$, Eq. 3-17 should be reconsidered and replaced by Eq. 3-23,

$$\sigma^* = r^{-1}\Big(\Delta f_b - \frac{\Delta f_g}{1-p}\Big). \tag{3-23}$$

Analogously, in the third scenario, where $\sigma_b < \sigma_g \leq \sigma$, Eqs. 3-22 and 3-20 yield Eq. 3-24,

$$\sigma^* = r^{-1}\Big[(1-p)(\Delta f_b - \Delta f_g)\Big]. \tag{3-24}$$

Qualitatively, the constraint imposed on l_c does not change the conclusions that follow from propositions 2 and 3. Thus, for both scenarios, a lower propensity to good time induces a higher proportion of the population playing cooperatively.

Considering all of the above scenarios, it is helpful to visualize the relationship between σ^* – the share of cooperative players when agents are indifferent with respect to the chosen protocol – and p, the perceived probability of good time. Figure 3.2 provides such a mapping, following the production function described in Eq. 3-1.

As one can see, there is no cooperation at all if the proportion of cooperators is below σ_b: $\sigma* = 0$. However, when the second scenario is reached, where there is punishment only in bad times, players can play the Kantian protocol if their prior over the proportion of cooperators is such that $\sigma > \sigma* > \sigma_b > 0$. Finally, an analogous condition is observed for the third scenario, when punishment is independent of the state of nature. In this case, cooperation can be achieved if the prior over the proportion of cooperators is such that $\sigma > \sigma^* > \sigma_g > 0$. Moreover, for both scenarios, the larger the differential benefit of cooperation in bad times compared to good times[10], the more agents are willing to cooperate. As a result, the proportion of agents required to sustain cooperation would decrease. This is a consequence of the larger benefit extracted from the club good in bad times, and thus the higher relevance of cooperative behavior.

[10] i.e., the larger Δf_b is relative to Δf_g

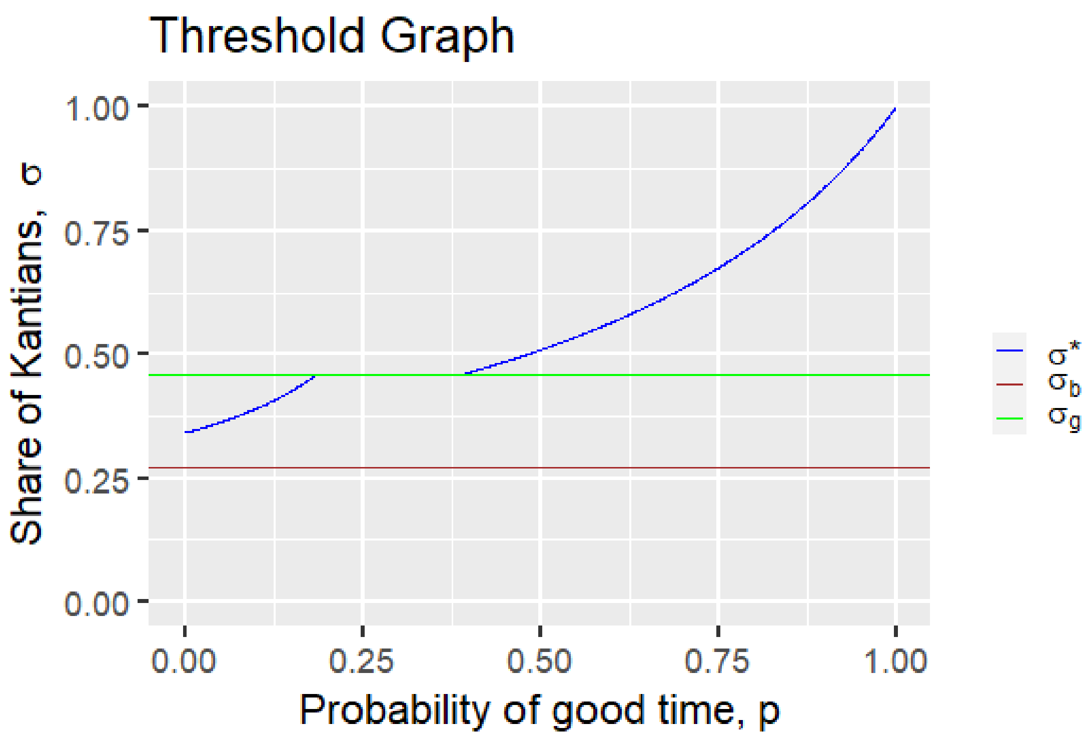


Figure 3.2: Mapping between the propensity of good time and the share of cooperators when agents are indifferent. σ_b stands for the threshold between the first and the second scenarios, σ_g stands for the threshold between the second and the third scenarios and σ_* indicates the share of cooperators for which players are indifferent between playing cooperatively and individualistically.

3.4.1.5 Evolutionary stability

An important point in analyzing the evolution of a population subject to such protocols is whether they are stable when some kind of mutation (or invasion by the other type) is observed (Sethi and Somanathan, 2001; Dekel et al., 2007; Alger and Weibull, 2019). Thus, we consider the cases when the population consists only of cooperators ($\sigma = 1$) or only of individualists ($\sigma = 0$), and examine their behavior when invaded by the other type.

Suppose a population consists of cooperators ($\sigma = 1$) and there is a risk that it will be invaded by an amount ϵ of individualists. We want to check if there is a number $\bar{\epsilon} > 0$ such that $\forall \epsilon < \bar{\epsilon}$, cooperative play is preferred. Since we are sufficiently close to a population consisting only of cooperative players, it is reasonable to assume that $\sigma \in [\sigma_g, 1]$, meaning that defectors would be punished in every scenario. From Eq. 3-24, the amount $\bar{\epsilon}$ of individualists that would make agents indifferent between individualistic and cooperative play is such that

$$r(1-\bar{\epsilon}) = (1-p)(\Delta f_b - \Delta f_g). \tag{3-25}$$

It follows that for any $\epsilon \in [0, \bar{\epsilon})$, cooperative play is preferred – since the costs of cooperation are more than offset by the benefits – and consequently mutants would not outweigh them. Considering also that $r'(\sigma) < 0$, we have that $\frac{\partial \bar{\epsilon}}{\partial r^{-1}} > 0$. As a consequence of Eq. 3-25, we have that $\frac{\partial \bar{\epsilon}}{\partial p} = \frac{\partial \bar{\epsilon}}{\partial r^{-1}} \frac{\partial r^{-1}}{\partial p} < 0$. The higher the propensity for good times, the lower the threshold for invasion by individualists. This means that cooperation is more likely to be a stable condition when the population is experiencing bad times.

On the other hand, if we consider the case of a population consisting of individualists, Proposition 1 states that $\forall \epsilon < \sigma_b$, no cooperation can be sustained, which naturally leads to stability of the equilibrium reached. Thus, for cooperation to be possible, it would be necessary that $\epsilon > \sigma_b$. In this case, based on Eq. 3-23, we would have that

$$r(\bar{\epsilon}) = \Delta f_b - \frac{\Delta f_g}{1-p}. \tag{3-26}$$

Consequently, $\frac{\partial \bar{\epsilon}}{\partial p} = \frac{\partial \bar{\epsilon}}{\partial r^{-1}} \frac{\partial r^{-1}}{\partial p} > 0$. In other words, the higher propensity for good time leads to a higher threshold for Kantian invasion, i.e., the limit to which the population of individualists would resist mutation. From another perspective, the lower the propensity for good times, the easier it should be for cooperators to populate the community. In both cases, the perception of bad times leads to a higher value of cooperation, since the quality of the environment and the benefit of the common good are substitutes.

3.4.2 Dynamic evolution

To observe the dynamic evolution of the population, we use the same functional form as in Eq. 3-1. In addition, as shown in Figure 3.3, four different initial conditions are suggested. As a result, one can observe the evolution of the populations according to different scenarios in terms of priors regarding the initial proportion of cooperatively playing agents in the population and the probability of occurrence of a good time.

Thus, on the one hand, if an agent expects a high share of cooperative players and a low probability of good time, he/she is at the black (northwest) point. On the other hand, agents expecting a high probability of good time and a low proportion of cooperative players are at the purple (southeast) point. As it can be observed, all but the black dot are below the blue line indicating indifference between cooperative and individualistic play.

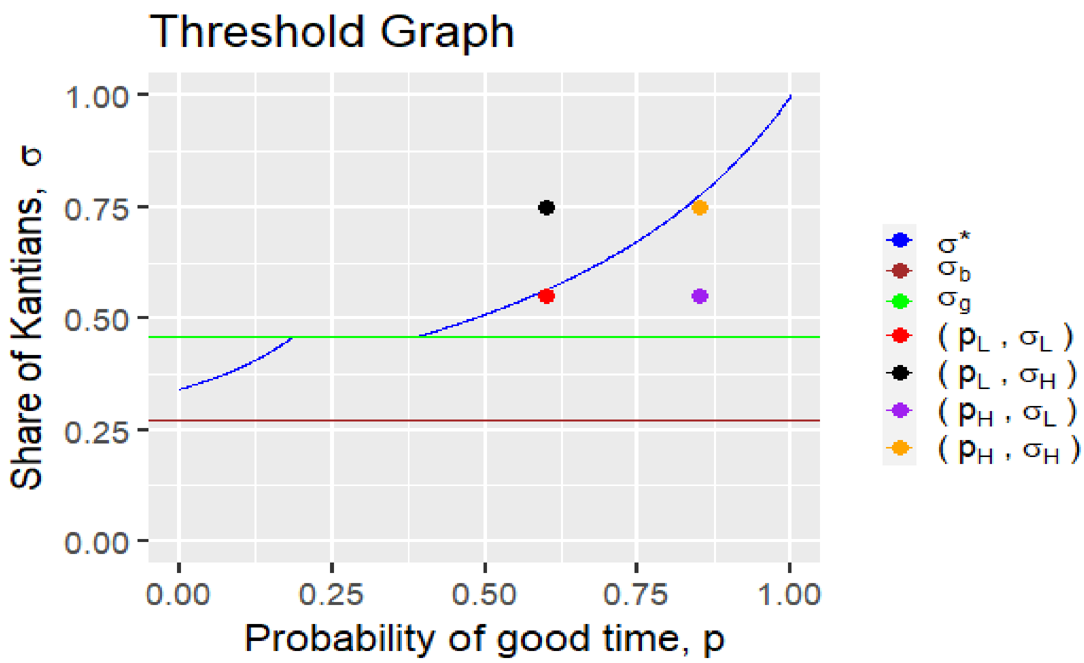


Figure 3.3: Threshold graph, including four different initial conditions. p_L (p_H) indicates a low (high) probability of good time, whereas σ_L (σ_H) represents a low (high) share of cooperative players.

This means that the agents' priors are such that they (with the exception of the black dot) would rather play individualistically than cooperatively under these conditions.

First, one can compare the evolution of the population composition when the agents agree that 75% of the population will play cooperatively, but have different priors depending on the environment. For the scenario where the population is at the black point, it is assumed that the probability of having a good time is 60%, while the population at the orange dot assumes that this probability is 85%[11]. Figure 3.4 represents the path.

As one can observe, according to Eq. 3-11, by laying above the indifference curve, the population with a lower expectation of a good time ($p = p_L = 60\%$) will have an increasing proportion of cooperative agents, while the population with a higher expectation of a better environment ($p = p_H = 85\%$) will be less and less cooperative. This conclusion follows from the higher value of cooperation when the prospects of a better future are not so high. Since the common good and the environment are substitutes in character, the assumption that the latter does not provide much resource leads to a higher value for the former under these conditions. The more Kan-

[11]It is important to note that the values are not important and were chosen here only for illustrative purposes. What should be noted is whether the condition lies above or below the indifference curve and how far it is from that curve.

