Essays on Macroeconomics and Textual Analysis

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“In the beginning the Universe was created. This has made many people very angry and has been widely regarded as a bad move.”

– Douglas Adams

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Resum

Aquesta tesi conté tres assaigs sobre macroeconomia i anàlisi textual. En el primer capítol, estudio l'impacte de la polarització política sobre les polítiques mediambientals utilitzant propostes de llei de les legislatures estatals dels Estats Units d'Amèrica. Explotant la variació estatal en les respostes a la polarització política del Congrés dels Estats Units d'Amèrica, trobo que la polarització política redueix el nombre de propostes de llei relacionades amb el canvi climàtic i modera les posicions de legisladors demòcrates i republicans. A la vegada, ambdós partits reverteixen la legislació quan el control de la legislatura canvia. Per tal d'entendre les implicacions a llarg termini de la polarització sobre el canvi climàtic, incorporo un component polític dintre d'un model de creixement neoclàssic amb una externalitat climàtica. Seguidament, mostro que els efectes de la polarització política estan mitigats per l'exposició de l'economia al canvi climàtic. En el segon capítol, documento que la cobertura econòmica per part dels mitjans de comunicació es converteix en domini públic durant les recessions econòmiques mitjançant l'aplicació de models temàtics a les primeres planes dels diaris publicats als Estats Units d'Amèrica. Motivat per aquesta evidència, desenvolupo un model de cicles econòmics en el qual els mitjans de comunicació exerceixen un rol central a l'hora d'amplificar la decisió de les empreses de no invertir. En el tercer capítol, aplico el marc empíric desenvolupat en el primer capítol per estudiar l'impacte de la polarització política sobre la complexitat de les propostes de llei de les legislatures estatals dels Estats Units d'Amèrica. Els meus resultats mostren que la polarització incrementa la complexitat de les propostes de llei, però a la vegada redueix la bretxa entre la complexitat de les

propostes de les legislatures demòcrates i republicanes.

Abstract

This thesis contains three essays on macroeconomics and textual analysis. In the first chapter, I study the impact of party polarization on environmental policy-making using bill data from the United States legislatures. Exploiting regional variation in responses to aggregate trends in the United States Congress, I find that party polarization reduces the amount of climate-related bills, and moderates the positions of both Republican and Democratic legislators. At the same time, both parties revert policy when control of the legislature changes. I then embed a simple model of the legislature into a neoclassic growth model with a climate externality to understand the long-run implications of polarization on climate change. I show that the effects of polarization are mitigated by the exposure of the economy to climate change. In the second chapter, I document that economic news become more common knowledge during economic recessions by applying topic modeling to the front page of newspapers published in the United States. Based on this observation, I build a business cycle model in which media play a central role by amplifying the decision of firms not to invest. In the third chapter, I apply the empirical framework developed in the first chapter to study the impact of party polarization on the complexity of bills proposed in the United States legislatures. I find that polarization increases legal complexity, while it narrows the gap between the complexity of bills proposed in Democratic and Republican legislatures.

Preface

The aim of this thesis is to investigate the possibilities of applying textual analysis techniques in the field of Macroeconomics. The two main chapters of this thesis start with an empirical section based on textual data that motivate a theoretical model. Thanks to this approach combining Economics and textual analysis, I am able to shed light on areas of Economics that until now could primarily be studied from a theoretical perspective, such as climate change, the role of media, or complexity.

In the first chapter, I use textual data from the United States legislatures to measure the environmental position of all bills related to climate change proposed between 2009 and 2018. I estimate the effect of party polarization on climate policies by exploiting regional variation in responses to aggregate trends in the U.S. Congress. I find that party polarization reduces the amount of climate-related bills and moderates the positions of both Republican and Democratic legislators. At the same time, both parties revert policy when control of the legislature changes. To rationalize these findings, I develop a simple model of the legislature incorporating party seat distribution. When polarization between parties is high, the legislature can either enter a period of gridlock or approve extremist policies depending on the seat distribution. To understand the long-run implications of polarization on climate change, I embed the legislative bargaining process into a neoclassic growth model with a climate externality and show that the effects of polarization are mitigated by the exposure of the economy to climate change.

In the second chapter, I apply topic modeling to the front page of U.S.

newspapers to document that mass media become more coordinated in economic reporting when the economy is in a recession. In addition, economic content also becomes more homogeneous, thus suggesting economic conditions become more common knowledge during recessions. Motivated by this evidence, I present a business cycle model in which mass media play a central role in amplifying economic fluctuations. In particular, as newspapers become more coordinated, economic conditions become increasingly more common knowledge among firms. Thus, during a recession, the decision of firms not to invest is amplified because they are aware that other firms are also not willing to invest.

In the third chapter, joint with Dana Foarta and Victoria Vanasco, I use textual data from the United States legislatures to measure the complexity of a random sample of bills proposed between 2009 and 2018. I estimate the effect of party polarization on the complexity of legal documents by applying the same empirical strategy developed in the first chapter. I find that polarization increases legal complexity and that it narrows the gap between the complexity of bills proposed in Democratic and Republican legislatures. We also propose a mechanism driving this phenomenon. Ideological polarization effectively reduces the number of potential coalition partners, which in turn increases each partner’s bargaining power. Reaching an agreement on any bill thus requires adding into the bill more elements demanded by coalition members, thus resulting in more complexity.

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Chapter 1

The Effect of Party Polarization on Environmental Policy: Evidence from Textual Data

1.1 Introduction

The scientific community has long established that human activity is affecting Earth's climate (Oreskes, 2004, 2018). Experts may face uncertainty about certain aspects of climate change, such as the most likely emissions scenario (IPCC, 2014) or the potential economic damages (Burke et al., 2018). Nonetheless, scientific consensus is clear and governments have recognized on many occasions the need to cut CO_2 emissions. Environmental policies are key to addressing climate change. Instruments such as Pigouvian schemes taxing the social cost of CO_2 emissions have been proposed multiple times (Oates & Portney, 2003; Stern, 2006). However, effective policies against climate change are not prevalent in developed economies. For instance, the United States has no landmark climate policy at the federal level, and leaves most of environmental policy at the states' discretion (Klyza & Sousa, 2008). The European Union does have a CO_2 emissions market, but it is widely regarded as not ambitious enough.[1]

In this context, it remains an open question why climate change has not been addressed in the United States. According to Layman et al. (2006), "parties have grown increasingly divided on all the major policy dimensions in American politics", and climate change policy is not an exception. In fact, climate change is one of the exemplifying areas affected by this division (Gallup, 2008; Pew, 2016). In democratic countries, the actions taken by policymakers will necessarily reflect disagreement in public opinion. The effects of this increase in disagree-

[1]The EU Emissions Trading Scheme (ETS) covers 50% of EU carbon emissions, and is estimated to have cut emissions by 4% (Bayer & Aklin, 2020).

ment on the trends of environmental policy-making are visible to any casual observer. The bipartisan alliances that lead to the “golden age” of environmental lawmaking mid 20th century fell apart during the 80s to the extent that currently, both parties have very antagonistic views on environmental protection.[2]

This paper studies the effect of disagreement on policies addressing climate change. To do so, I focus on party polarization. Party polarization is a form of disagreement that consists of a profound division on a certain topic along party lines. In principle, party polarization could affect environmental policy in two opposite ways. It could result in policy switches, i.e. the approval of different policies by parties alternating in power; or it could lead to gridlock, i.e. to paralysis in the process of policy-making. Notable examples of policy switches in the area of climate change include the withdrawal and posterior rejoining of the U.S. to the Paris Climate Accords;[3] and the Keystone XL pipeline project, an infrastructure destined to connect the oil sands of Alberta, Canada, to Nebraska.[4] On the other hand, party polarization is also responsible for the delay of the approval of the Inflation Reduction Act (IRA), a landmark policy promoting clean energy by President

[2]Most of the major environmental laws (such as the Clean Air Act, the Clean Water Act, and the Endangered Species Act) were approved during the 60s and the 70s; and the Environmental Protection Agency (EPA) was created by a Republican President, Richard Nixon (Rosenbaum, 2016).

[3]The Paris Climate Accords, an international treaty on climate change adopted in 2015 was initially ratified by the U.S., under the Obama administration. In 2020 the U.S. withdrew from the agreement, under the Trump administration. President Joe Biden signed an executive order on his first day in office to re-admit the United States.

[4]The Obama administration never granted permits for the project. In their first day in office, Presidents Donald Trump and Joe Biden issued executive orders to grant and cancel permits, respectively (BBC, 2021).

Joe Biden (Economist, 2022a). However, anecdotal evidence aside, it is unclear which of these two effects is the empirically relevant one.

To evaluate the effect of party polarization on environmental policy, I first apply textual analysis techniques to measure the ideological content of bills related to climate change proposed in state chambers between 2009 and 2018. Specifically, I use Wordfish, an algorithm that estimates policy positions of documents based on their word frequencies developed by Slapin and Proksch (2008). The ideological dimension captured by Wordfish corresponds to the climate position of the proposed bills. Perhaps unsurprisingly (Grumbach, 2018; Kim & Urpelainen, 2017), bills proposed by Democratic legislators are more environmentally friendly, and state legislatures controlled by the Democratic Party are more environmentally friendly.

The key contribution of this paper is to use textual analysis techniques to measure the environmental policy of the U.S. state legislatures. Measurement of environmental policies is not trivial. Unlike the federal funds rate for monetary policy, there is no single indicator that summarizes the environmental stance of a governing body. State legislatures are very active in environmental policy-making (Grumbach, 2018; Rosenbaum, 2016), and each of them partakes in environmental policy in different ways (see Klyza & Sousa, 2008, ch. 7). Among other tools, states in the U.S. can support environmental protection through the creation of cap-and-trade markets (e.g. the Regional Greenhouse Gas Initiative in northeastern U.S. or the Western Climate Initiative in California), environmental spending (List & Sturm, 2006), or enforcement actions by regional EPAs (Fredriksson & Wang, 2020). By applying Wordfish to bills, I am able to measure the environmental policy stance of legislatures with very heterogeneous policies.

Using textual analysis to measure environmental policy is preferable to previously used measures in two key aspects. First, it allows me to exploit the intensive margin of policies. Alternative measures using count data as a proxy (such as the number of green initiatives approved; see CleanTech, n.d.; Grossmann et al., 2021) are likely to overestimate the scale of policy. This is especially true for policies addressing climate change, which is fundamentally a coordination problem.[5] Second, this measure focuses exclusively on climate policies. Alternative measures of environmental policy include aspects that are not necessarily related to climate change, such conservation of natural resources, or waste management. These aspects have been regulated at the federal level for decades, and give the legislature less range of action.[6]

I then provide evidence that political polarization has a significant impact on environmental policy. Regressing the policy stance of bills related to climate change on measures of party polarization developed by Poole and Rosenthal (2001), I establish the following four facts. First, the effect of polarization on environmental policy depends on the seat distribution of the legislature. Second, polarization moderates the environmental policy proposals by both parties when the seat distribution of the legislature is tight. Third, polarized legislatures are less likely

[5] Through this lens, a series of small initiatives tackling climate change are going to be less effective than combining the effort in a single policy action.

[6] For instance, Azzimonti et al. (2022) note that most federal spending is mandatory, i.e. governed by criteria set by law.

to pass environmental legislation when the seat distribution of the legislature is tight. Fourth, parties reverse legislation when taking over a chamber; and the magnitude of this switch is greater the more extreme is the status quo environmental policy is.

One potential concern regarding the validity of these results is that polarization might be endogenous to the environmental stance of a bill. Measures of disagreement at the state level are going to be – to some degree – mechanically correlated to the environmental position of a bill. However, estimates of polarization capture disagreement in all topics, which could dilute this problem. Omitted variables might be another potential concern. Several factors explain the recent surge in party polarization.[7] If any of these factors have a state-specific trend, endogeneity might arise. To address this concern, I employ an identification strategy based on the sensitivity analysis followed by Nakamura and Steinsson (2014). This strategy exploits the heterogeneity in the response to aggregate trends in polarization. In particular, I instrument polarization at the state level using polarization at the U.S. Congress interacted with state dummies. The identifying assumption is a state's response to aggregate trends in polarization is not correlated to bill-specific environmental policy, conditional on observable variables. In addition, the results of the empirical section are robust to a series of alternative specifications including different measures of polarization, focusing the analysis on different chambers (i.e. House vs. Senate) and

[7] Scholars in the political science literature have come up with several candidates to explain the trends in polarization. The most prominent are redistricting or *gerrymandering*, the Southern Realignment, and increasing inequality and immigration. See McCarty et al. (2016) for a review of the topic.

samples restricting the analysis to bills that are either (a) proposed by the majority party; or (b) decided by a narrow margin.