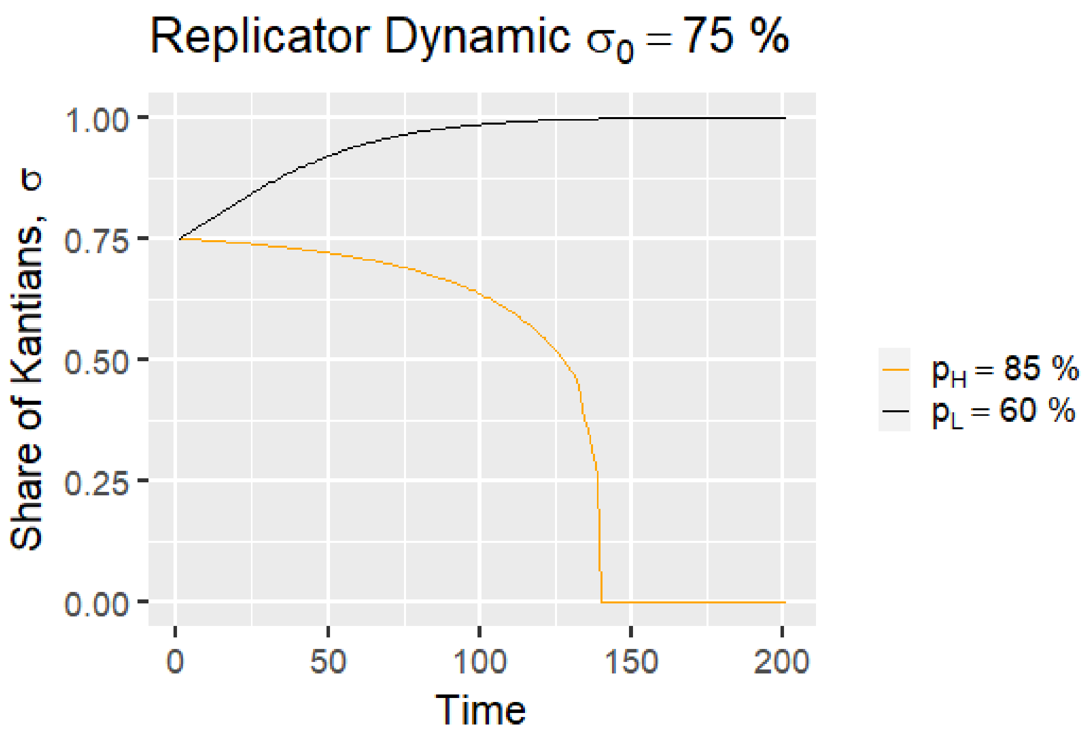


Figure 3.4: Evolution path of populations that agree that a high share of the community plays cooperatively but diverge about the environment condition.

tians comply, the less costly cooperation becomes, as punishment becomes less demanding.

Another interesting comparison can be made between conditions on the same side of the indifference curve. For example, consider the scenarios in which agents still (and equally) diverge on the future state of the environment, but now agree that 55% of the population consists of cooperators, as represented by the lower dots in Figure 3.4. According to Figure 3.5, both scenarios lead to a population consisting of individualists, but for the condition that agents are less optimistic about the future ($p = p_L = 60\%$), the path is longer.

An interesting point concerns the role of technology. From the adopted production function, it follows that agricultural technology, A, and the influence of the common good C, have a substitutive relationship. From Eq. 3-1, it can be easily demonstrated that the higher the technology, the lower the marginal benefit brought by the common good, $\frac{\partial}{\partial A}\left(\frac{\partial f}{\partial C}\right) < 0$. Intuitively, when agricultural technology is highly developed, the effects of the higher-quality common good are not as pronounced as when technology quality is low. As a result, the relative value attributed to the common good also depends on this relationship. This can first be observed in Figure 3.6, where

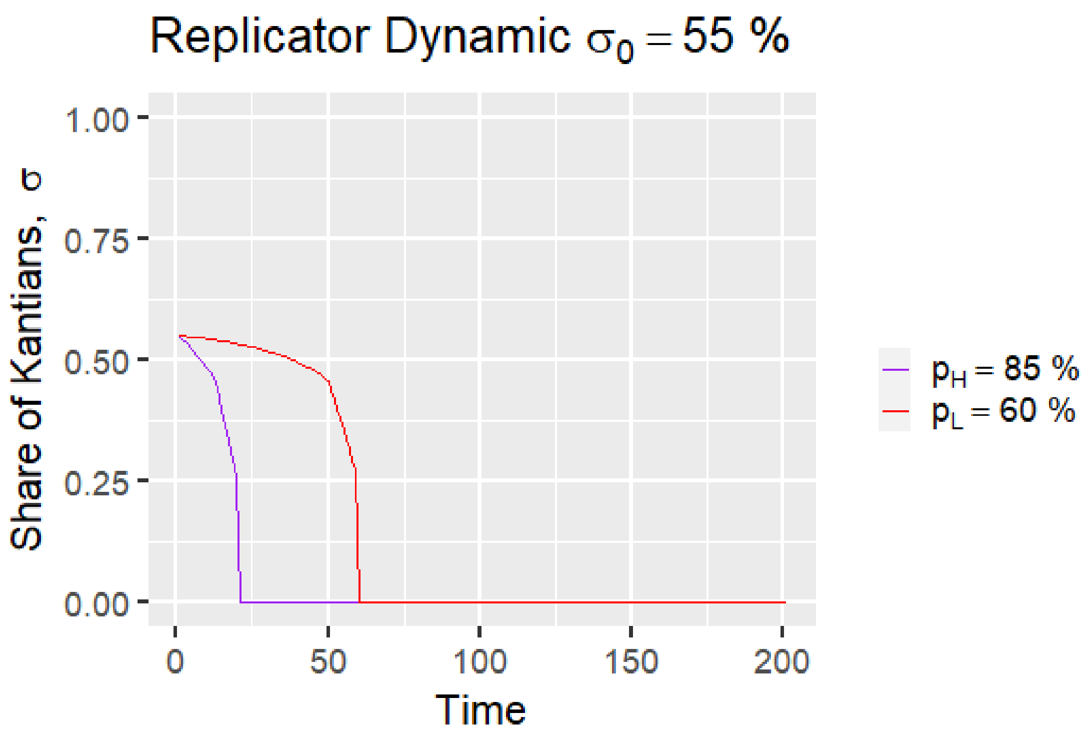


Figure 3.5: Evolution path of populations that agree that a high share of the community plays cooperatively but diverge about the environment condition.

the threshold graph is plotted on the space (p, σ).

If we take as a reference the case in which both the probability of a good time and the perceived proportion of cooperators are low (red dot), we can see that this scenario now lies above the indifference curve, which means that, for the same initial conditions, the lower technology leads to a condition in which cooperative play becomes more valuable. Indeed, if one considers, in Figure 3.7, the replicator dynamic evolution, the resulting path leads to a population of cooperators for those at the starting point (p_L, σ_L). A similar result is also reached by Litina (2016).

3.4.3 Public policy

So far, it has been assumed that the community acts on its own. Depending on the initial conditions, households decide whether to cooperate or act individualistically, and whether to punish defectors if they cooperate. However, it is interesting to assess what would happen if a government were willing to adopt policies that create incentives to cooperate. One possible motivation would be that, in our case, cooperation would lead to higher production, as the higher-quality club good would make households more

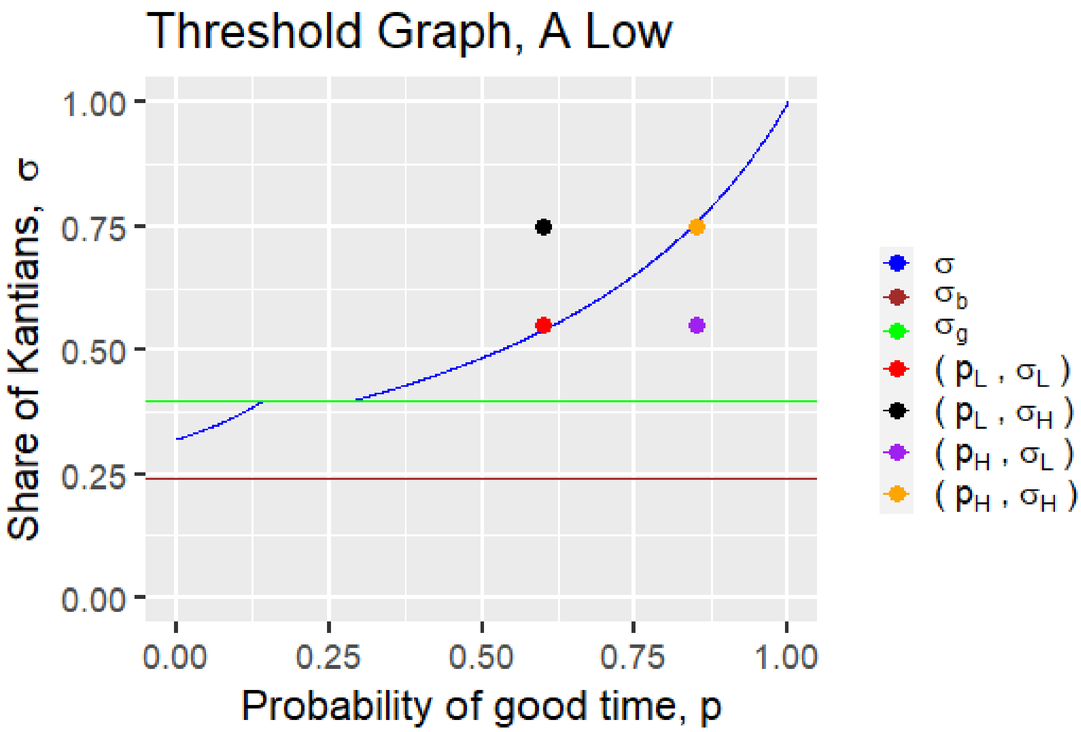


Figure 3.6: Threshold graph for the scenario with lower technology, including four different initial conditions. p_L (p_H) indicates a low (high) probability of good time, whereas σ_L (σ_H) represents a low (high) share of cooperative players.

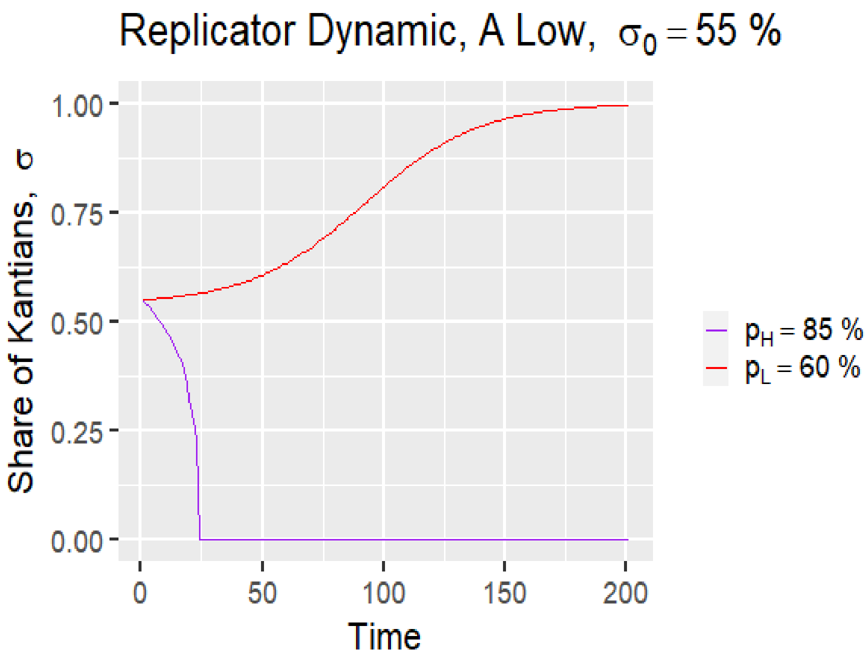


Figure 3.7: Evolution path of populations that agree that a high share of the community plays cooperatively but diverge about the environment condition.

productive. In addition, other desirable effects may result from cooperation. For example, as Fraser (2021) and Aldrich and Meyer (2015) point out, social capital can be an extremely relevant property in post-disaster recovery scenarios, and such ties can be built, for example, in the workplace and in unions. Since we are dealing with the possibility of a bad time to come, this is likely to be a relevant issue. Moreover, even when disasters are not involved, fostering social capital can be linked to faster technological development, as Litina (2016) argues.