A second contribution of this paper is to develop a framework in which climate policies are endogenous to ideological differences. This framework can be used to analyze the economic impact of party polarization. Even though party polarization is a recurrent concern in the public debate, its economic impact is underexplored. The economic impact of disagreement in environmental policies is not negligible. For example, the Keystone XL pipeline had secured \$8 billion (Reuters, 2021), while the withdrawal from the Paris Agreement entailed the termination of \$3 billion for the Green Climate fund (Zhang et al., 2017). On the other hand, the expected increase in spending in the IRA falls \$2 trillion short of the proposals in previous drafts (Economist, 2022b). Previous literature has linked different measures of political instability to lower growth rates at the country level (see Aisen & Veiga, 2013; Barro, 1991), and a similar pattern can be observed within the United States (see Table 1.9). Although the general consensus is that polarization is harmful to growth, the underlying mechanisms are not clear.

In the theoretical part of the paper, I develop a simple model of the legislature that shows how accounting for the party seat distribution of the legislature can explain two opposite views of the effect of polarization on policy. First, the prevalent view that polarization leads to policy switches (Alesina, 1988; Fiorina, 1996; Hare & Poole, 2014; Polborn & Snyder, 2017). Second, the alternate view that polarization leads to gridlock and policy moderation (for a review in the political science literature see Lee, 2015). To my knowledge, this is the first paper to provide a mechanism that rationalizes these two phenomena with one single explanation, i.e. party seat distribution. In the model, legislators facing political pressures à la Grossman and Helpman (1995) have to decide on a distortionary transfer between two sectors. Legislators are grouped into two parties with polarized preferences. Parties also differ in their seat distribution, i.e. they control a different share of the legislature’s seats. The tax is decided by bargaining in a model in the spirit of Baron and Ferejohn (1989), playing a one-round negotiation game in which an agenda-setter makes a proposal, and the rest of the legislators can either accept it or reject it.

Incorporating the seat distribution of the legislature, I find that polarization has a non-monotonic effect on policy. When polarization between parties is low, the preferences between both parties are overlapping, and reaching an agreement is easy. On the other hand, the effect of high party polarization depends on the degree of control of the legislature. When the majority party’s margin of votes is very narrow, bargaining between the two parties becomes too burdensome and a period of gridlock follows. Instead, when the majority party has a sufficient margin of control of the legislature, the response of policy will be towards extremism.

I then characterize the equilibrium behavior of the agenda-setter and derive two results detailing the impact on policy of an increase in polarization. In equilibrium, the action set of the agenda-setter is divided into three regions. The equilibrium proposal will depend on the seat distribution of the legislature, which amounts to the bargaining power of the agenda-setter. If the agenda-setter controls the legislature by a wide margin, then the agenda-setter will have free rein to propose their ideal (i.e. unconstrained) policy. If control of the legislature is intermediate, the resulting proposal will be the result of bargaining with members from the other party. Finally, if control of the legislature is low, gridlock will ensue.

The effect of an increase in polarization is characterized by two seemingly opposite results. First, higher polarization increases the distance between the ideal (unconstrained) policies of the two parties' agenda-setters. Second, higher polarization increases the region of gridlock and forces policy convergence when bargaining takes place. In line with the results from the empirical section, the effect that dominates will depend on the seat distribution of the legislature. These results are true under broad parameter combinations ensuring that (a) the output of the two sectors is substitutable; and (b) legislators' political motives dominate over welfare concerns. Finally, in line with the empirical results, the model also gives a prominent role to the status quo policy. The status quo is a key factor in determining the outcome of the bargaining process and the size of the gridlock regions. Intuitively, the status quo is a source of bargaining power for the minority party. Moderate values of the status quo prevent the majority party from reaching an agreement with the minority party's moderates.

To understand the long-run implications of polarization on climate change, I embed the legislative bargaining into a simplified version of the dynamic stochastic general-equilibrium (DSGE) model with a climate externality developed by Golosov et al. (2014). I show that the effects of polarization are mitigated by the exposure of the economy to climate change. In particular, an increase in exposure to climate change (i.e. an increase in the parameter that links emissions to economic damages) reverts the results of an increase of polarization. That is, it brings the ideal policies of the two parties closer and reduces the region of gridlock. The framework is based on a multi-sector neoclassic growth model that incorporates output damages due to CO_2 emissions. In the model, the final good can be produced with two energy inputs, a clean and a dirty one. Production of the dirty input generates emissions that decrease productivity. Each period, the government taxes the sale of these two inputs. Taxes have a distortionary effect on production, but they can also be used to address the climate externality. The economic impact of polarization depends on which of the two effects of polarization prevails. If polarization leads to policy divergence, switches in climate policy can lower output to a suboptimal level. On the other hand, if policy stalemate prevails, delays in addressing the climate externality might generate important welfare losses.[8]

Finally, the static nature of the one-period model ignores potential concerns regarding to whether the equilibrium behavior extends to a dynamic setting. Taxation is an intertemporal decision that propagates to the future through an endogenous status quo. This endogeneity opens the door for the agenda-setter to manipulate the outcome of tomorrow's bargaining process. Similarly, legislators might be willing to accept proposals that they would not in a static setting. To this effect, I extend and solve computationally a two-period version of the model in which

[8]Battaglini et al. (2014) show that in dynamic settings with free riding and irreversibility, welfare losses might occur due to slow convergence, even though the optimum is attainable.

legislators have to bargain over taxes every period. Legislators and the agenda-setter are forward-looking. In this dynamic setting, I show that the two main results of the model are preserved.

Literature Review

By focusing on environmental policies, this paper contributes to two branches of environmental economics. First, the relatively new macro-environmental literature (Hassler et al., 2016), and in particular the applications of models of Directed Technical Change (DTC) with environmental constraints (Acemoglu et al., 2012). This literature focuses on the development of growth models that incorporate a climate module, in order to determine the optimal carbon tax (see Barrage, 2020; Golosov et al., 2014; Nordhaus, 2018). Second, the political economy of environmental policy (for an early review see Oates & Portney, 2003). This literature highlights the interactions between environmental policy and political constraints. For instance, there is ample evidence that politicians' decisions over secondary policy issues (such as environmental policies) are affected by electoral motives (see, for example, Bouton et al., 2021; Fredriksson & Wang, 2020; Fredriksson et al., 2011; List & Sturm, 2006). The effect of polarization on environmental policy is relatively understudied. Fisher et al. (2013) use natural language processing (NPL) techniques to determine the source of the political divide in the climate debate in the U.S. Congress. Austen-Smith et al. (2019) develop a model to explain how inefficient policy instruments can be used to overcome gridlock when polarization is high. In this paper, I endogenize environmental policy through party polarization, and close the gap between the political and macroeconomic branches of the literature.

Another main contribution is to study the effects of political conflict on government policy (see Alesina & Drazen, 1989; Alesina & Tabellini, 1990; Azzimonti, 2011; Persson & Svensson, 1989), and in particular of party polarization. The literature studying the economic consequences of polarization is scarce and is based on the interaction between two factors: policy uncertainty and fiscal policy. The leading example in this area is Azzimonti (2011). Drawing from Alesina and Tabellini (1990), the author shows that polarization can induce governments to overspend in order to increase the probability of reelection. Because spending must be financed with distortionary taxes, polarization depresses investment and thus growth. Azzimonti and Talbert (2014) show that this mechanism can also be extended to the business cycle. Azzimonti (2021) adds an additional channel by which polarization also increases the tail risk associated with the occurrence of an institutional crisis.

This paper also contributes to the large theoretical literature in political economy studying models of voting. Ever since the traditional median voter results (Downs, 1957), the literature has sought to explain the apparent policy divergence observed since the second half of the 20$^{\text{th}}$ century (Fiorina, 1996). Explanations include politically-motivated politicians (Alesina, 1988), strategic motives (Kalai & Kalai, 2001), voter turnout (Glaeser et al., 2005), and, more recently, behavioral biases (Callander & Carbajal, 2022). The seminal paper by Alesina (1988) sparked the wide belief that polarization in preferences translates to platform polarization (see Fiorina, 1996; Hare & Poole, 2014; Levy & Razin, 2015; Polborn & Snyder, 2017, footnote 3). However, this is not necessarily the case. Levy and Razin (2015) show that in the presence of correlation neglect, polarization in opinions can induce lower levels of policy polarization when the electoral system is not too competitive. In this paper, I provide empirical evidence supporting the view that party polarization does not necessarily translate to policy polarization; and develop a mechanism that can explain this phenomenon without behavioral biases. In my case, party moderation takes place because of the need to reach a coalition between agents with polarized preferences.

This paper also contributes to the legislative bargaining literature that originated from Baron and Ferejohn (1989). There are several applications of legislative bargaining in macroeconomic settings. For example, Battaglini and Coate (2007, 2008) develop a model in which legislative bargaining crowds out productive investment in a public good at the expense of pork-barrel spending. Battaglini et al. (2012, 2014) study the provision of irreversible investments in public goods under different legislative bargaining rules. Similarly, Bowen et al. (2014) study the relative efficiency between mandatory and discretionary spending rules in a model with two parties. In modeling terms, Azzimonti et al. (2022) is the closest paper to this one. Relative to this literature, I develop a procedure that bargains over the size of the public good rather than the distribution of a public good with a fixed size.

There is a large political science literature that explores the causes of gridlock in the United States in particular. Legislative gridlock in the United States has been increasing since the last decades of the 20$^{\text{th}}$ century, and this literature has focused on finding the root cause of this phenomenon. The standard partisan explanation is the divided government hypothesis (Fiorina, 1996), whose empirical support has been mixed at best (Mayhew, 1991). Alternative theories also highlight the role of the bicameral system (see Binder, 2004). Scholars have also explored non-partisan explanations for gridlock (Brady & Volden, 2005; Krehbiel, 1996, 1998). In particular, Krehbiel (1996, 1998) highlights that in legislatures that require supermajorities, the key agent ("pivotal player") is not the one that gives a bill a simple majority, but the vote that allows its supporters to stop the filibuster. However, most of these theories focus on institutional features that are very specific to the U.S. setting. Instead, I propose a theory in which gridlock is the product of the interaction between two factors: party polarization and party seat distribution. Some scholars have tested the validity of this theory (Hicks, 2015; Jones, 2001) but to my knowledge, this is the first paper to formalize this argument.

1.2 Empirical Evidence

In this section, I introduce the main results that motivate the model. The analysis focuses on a cross-section of bills proposed at the state level. I first measure the ideological direction of climate change policies using bills proposed in the state legislatures.[9] I then estimate the impact of polarization on the environmental bills proposed in U.S. state legislatures exploiting states' different responses to aggregate trends in polarization.

[9] Locating policy in the left-right axis is common in the political science literature (see Clinton, 2017, for a comprehensive review on the topic).

My findings are the following: First, the effect of polarization on environmental policy depends on the seat distribution of the legislature. Second, polarization moderates the environmental policy proposals by both parties when the seat distribution of the legislature is tight. Third, polarized legislatures are less likely to pass environmental legislation when the seat distribution of the legislature is tight. Fourth, parties reverse legislation when taking over a chamber; and the magnitude of this switch is greater the more extreme the status quo environmental policy is.

1.2.1 Data & Methodology

In order to determine the impact of polarization on climate policy, I need a measure of climate policy. To my knowledge, there is no comprehensive database suited for that purpose.[10] For this reason, I turn to bills proposed in state legislatures related to climate change. In the United States, states take an active role in environmental policy through enforcement (Fredriksson et al., 2011) and through other state-level initiatives (e.g. regional cap-and-trade programs; see Rosenbaum, 2016). However, environmental policy materializes in a series of policies that are not necessarily harmonized across states the same way other policies are (e.g. fiscal policy). Bills provide a unique access to a policy that is not harmonized across states. In addition, exploiting cross-section and time-series variation of environmental policy is a better setup to isolate the effect of polarization on policy from other institutional fac-

[10] The Correlates of State Policy Database (Grossmann et al., 2021) is a notable candidate. However, the time span of the measures included is not complete, and most of the variables refer to other areas of environmental protection (e.g. local pollutants, waste management, etc.).

tors (Besley & Case, 2003).

Climate Change Policy

To obtain a measure of climate policy for states I use data from LegiScan. LegiScan is a nonpartisan organization that provides access to bills proposed in all U.S. state legislatures since 2009. I apply to these bills a procedure called Wordfish, which allows me to extract the ideological component of the documents. Wordfish is an algorithm widely used in political science (see Proksch & Slapin, 2010; Slapin & Proksch, 2008). Briefly, Wordfish assumes the following functional form for the text

$$y_{ij} \sim Poisson(\lambda_{ij})$$
$$\lambda_{ij} = exp(\alpha_i + \psi_j + \beta_j \theta_i)$$

where y_{ij} is the number of times the term j is used in bill i, α_i are document fixed effects, ψ_j are word fixed effects, β_j is the ideological direction of word j and θ_i is the ideological direction of bill i. The parameter λ_{ij} measures the rate at which a term j appears in document i. In Wordfish's specification, this rate can increase for two reasons. First, λ_{ij} can be high if either document fixed effects α_i or word fixed effects ψ_j are high. For example, if the word count of document i is high, the probability that any term j appears will be higher relative to shorter documents. Similarly, in this setup focusing on climate policy, the term "climate" is more likely to appear in documents than the term "immigration". Second, λ_{ij} can be high if the policy positions of document i and term j are aligned. The terms β_j and θ_i indicate the policy loading of words and documents, respectively; positive values indicate a pro-environmental stance, and vice versa for negative values. Consider for example the term "carbon tax", which has a very positive loading. The probability that this term appears is higher in bills that are more environmentally friendly.

The parameter of interest, in this case, is θ_i, the environmental position of a bill. Implicit in the analysis is the assumption that text is determined by the actors' ideological leaning (the so-called ideological dominance assumption; Grimmer & Stewart, 2013). However, there are other sources of variation in word use that can mask ideological positions (Lauderdale & Herzog, 2016). In this case, I want to ensure that the dimension captured by the algorithm is the ideological stance against climate change. For this purpose, I pre-select the bills proposed in the state legislatures to those bills that discuss environmental policy, and apply standard text cleaning procedures.[11] In addition, I select the set of words that are diagnostic of the legislator's political party following Gentzkow and Shapiro (2010).

The results show that Wordfish captures the environmental stance of the bills. Table 1.1 presents the top and bottom-most environmentally-friendly bills proposed in U.S. state legislatures. Among the most pro-environmental bills, we can find symbolic statements recognizing the

[11] I select terms that mentioned at least two of the following terms: *climate change*, *global warming*, *greenhouse gases*, *carbon dioxide*, *fossil fuel*, *energy efficiency*, *renewable energy*, *environmental policy*, *electric grid*, *fossil energy*, *green jobs*, *hydraulic fracturing*, *nuclear energy*, *utility regulation*, *Environmental Protection Agency*, *Clean Air Act* and drop the bills with the lowest relevance, as expressed by LegiScan. These terms are also among the most frequently used in the bills related to "Environmental Protection" proposed in the U.S. Congress since 1981. All bills presented in the U.S. Congress are hand-coded into 32 policy areas.

human impact on climate change (HCR24, 2013) as well as proposals requiring that legislation account for scientific evidence regarding climate change (A4606, 2018). On the other hand, anti-environmental proposals include downwards revisions and delays in the application of energetic standards (HB798, 2019; SB374, 2015).

Figure 1.1 depicts the average environmental policy at the state level between the years 2009 and 2018. Northeastern and Pacific states are the more environmentally friendly both at the extensive and intensive margin. That is, they propose more environmental policies, and the content of these proposals is more environmentally friendly. The least environmentally friendly states can be roughly categorized into two groups: states with a low environmental stance at the intensive margin (e.g. Midwestern states), and states with a low environmental stance at the extensive margin (e.g. Southern states). Figure 1.2 illustrates the environmental position of bills θ per state. The distribution of the ideological positions of the proposals clearly differs depending on the party controlling the legislature. These results at the state level are also consistent with common wisdom and prior evidence (Grumbach, 2018; Kim & Urpelainen, 2017). To confirm in a more rigorous fashion that the dimension captured by Wordfish corresponds to the environmental position of bills, I present two additional validation exercises. In the first one, I show that the environmental position of a particular document is lower for bills sponsored by more conservative legislators. I thus estimate the following equation

$$\theta_{ist} = \beta_0 + \beta_1 Conservativeness_{ist} + f_s + f_t + \varepsilon_{ist} \tag{1.1}$$

Pro-environmental (high θ)			**Anti-environmental (low θ)**		
To recognize that human actions have contributed to he rise in global sea and atmospheric temperatures and the increase in concentration of greenhouse gases, and to declare that Ohio will actively participate in diminishing and minimizing future greenhouse gas emissions.	OH	2013	Delays certain provisions [...]; revises the energy law.	OH	2016
Requires State to use 20-year time horizon and most recent Intergovernmental Panel on Climate Change Assessment Report when calculating global warming potential to measure global warming impact of greenhouse gases.	NJ	2018	Revises provisions relating to energy.	NV	2015

Table 1.1: Bills proposed in U.S. state legislatures with the highest and lowest θ_i according to Wordfish.

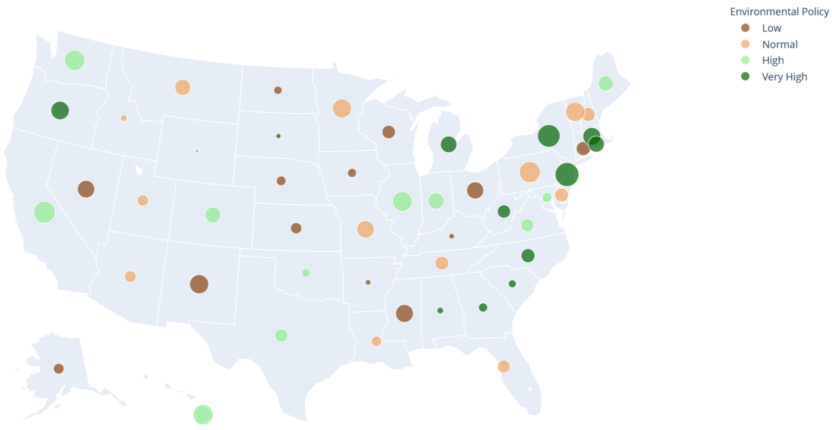

Figure 1.1: Environmental policy as denoted by mean θ by state. Size of the dot denotes the amount of environmental bills proposed.

where θ_{ist} is the environmental stance of bill i, $Conservativeness_{ist}$ is a continuous variable measuring how conservative are the sponsors of bill i and f_s, f_t are state and year fixed effects, respectively. $Conservativeness$ is constructed by averaging the ideal policy estimates of the sponsors of bill i.[12] Table 1.2 presents the results of estimating eq. (1.1). The negative and significant value of coefficient β_1 indicates that more conservative sponsors are linked to bills with a lower environmental stance. Second, I show that the environmental position of bills is higher in states in which the House of Representatives is controlled by the Democratic party. In this case, I estimate

$$\theta_{ist} = \beta_0 + \beta_1 D_{st} + f_s + f_t + \varepsilon_{ist} \tag{1.2}$$

where D_{st} is a dummy equal to one if the chamber is controlled by the

[12]The estimates by Shor and McCarty (2011) label positions greater (lower) than zero as conservative (liberal).

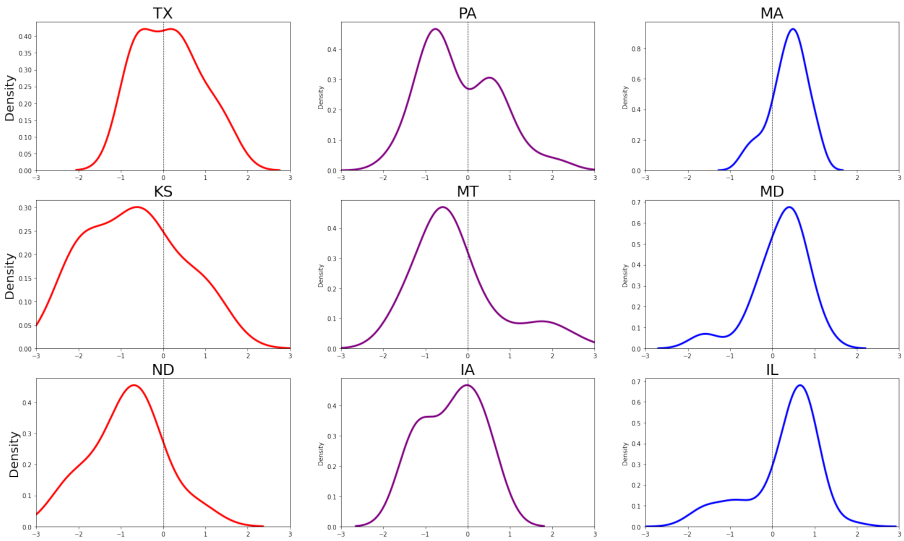

Figure 1.2: Density of policy proposals’ θ for selected states. The color indicates whether the lower house was controlled by the Republicans (left columns), the Democrats (right columns), or by both parties (center columns) in the period 2009 - 2018.

Democratic party. Table 1.3 presents the results of estimating eq. (1.2). Similarly, the positive and significant value of coefficient β_1 indicates that chambers controlled by the Democratic Party propose bills that are more environmentally friendly.

Polarization Data

The data for polarization comes from Shor and McCarty (2011). The political science literature has a tradition of estimating politicians’ ideal points using roll call data (Poole & Rosenthal, 2000). Intuitively, the procedure of these models is the following. Consider a chamber with only one legislator i voting on R roll calls. Let $x_i \in (-1, 1)$ be legis-

	(1) Environmental	(2) Environmental	(3) Environmental
Sponsor Conservativeness	-0.136**	-0.106***	-0.0968**
	(0.057)	(0.038)	(0.038)
Constant	4.653		
	(3.923)		
N	1090	1089	1089
State FE	No	Yes	Yes
Year FE	No	No	Yes
Adjusted R2	0.266	0.378	0.382

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.2: Results of estimating eq. (1.1) by OLS.

	(1) Environmental	(2) Environmental	(3) Environmental
Democratic House	0.303***	0.380**	0.274*
	(0.101)	(0.149)	(0.142)
Constant	3.921		
	(3.592)		
N	1337	1336	1336
State FE	No	Yes	Yes
Year FE	No	No	Yes
Adjusted R2	0.264	0.367	0.368

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.3: Results of estimating eq. (1.2) by OLS.

lator i's coordinate on a unique ideological dimension. The points z_{rY} and z_{rN} are the outcome coordinates of voting Y or N, respectively, on a roll call r. The model uses the random utility framework to determine a legislator's choices. That is, legislator i will vote Y with probability

$$Pr(U_{irY} > U_{irN}) = Pr(\varepsilon_{irN} - \varepsilon_{irY} < u_{irY} - u_{irN})$$

where the deterministic part of the utility, u, depends on some distance between the ideal point of the legislator, x_i, and the outcome of the roll call, z_{rY}, z_{rN}.

Different procedures are characterized by particular assumptions on both the deterministic and stochastic terms of the utility. Suppose error terms are normally distributed and $u_{iY} = (x_i - z_{rY})^2$. Then legislator i will vote Y with probability $\Phi\left(\beta_0 + \beta_1 x_i\right)$, where β_0, β_1 are both a function of z_{rY}, z_{rN}. The likelihood of the model is given by

$$L = \left[\Phi\left(\beta_0 + \beta_1 x_i\right)^{C_{irY}} \left(1 - \Phi\left(\beta_0 + \beta_1 x_i\right)\right)^{C_{irN}}\right]$$

where $C_{irY} = 1$ if i votes Y on roll call r. Given this structure, the parameters of the model can be recovered from the roll call data using an iterative procedure. Shor and McCarty (2011) apply a similar methodology to state legislators.[13]

[13] The dynamic component of Poole and Rosenthal (2000)'s DW-NOMINATE measure relies on legislators that served several legislatures. These legislators are used to "glue" different Congresses, in order to allow for comparison between the scores of congress members that did not serve together. A similar procedure is not possible for state legislators at the cross-sectional level. Shor and McCarty (2011) use a procedure based on standardized surveys as a way to "glue" different states.

Figure 1.3 illustrates the ideological estimates from Shor and McCarty (2011) for the legislatures of Washington State and Rhode Island, two states known for being among the most and least polarized in the U.S., respectively. Legislators in the two states are clearly divided along party lines. However, there are some key differences. For example, while the clusters of legislators are very close in ideological terms in Rhode Island, there is a substantial gap in the Washington legislature. In fact, an extreme legislator in the Rhode Island legislature from either party would be considered a moderate in Washington. The usual measure of

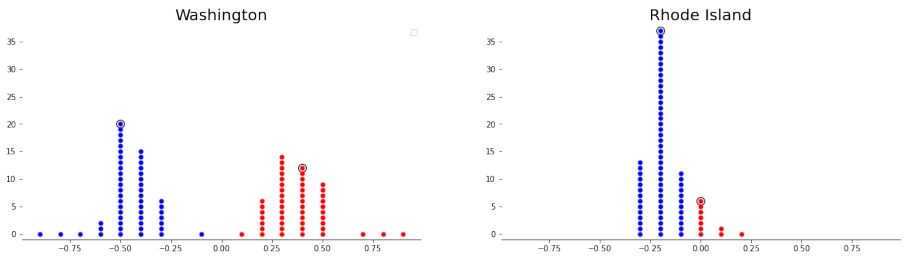

Figure 1.3: Distribution of ideological estimates in the 2017 legislatures. The marker indicates the party median. Blue (red) indicates Democratic (Republican) legislators.

polarization is the difference between the estimate of the median Democratic and Republican legislators in each chamber (the circled points in Figure 1.3). In Section 1.2.2, I will focus on this measure of polarization. However, the results are also robust to alternative party-free measures of disagreement. These include the standard deviation and the coefficient of variation of all estimates, and the average distance between all estimates. Polarization data at the state level is available for all legislatures from 1993 to 2018.