One way the government can act is to centralize the punishment stage of the proposed game. The literature often assumes that punishment is assessed considering that the community itself would bear the burden of punishing defectors. For example, in Ostrom et al. (1992); Fehr and Gächter (2000); Boyd et al. (2003); Ambrus and Greiner (2012); Grieco et al. (2017), various scenarios and dynamics are reviewed to promote a better understanding of the consequences of punishment when the community "holds the sword." In another approach, Andreoni and Gee (2012) evaluate the consequences of a "hired gun." In this case, a hired enforcer imposes a penalty on those who exhibit the most extreme defecting behavior. As a result, defectors would try to be the "second most defector," leading to a scenario in which no defections would be observed. As the authors show experimentally, this strategy tends to lead to lower costs of punishment compared to community punishment.

A possibility for the government would then be to levy a tax, t, that would be sufficient to afford the external enforcer, as long as it is no greater than the cost of community enforcement. Under this approach, punishment would occur regardless of the state of nature, whenever defection was observed. Given the choice facing agents, represented by Eqs. 3-18 and 3-19, and applying the restriction that $l_c = \Delta f_g$, it follows that

$$t \leq r(\sigma = \sigma^*) = (1-p)(\Delta f_b - \Delta f_g). \tag{3-27}$$

In words, as long as the tax levied by the government obeys Eq. 3-27, agents would prefer to provide labor for the common good, enjoy its benefits, and pay the tax to enforce cooperation, i.e., cooperation would be incentive compatible. Interestingly, one can observe that the lower the propensity of a good time, p, the higher the value charged by the government (or by the external enforcer). If $t > r(\sigma = \sigma^*)$, defectors would not only not cooperate, but also not pay the tax.

It is also important to note that such a strategy would not have much effect if $\sigma \to 1$. In this case, we would have that $r(\sigma \to 1) \to 0$, which means that the cost to the community of enforcing cooperation would be quite small and it would not require any external help. One might then assume that the government, observing the community conditions, would adopt such a strategy whenever $t \leq r(\sigma^*)$.

Another point that should be made regarding public policy is the possibility of promoting social capital in good times. While we have shown in this article that one possible mechanism for building a cooperative community is to get through bad times together, a prior about cooperation, σ, has been shown to be of great importance. For example, in our model, if the environment favors cooperation, but agents believe that their counterparts behave in an individualistic manner (low σ), cooperation would not be sustained. As Fujiie et al. (2005) discuss using the example of communities dependent on irrigation systems, it is possible to encourage collective action through incentives. Such incentives may be directed toward a higher belief in cooperation, σ, or compensation (financial or nonfinancial) for cooperative labor supply, l_c.

3.5 Conclusion

In this paper, we attempt to provide an explanation for the evolution of cooperative behavior under certain environmental conditions. To this end, we rely on the relationship between a common club good and the environment. More precisely, their interaction is such that the worse the quality of the environment, the higher the marginal benefit of the club good. As a result, agents decide whether or not to cooperate – and supply labor for the common good. If agents cooperate, they can, as a group, punish defectors – individualists who are free- riders and profit from the common good without committing to its proper functioning. However, punishment is costly, and the smaller the proportion of cooperators, the more expensive the punishment. On the other hand, agents who do not cooperate can be punished and have no access to the common property. Thus, agents can adopt the protocols of cooperation (Kantians) or individualism (Nash). Such a categorization follows the idea that cooperators maximize their utility based on Kant's categorical imperative and play the best generalizable strategy. In contrast, individualists do not absorb their externalities on others, possibly leading to the fate of Hardin's tragedy of the commons.

Indeed, we find that substitutability between the environment and the common good leads to conditions under which a given community may take different paths. When actors believe that the future promises high prosperity, individualism is more likely to flourish because cooperation is not highly valued. On the other hand, if the prospects for a prosperous future are low, cooperation becomes more important because it should mitigate bad times. These results are consistent with those of Litina (2016) and Buggle (2020), for example. However, we show that this depends strongly on how agents estimate the proportion of cooperators. Even in low-quality environments where cooperation yields high return, cooperation enforcement can be prohibitively high and unsustainable. Moreover, we can rationalize outcomes when the common good and the environment behave as complements, which is usually the case when the environment is of very low quality. In this case, as expected, a better environment would lead to a higher willingness to cooperate, but this conclusion is also subject to the costs of punishment.

Note that this paper does not assume that agents belong to a particular type, but rather that agents can choose their own optimization protocol given the boundary and initial conditions. Such an approach adds flexibility to our game and allows agents to make their action decisions based on their evolving beliefs about the environmental conditions and the composition of their community.

Finally, we provide policy suggestions for fostering a cooperative community. According to the literature, such social capital building may be important for future technological development (Litina, 2016) and disaster resilience (Aldrich and Meyer, 2015), for example.

3.6
Appendix

As Ito (2012) argues, according to the boundary conditions, it may be the case that the environment and the public good behave as complements, $\frac{\partial^2 f}{\partial R \partial L_c} > 0$ [12]. As a result, given the labor allocated to the common good, productivity variation would be higher in good times, $\Delta f_g > \Delta f_b$. As of the last stage of the game, where cooperators would only punish if and only if $r(\sigma) \leq \Delta f_e$, $e \in \{b, g\}$, the three scenarios described earlier are now changed.

In the first scenario, $r(\sigma) \geq \Delta f_g \geq \Delta f_b$, resulting in $\sigma \leq \sigma_g < \sigma_b$. In this case, the punishment is more costly than its benefit in any scenario. As a result, no punishment would occur. In this case, Eqs. 3-12 and 3-13 can be used and Proposition 1′ is reached. Note that this is equivalent to Proposition 1, with the only caveat that $\sigma \in [0, \sigma_g]$.

Proposition 1′: *for any probability of a good time and when the share of cooperators is sufficiently low so that it never allows for punishment to be held, i.e. $\sigma \in [0, \sigma_g]$, playing individualistically is dominant and no cooperation can be sustained.*

In the second scenario, the retaliation cost is between productivity gains in good times and in bad times, $\Delta f_g \geq r(\sigma) \geq \Delta f_b$. Consequently, cooperators will punish in good times but not in bad times. From Eqs. 3-8 and 3-9, this condition leads to

$$\mathbb{E}[y^K] = pf\Big(C(L_c, R_g) - r(\sigma)\Big) + (1-p)\Big[f\Big(C(\sigma L_c, R_b)\Big)\Big] - l_c, \tag{3-28}$$

$$\mathbb{E}[y^N] = pf\Big(C(0, R_g)\Big) + (1-p)f\Big(C(\sigma L_c, R_b)\Big), \tag{3-29}$$

.

For agents to become indifferent between cooperating or not, it should be true that $\mathbb{E}[y^K] = \mathbb{E}[y^N]$, and, from Eqs. 3-28 and 3-29,

$$r(\sigma^*) = \Delta f_g - \frac{l_c}{p} \implies \sigma^* = r^{-1}\Big(\Delta f_g - \frac{l_c}{p}\Big). \tag{3-30}$$

Proposition 2′: *For all $\sigma \in (\sigma_g, \sigma_b)$, the higher the propensity of a good time, the larger the share of individuals playing the cooperative protocol.*

Indeed, it is straightforward to observe that provided that $r'(\sigma) < 0$, $\frac{\partial \sigma^*}{\partial p} < 0$. Since for $\sigma > \sigma^*$, households play cooperatively, this condition is

[12] This would occur whenever the endowment of the environment is low, which is a consequence of $\frac{\partial^3 f}{\partial R^2 \partial L_c} < 0$.

more easily achieved for lower values of σ^*. As expected, this is in contrast to what is achieved in Proposition 2.

Finally, for the third scenario, the retaliation cost is sufficiently low to allow punishment under all conditions, $\Delta f_g \geq \Delta f_b \geq r(\sigma)$. Thus, the expected values for cooperative and individualistic play are the same as those obtained in Eqs. 3-18 and 3-19. When the agents are indifferent, we again obtain Eq. 3-20,

$$r(\sigma^*) = \Delta f_b - l_c + p\Big(\Delta f_g - \Delta f_b\Big). \tag{3-31}$$

Relevantly, however, it should now be noted that $\Delta f_g - \Delta f_b > 0$.

Proposition 3': *For all $\sigma \in [\sigma_b, 1]$, the higher the propensity of good time, the larger the share of individuals playing the cooperative protocol.*

Indeed, given that $r'(\sigma) < 0$, it follows that $\frac{\partial \sigma^*}{\partial p} < 0$. Intuitively, a smaller proportion of cooperators is required to maintain cooperation when the probability of a good time is higher. Consequently, cooperation is played by a larger proportion of households.

3.6.1 Hypothesis over l_c under complementarity

As for the case where the environment and the club good are considered as substitutes, it is relevant to impose a hypothesis over l_c for the case where they are considered as complements. As before, it is coherent to consider what happens when the population consists of cooperators, $\sigma = 1$, leading to retaliation costs of $r(\sigma = 1) = 0$. Under this condition, one should observe the third scenario, i.e., $\sigma \in [\sigma_b, 1]$, as described in Eq. 3-32,

$$l_c = \Delta f_b + p\Big(\Delta f_g - \Delta f_b\Big). \tag{3-32}$$

Unlike the previous case, however, it is now reasonable to assume that, during bad times and considering that agents will play cooperatively, agents should be indifferent between cooperating and defecting. Consequently, assuming $p = 0$, one should have that

$$0 \leq l_c \leq \Delta f_b = f(L_c, R_b) - f(0, R_b) > 0. \tag{3-33}$$

If this condition is not met and $l_c > \Delta f_b$, low expectations of a good time would likely lead agents to play individualistically, leading to an inconsistency given the belief that $\sigma = 1$. Thus, the safe side now lies in the assumption that $l_c = \Delta f_b$, which implies that the cost of providing labor for the common good is equal to the gains from the high-quality common good in bad times. As a result, Eqs. can now be rewritten as Eqs. 3-34 and 3-35, respectively,

$$r(\sigma^*) = \Delta f_g - \frac{\Delta f_b}{p}, \tag{3-34}$$

$$r(\sigma^*) = p\Big(\Delta f_g - \Delta f_b\Big). \tag{3-35}$$

3.6.2 Evolutionary stability

Considering the evolutionary stability, as described in Section 3.4.1.5, it is relevant to consider what happens when the population consists of either individualists ($\sigma = 0$) or cooperators ($\sigma = 1$) and is subject to invasion of the other type (protocol). In the latter case, we should be dealing with the third scenario governed by Eq. 3-35. If this corresponds to a stable condition, it should be true that there exists an amount $eps\bar{i}lon$ such that

$$r(1 - \bar{\epsilon}) = p\Big(\Delta f_g - \Delta f_b\Big), \tag{3-36}$$

and $\forall \epsilon \in [0, \bar{\epsilon})$, cooperative play would be favored. Consequently, higher values of p would lead to higher values of $r(1 - \bar{\epsilon})$ under the indifference condition in Eq. 3-36, corresponding to higher values of $\bar{\epsilon}$. This implies that if there is a higher propensity for good times, the more resilient the population of cooperators is against invasions.