1.2.2 Results

To measure the impact of polarization on environmental policy proposals, I estimate the following equation

$$\begin{aligned}\theta_{ist} = \beta_0 + \beta_1 D_{st} + \beta_2 Polarization_{st} \\ + \beta_3 Polarization_{st} \times D_{st} \\ + \boldsymbol{\gamma X} + f_s + f_t + \varepsilon_{ist}\end{aligned} \tag{1.3}$$

The dependent variable θ_{ist} is the environmental stance of a bill i proposed in state s in year t obtained using Wordfish. The main explanatory variables are the measure of polarization, and D_{st}, a dummy equal to one if a chamber (either the House/Assembly or the Senate) in state s is controlled by the Democrats.[14] To show the importance of the interaction between polarization and seat distribution, I will use two different explanatory variables. First, the polarization estimates of Shor and McCarty (2011). Second, the interaction of this measure with a dummy equal to one when the seat distribution between the two parties is tight, i.e.

$$Margin_{st} = 1 \text{ if } \frac{|DemSeats_{st} - RepSeats_{st}|}{TotalSeats_s} < k \text{ for } k \in [0, 1]$$

where $Margin_{st}$ is normalized with respect to chamber size. In what follows, I will set $k = 5\%$ as a benchmark. However, the results are robust to variations in the threshold, and to a continuous equivalent.

The vector $\boldsymbol{X}$ includes a series of control variables (see Table 1.4) rang-

[14] In what follows, I use the state's House of Representatives (or equivalent) as the benchmark. Results are similar using the Senate (see Section 1.B).

Bill	**Legislature**	**Economic & Demographic**
Mismatch	# of bills proposed	Per capita GDP
Resolution	# of bills accepted	Industry composition
Length	Party of the governor	Population
	Trifecta	# of environmental programs

Table 1.4: List of the controls included in vector $\boldsymbol{X}$.

ing from bill characteristics (length, type) and legislature characteristics (party of the governor, legislative production) to state characteristics (population, industrial composition). Finally, f_s and f_t are state and year fixed effects, respectively.

Fact 1: The effect of polarization on environmental policy depends on the seat distribution of the legislature. Overall, Democratic chambers propose more environmentally friendly legislation, as indicated by the coefficient β_2 greater than zero and significant. The coefficient of interest is β_3, that is, the impact of an increase in polarization in a Democratic-controlled chamber. Table 1.5 shows the results of estimating eq. (1.3). The first two columns use only Shor and McCarty (2011)'s measure of polarization. In this specification, β_3 is not significant and is close to zero. One would be tempted to conclude that polarization has no effect on policy. However, measures of ideological distance like the ones computed by Shor and McCarty (2011) cannot explain by themselves movements in the environmental stance of a legislature. The reason is simple. Policy in a legislature in which the two main parties are very polarized is not necessarily going to be affected. Consider for instance the case of California. According to Shor and McCarty (2011), the legislature of California is the most polarized one across all U.S. States. However, if the majority party has a wide margin consistently through the years (as is the case in California), the ideological gap between the Republicans and Democrats will not have an effect on policy. This fact is consistent with previous evidence highlighting the role of seat distribution in legislative bargaining (Hicks, 2015; Jones, 2001).

Fact 2: Polarization moderates the environmental policy proposals of both parties when seat distribution is tight. The last four columns of Table 1.5 include the interaction with the dummy indicating whether the chamber is controlled by a narrow margin. When including state and time fixed effects, the main coefficient of interest β_4 is negative and significant. That is, in chambers controlled by the Democratic Party by a small margin, more polarization is linked to a lower environmental stance of the bills proposed. In terms of magnitudes, the results imply that increasing polarization in a narrowly controlled chamber from a Rhode Island level (the least polarized state) to the level of California (the most polarized) is linked to a reduction of the environmental stance of policy of half a standard deviation. Despite these results, the coefficient β_2 is still positive, such that the overall effect of a chamber controlled by the Democratic Party on environmental policy is still positive, consistent with common wisdom and prior evidence (Grumbach, 2018; Kim & Urpelainen, 2017).

This fact puts in perspective median voter type of results by highlighting the importance of seat distribution. In the presence of a supermajority, agreement with the other party is not necessary. Policy convergence will arise when there is sufficient competition within the chamber. This fact also resonates with the results from Polborn and Snyder (2017) that policy divergence between parties arises when uncertainty about election outcomes is low. The model presented here features no uncertainty, but focuses instead on competition after the election.

The significance of these results occurs despite the fact that there are states that never switched parties between 2009 and 2018. For these states, the variable D_{st} and state fixed effects will be completely correlated. These states constitute half of the states (see Figure 1.4) and around half of the observations. This loss of observations can explain the increase in standard errors.

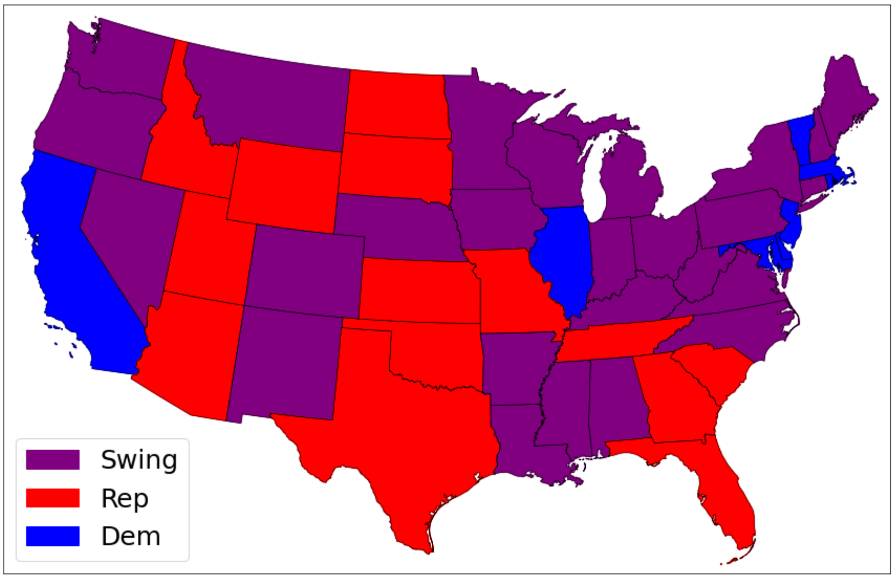

Figure 1.4: Party controlling the House (or equivalent) in each state during the period 2009 - 2018. Not shown: Alaska (Swing), and Hawaii (Dem).

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental	(5) Environmental	(6) Environmental
Democratic House	0.303*	0.209	0.280*	0.186	0.195	0.213
	(0.154)	(0.151)	(0.151)	(0.153)	(0.151)	(0.152)
Polarization (Hou)	-0.117	-0.0957	-0.0826	-0.0772	0.00469	-0.378
	(0.340)	(0.322)	(0.360)	(0.332)	(0.396)	(0.378)
Democratic House × Polarization (Hou)	-0.107	-0.128	-0.0487	-0.0331	0.0522	-0.169
	(0.190)	(0.172)	(0.228)	(0.207)	(0.226)	(0.263)
Democratic House × Margin <5% × Polarization (Hou)			-0.191*	-0.215*	-0.225**	-0.370*
			(0.111)	(0.111)	(0.109)	(0.219)
N	1267	1267	1267	1267	1268	855
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	Yes
Sharp RDD	No	No	No	No	No	Yes
Method	OLS	OLS	OLS	OLS	2SLS	2SLS
Adjusted R2	0.368	0.368	0.368	0.368		

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.5: Results of estimating eq. (1.3) by OLS.

To measure the impact of polarization on the probability of passing environmental law, I estimate the following equation

$$\begin{aligned} Enacted_{ist} = \beta_0 + \beta_1 Polarization_{st} + \beta_2 Margin_{st} \\ + \beta_3 Polarization_{st} \times Margin_{st} \\ + \beta_4 D_{st} + \boldsymbol{\gamma X} + f_s + f_t + \varepsilon_{ist} \end{aligned} \tag{1.4}$$

where $Enacted_{ist}$ is a dummy indicating whether a bill was enacted into a law.

Fact 3: Polarized legislatures are less likely to pass environmental legislation when seat distribution between both parties is tight. Table 1.6 presents the results of estimating eq. (1.4). Overall, Democratic chambers are more likely to pass environmental legislation, as indicated by the coefficient β_1 greater than zero and significant. However, in chambers controlled by a narrow margin, the probability of enacting an environmental bill is reduced. In terms of magnitude, these results imply that losing a supermajority in the average state in terms of polarization is linked to a 15% reduction in the probability of passing environmental legislation.[15] Ideological distance by itself does not seem to be related to the probability of enacting a bill. The results are qualitatively similar when estimating by logit and probit instead (see Section 1.2.3).

[15] In the average state, polarization takes a value of 1.5.

	(1)	(2)	(3)	(4)	(5)	(6)
	Enacted	Enacted	Enacted	Enacted	Enacted	Enacted
Democratic House	0.0647	0.0617	0.0407	0.0376	0.0325	-0.0135
	(0.076)	(0.078)	(0.065)	(0.071)	(0.071)	(0.096)
Polarization (Hou)	-0.0181	0.0214	-0.00138	0.0243	0.0410	-0.115
	(0.102)	(0.114)	(0.103)	(0.113)	(0.161)	(0.180)
Margin <5%			-0.115***	-0.101***	-0.109***	-0.105
			(0.031)	(0.034)	(0.037)	(0.064)
Margin <5% × Polarization (Hou)			-0.0542**	-0.0452	-0.0134	-0.137**
			(0.025)	(0.032)	(0.031)	(0.054)
N	1267	1267	1267	1267	1268	855
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	Yes
Sharp RDD	No	No	No	No	No	Yes
Method	OLS	OLS	OLS	OLS	2SLS	2SLS
Adjusted R2	0.156	0.163	0.160	0.165		

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.6: Results of estimating eq. (1.4) by OLS.

The result that polarization is linked to lower legislative productivity is not surprising (Lee, 2015). Although environmental policy was seen as a bipartisan issue during the 60s and the 70s, it soon became a very polarizing topic (Rosenbaum, 2016). According to Klyza and Sousa (2008), pretenses of bipartisanship on the environment were abandoned around the 104$^{\text{th}}$ Congress.

However, environmental policy is not necessarily characterized by policy gridlock and moderation only. The results from Table 1.5 establish that environmental policy in chambers controlled by a narrow margin is tempered by polarization. Yet, policy switches could also arise from changes in the control of the legislature.

To measure the impact on bill proposals of changes in the majority party controlling the chamber, I estimate the following equation

$$\begin{aligned}\theta_{ist} = \beta_0 &+ \beta_1 LegisTakeOver_{st} + \beta_2 Polarization_{st} \\ &+ \beta_3 LegisTakeOver_{st} \times Polarization_{st} \\ &+ \beta_4 LegisTakeOver_{st} \times Polarization_{st} \times EnvironmentalAvg_{st-1} \\ &+ \boldsymbol{\gamma X} + f_s + f_t + \varepsilon_{ist}\end{aligned} \tag{1.5}$$

where $LegisTakeOver_{st}$ is a dummy equal to one for chambers that switch from a Democratic to a Republican majority (or vice versa) in state s relative to $t-1$, and $EnvironmentalAvg_{st-1}$ is the average environmental stance of bills proposed in the previous legislature. That is, $\bar{\theta}_{st-1} \equiv \sum_i \frac{\theta_{ist-1}}{N_i}$.

Fact 4: Parties reverse legislation when taking over a chamber. The magnitude of the change is greater the more extreme is the status quo environmental policy. Tables 1.7 and 1.8 present the estimates of this model for Republican and Democratic takeovers, respectively. From the first three columns, it follows that the takeover of a chamber by the Republican Party is linked to a decrease in the environmental policy stance of the legislature, as indicated by $\beta_1, \beta_3 < 0$ (but not significant). Including the status quo policy left by the Democratic Party in the previous legislature strengthens this result, both in terms of magnitude and significance. Consider a chamber taken over by the Republican Party with a status quo policy equivalent to the average Democratic state ($\bar{\theta}_{st-1} \approx 0.2$). In this case, increasing polarization from a Rhode Island level to a California level is linked to a reduction of the environmental stance of policy by one-fourth of a standard deviation. The opposite results are true for chambers taken over by the Democratic Party. This fact is consistent with the result theories of lawmaking that focus on the pivotal player (Krehbiel, 1996, 1998) and with models of dynamic legislative bargaining (Eraslan et al., 2022), according to which gridlock is crucially dependent on the status quo policy.

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental	(5) Environmental	(6) Environmental
Republican Take Over	-0.158	-0.173	-0.0796	-0.0850	-0.0754	0.127
	(0.098)	(0.121)	(0.108)	(0.128)	(0.125)	(0.150)
Polarization (Hou)	-0.162	-0.153	-0.234	-0.159	0.180	0.225
	(0.281)	(0.278)	(0.357)	(0.364)	(0.458)	(0.338)
Republican Take Over × Polarization (Hou)	-0.0564	-0.0269	-0.245	-0.266*	-0.256*	-0.414***
	(0.132)	(0.133)	(0.150)	(0.155)	(0.142)	(0.113)
Republican Take Over × Polarization (Hou) × EnvironmentalAvg			-0.423***	-0.410**	-0.401***	-0.737***
			(0.156)	(0.162)	(0.155)	(0.224)
N	1267	1267	893	893	893	556
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	Yes
Sharp RDD	No	No	No	No	No	Yes
Method	OLS	OLS	OLS	OLS	2SLS	2SLS
Adjusted R2	0.366	0.368	0.386	0.385		

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.7: Results of estimating eq. (1.5) by OLS for chambers taken over by the Republican Party.

	(1)	(2)	(3)	(4)	(5)	(6)
	Environmental	Environmental	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.238*	0.185	-0.0345	0.0512	0.0795	0.215
	(0.120)	(0.121)	(0.136)	(0.139)	(0.136)	(0.366)
Polarization (Hou)	-0.203	-0.170	-0.214	-0.0735	0.481	-0.0547
	(0.281)	(0.270)	(0.441)	(0.448)	(0.562)	(0.558)
Democratic Take Over × Polarization (Hou)	0.130	0.0797	0.330**	0.286*	0.252*	-0.124
	(0.111)	(0.113)	(0.145)	(0.153)	(0.142)	(0.306)
Democratic Take Over × Polarization (Hou) × EnvironmentalAvg			-0.0985	-0.135	-0.159	-0.321
			(0.114)	(0.106)	(0.106)	(0.265)
N	1267	1267	893	893	893	556
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	Yes
Sharp RDD	No	No	No	No	No	Yes
Method	OLS	OLS	OLS	OLS	2SLS	2SLS
Adjusted R2	0.367	0.368	0.384	0.382		

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.8: Results of estimating eq. (1.5) by OLS for chambers taken over by the Democratic Party.

1.2.3 Identification and Robustness

An important challenge to identifying the effect of polarization is the potential endogeneity since environmental policy is notoriously ideological. In addition, the identity of the party controlling a chamber is also potentially endogenous to environmental policy. To this effect, I estimate again eqs. (1.3) to (1.5) employing an identification strategy that combines the fixed effect instrumental variable (FE-IV) approach from Murtazashvili and Wooldridge (2008) to control for polarization and the "sharp" RDD developed by Fredriksson et al. (2011) to control for the identity of the majority party. The results of this estimation are presented in the last two columns of Tables 1.5 to 1.7. Both in terms of magnitude and significance, the results presented in Section 1.2.2 are strengthened by applying this procedure.

The application of the FE-IV approach (Murtazashvili & Wooldridge, 2008) in this setup follows from the observation that states are affected differently by trends of polarization in the U.S. Congress. This approach consists in instrumenting for polarization at the state level using polarization in the U.S. Congress interacted with a state dummy (see Nakamura & Steinsson, 2014). Consider the reduced model $\theta_{ist} = \beta Pol_{st} + \varepsilon_{ist}$ where Pol_{st} is our potentially endogenous independent variable, and the instrument $z_{st} = f_s Pol_t$, where Pol_t denotes polarization in the U.S. Congress. In this setup, the moment conditions necessary for identification are

$$\mathbb{E}\left(f_s Pol_t \varepsilon_{ist}\right) = 0 \, \forall \, t$$

That is, a state’s sensitivity to polarization in the U.S. Congress is exogenous to the unobserved factors affecting the environmental stance of a bill.

The sharp RDD method exploits the fact that the election outcome is a deterministic function of vote margin,

$$D_{st} = \mathbb{1}(m_{st} > 0)$$

where m_{st} is the vote margin. In eqs. (1.3) and (1.4) we might have that the moment condition with respect to D_{st} might not be satisfied, i.e. $\mathbb{E}\left[\varepsilon_{ist} \mid D_{st}\right] \neq 0$. However, conditional on the vote margin,

$$\mathbb{E}\left[\varepsilon_{ist} \mid D_{st}, m_{st}\right] = \mathbb{E}\left[\varepsilon_{ist} \mid m_{st}\right] = f(m_{st}) \tag{1.6}$$

Explicitly controlling for the function $f(m_{st})$ in the regression takes care of the endogeneity of D_{st}. I follow Fredriksson et al. (2011) in approximating f with polynomials of the fourth order.

One key difference with the approach employed in Fredriksson et al. (2011), is that the majority party of a legislature depends on the distribution of seats between both parties, which are decided at the district level. Therefore, I use instead the average vote margin at the district level. That is, for every state I calculate

$$m_{st} \equiv \sum_{d} \frac{1}{N_d} MoV_{dst}$$

where MoV_{dst} is the margin of votes of the Democratic party in a district d in state s, and N_d is the number of districts in state s. The district-level results of the legislative elections are available in Klarner (2018)'s State Legislative Election Returns dataset.

It is key for eq. (1.6) to hold that there is no strategic voting. This assumption could be violated in chambers that are renovated in a staggered process, and I therefore exclude them. I also exclude legislatures in which elections are not conducted using a winner-takes-it-all system (see Ballotpedia, n.d.).

The last two columns of Tables 1.5 to 1.7 present the estimates of eqs. (1.3) to (1.5) instrumented and controlling for the margin of vote. The results from the IV regression are qualitatively similar to those of Section 1.2.2. The coefficient of the preferred specification with state and year fixed effects is still negative and significant. In addition, when controlling for the margin of vote, the effect of polarization on the policy stance of legislatures controlled by the Democrats is stronger.

In addition, the results are robust to a series of alternative specifications. First, I restrict the sample to competitive bills. That is, bills that satisfy two conditions: (i) they have at least one roll call recorded; and (ii) the margin of votes of these roll calls is below a threshold (e.g. $\pm 50\%$). The idea under this pseudo-RDD approach is that bills that have been approved or rejected by a small margin are comparable, regardless of the majority party. This procedure excludes from the analysis bills proposed by strategic motives, meant to be approved or rejected with an almost 100% chance. Tables 1.11, 1.13 and 1.14 present these results.

In Section 1.B.3, I also restrict the sample to bills proposed in states in which the control of the legislature changes hands at least once in the period covered by the data (see Figure 1.4). In Section 1.B.4, I restrict the sample to bills proposed by the majority party. In Section 1.B.5, I include in the regression the interaction terms that were not included in the main regressions because of potential colinearity between $Polarization_{st}$ and D_{st}.

Finally, in Sections 1.B.6 to 1.B.11 I rerun the analysis using different party-free measures of polarization, and the equivalent measures of the state Senates. These party-free measures of polarization are (i) the average distance between the ideal points of any two members of a chamber; (ii) the standard deviation of legislators' ideal points; and (iii) the coefficient of variation of legislators' ideal points. The three of them are either available or easily constructed from Shor and McCarty (2011)'s data. Results in these specifications are both qualitatively and quantitatively similar.

1.3 Theoretical Model

In this section, I develop a simple model of the legislature that can explain the facts of Section 1.2 and highlight the importance of accounting for the degree of control of a legislature when considering the impact of polarization on policy. The inclusion of a second dimension (i.e. margin of control) is crucial for polarization to have a dual effect on policy. That is, polarization can either lead to policy extremism, or it can generate gridlock. I then embed this mechanism into a simplified version of the Integrated Assessment Model (IAM) developed by Golosov et al. (2014) and show the potential that polarization can have on long-run growth.[16]

The model has two sub-periods: a political stage and a production stage. The economy is populated by a continuum of economically identical agents. Agents in this model consume a final good and provide labor inelastically. The final good can be produced with two inputs, a clean and a dirty one. Production of both inputs requires labor. Production of the dirty energy input generates emissions. Damages from emissions materialize in the form of productivity losses.

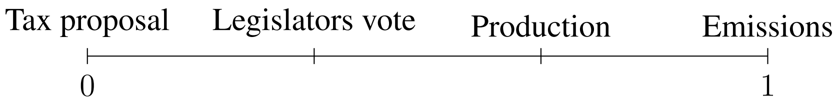

Figure 1.5: Timing of the model.

Before production takes place, the government can impose a tax on the production of energy inputs. This tax is effectively a transfer between the two energy sectors, and represents the concession of political favors. The tax has a distortinary effect, but at the same time can be used to address the climate externality. The governing body of this economy is a legislature, modeled in the spirit of the bargaining model of Baron and Ferejohn (1989). The legislature is constituted by a subset of agents.

[16]Integrated Assessment Models is an umbrella term that refers to models that study the feedback between economic production and climate change. The principal frameworks include the DICE (Nordhaus, 2018), the PAGE (Yumashev et al., 2019) and the FUND (Waldhoff et al., 2014) models.

Once in the legislature, agents receive political pressure to favor either energy sector (following Grossman & Helpman, 1995). Legislators are heterogeneous in the degree they are affected by political pressures. The tax schedule is determined by the legislators in a one-round bargaining process. Figure 1.5 presents the timing of the model.

1.3.1 The Economic Setup

In this section, I present a simplified version of the IAM developed by Golosov et al. (2014) to which I will embed a political process. The economy is populated by a representative household that maximizes the following utility function $U(C)$ where U is a standard concave utility function and, C is consumption.

Production of the final good is described by the following aggregate production function

$$Y = e^{-\gamma(S-\bar{S})}AE \tag{1.7}$$

where $S - \bar{S}$ denotes the excess of emissions with respect to a baseline level $\bar{S}$, the coefficient γ scales the impact on productivity of excess emissions, A denotes the usual productivity shifter and E is the amount of energy used in production.

Aggregate productivity is the product of two components, an exogenous and an endogenous one. The productivity shifter A is exogenous. The term $e^{-\gamma(S-\bar{S})}$ is endogenous, and denotes climate damages. Productiviy losses follow from excess emissions of carbon, S, with respect to its pre-industrial stock, $\bar{S}$. Damages are scaled by the parameter γ. The inclusion of climate damages into the production function is the basis of all IAMs. It is a reduced-form approximation to the idea that increases in the stock of CO_2 emissions have a negative impact on productivity, a fact long established by the climate-economy literature (Dell et al., 2014; Waldinger, 2022). This expression in particular bypasses the carbon cycle present in climate models (Rosenbaum, 2016).[17] The total energy is aggregated from two energy sources

$$E = \left(E_d^{\frac{\varepsilon-1}{\varepsilon}} + E_c^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{1.8}$$

where E_c, E_d are the product of the clean and the dirty energy sectors, respectively. The parameter $\varepsilon \in (0, \infty)$ determines the elasticity of substitution between the two energy sources.

In this model, contribution to the stock of emissions in the atmosphere is driven only by production in the dirty sector

$$S - \bar{S} = \rho E_d \tag{1.9}$$

where $\rho \in [0, 1]$. The term ρ denotes the amount of carbon that stays in the atmosphere. I follow Golosov et al. (2014) in using

$$\rho = \phi_L + (1 - \phi_L)\phi_0$$

where ϕ_L denotes the share of emissions that will stay permanently in the atmosphere, and $(1 - \phi_L)\phi_0$ the share of emissions that will exit the

[17]In its most reduced form, carbon progressively abandons the atmosphere and flows towards the reservoirs in the ocean (see Hassler & Krusell, 2018, p. 365), with the latter progressively absorbing the stock of carbon in the atmosphere.

atmosphere in one period. Note the delay in the impact of emissions on output. The production technology of the energy sectors is given by

$$E_i = N_i^{\alpha} \text{ for } i = \{c, d\} \tag{1.10}$$

where N_c and N_d denote the amount of labor allocated to each sector, and $\alpha \in (0, 1)$. Production in the energy sectors exhibit decreasing returns to scale. Positive profits are an essential ingredient for the political bloc. In what follows, I normalize the amount of labor to one

$$N_c + N_d = 1 \tag{1.11}$$

Finally, the budget constraint of the economy is given by

$$C = w + \Pi_Y + \Pi_d + \Pi_c + T \tag{1.12}$$

where Π_Y, Π_d, Π_c denote profits from the final good, the dirty, and the clean sector, respectively; and T denotes transfers from the government. The price of the final good is normalized to 1, resulting in the following relation

$$\left[p_d^{1-\varepsilon} + p_c^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} = 1 \tag{1.13}$$

1.3.2 The Political Game

In this section, I develop a simple model of the legislature that accounts for the margin of control of the chamber. The legislative bargaining process described here will determine how the tax of the production stage is set. The legislature consists of a measure one of legislators. Legislators can belong to one of two parties, $\{D, R\}$, which are heterogeneous in their preferences. The role of the legislature is to decide the tax level for the following periods.