It is already known that $\forall \sigma \in [0, \sigma_g)$, playing individualistically is preferred, regardless of beliefs about environmental conditions. When analyzing the second scenario, Eq. 3-34 leads us to

$$r(\bar{\epsilon}) = \Delta f_g - \frac{\Delta f_b}{p}, \tag{3-37}$$

pointing out that $\forall \epsilon \in [0, \bar{\epsilon})$, playing individualistically is preferred. It is straightforward to verify that higher values of p are related to lower values of $\bar{\epsilon}$, leading to the conclusion that for a higher propensity of good time, the easier it is for cooperators to survive. As expected, when the common good and the environment are complementary, more importance is attached to cooperation in good times.

4
The Long-term Effect of Natural Disasters on Culture. The Case of Japan

Abstract

Although the importance of cultural traits to economic outcomes is increasingly recognized, not much is known about how they are formed in the first place and the extent to which they persist over time. Using data on earthquakes dating back to AD 684, we assess the impact of such events on the current values of individuals in rural Japan. More specifically, we assess their preferences in terms of trust and political engagement using results from the seventh wave of the World Values Survey. We find that people in rural areas that were severely affected by earthquakes more than 100 years ago now have higher levels of trust and are more politically engaged. These results add to both the literature on the effects of natural disasters on social capital and on the long-term persistence of preferences.

4.1
Introduction

While until recently not much attention had been paid to the influences of culture on economic outcomes, the economics literature has become increasingly concerned with such effects[1]. In addition, the growing literature on the connection between culture and economics has addressed how cultural traits are persistent and can be traced back to the past (Carmil and Breznitz, 1991; Bellows and Miguel, 2009; Nunn and Wantchekon, 2011; Alesina et al., 2013; Cassar et al., 2013; Giuliano and Nunn, 2021). However, little has been said about how natural disasters have helped shape enduring features of trust and political values.

To fill this gap, this article examines the influence of ancient earthquakes on current trust and political values in rural Japan. The focus on rural areas stems from the social fabric that was built in Japanese villages in the past. Due to natural conditions and social structure, communities formed around a common-pool resource associated with irrigated agriculture. As a

[1]The following papers provide a fairly clear picture of the influences of culture on economic outcomes: Bisin and Verdier (2000, 2001); Guiso et al. (2006, 2008); Fernández and Fogli (2009); Tabellini (2010); Spolaore and Wacziarg (2013); Alesina and Giuliano (2015); Bezin (2015, 2019); Gorodnichenko and Roland (2017).

result, villages formed a "body character" that created a fairly strong sense of social capital. Therefore, dealing with threats was a group activity that potentially strengthened ties and social engagement.

By proposing an index that measures how severely a city was affected by earthquakes up to 1900, we are able to compare individuals living in rural areas today based on the magnitude of the impact these regions suffered in the past. For that matter, our empirical strategy takes into account prefecture fixed effects[2], so that we can compare rural cities within these regions. With this strategy, we avoid having our results affected by the intrinsic differences among the regions of Japan and their potentially different vulnerabilities to earthquakes. In addition, we control for earthquakes that occurred after our cut-off year to ensure that our results are actually driven by past events rather than more recent ones.

In our results, we find that individuals living in rural areas which were more affected in the past currently show higher levels of trust and sociopolitical engagement, according to the corresponding variables from the seventh wave of the World Values Survey (WVS). In terms of trust, people in these areas generally have more trust in people, more trust in people they know, in people they meet for the first time, and in people of other religions. In terms of socio-political variables, these people are more likely to donate to groups or campaigns, encourage other people to vote, and vote in local elections. They are also more interested in politics and consider it more important. Finally, they attribute more importance to the fact that elections are held honestly. These findings, associated with the rural scene in Japan, suggest that villages that were more affected by such events developed a stronger sense of community and strengthened their ties and social capital. It is important to note that these characteristics survived over time and could be observed more than a hundred years after the events.

First, this paper relates to the literature on the effects of natural disasters on the formation of preferences and social capital. Regarding trust, Hommerich (2012) finds that younger people who were most affected by the Great East Japan Earthquake of 2011 have higher levels of social trust, but also finds higher levels of distrust of the government; Toya and Skidmore (2014) assess the impact of different types of disasters in a cross-country analysis and find that more severely affected regions have higher levels of social trust; and Cassar et al. (2017) finds that higher levels of trust were observed in Thailand after the 2004 tsunami.

[2]As explained earlier, there are 47 prefectures in Japan, which are administrative regions analogous to U.S. states.

In terms of sociopolitical values and engagement, Fair et al. (2017) note that after the floods in Pakistan, the more affected regions were associated with higher turnout. Sinclair et al. (2011), in turn, find a more complex relationship between turnout and the impact of flooding due to Hurricane Katrina. While overall turnout was lower, those more affected showed higher levels of engagement. In terms of social engagement, Shaw and Goda (2004) found higher levels of volunteering and cooperation between residents and local authorities after the 1995 Kobe earthquake in Japan. Similarly, Yamamura (2016) found higher levels of participation in community activities in places close to the affected region when studying the same event. We are also in dialog with the literature on the relationship between social capital and political engagement (Putnam et al., 1993; Krishna, 2002; Helliwell and Putnam, 2007; Nannicini et al., 2013; Atkinson and Fowler, 2014; Enke, 2020; Giuliano and Wacziarg, 2020; Gethin et al., 2022). Although not directly related to the occurrence of disasters, the impact of such events on political values and political engagement should be a consequence, considering that such events lead to the building of higher levels of social capital.

We also interact with the literature on the persistence of cultural traits. On the one hand, from a theoretical standpoint, various works have proposed a number of potential mechanisms to describe the persistence of cultural traits (Boyd and Richerson, 1985; Bisin and Verdier, 2000, 2001; Henrich and Boyd, 2001; Hauert et al., 2002; Bowles and Gintis, 2004; Belloc and Bowles, 2017). On the other hand, empirical work has also addressed this issue. For example, Nunn and Wantchekon (2011) find that individuals whose ancestors were heavily affected by the slave trade in the past are less trusting today. Carmil and Breznitz (1991), in turn, find that Holocaust survivors and their children exhibit different levels of belief in God and less extreme political views than control groups five decades after the event. Alesina et al. (2013), looking at current gender norms in society, point out that cultural differences can be traced back to roles that men and women played in their ancestral societies. Cassar et al. (2013), in a study of individual exposure to civil war in Tajikistan, find that those exposed to violence more than ten years after the war have lower levels of trust. In another example, Voigtländer and Voth (2012) examine the impact of anti-Semitism in Germany over time. The authors find that regions that experienced more pogroms against Jews in the 1300s were good predictors of persecution of Jews in the 1920s. Looking at the influence of the environment, Buggle and Durante (2021) find that people in regions where climate has been more variable in the past show higher levels of trust. Buggle (2020) in turn, show that societies where resource management required higher levels of cooperation in the past now exhibit more collectivist norms. Litina (2016) finds that regions where land productivity was lower in the past have higher levels of general trust today due to the requirement for higher levels of cooperation. Finally, Bentzen (2019) find that in regions that are strongly hit by earthquakes, people are more religious, and that this characteristic persists over time.

Our contribution lies at the intersection of the above branches of literature. On the one hand, we add to the literature on the impact of natural disasters on social capital by providing suggestive evidence that earthquakes in rural Japan have indeed led to increased trust and political engagement. On the other hand, we contribute to the literature on the persistence of cultural traits by showing that such changes persisted for more than a hundred years. To the best of our knowledge, this is the first work to point to the persistence of political commitment over time.

The paper is organized as follows. In Sec. 4.2, we provide the context of rural Japan in the past and explain the dynamics observed in its villages. Then, in Sec. 4.3, we present the data used for the analysis conducted, which is further elaborated in Sec. 4.4, where the empirical strategy is described. Sec. 4.5 discusses the results, and finally Sec. 4.6 concludes this paper.

4.2 The rural Japanese context

For the analysis conducted here, it is firstly relevant to provide a brief overview on the Japanese rural context. As our aim is to understand how natural disasters affect cultural traits in the long run, it is relevant to understand how the country was structured in the past. As Kuroda (1986) points out, by the early 1900's, the urban population in Japan was around 10%, so our focus lies on how was the organization of the country's rural areas. By restricting our analysis to such areas, we intent to minimize the potential influences that the industrialization and urbanization processes had on the evolution of traits.

Given the Japanese natural resources characteristics, having had rice as one of its main goods, irrigation agriculture was rather important for its productivity (Francks, 2006; Takayama et al., 2018). Indeed, during the 19^{th} century, one of the factors that led to an increase in agricultural output was the improvement in irrigation systems, which were essential to the preservation of scarce water supplies (Francks, 2002, 2006). As Sarker and Itoh (2003) describe it, until the 9^{th} century, irrigation systems were managed by the state. From that point onwards, paddy fields expanded along rivers and "a community-based self-governance system of irrigation gradually developed" Sarker and Itoh (2003), p.162. During the Edo Period (1600-1868), such structure expanded, with farmers in and across villages cooperating in the construction of irrigation infrastructure, such as dams, ponds, irrigation canals, and on its management and maintenance. Indeed, irrigation systems are one of the classical examples of management of common-pool resources (CPR) (Bardhan, 1993; Ostrom, 2000; Sarker, 2013), and found to be positively correlated with higher levels of collective action in a community (Araral, 2009; Takayama et al., 2018).

In fact, the rural Japan was characterized by autonomy and self-government. As Befu (1965) depicts, villages had a "corporate body" character, "a legal entity which owned, bought, and sold property; loaned and borrowed money; and sued, was sued by, and entered into agreements with other villages" p. 26. As such, it fundamentally demanded from its members the necessary commitment to make it as a unit. Such commitment was strongly related to the households' solidarity towards the village's issues, which was, in turn, reflected in the village's code. While not formally defined, the codes dealt with topics such as taxation, agriculture, policing, etc, seeking to decrease internal conflicts, such as in the management of communal land and irrigation systems (Befu, 1965)[3].

During the first half of the Edo Period, villages were composed of fairly similar households, concerned about their subsistence and cooperating through activities such as in irrigation organizations. The threats they faced were similar, mostly related to environmentally-led crop losses and expropriations from the ruling class (Francks, 2006). As the author follows, in order to deal with such issues, the villages had to build their own organizational structure, which would help in the collective negotiations and protests. In addition, connections among villages, mostly due to mutual irrigation organizations, also made easier the mobilization of neighboring villages in the support for the same pleads. Whereas the structure of the Japanese rural villages evolved throughout the Edo Period, from a mainly feudal organization to a more market-oriented, the "body character" of villages remained, and so did their engagement in organization, petitions and protests in face of the perceived threats.