The tax level is decided in a two-step bargaining game (Baron & Ferejohn, 1989). First, an agenda-setter offers a proposal to the rest of legislators. Legislators can then approve or reject the proposal. If the proposal is approved, the tax level is implemented and the economy moves to the production stage. If the proposal is rejected, the economy moves to the production stage with the status quo tax level.

Legislators have preferences based on Grossman and Helpman (1995). Each legislator cares for the representative agents, but also has vested interests in the energy sectors. In particular, I assume the following preferences for legislators

$$V(\tau, \bar{S}, \omega_\ell) \equiv U(C) + \omega_\ell \Pi_d + (1 - \omega_\ell)\Pi_c \tag{1.14}$$

with $\omega_\ell \in [0, 1]$. The term ω_ℓ denotes the relative weight of the dirty sector in the legislator's ℓ political motives.[18] Two remarks regarding legislators' preferences are on point. First, this functional form is consistent with legislators caring about the representative agent while at the same time facing political pressures to cater to the energy sectors. This interpretation implicitly assumes that legislators are drawn from the pool of representative agents. Second, this assumption is not the only one that

[18]Grossman and Helpman (1995) posit that the government's preferences take the form $\sum_{i \in L} C_i + aW$ where the first term is the contribution of lobbies and the second represent weighted welfare. The preferences eq. (1.14) correspond to the special case in which $a = 1$, $C_d = \omega_\ell \Pi_d$ and $C_c = (1 - \omega_\ell)\Pi_c$.

can generate the results presented in this section. For example, assuming that parties represent agents with different discount factors could achieve similar results in a dynamic version of the model. However, the preferences presented here are more empirically relevant.[19]

Legislators are heterogeneous in their political motives both between and within parties. Their relative weight is drawn from the following distribution

$$\omega_\ell \sim \begin{cases} Beta\,(k, \psi_D) \text{ for } \ell \leq \mu \\ Beta\,(\psi_R, k) \text{ for } \ell > \mu \end{cases} \tag{1.15}$$

where $\mu \in [0, 1]$ denotes the fraction of legislators affiliated to party D, the parameters $\psi_D, \psi_R > 0$ affect the shape of polarization between the two parties and $k > 0$ is a constant term. For now, I will assume that μ follows an exogenous process. This assumption does not necessarily state that the control over a legislature is random, but rather that it is independent of environmental policy.[20] The choice of beta-distributed ideal points, ω_ℓ is natural in this context, as it is bounded between $[0, 1]$.

The agenda-setter is selected from the pool of legislators in the majority party.[21] I abstract from uncertainty and assume that the agenda-setter

[19]For instance, contribution from environmental groups to Democratic congressional candidates has systematically surpassed that of Republican candidates (Rosenbaum, 2016, fig. 2.2). On the other hand, there is no evidence or a priori reason to think that discount factors differ between voters of both parties.

[20]In the political economy literature, environmental issues are usually considered secondary (Bouton et al., 2021; List & Sturm, 2006). In addition, climate change does not rank as a top priority for U.S. voters (Gallup, 2022; Pew, 2022).

[21]There is a general consensus in the political science literature that the majority

from each party corresponds to the average legislator. That is,

$$\omega_{AD} = \frac{k}{k + \psi_D} \qquad\qquad \omega_{AR} = \frac{\psi_R}{k + \psi_R} \tag{1.16}$$

where ω_{AD}, ω_{AR} denotes the agenda-setter of party D and R, respectively. Setting the parameter $k^2 < \psi_D \psi_R$ ensures that the average R legislator caters more to the pressures of the dirty sector compared to the average D legislator, i.e. $\omega_{AD} < \omega_{AR}$. In this setup, an increase in the parameters ψ_D, ψ_R corresponds to an increase in party polarization (see Figure 1.6).[22]

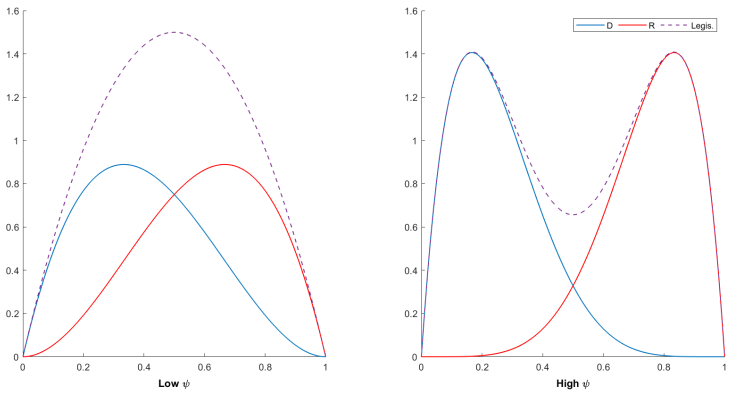

Figure 1.6: Distribution of the ideal points ω_ℓ for D legislators (blue line), R legislators (red line), and for the legislature (dashed line) for the parameter values $\psi_D = \psi_R = 3$ (left panel), $\psi_D = \psi_R = 6$ (right panel), $k = 2$ and $\mu = 0.5$.

party has a prominent role in controlling the agenda of the U.S. Congress (Cox & McCubbins, 2005).

[22]Note that ω_{AD} is decreasing in ψ_D, and ω_{AR} is increasing in ψ_R. Therefore, an increase in either ψ_D, ψ_R increases the distance between the mean of both parties' ideal points.

1.3.3 Equilibrium

The equilibrium can be characterized in two steps. First, we can solve for the equilibrium of production. The political stage can then be solved using the solution of the second stage as input.

Production Stage

The representative firm in the final good sector solves the following problem

$$\max_{E_c,E_d} Y - \sum_{i=c,d} p_i E_i$$

subject to eqs. (1.8) to (1.13). Maximization yields two first-order conditions for the price of each energy input

$$p_i = \left(\frac{Y}{E_i}\right)^{\frac{1}{\varepsilon}} \text{ for } i = \{c, d\} \tag{1.17}$$

Taking the ratio between both expressions, we obtain the relative prices of inputs

$$\frac{p_d}{p_c} = \left(\frac{E_c}{E_d}\right)^{\frac{1}{\varepsilon}} \tag{1.18}$$

That is, the relative prices of the energy inputs are inversely proportional to the relative supply of energy. The intensity of this relationship is determined by the elasticity of substitution between the inputs, ε. Similarly, the representative firms in the two energy sectors face the following problem

$$\max_{N_i} p_i(1-\tau_i)N_i^{\alpha} - wN_i$$

where τ_i is a value-added tax charged to the energy producers, and w denotes wages. In what follows, I will focus on the symmetric case $\tau_d = \tau \in (-1, 1)$ and $\tau_c = -\tau$. That is, politicians influence the energy sector by transferring resources from one input sector to the other. The first-order conditions of this problem give the demand for labor

$$N_i = \left[\frac{\alpha(1 \pm \tau)p_i}{w}\right]^{\frac{1}{1-\alpha}}$$

Taking the ratio between the labor demand of the two sectors gives the relative demand of labor

$$\frac{N_d}{N_c} = \left[\frac{(1-\tau)}{(1+\tau)}\frac{p_d}{p_c}\right]^{\frac{1}{1-\alpha}} \tag{1.19}$$

That is, relative labor demand is proportional to relative prices. Compared to the *laissez-faire* case, the equilibrium allocation of labor is distorted whenever the government sets any tax different from zero.

The effect of policy on consumption in this model is twofold. Unsurprisingly, taxation has a distortionary effect on the labor market decisions of firms, which extends downstream to the final good sector. Note that in the decentralized equilibrium, agents do not internalize the damage that production of the dirty input cause on output through eq. (1.9). Therefore, an increase in clean energy is not privately optimal. Further allowing the model to exhibit endogenous growth would extend this logic to the growth rate of the economy.[23]

[23]For example, allowing productivity in sectors $i = \{c, d\}$ to follow a process $A_{i,t+1} = G(A_{it}, N_{it})$ where G is differentiable, convex function increasing in both arguments.

On the other hand, the presence of a tax can help correct the climate externality given by eq. (1.9). It can be easily shown that, in this setup, the externality damage (i.e. the social cost of carbon) can be expressed as follows (see Golosov et al., 2014)

$$SCC \equiv \rho\gamma Y \tag{1.20}$$

which is strictly greater than zero. The social cost of carbon is proportional to output and increasing in two key parameters of the model: (i) the amount of carbon emitted that stays in the atmosphere; and (ii) the degree to which excess emissions impact output. A social planner could easily reach the social optimum by setting $\tau_d = \frac{SCC}{p_d}$ and $\tau_c = 0$ (see Golosov et al., 2014, p. 57). For sufficiently small values of either parameter (specified in Lemma 1), the distortionary effect of taxes will dominate with respect to this last effect.

Political Stage

Consider the problem faced by a legislator ℓ who is proposed a tax level $\hat{\tau}$. The legislator can either accept or reject the proposal

$$\max_{Y,N} \left\{ V_\ell \left(\hat{\tau}, \bar{S}\right), V_\ell \left(\bar{\tau}, \bar{S}\right) \right\}$$

where $\bar{\tau}$ denotes the status quo tax level, which is determined exogenously. Clearly, ℓ will vote in favor of the proposal if it exceeds the value of the status quo policy. That is, ℓ will vote Y if

$$V_\ell \left(\hat{\tau}, \bar{S}\right) \geq V_\ell \left(\bar{\tau}, \bar{S}\right) \Leftrightarrow \omega_\ell \leq \bar{\omega} \left(\hat{\tau}, \bar{\tau}, \bar{S}\right)$$

where

$$\bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \equiv \frac{U(C) - U(\bar{C}) + \Pi_c - \bar{\Pi}_c}{\Pi_c - \bar{\Pi}_c - (\Pi_d - \bar{\Pi}_d)}$$

identifies the marginal legislator, i.e. the legislator that is indifferent between voting in favor or against the proposal $\hat{\tau}$. The upper bar, $\bar{\cdot}$, denotes the value of variables under the status quo tax level $\bar{\tau}$.

Under the assumption of the ideal points' distribution (eq. 1.15), the fraction of supporters for a given policy proposal $\hat{\tau}$ is given by

$$\mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell \leq \mu\right) \\ + (1-\mu) Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell > \mu\right) \tag{1.21}$$

The agenda-setter's objective is to pass legislation catering to her own political pressures. The problem of the agenda-setter is given by

$$\max_{\hat{\tau}} V_{AD}\left(\hat{\tau}, \bar{S}\right)$$

subject to eqs. (1.7) to (1.13), to the constraint $\hat{\tau} \in (-1, 1)$ and to the coalition constraint (eq. 1.23). This last constraint states that the agenda-setter must assemble a simple majority in order to have her proposal approved. Note the absence of strategic considerations between parties (e.g. party discipline). Support to the proposal can come from both sides of the spectrum, as long as the ideal points are close enough.

The tax level resulting from this bargaining process will depend on the identity of the agenda-setter. Consider the case $\mu > \frac{1}{2}$ in which the agenda-setter is affiliated to D. The tax level proposal in equilibrium of the D agenda-setter is given by

$$\hat{\tau}_D = \begin{cases} \tau_D^u & \text{if } \mu > \overline{\mu}_D(\bar{\tau}) \\ \tau_D^b & \text{if } \mu \in \left[\underline{\mu}_D(\bar{\tau}), \overline{\mu}_D(\bar{\tau})\right] \\ \bar{\tau} & \text{if } \mu < \underline{\mu}_D(\bar{\tau}) \end{cases} \tag{1.22}$$

where τ_D^b, the tax level that makes the constraint binding, solves

$$\begin{aligned} &\mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell \leq \mu\right) \\ &\quad + (1-\mu) Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell > \mu\right) = \frac{1}{2} \end{aligned} \tag{1.23}$$

and τ_D^u, the ideal tax level for the D agenda-setter, solves

$$-U_C' \frac{\partial C}{\partial \tau} = \omega_{AD} \frac{\partial \Pi_d}{\partial \tau} + (1-\omega_{AD}) \frac{\partial \Pi_c}{\partial \tau} \tag{1.24}$$

That is, the ideal policy set by an unconstrained agenda-setter is the result of setting the marginal disutility due to the loss of consumption equal to the marginal utility gains obtained by catering to the political pressures.