Whereas the above description referred to the Edo Period, Smith (1961) argues that the solidarity and the social unit within Japanese hamlets were

[3]The commitment to the village was not only important, it was enforced. Breaking the code led to punishment according to the violation severity, varying from the demand for formal apologies to the village assembly to the complete banishment from the settlement. The violation of irrigation violations, for instance, would most likely lead to monetary fines.

observed even after the World War II. In such regions, every household should participate in community endeavors such as the maintenance of irrigation systems, roads, ditches, etc., and failing to follow the village's code would lead to punishment. Similarly, as Nakanishi (2022) points out, by not working in the prevention and preparation for natural disasters, villagers would be ostracized (the so called *mura-hachibu*).

Summarizing the above picture concerning the Japanese rural context, Japanese rural villages were a quite clear example of communities dealing with a common-pool resource. The demands faced in terms of production, subsistence, and protection from threats acted so as to strengthen the connections among households within villages. Such structure developed, providing a sense of social and political engagement, leading to a self-governance structure, which would act against internal and external threats against the community.

Relevantly for our purposes, the households acted as a unit in the protection against natural threats. As discussed above, given the nature of production, the influence of the environment was rather relevant. Thus, one can naturally conjecture a stronger commitment among households in regions more susceptible to natural disasters, such as earthquakes. If one considers the vulnerability of irrigation systems to such events, for instance, one can find cases of earthquake-led damages to infrastructure even in the very recent past (Suzuki and Kohgo, 2015; Tanaka and Itsukushima, 2021). In addition, there are even cases in which the irrigation system itself increased the local earthquake impact, due to the stronger landslides caused by the modifications in the land structure (Watkinson and Hall, 2019).

As discussed in Sec. 4.1, evidences in literature point to higher levels of social engagement and trust in the aftermath of natural disasters. As such, given the Japanese susceptibility to such events and the social fabric of its rural villages, next sections assess the effect of natural disasters in in the building of social capital in these areas.

4.3
The Data

In order to better understand the role played by natural disasters in cultural traits, it is necessary to have information both on the strong earthquakes that happened in a distant past and on the distribution of preferences today (or in a recent past). In this section, both sources of data are presented, as well as the strategy adopted to connect the data on the seismic events with the information on cultural characteristics.

4.3.1
Data on cultural traits

In order to promote the understanding of the cultural values in Japan, we use the most recent wave of World Values Survey (Haerpfer et al., eds, 2020), which, for Japan, was conducted in 2019. The survey consists of a set of more than 300 questions asked to a nationally representative sample of individuals on a broad range of topics. For our purposes, the relevant themes are those connected to political engagement and trust.

As an example, in order to measure the degree of trust, individuals are asked: "Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?". In this case, possible valid answers are "Most people can be trusted" or "Need to be very careful". In Table 4.1 the set of variables regarding the measurement of trust is presented and, in Appendix 4.7, the questions are further detailed. As one can observe from Table 4.1, the number of observations changes according to the question. This results from the fact that not every respondent answered to every question. Therefore, for the analysis undertaken here, only the valid ones were considered.

Table 4.1: Description of trust variables

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Most people can be trusted	1,280	0.4	0.5	0.0	0.0	1.0	1.0
Trust: Your family	1,332	3.7	0.5	1.0	3.0	4.0	4.0
Trust: Your neighborhood	1,253	2.6	0.6	1.0	2.0	3.0	4.0
Trust: People you know personally	1,307	3.0	0.6	1.0	3.0	3.0	4.0
Trust: People you meet for the first time	1,092	1.9	0.6	1.0	1.0	2.0	4.0
Trust: People of another religion	824	1.9	0.7	1.0	1.0	2.0	4.0
Trust: People of another nationality	817	2.1	0.7	1.0	2.0	3.0	4.0

Notes: This table presents the descriptive statistics for the variables concerning trust values. Whereas for the variable "Most people can be trusted", valid answers were either 0 (need to be very careful) or 1 (most people can be trusted), the remaining varied between 1 (do not trust at all) and 4 (trust completely). Relevantly, such scale is inverted in regards to the one provided by the World Values Survey questionnaire, where 1 meant "trust completely" and 4, "do not trust at all". The idea is to positively correlate high levels of trust with the variable's value. The full questions are available in Appendix 4.7.

Concerning the variables on political engagement, questions range from the importance attributed to politics, through the knowledge about what democracy is, to having taken online political actions. Given the purpose of this work, we gathered the questions regarding social activism variables and the importance attributed to politics. The set of variables is indicated in Table 4.2, and, in Appendix 4.7, the questions are fully described. In regards to the varying number of observations, the same observation made for Table 4.1 applies here: not all answers were valid.

Table 4.2: Description of political engagement variables

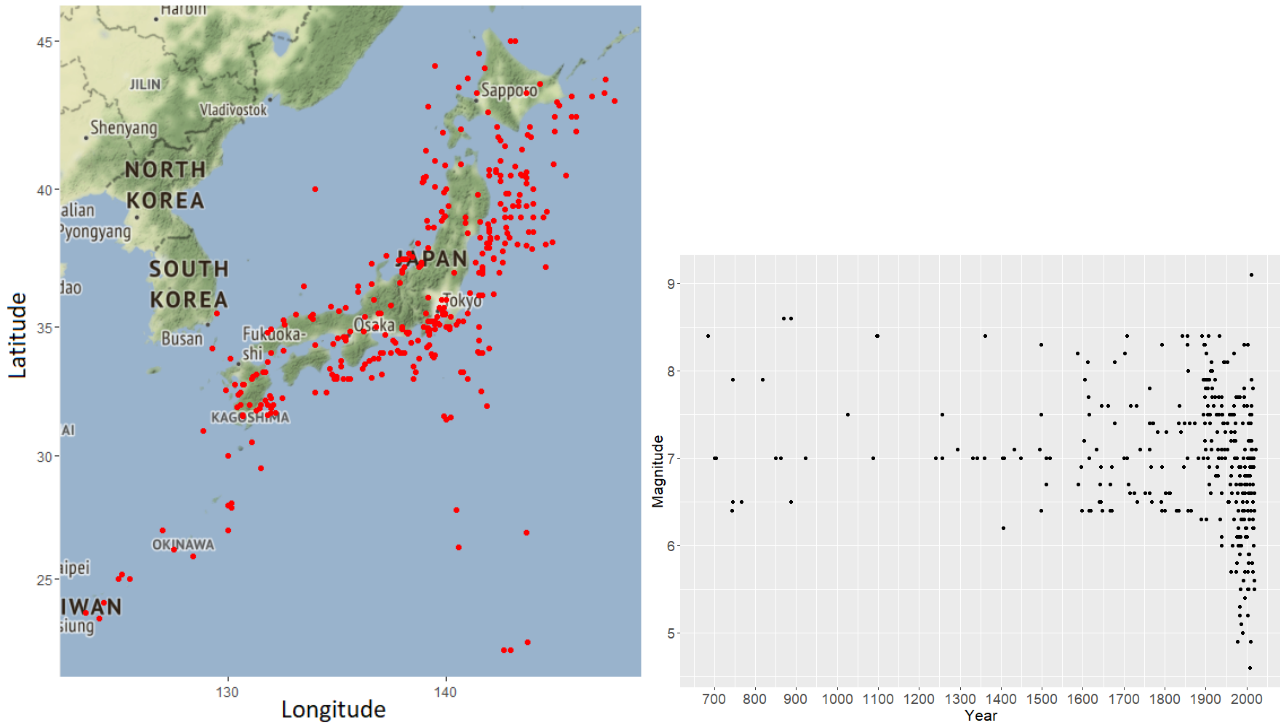
Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Social activism: Donating to a group or campaign	1,202	2.3	0.8	1.0	2.0	3.0	3.0
Social activism: Contacting a government official	1,094	1.4	0.6	1.0	1.0	2.0	3.0
Social activism: Encouraging others to take action about political issues	1,118	1.2	0.5	1.0	1.0	1.0	3.0
Social activism: Encouraging others to vote	1,200	1.8	0.8	1.0	1.0	2.0	3.0
Vote in elections: local level	1,339	2.5	0.7	1.0	2.0	3.0	3.0
Vote in elections: national level	1,337	2.5	0.7	1.0	2.0	3.0	3.0
Important in life: Politics	1,290	2.8	0.8	1.0	2.0	3.0	4.0
Interest in politics	1,319	2.7	0.7	1.0	2.0	3.0	4.0
Having honest elections is important	1,289	3.5	0.7	1.0	3.0	4.0	4.0

Notes: This table presents the descriptive statistics for the variables concerning political engagement values. Variable "Important in life: Politics" ranges from 1 (Not important at all) to 4 (Very important). Variable "Interest in Politics" ranges from 1 (Not at all interested) to 4 (Very interested). Variable regarding Social Activism range from 1 (Would never do) to 3 (Have done). Variables "Vote in election" range from 1 (Never) to 3 (Always). Finally, variable "Having honest elections is important" ranges from 1 (Not at all important) to 4 (Very important). Relevantly, such scales are inverted in regards to the one provided by the World Values Survey questionnaire. The idea is to positively correlate high levels of political engagement with the variable's value. The full questions are available in Appendix 4.7.

One important attribute held by the WVS 7^{th} wave for Japan is that it indicates the city where the respondent was from, providing us with more than 300 different localities. The previous version of the survey, for instance, was not as granular, providing information only in which of 11 possible regions the respondents lived. Furthermore, important for our purposes is the fact that the 7^{th} wave informs whether the city is rural or urban. More specifically, we have data on 251 urban cities and 51 rural cities. Such qualification allows us to compare cities of the same type. Besides such information, we also have information on the city size, according to population tiers; its type, which informs whether it is a capital, regional center, district center, other type of city, or village; and to which of the 47 prefectures it belongs. In addition, we have information on the respondents' characteristics: their sex, age, income level, and religiosity. With such data, we are able to establish a comparison between individuals' preferences, while controlling for their attributes, as well as those from their cities.

4.3.2 Ancient earthquakes

The second piece of information relevant for our analysis concerns the data on ancient seismic events. For that matter, we use the dataset on natural hazards from the National Centers for Environmental Information (National Geophysical Data Center / World Data Service , NGDC/WDS), which lists more than 5700 earthquakes from 2150 BC to the present throughout the world. For Japan, which presents its first record in AD 684, 406 events were captured, of which 345 indicate magnitude measurements. Fundamentally,



(a) Spatial distribution. (b) Time distribution and magnitude.

Figure 4.1: Distribution of earthquakes in time and space, based on National Geophysical Data Center / World Data Service (NGDC/WDS). In both figures, each dot corresponds to an earthquake.

all events include data on the latitude and the longitude of the epicenter. In Fig. 4.1a, one can observe the map of Japan and the events recorded in the used dataset, and in Fig. 4.1b, it is shown the distribution in time of earthquakes, considering their respective magnitudes.

As Lackner (2018) discusses, many factors influence the actual impact of an earthquake in a given locality, such as its magnitude, distance, depth, and local geology. As the available data on the physical characteristics of the ancient events is limited to its magnitude and geolocation, we suggest a metric so as to infer the impact each earthquake exerts onto each city based on such information. Firstly, the magnitude is considered. As U.S. Geological Survey (n.d.) describes it, the earthquake magnitude is measured in a logarithmic scale, such that one point in the scale is related to a 10-times increase in the event amplitude[4]. In addition, as we know the epicenter location of the event, we can trace the distance between each earthquake and the centroid of each Japanese city.

As our intention is to understand how the fact that a given region was strongly affected by disasters influences in its current cultural characteris-

[4]There are other strategies for the measurement of earthquakes, but given the information we have for the current analysis, the amplitude is used as basis for out metrics.

tics, it is first relevant to capture the degree to which regions were struck by strong events. Therefore, based on the aforementioned data, we build an index to capture how affected each city was. Relevantly, since our purpose is to identify the effects of ancient events, such measurement is undertaken up to a given year. Thus, the impact of earthquake which took place before year t, e_t, on city c is described in Eq. 4-1,

$$Imp_{e_t,c} = \frac{10^{mag_{e_t}}}{10^9 d_{e_t,c}}, \quad (4\text{-}1)$$

where mag_{e_t} corresponds to the event's magnitude and $d_{e_t,c}$ to the distance between the epicenter and city c's centroid. Since the magnitude of earthquakes is generally lower than 9[5] the division by 10^9 corresponds to a normalization. As our intention is to capture the accumulated impact, our metric, $Imp_{c,t}$, considers the sum of all the N_t recorded events up to a given year t, as made explicit in Eq. 4-2

$$Imp_{c,t} = \sum_{e_t=1}^{N_t} Imp_{e_t,c}. \quad (4\text{-}2)$$

Whereas it is true that such metric considers the influence of all events in a given city, by considering the distance between the event and the region of interest, the influence of earthquakes that took place far away is negligible. Naturally, if it happens at a small distance to the city, its impact should be strongly felt. Moreover, as the impact index is calculated according to the exponential character of the measured magnitude, weak events should not play a relevant role in the final index $Imp_{c,t}$. The ones to stand out should be those strong events close to city under analysis. In Fig. 4.2, the histogram on the logarithm of our impact index for each of the cities present in the WVS 7^{th} wave is depicted, considering the 1900 as the cut-off year. As one can observe, whereas there is a mass of events on the left-hand side, a number of those stand out.

Given the described index, we know how affected a given Japanese city was up to year t. Thus, based on such information and on the cultural traits are discussed in Sec. 4.3.1, next section discusses the empirical strategy adopted to provide the understanding on how natural disasters affected preferences in rural Japan.

[5]Only five events recorded a magnitude at or above such value in history (U.S. Geological Survey, 2019), having the strongest record been equal to 9.5.

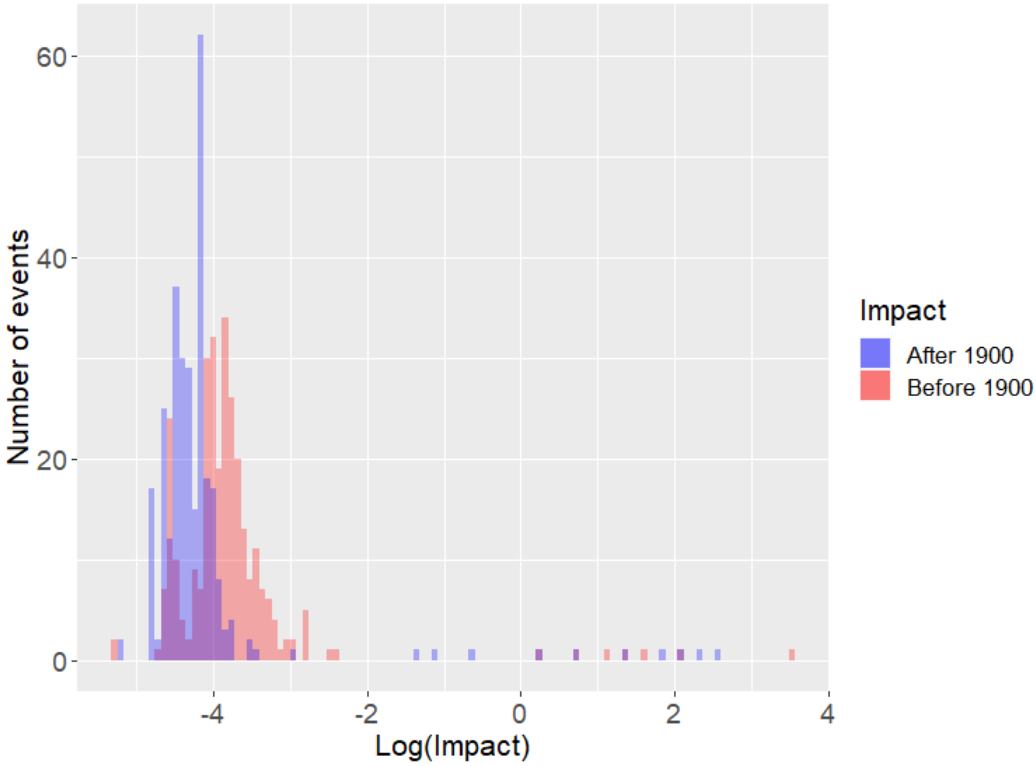


Figure 4.2: Histogram of the impact index.

4.4 Empirical Strategy

Our main objective is to understand how regions which were relevantly impacted by natural disasters are different from those which were not. As we have seen, the Japanese rural areas presented in the past a rather strong set of norms in regards to the management of common resources, establishing a close connection among the communities' households. Considering that natural catastrophes can indeed promote changes in the networks among individuals in such communities, i.e., induce changes in social capital, it is interesting to identify how different relevantly impacted rural regions are from others.

As discussed in Sec. 4.3.1, the seventh wave of the World Values Survey identified the cities where interviewees lived and whether these regions belonged to rural or urban areas. Moreover, given the impact index described in Sec. 4.3.2, it was possible to build a connection between each city and the reported earthquakes. Given the WVS dataset, our analysis is based on a cross-sectional data in which each observation represents an individual i living in city c from prefecture p.

Importantly, what is relevant for us is the effect of ancient earthquakes, as our interest lies in the observation of the persistence of cultural traits. For such reason, our index is built according to a cut-off year. This means that we assess, for each city, whether earthquakes up until year t were relevant. Our ideal experiment would be to compare some cities which were struck by an earthquake until year t with these same cities, but with no earthquake history. As this is naturally unfeasible, in order to estimate the differences between strongly impacted rural cities and the others, we resort to the following model, expressed in Eq. 4-3

$$y_{i,c,p} = \beta Imp^{-}_{c,t} * Rural_c + \gamma Imp^{-}_{c,t} + \eta Rural_c + \lambda Imp^{+}_{c,t} + \alpha_p + \mathbf{X_{i,c}}'\boldsymbol{\alpha} + \varepsilon_{i,c,p}, \tag{4-3}$$

where $y_{i,c,p}$ stands for the cultural trait of individual i, living in city c, from prefecture p, $Imp^{-}_{c,t}$ ($Imp^{+}_{c,t}$) is the impact index for city c while considering the earthquakes only up until (after) year t, $Rural_c$ is a dummy variable which equals 1 if city c is rural, α_p is a prefecture fixed effect, and $X_{i,c}$ is a set of controls for the individual (age, gender, income, interest on the interview and religiosity) and the city (size and type). The idea behind the inclusion of the index for earthquakes after the cut-off year, $Imp^{+}_{c,t}$, is to protect our analysis from a possibility of spatial correlation between the events. If some city was more hit than others both before and after our cut-off year, this could influence our results, as we could be capturing the effects of the recent events, instead of the ancient ones. Our coefficient of interest is the one related to the interaction term, which captures the the differential effect of being in a rural city strongly impacted, as compared to the other rural cities. Importantly, by using the prefecture[6] fixed effects, we focus our comparison on rural regions within the same prefecture. In such manner, we seek to protect our results from potential regional differences that could be correlated with both our outcome variables and the occurrence of earthquakes. Our standard errors are thus clustered at the prefecture level.

As Toya and Skidmore (2014) point out, an effect of disasters in communities is the strengthening of the bonds among their inhabitants. As a consequence, it is expected that among cultural traits influenced by such catastrophes are be those mostly related to trust. For such reason, for the first set of outcomes of interest, we investigate how different individuals are in terms of those variables from the WVS representing trusting relations. Moreover, social capital is also connected to a more politically engaged community (Gasper and Reeves, 2011; Cole et al., 2012; Bodet et al., 2016; Fair et al., 2017). For such reason, we verify how, in rural areas, having been im-

[6]Prefectures in Japan are an administrative level analogous to states in the United States.

pacted by earthquakes in a distant past helped to shape their trust relations and political mindset.

4.5 Results

The results on the influence of natural disasters on the persistence of cultural traits are now presented. It is firstly relevant to discuss the choice of the cut-off year, i.e., up to which year we will consider earthquakes to be included in our metrics. We chose 1900 as the year until which we consider the events. While inevitably arbitrary, such choice followed a few criteria. Since the main aim of the paper is to assess the long-run effect of impacts, the chosen cut-off should be sufficiently far in time to allow for traits to have evolved. Moreover, as our focus is on the rural Japan, it is relevant that the country experienced a demographic restructuring throughout the 20^{th} century, mainly after the World War II. While it is true that we are assessing cultural traits in current rural regions, we want to ensure that our comparisons are appropriate. As such, it is important that at the time of the impact, the regions were fairly equal. In addition, given the data availability, the further we go in past, the fewer events we have. To lie on the safe side, we promote a robustness check to confirm whether our choice is appropriate.

The results regarding the variables related to trust are indicated in Table 4.3. The coefficient of interest is the one connected to the interaction between the impact and the indication of rural city. As it can be observed, whereas all of the analyzed coefficients are positive, indicating a higher presence of trust in more impacted regions, four of them are statistically significant. More precisely, in rural regions where the impacts were stronger, there is a higher tendency to trust in most people, known people, people met for the first time and those from other religions. As previously discussed, such results point to a higher presence of social capital, as proxied by trust, in hardly hit regions, which comes in line with literature considering shorter time spans (Hommerich, 2012; Toya and Skidmore, 2014; Cassar et al., 2017). Results in Table 4.3 are also in line with the Japanese rural context, as discussed in Sec. 4.2, in which villages relied on themselves to deal with external threats to its subsistence and survival, thus fostering social capital.

Concerning the measurements for social engagement and political values, Table 4.4 presents the results. As one can verify, in terms of social engagement, individuals in rural cities more impacted by earthquakes in the past are currently more likely to donate to groups or campaigns, encour-

Table 4.3: Trust - Pre 1900

	Dependent variable:						
	Most ppl.	Family	Neighborhood	Know Pers.	Meet first time	Other Relig.	Other Nation.
$Imp^{-}_{c,1900}$	-6.028^{**}	-6.647	-4.064	-9.499^{*}	-11.323^{***}	-22.414^{**}	-3.906
	(3.009)	(7.013)	(6.862)	(5.192)	(4.170)	(9.775)	(10.567)
Rural	-0.057	-0.301	-0.127	-0.276^{**}	-0.233	-0.351	-0.187
	(0.108)	(0.185)	(0.246)	(0.130)	(0.145)	(0.268)	(0.255)
$Imp^{-}_{c,1900} * Rural$	6.034^{**}	6.673	4.022	9.522^{*}	11.276^{***}	22.366^{**}	3.881
	(3.006)	(7.013)	(6.868)	(5.195)	(4.166)	(9.794)	(10.571)
Base Controls	YES	YES	YES	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES	YES	YES	YES
Observations	920	949	895	931	777	585	584
R^2	0.441	0.985	0.955	0.971	0.915	0.907	0.932

Notes: This table presents the regression described in Eq. 4-3 for the variables concerning trust values. Dependent Variables are analogous to the ones presented in Table 4.1, in the same order. The full questions are available in Appendix 4.7. Variable $Imp^{-}_{c,1900}$ is the established metric for the impact city c suffered up until the year of 1900 and $Rural$ is a dummy equal to 1 if the city is rural. Standard errors are clustered at the prefecture level. *p<0.1; **p<0.05; ***p<0.01

age others to vote, vote in local elections. As for their political values, they attribute more importance to politics and have higher interest in it. Moreover, they value more honestly held elections. Such results indicate, in a general manner, that higher values are attributed to politics in such regions. Whereas current literature presents mixed results in how extreme events affect political engagement in the short run, it generally points to a relevant interaction (Gasper and Reeves, 2011; Cole et al., 2012; Bodet et al., 2016; Fair et al., 2017).