The action set of both agenda-setters is divided in three regions, depending on the seat distribution of the legislature. The agenda-setters can either have free rein over the policy decision, in which case they set their ideal policy τ^u, or resort to bargain. In case of bargaining, the result of the negotiation process can either lead to an agreement, τ^b, or in gridlock, $\bar{\tau}$. The equilibrium proposal features the minimum winning coalition principle, as is common in models of agenda-setting (Persson & Tabellini, 2002). Figure 1.7 illustrates this process for a D agenda-

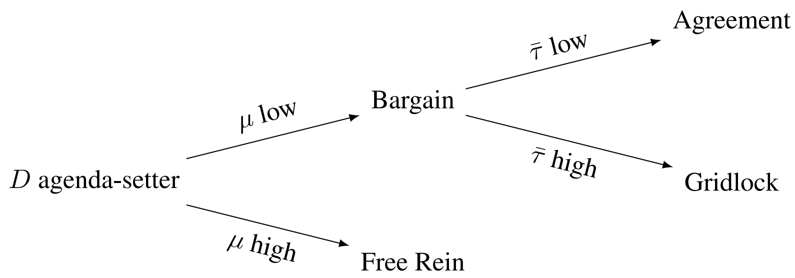

Figure 1.7: Diagram of the action space of a D agenda-setter.

setter. The limit of the three regions is determined by the threshold values $\overline{\mu}_D(\bar{\tau})$ and $\underline{\mu}_D(\bar{\tau})$. The first is the threshold level of within-party support that gives the agenda-setter free rein over the policy decision. Intuitively, if $\mu > \overline{\mu}_D(\bar{\tau})$ then the majority party controls the legislature by a wide margin. Because preferences between the two parties are polarized, a wider control over the chamber reduces the necessity to bargain with legislators whose preferences are further away. The object $\overline{\mu}_D(\bar{\tau})$ is defined as the μ that solves

$$\begin{aligned}\overline{\mu}_D(\bar{\tau})Pr\left(\omega_\ell \leq \bar{\omega}\left(\tau^u_D, \bar{\tau}, \bar{S}\right) \mid \ell \leq \mu\right) + \\ (1-\overline{\mu}_D(\bar{\tau}))Pr\left(\omega_\ell \leq \bar{\omega}\left(\tau^u_D, \bar{\tau}, \bar{S}\right) \mid \ell > \mu\right) = \frac{1}{2}\end{aligned} \tag{1.25}$$

That is, $\overline{\mu}_D(\bar{\tau})$ is the margin of control that allows the agenda-setter to propose her ideal policy and approve it with an exact simple majority.

Similarly, $\underline{\mu}_D(\hat{\tau})$ is the threshold level of support that makes the agenda-setter indifferent between bargaining or entering gridlock. In this case,

$\underline{\mu}_D(\hat{\tau})$ is defined as the μ that solves

$$\underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right) \mid \ell \leq \mu\right) + \\ (1 - \underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right) \mid \ell > \mu\right) = \frac{1}{2} \tag{1.26}$$

Let us now consider the case $\mu < \frac{1}{2}$ in which the agenda-setter is affiliated to R. The equilibrium tax level proposal of the R agenda-setter is then given by

$$\hat{\tau}_R = \begin{cases} \tau_R^u & \text{if } \mu < \overline{\mu}_R(\bar{\tau}) \\ \tau_R^b & \text{if } \mu \in [\overline{\mu}_R(\bar{\tau}), \underline{\mu}_R(\bar{\tau})] \\ \bar{\tau} & \text{if } \mu > \underline{\mu}_R(\bar{\tau}) \end{cases} \tag{1.27}$$

where τ_R^u, the ideal tax level for the D agenda-setter, solves

$$-U_C' \frac{\partial C}{\partial \tau} = \omega_{AR} \frac{\partial \Pi_d}{\partial \tau} + (1 - \omega_{AR}) \frac{\partial \Pi_c}{\partial \tau} \tag{1.28}$$

and τ_R^b, the tax level that makes the constraint binding is given by eq. (1.23). The objects $\overline{\mu}_R(\bar{\tau}), \underline{\mu}_R(\bar{\tau})$ are defined as in eqs. (1.25) and (1.26), respectively. Note that despite being defined similarly, the optimal behavior by the agenda-setters of both parties will not necessarily be symmetric. The reason is that even though the two effects of taxes have opposite signs, they will not necessarily cancel each other. Figure 1.8 illustrates the tax level proposed by the R and the D agenda-setter in equilibrium. It is worth noting that proposals by the D party will be closer to the social optimum than those of the R party. The social cost of carbon implies a strictly positive optimal tax (eq. 1.20). Members of

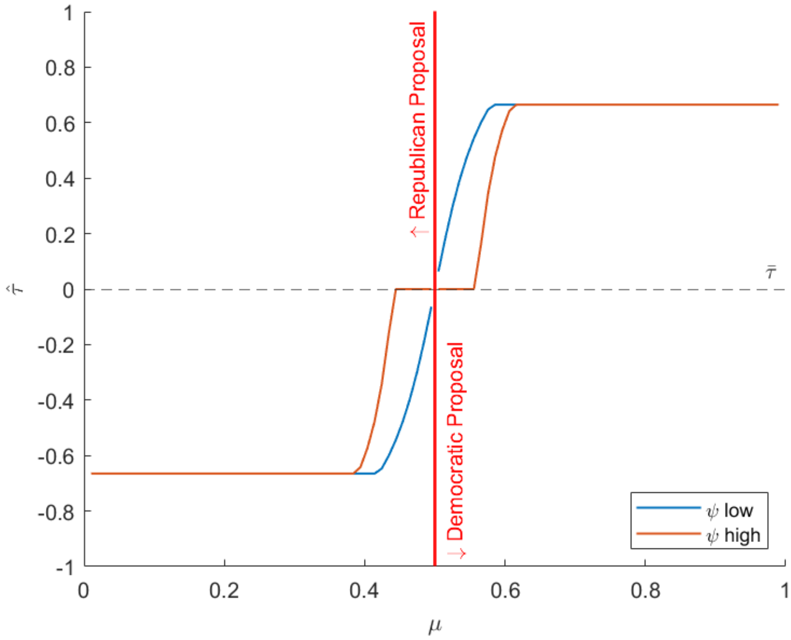

Figure 1.8: Equilibrium policy of the legislature for given levels of ideological distance. For $\mu < \frac{1}{2}$ the agenda-setter belongs to R, otherwise she belongs to D.

the D party will tend to cater to the clean sector, and thus set $\tau > 0$; and vice versa for members of the R party.

However, politicians are not driven by climate motives. Legislators represent agents and have political pressures, none of which internalize the impact of emissions. Therefore, legislators will not act the way a social planner would. In addition, the specification of taxes as a transfer system ensures that the effect of taxes on consumption is symmetrical. The distortionary effect of taxes depends on the absolute values of the proposal, $|\tau|$, and not on the sign. Hence, even if D party is consistently closer to the socially optimal, voters would not have any reason to be electorally biased towards them.

1.3.4 The Impact of Polarization

In this section, I characterize the effects of ideological distance between parties under generally broad conditions. This model can encompass two opposite effects of polarization. The traditional view that polarization leads to more extremism is formalized in Theorem 1. The alternative view that polarization leads to gridlock is formalized in Theorem 2. In addition, the model also makes delivers predictions about the impact on policy of exposure to climate change. These are characterized in Corollaries 2 and 3.

Assumption 1. *Suppose that the following conditions hold:*

(i) $SCC < ((1-\tau)^{-1} - (1+\tau)^{-1}) \dfrac{(1-\tau)^{\frac{\varepsilon(1-\alpha)}{1-\zeta}} \left((1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}} \right)^{\alpha}}{\left((1+\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}} + (1-\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}} \right)}$

(ii) $\varepsilon > \left(\frac{1}{1+\tau}\right) \dfrac{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}} + (1-\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}}}$

(iii) $\varepsilon > \left(\frac{1}{1-\tau}\right) \dfrac{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}} + (1-\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}}}$

Intuitively, the first condition states that the distortion generated by taxes is large relative to the climate externality. This condition ensures that taxes will have a negative effect on output. The last two conditions of Assumption 1 ensure that the effect of taxes on the energy sectors is opposed. That is, if energy substitution is high enough, then the clean sector benefits from a tax to the dirty sector (within a limited range); and vice versa.

Theorem 1 presents the key results supporting the prevalent view in economics that more polarization leads to more polarized policy. In particular, it states that the distance between R and D agenda-setters' ideal tax, $\{\tau_R^u, \tau_D^u\}$ increases with polarization. Theorem 1 also defines the disagreement region as the set of status quo taxes, $\bar{\tau}$, for which both political parties will choose to change taxes in opposite directions.

Theorem 1. *For the set of status quo tax levels $\bar{\tau} \in [\tau_R^u, \tau_D^u]$, and if Assumption 1 holds, the D (R) agenda-setter proposes to increase (decrease) taxes. The length of this set is weakly increasing in both parameters ψ_D, ψ_R.*

Proof. Let us begin by showing what happens when $\bar{\tau} \notin [\tau_R^u, \tau_D^u]$. The definition of τ_D^u (eq. 1.24) and Lemma 1 (see Section 1.C.2) imply that in the case $\bar{\tau} > \tau_D^u$, the marginal loss of consumption exceeds the marginal utility of catering to political pressures, i.e.

$$U_C' \frac{\partial C}{\partial \tau} + \omega_{AD} \frac{\partial \Pi_d}{\partial \tau} + (1 - \omega_{AD}) \frac{\partial \Pi_c}{\partial \tau} < 0$$

Since $\omega_{AR} < \omega_{AD}$, this expression is also negative for agenda-setter R.

Therefore, even though there is disagreement in the level of taxes, both agenda-setters agree in wanting to decrease them. The reverse argument applies to $\bar{\tau} < \tau_R^u$.

Because U, Π are continuous and monotonic, it follows that in the range $\tau \in [\tau_R^u, \tau_D^u]$, the first-order conditions of both agenda-setters differ in sign. Therefore, both parties disagree in the desired direction for the policy change.

Lastly, the limit of the disagreement region is defined by the first-order conditions, eqs. (1.24) and (1.28). The tax level τ_D^u is increasing in ω_{AD}, while τ_R^u is increasing in ω_{AR}. From eq. (1.16) we know that ω_{AD} is decreasing in ψ_R, and ω_{AR} is increasing in ψ_R. Therefore, an increase in either ψ_D or ψ_R widens the range of disagreement. $\square$

Even though an increase in polarization leads to a greater distance in legislators' ideal tax, this increase does not necessarily translate into actual policy polarization. The reason is that even if agenda-setters' proposals depend on their ideal tax, their actual behavior will be distorted by the need to reach a coalition.

Consider an increase in the ideological distance between the two parties, reflected by an increase in the parameter ψ_{-i} of the party $-i$ who is currently not in power. Because ψ_i affects both the probability of members of the party i voting in favor of a proposal (eq. 1.21) and the ideal tax of the agenda-setter eqs. (1.24) and (1.28), the two effects are confounded. Instead, an increase in ψ_{-i} alone isolates the effect of ideological distance. Figure 1.8 illustrates this phenomenon.

In line with the evidence presented in Equations (1.3) and (1.4), an increase in ideological distance affects the proposals of the political parties in two ways. First, it increases legislative inactivity in the sense that it takes a greater margin to pass a proposal. Second, when an agreement is reached, more concessions, in the form of a more moderate proposal, are needed for the legislation to be approved. Theorem 2 and Corollary 1 generalize these results under generally broad conditions.

Assumption 2. *Suppose that the following condition holds*

$$\left| U_C' \frac{\partial C}{\partial \tau} \right| < \left| \frac{\partial \Pi_c}{\partial \tau} \right| \forall\, \tau$$

Intuitively, Assumption 2 states that, for any tax level, the marginal losses of consumption have to be small relative to the gains of the clean sector. Since the clean sector is the only one favored by τ, this assumption ensures that there will be some degree of conflict between both parties. This assumption is only necessary for Corollary 3.

Theorem 2 states that an increase in ψ_R will lead to more gridlock in the sense that the D agenda-setter will require a higher control of the chamber in order for the bargaining to be more worth it than the status quo policy.[24]

[24]Having proved the statement for a D agenda-setter, it is straightforward to show that the opposite occurs for an R agenda-setter.

Theorem 2. *For any given status quo tax level $\bar{\tau}$, and if Assumption 2 holds, the threshold $\underline{\mu}_D(\hat{\tau})$ is weakly increasing in ψ_R.*

Proof. See Section 1.C.2 for the remainder of the proofs. □

Intuitively, an increase in ψ_R shifts the distribution of R legislators' ideal points away from the center. Thereby making bargaining less attractive for the agenda-setter (see Corollary 1). Note that the proof of Theorem 2 does not rely on the assumption that ideal points are beta distributed, as in eq. (1.15). In fact, any structure in which an increase in ψ_R decreases the probability of R legislators voting in favor while keeping the support from D legislators intact can achieve this result.[25]

Corollary 1. *For any given status quo tax level $\bar{\tau}$, and if Assumption 2 holds, the bargaining tax level τ_D^b is weakly decreasing in ψ_R.*

Perhaps unsurprisingly, the effects of polarization can be less intense the more vulnerable is the economy to climate damages. Corollaries 2 and 3 show that an increase in the vulnerability of the economy to climate damages (i.e. decreases in $\bar{S}$) have the opposite effect as increases in ideological distance (i.e. in ψ_{-i}). Notice that in this model, a reduction in $\bar{S}$ is akin to more vulnerability to climate damages. From eq. (1.7), CO_2 accumulation hurts the economy insofar as it exceeds the pre-industrial stock of carbon, $\bar{S}$. The lower $\bar{S}$, the easier it is for the economy to suffer damages from emissions.