Table 4.4: Social engagement and political values - Pre 1900

	Dependent variable:								
	Donate	Contact gov.	Enc action	Enc voting	Vote local	Vote national	Politics imp.	Interest politics	Honest elections
$Imp^{-}_{c,1900}$	-20.773^{**}	2.702	0.489	-19.992^{***}	-13.478^{*}	-6.431	-14.342^{***}	-22.592^{***}	-13.738^{**}
	(9.547)	(7.129)	(7.668)	(6.783)	(7.017)	(5.441)	(5.398)	(5.087)	(5.483)
Rural	-0.437	0.025	0.135	-0.324	-0.245	-0.047	-0.534^{***}	-0.514^{***}	-0.390^{*}
	(0.287)	(0.213)	(0.250)	(0.263)	(0.231)	(0.226)	(0.198)	(0.199)	(0.231)
$Imp^{-}_{c,1900} * Rural$	20.811^{**}	-2.734	-0.492	19.996^{***}	13.444^{*}	6.430	14.252^{***}	22.558^{***}	13.716^{**}
	(9.548)	(7.130)	(7.674)	(6.782)	(7.020)	(5.442)	(5.390)	(5.086)	(5.486)
Base Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	877	800	829	883	955	955	928	952	939
R^2	0.914	0.849	0.872	0.856	0.946	0.946	0.946	0.947	0.850

Notes: This table presents the regression described in Eq. 4-3 for the variables concerning political engagement values. Dependent Variables are analogous to the ones presented in Table 4.2, in the same order. The full questions are available in Appendix 4.7. Variable $Imp^{-}_{c,1900}$ is the established metric for the impact city c suffered up until the year of 1900 and $Rural$ is a dummy equal to 1 if the city is rural. Standard errors are clustered at the prefecture level. *p<0.1; **p<0.05; ***p<0.01

However, the questions asked in such literature are slightly different from the one proposed here, for besides its attempts to understand how individuals in strongly impacted regions engage in politics, it seeks to observe how they punish or reward their governors. Considering that we are looking at past events, the link between disaster and politics should not come by punishment or rewards. The bond between ancient disasters and current politics should be more related to the value attributed to governance. It is interesting at this point to interact the results with the Japanese rural context. As discussed in Sec. 4.2, rural villages displayed a "body character", having its own self-governance, dealing with internal and external threats by its own means. It is revealing, for example, that Table 4.4 shows a more relevant result for voting at local level (5^{th} column) than for voting at national level (6^{th} column). A tentative explanation is that governance matters – and thus politics matters – but more relevantly, local governance matters. As such, the strengthening of its social capital given the impacts should be closer to the mechanism observed here. Thus, such results are related to the literature on social capital and political participation, which points to the higher political engagement in regions presenting higher levels of social capital (Putnam et al., 1993; Krishna, 2002; Szreter and Woolcock, 2004; Nannicini et al., 2013). Interestingly, the results observed here are intimately related to the persistence in cultural traits, for the potential differentiation in social capital, as a consequence of natural disasters, took place in a remote past, and was kept to the present day.

Even though our treatment comes from a natural disaster, lending its random character to our impact index – even more so once we control for the impacts after our cut-off year –, it is relevant to highlight an important caveat. As Kuroda (1986) discusses, most of the Japanese migration from rural to urban areas took place around the mid of the twentieth century. If in any manner the migratory pattern is both correlated to our measures of social capital and with the presence of severe events, our estimator would be biased. It should be recalled at this point that our comparison is between individuals in rural areas within the same prefecture. As such, we would have problems if different rural areas from the same prefecture had migratory patterns correlated with our impact index.

Another possibility in this sense is that having been struck by earthquakes induced a different migratory pattern, causing some sort of selection in individuals. It could be the case, for instance, that such disasters, by affecting the region's characteristics – say, by worsening its land productivity –, incentivized individuals to migrate to urban areas during the Japanese industrialization process. As a consequence, those who decided to stay may have done so due to a higher connection with the community, which is then observed in our results. Although relevant, the disentangling of these mechanisms is left for future research.

A rather interesting pattern observed in Tables 4.3 and 4.4 is that while the coefficients for highly affected rural regions are positive, the coefficients for highly affected non-rural regions are negative. Moreover, they are quite symmetric. One possible reason for this pattern is the differential impact of disasters on social capital formation depending on the structure and governance of the region. For example, in assessing the impact of the Fukushima disaster in 2011, Hommerich (2012) finds that while trust in people living nearby and in people "outside the family" was higher, trust in the government decreased significantly. Following the literature on social capital, its division into bonding, bridging, and linking (Aldrich and Meyer, 2015) may play a role at this point. Szreter and Woolcock (2004), for example, note that bridging and bonding may have quite different effects in fostering collective action. While bridging tends to promote the flow of different types of resources, bonding may actually impede it. Thus, while in places characterized by self-governance and an organization around a common-pool resource, the occurrence of a disaster helped to promote the expressions of social capital observed in Tables4.3 and 4.4, the result in other places may have been quite the opposite. While the precise description of these mechanisms is important for an accurate understanding of the forces behind the formation of social capital, this is not addressed in this paper.

Indeed, if one considers the results obtained in chapter 2, they may seem to be at odds with those obtained here. However, the context in which the reactions to the catastrophes take place is different. In chapter 2, the observed pattern is related to the lack of trust in government and the resulting demand for short-term punishment of those in power at the national level. In this chapter, on the other hand, the observed pattern is related to the local formation of social capital in the face of the demand for social cohesion to counter potential threats to the community. In this sense, the results obtained by Hommerich (2012) are quite useful, as the author finds that the same disaster causes different types of trust to move in opposite directions.

4.5.1 Robustness check

One important concern in regards to the adopted empirical strategy is the occurrence measurement errors. As discussed, we include in our controls the impact index for earthquakes that happened after the cut-off year. The intention is to control for the potential spatial correlation between earthquakes and to ensure that the effects being captured are indeed from ancient events, rather than recent ones. However, such strategy may induce the emergence of measurement errors. From Fig. 4.1b, it gets quite clear that measurement capabilities were quite improved as time passed, and many more events were registered in the (more) recent past. Thus, if one considers that recent events are more accurately measured than ancient ones, the observed effect of ancient impacts might not be caused by an actual change in culture and preferences, but to the fact that the ancient events had been measured with more noise than the recent. As a consequence, we would be capturing some potential correlation between our variables of interest and the difference in measurement noise.

In order to confirm whether this is the case, we undertake a second analysis in which the control for impacts after the cut-off, $Imp^{+}_{c,t}$, is not included. The results are displayed in Tables 4.5 and 4.6, respectively for the variables related to trust and to political preferences. As one can observe, there is barely no difference between the results obtained here and the ones presented in Tables 4.3 and 4.4. Thus, it reinforces the fact that the drivers of our results are the events before 1900.

Table 4.5: Trust - Pre 1900, no post control

	Dependent variable:						
	Most ppl.	Family	Neighborhood	Know Pers.	Meet first time	Other Relig.	Other Nation.
$Imp^{-}_{c,1900}$	−6.893***	−5.485	−3.973	−9.989**	−13.530***	−24.432***	−4.119
	(2.611)	(7.004)	(6.901)	(5.060)	(4.371)	(9.137)	(10.705)
Rural	−0.085	−0.264	−0.124	−0.291**	−0.300**	−0.407	−0.193
	(0.098)	(0.187)	(0.246)	(0.127)	(0.147)	(0.251)	(0.259)
$Imp^{-}_{c,1900} * Rural$	6.907***	5.501	3.930	10.016**	13.499***	24.395***	4.095
	(2.609)	(7.008)	(6.907)	(5.062)	(4.364)	(9.158)	(10.713)
Base Controls	YES	YES	YES	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES	YES	YES	YES
Observations	920	949	895	931	777	585	584
R^2	0.440	0.985	0.955	0.971	0.915	0.907	0.932

Notes: This table presents the regression described in Eq. 4-3 for the variables concerning trust values, except that here the control for impacts after the cut-off year, $Imp^{+}_{c,1900}$, is not considered. Dependent Variables are analogous to the ones presented in Table 4.1, in the same order. The full questions are available in Appendix 4.7. Variable $Imp^{-}_{c,1900}$ is the established metric for the impact city c suffered up until the year of 1900 and *Rural* is a dummy equal to 1 if the city is rural. Standard errors are clustered at the prefecture level. *p<0.1; **p<0.05; ***p<0.01

In regards to the cut-off year, as it has been mentioned, it is important to establish a limit in the past to consider the events, as our intention is the assessment of ancient events; to have enough measurements and to be in a period that is appropriate for our purposes, in terms of the considerations in regards to the Japanese rural areas. Thus, the year of 1900 was chosen. It is also relevant to consider how such choice influences our results. For such, from 1700 on, a number of cut-off years – 50 years apart – were considered. For the trust variables, the results are shown in Fig. 4.3, and, for the political engagement variables, Fig. 4.4 presents the results. For both cases, as it can be observed, the different cut-offs do not produce much

Table 4.6: Social engagement and political values - Pre 1900, no post control

	Dependent variable:								
	Donate	Contact gov.	Enc action	Enc voting	Vote local	Vote national	Politics imp.	Interest politics	Honest elections
Impact	-19.908^{**}	2.678	0.506	-19.383^{***}	-13.912^{**}	-6.422	-14.723^{***}	-20.920^{***}	-13.801^{***}
	(9.625)	(7.018)	(7.556)	(6.586)	(6.860)	(5.449)	(5.375)	(4.797)	(5.244)
$Imp^{-}_{c,1900}$	-0.408	0.025	0.136	-0.305	-0.259	-0.047	-0.546^{***}	-0.461^{**}	-0.392^{*}
	(0.287)	(0.210)	(0.246)	(0.257)	(0.227)	(0.226)	(0.195)	(0.189)	(0.224)
$Imp^{-}_{c,1900} * Rural$	19.935^{**}	-2.710	-0.508	19.382^{***}	13.882^{**}	6.421	14.636^{***}	20.872^{***}	13.781^{***}
	(9.621)	(7.018)	(7.560)	(6.584)	(6.864)	(5.450)	(5.369)	(4.799)	(5.245)
Base Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	877	800	829	883	955	955	928	952	939
R^2	0.914	0.849	0.872	0.856	0.946	0.946	0.946	0.947	0.968

Notes: This table presents the regression described in Eq. 4-3 for the variables concerning political engagement values, except that here the control for impacts after the cut-off year, $Imp^{+}_{c,1900}$, is not considered. Dependent Variables are analogous to the ones presented in Table 4.2, in the same order. The full questions are available in Appendix 4.7 . Variable $Imp^{-}_{c,1900}$ is the established metric for the impact city c suffered up until the year of 1900 and $Rural$ is a dummy equal to 1 if the city is rural. Standard errors are clustered at the prefecture level. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

variation in the results. Notoriously, as more measurements are observed, the confidence interval reduces substantially. In addition, potentially due to the higher precision in measurements, the coefficients from 1850 onwards suffer some change. It should be confirmed whether such effects are coming from specific events. Nevertheless, from Fig. 4.1b, none of the measurements from that period stand out in terms of magnitude. Another possibility is that, as the Meiji Restoration took place in 1868, putting an end to the Edo Period, there has been some influence on the interaction between earthquakes and the establishment of trust and political engagement. Such analyses, however, are left for future work.

4.6 Conclusion

In this work, we sought to answer to the question on whether natural disasters had a persistent effect on cultural traits. More precisely, we assessed the influence of ancient earthquakes on the persistence of trust values and political engagement in rural Japan. By profiting from a dataset including seismic events since the 7^{th} century, we built a metric to account for the impact suffered by Japanese cities. Also, to consider cultural traits, we used the results from the seventh wave from the World Values Survey in Japan, held in 2019.

The setting considering the rural Japan is interesting, as its villages were in the past quite clear examples of communities around common-pool resources. In that case, due to the Japanese agricultural characteristics, irrigation systems were of high relevance and helped to shape the regions' social fabric. Thus, such regions presented a "body character", with a strong

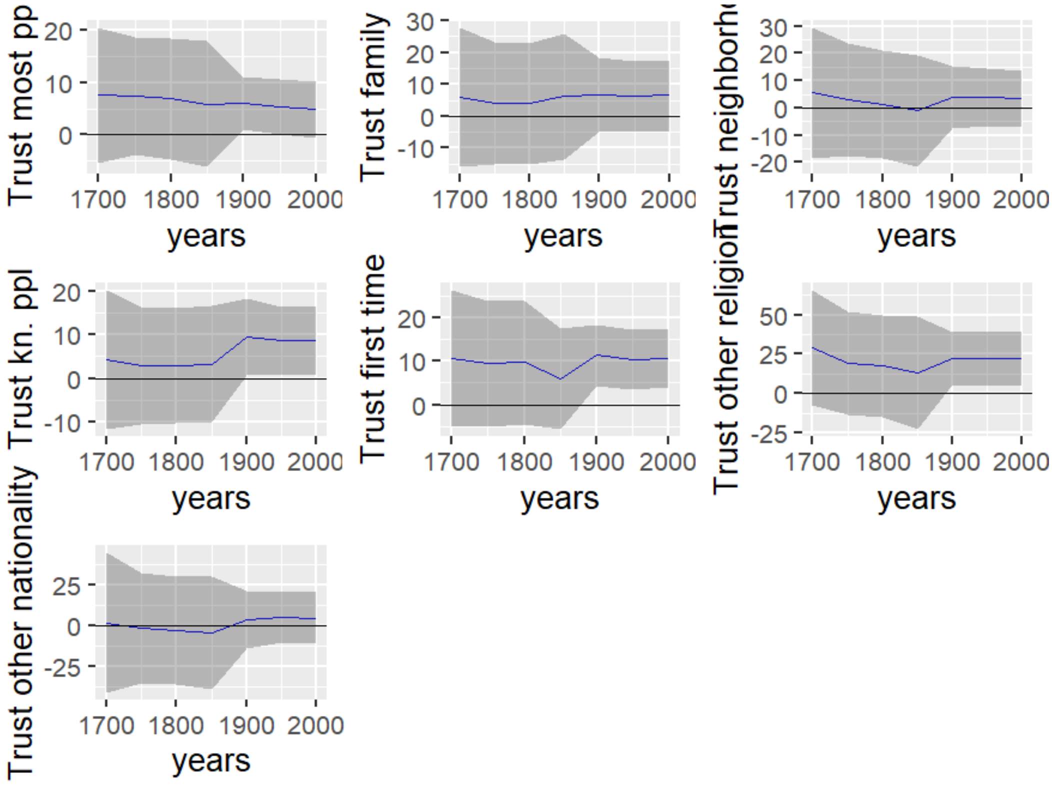


Figure 4.3: Influence of ancient impact on trust variables according to the cut-off year. The coefficient of each year in the graph is associated with all the events before that year. Confidence intervals are of 95%.

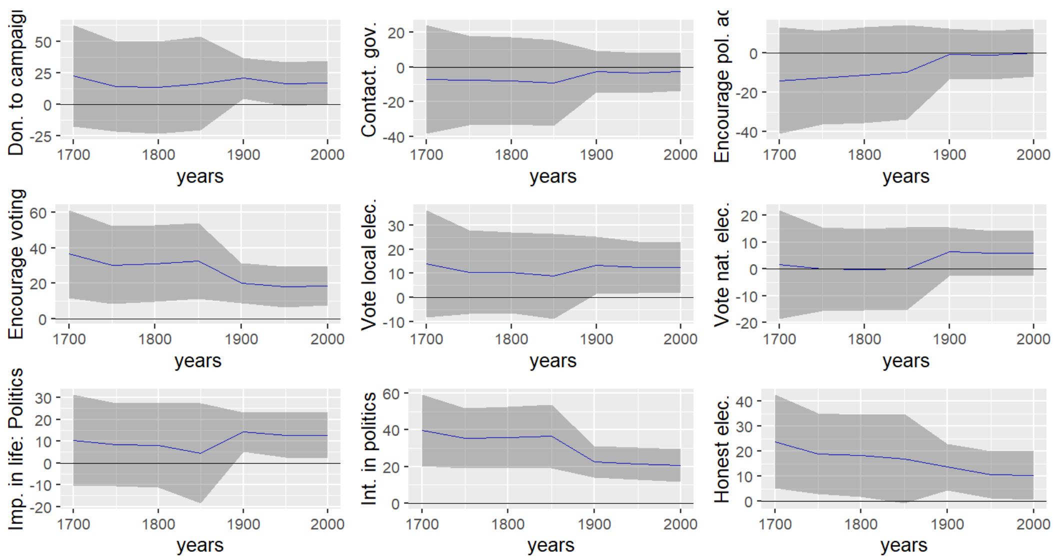


Figure 4.4: Influence of ancient impact on political engagement variables according to the cut-off year. The coefficient of each year in the graph is associated with all the events before that year. Confidence intervals are of 95%.

self-governance and acting as a unit against internal and external threats.

In our results, where we relate current traits to out metric on the impact suffered by each city in the past, we found that those places which had suffered most with disasters in the past present today higher levels of trust and higher levels of political engagement, as measures by WVS variables. Such results are quite interesting in that they portray the persistence in the higher levels of social capital presented in those regions. As argued in literature, one of the threats dealt with by villagers in rural Japan were those related to the environment, and led the whole community to deal with the issue. Moreover, it is also treated in literature the fact that such catastrophic events result in an increase in cooperation and in the building of social values. As results have shown, considering that indeed these events led to a higher social commitment, such characteristics have been kept throughout time.

Whereas our results are suggestive, some mechanisms may be at play. Besides the persistence in traits, the country urbanization process may also have interacted with the occurrence of earthquakes. One possibility is that hardly hit places may have had lower production capabilities due to the occurrence of the natural events, and led to a selection of those who fled for urban areas, leaving behind individuals with the observed characteristics. The disentangling of potential mechanisms are interesting paths for future research.

Also relevant are the potential measurement errors to which our metric is subject. Since we are dealing with data recorded in the remote past, such issues should be considered. Although we try to control for the potential presence of noise, result should be taken carefully. As such, for future research, it would be interesting to establish more precise metrics, seeking to establish more accurately the relationship between the disasters and the establishment and persistence of cultural traits.

4.7 Appendix

Table 4.7: Description of the questions related to trust variables

Variable	**Most people can be trusted**
Question	Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?
Answers	1 - Most people can be trusted
	0 - Need to be very careful
Variable	**Trust: Your family**
Question	I’d like to ask you how much you trust people from various groups. Could you tell me for each whether you trust people from this group completely, somewhat, not very much or not at all? Your family
Answers	4.- Trust completely
	3.- Trust somewhat
	2.- Do not trust very much
	1.- Do not trust at all
Variable	**Trust: Your neighborhood**
Question	I ’d like to ask you how much you trust people from various groups. Could you tell me for each whether you trust people from this group completely, somewhat, not very much or not at all? Your neighborhood
Answers	4.- Trust completely
	3.- Trust somewhat
	2.- Do not trust very much
	1.- Do not trust at all
Variable	**Trust: People you know personally**
Question	I ’d like to ask you how much you trust people from various groups. Could you tell me for each whether you trust people from this group completely, somewhat, not very much or not at all? People you know personally
Answers	4.- Trust completely
	3.- Trust somewhat
	2.- Do not trust very much
	1.- Do not trust at all
Variable	**Trust: People you meet for the first time**
Question	I ’d like to ask you how much you trust people from various groups. Could you tell me for each whether you trust people from this group completely, somewhat, not very much or not at all? People you meet for the first time
Answers	4.- Trust completely
	3.- Trust somewhat
	2.- Do not trust very much
	1.- Do not trust at all
Variable	**Trust: People of another religion**
Question	I ’d like to ask you how much you trust people from various groups. Could you tell me for each whether you trust people from this group completely, somewhat, not very much or not at all? People of another religion
Answers	4.- Trust completely
	3.- Trust somewhat
	2.- Do not trust very much
	1.- Do not trust at all
Variable	**Trust: People of another nationality**
Question	I’d like to ask you how much you trust people from various groups. Could you tell me for each whether you trust people from this group completely, somewhat, not very much or not at all? People of another nationality
Answers	4.- Trust completely
	3.- Trust somewhat
	2.- Do not trust very much
	1.- Do not trust at all

Table 4.8: Description of the questions related to political engagement variables

Variable	**Social activism: Donating to a group or campaign**
Question	What about these forms of political action and social activism that people can take?. Please, tell me for each of them if you have done any of these things, whether you might do it or would never under any circumstances do it: Donating to a group or campaign
Answers	3.- Have done
	2.- Might do
	1.- Would never do
Variable	**Social activism: Donating to a group or campaign**
Question	What about these forms of political action and social activism that people can take?. Please, tell me for each of them if you have done any of these things, whether you might do it or would never under any circumstances do it: Donating to a group or campaign
Answers	3.- Have done
	2.- Might do
	1.- Would never do
Variable	**Social activism: Donating to a group or campaign**
Question	What about these forms of political action and social activism that people can take?. Please, tell me for each of them if you have done any of these things, whether you might do it or would never under any circumstances do it: Donating to a group or campaign
Answers	3.- Have done
	2.- Might do
	1.- Would never do
Variable	**Social activism: Donating to a group or campaign**
Question	What about these forms of political action and social activism that people can take?. Please, tell me for each of them if you have done any of these things, whether you might do it or would never under any circumstances do it: Donating to a group or campaign
Answers	3.- Have done
	2.- Might do
	1.- Would never do
Variable	**Vote in elections: local level**
Question	Vote in elections: Local level
Answers	3.- Always
	2.- Usually
	1.- Never
Variable	**Vote in elections: National level**
Question	Vote in elections: National level
Answers	3.- Always
	2.- Usually
	1.- Never
Variable	**Important in life: Politics**
Question	For each of the following aspects, indicate how important it is in your life. Would you say it is very important, rather important, not very important or not important at all? – Politics
Answers	4.- Very important
	3.- Rather important
	2.- Not very important
	1.- Not at all important
Variable	**Interest in politics**
Question	How interested would you say you are in politics?
Answers	4.- Very interested
	3.- Somewhat interested
	2.- Not very interested
	1.- Not at all interested
Variable	**Having honest elections is important**
Question	Do you think that honest elections play an important role in deciding whether you and your family are able to make a good living?. How important would you say this is—very important, fairly important, not very important or not at all important?
Answers	4.- Very important
	3.- Rather important
	2.- Not very important
	1.- Not at all important

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