[25] Alternative assumptions could include a truncated normal or a continuous uniform distribution for ω_ℓ.

Corollary 2. *The unconstrained tax level τ_R^u (τ_D^u) is weakly increasing (decreasing) in $\bar{S}$.*

That is, whereas disagreement increases with polarization, it decreases the more prone is the economy to suffer damages from emissions.

Corollary 3. *If Assumption 2 holds, then the threshold $\underline{\mu}_D(\hat{\tau})$ weakly decreases with a lower $\bar{S}$.*

Similarly, Corollary 3 states that the threshold defining the gridlock region for party D is decreasing with sensitivity to climate damages.

Finally, the model also highlights the effects that the status quo tax has on the bargaining process, in line with the dynamic legislative bargaining literature (Eraslan et al., 2022). The following two corollaries extend the results from Theorem 2 and Corollary 1.

Corollary 4. *If $\left|U_C' \frac{\partial^2 C}{\partial \tau^2}\right| > \left|\frac{\partial^2 \Pi_c}{\partial \tau^2}\right| \; \forall \; \tau$, then the threshold $\underline{\mu}_D(\bar{\tau})$ is increasing in $\bar{\tau}$.*

Corollary 5. *If $\left|U_C' \frac{\partial^2 C}{\partial \tau^2}\right| > \left|\frac{\partial^2 \Pi_c}{\partial \tau^2}\right| \; \forall \; \tau$, then the bargaining tax level τ_D^b is weakly decreasing in $\bar{\tau}$.*

Intuitively, the assumption states that the slope of the marginal utility is greater in absolute value than that of the profits of the clean sector.

1.4 Two-period Taxation

The static nature of the model presented in Section 1.3 ignores a potential concern regarding whether the equilibrium behavior extends to a dynamic setting. In this Section, I extend the model of Section 1.3 to a two-period model in which legislators have to bargain over taxes every period. Legislators and the agenda-setter are forward-looking, which makes the model intractable for the first period. I solve it computationally and show that the logic of policy stalemate is reinforced even under a dynamic setting.

There are two periods, $t = \{1, 2\}$. Absent any intertemporal economic decisions (i.e. capital decision), the economic structure of the model is the same as in the previous version of the model for both periods. Legislators, however, are forward looking. Their problem in the first period is given by

$$\max_{Y,N} \left\{ V_\ell\left(\hat{\tau}_1, S_0\right) + \beta \mathbb{E}_{\hat{\tau}_1}\left[V_\ell\left(\tau_2, S_1\right)\right], V_\ell\left(\tau_0, S_0\right) + \beta \mathbb{E}_{\tau_0}\left[V_\ell\left(\tau_2, S_1\right)\right] \right\}$$

where τ_0, S_0 are the status quo tax and the pre-industrial stock of carbon for the first period, respectively. As in the one-period case, the mass of legislators voting in favor of any proposal is given by eq. (1.21), with the difference that the marginal legislator is now defined by

$$\bar{\omega}\left(\hat{\tau}_1, \tau_0, S_0\right) \equiv \frac{U(C_1) - U(\bar{C}_1) + \Pi_{c1} - \bar{\Pi}_{c1} + \beta\left(\mathbb{E}_{\hat{\tau}_1} - \mathbb{E}_{\tau_0}\right)\left(U(C_2) + \Pi_{c2}\right)}{\Pi_{c1} - \bar{\Pi}_{c1} - \left(\Pi_{d1} - \bar{\Pi}_{d1}\right) + \beta\left(\mathbb{E}_{\hat{\tau}_1} - \mathbb{E}_{\tau_0}\right)\left(\Pi_{c2} - \Pi_{d2}\right)}$$

where $\left(\mathbb{E}_{\hat{\tau}_1} - \mathbb{E}_{\tau_0}\right)(x) \equiv \mathbb{E}_{\hat{\tau}_1}(x) - \mathbb{E}_{\tau_0}(x)$. That is, legislators take into account the fact that the tax set today will become the status quo tomorrow.

Similarly, the problem of the agenda-setter in the first period is given by

$$\max_{\hat{\tau}_1} V_A\left(\hat{\tau}_1, S_0\right) + \beta\mathbb{E}_{\hat{\tau}_1}\left(V_A\left(\tau_2, S_1\right)\right)$$

subject to eqs. (1.7) to (1.13), to the constraint $\hat{\tau}_1 \in (-1, 1)$ and to the coalition constraint (eq. 1.23).

In the two-period version of the model, taxation is an intertemporal decision that propagates to the future through an endogenous status quo. From Corollaries 4 and 5, we know that the presence of a status quo has effects on future policy. This endogeneity opens the door for the agenda-setter to manipulate the outcome of tomorrow's bargaining process. Similarly, legislators are willing to accept proposals that they would not in a static setting.

To see how the dynamic nature of the model affects the behavior of both legislators and the agenda-setter, we can rewrite the expression of the expected value as follows

$$\begin{aligned}
\mathbb{E}_{\hat{\tau}_1}\left(V_A\left(\tau_2, S_1\right)\right) = & Pr\left(\mu_2 > \overline{\mu}_D(\hat{\tau}_1)\right) V_A\left(\tau^u_{D2}, S_1\right) \\
& + Pr\left(\mu_2 \in \left[\underline{\mu}_D(\hat{\tau}_1), \overline{\mu}_D(\hat{\tau}_1)\right]\right) V_A\left(\tau^b_{D2}, S_1\right) \\
& + Pr\left(\mu_2 \in \left[\underline{\mu}_R(\hat{\tau}_1), \underline{\mu}_D(\hat{\tau}_1)\right]\right) V_A\left(\hat{\tau}_1, S_1\right) \\
& + Pr\left(\mu_2 \in \left[\overline{\mu}_R(\hat{\tau}_1), \underline{\mu}_R(\hat{\tau}_1)\right]\right) V_A\left(\tau^b_{R2}, S_1\right) \\
& + Pr\left(\mu_2 < \overline{\mu}_R(\hat{\tau}_1)\right) V_A\left(\tau^u_{R2}, S_1\right)
\end{aligned}$$

Figure 1.9 illustrates the limits of the different regions (i.e. free rein, bargain, and gridlock) in the second period depending on the status quo. In general, extreme values of τ grant the agenda-setter a higher utility. However, they also make it easier for the other party to reach a coalition to revert the policy, were they to control the legislature in the future. In line with the results from Tables 1.7 and 1.8, the policy reversal resulting from a change in the majority party will be greater the more extreme is the status quo $\bar{\tau}$. On the other hand, moderate values of τ reduce the overall probability of ending in gridlock, but this probability is more evenly distributed between both parties.

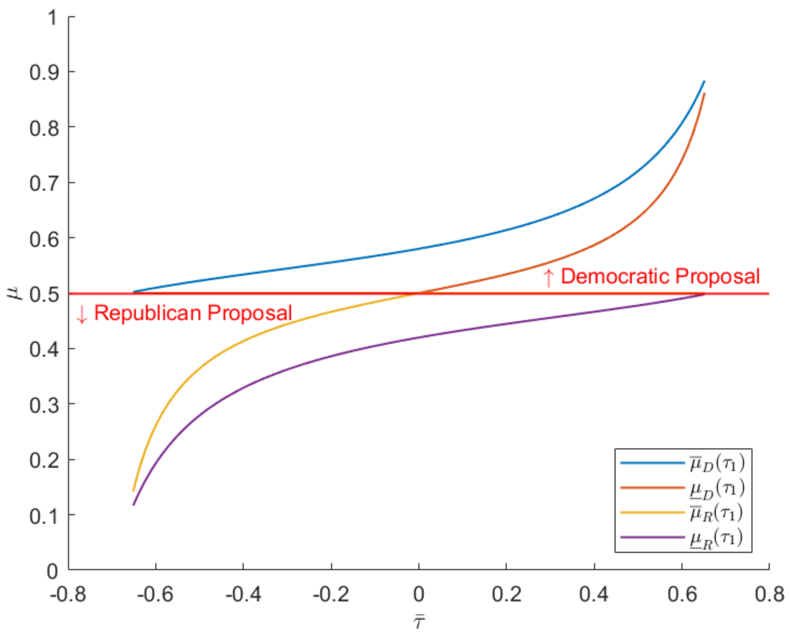

Figure 1.9: Thresholds defining the different action regions of agenda-setters for different values of μ and $\bar{\tau}$.

It is not obvious a priori which of the two motives will dominate in taking the decision. Figure 1.10 illustrates the equilibrium policy in a calibrated version of the two-period model. Clearly, in this dynamic setting, the policy stalemate motive dominates.

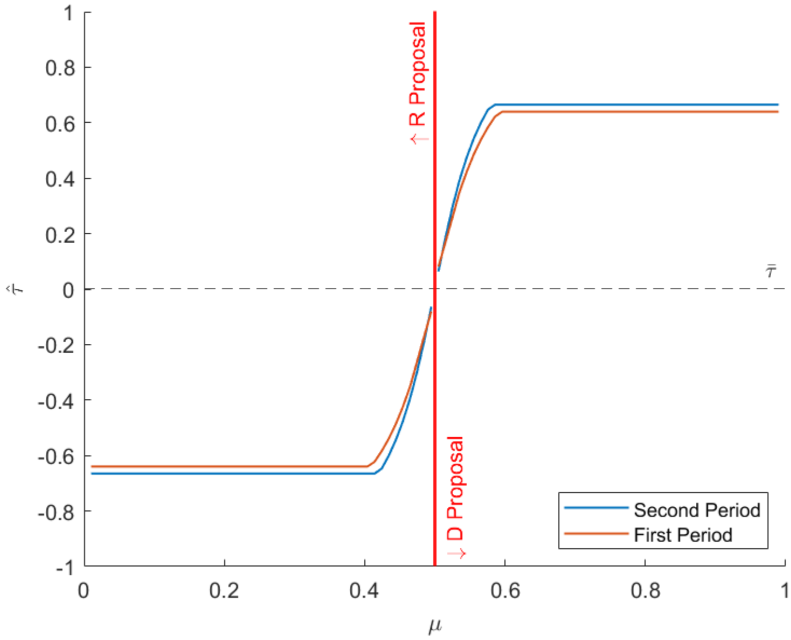

Figure 1.10: Equilibrium policy of the legislature in the two-period version.

As in the previous section, the effects of polarization can be less intense the more vulnerable is the economy to climate damages. Figure 1.11 illustrates the equilibrium policy in the two-version model when damages from emissions are high. In this case, both agenda-setter shift their proposals in the free-rein case upwards.

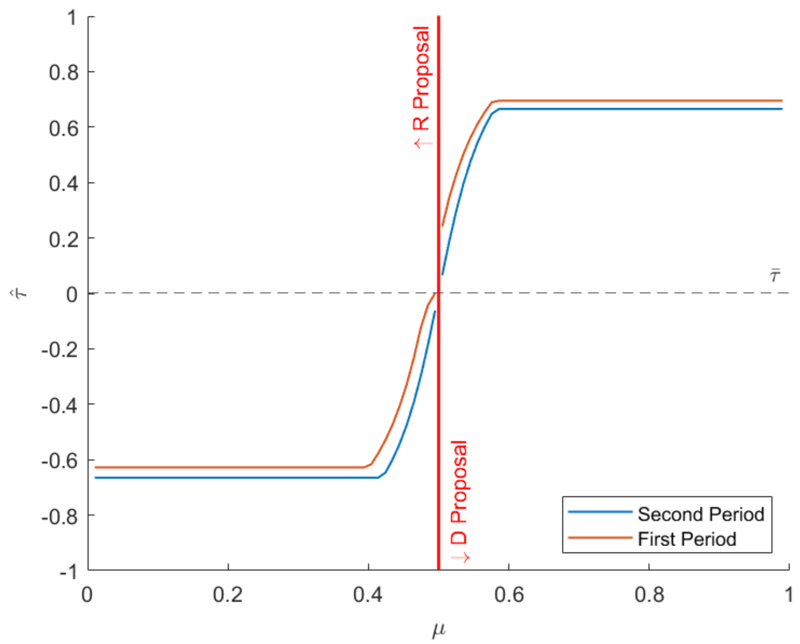

Figure 1.11: Equilibrium policy of the legislature in the two-period version when γ is high.

1.5 Conclusion

In this paper I study the effect of party polarization on climate policies. Despite consensus in the scientific community about the harmful effects of human activity on Earth’s climate, advanced economies have failed to pass effective legislation addressed to cut CO_2 emissions. At the same time, Western democracies, in particular the United States, have recently experienced a surge in party polarization. Increasing ideological differences have affected many areas, especially climate change.

To address this question I use textual analysis to measure environmental policy of the U.S. state legislatures. Measurement of environmental policies is not trivial. In particular, I apply Wordfish, an algorithm that estimates policy positions of documents based on their word frequencies, to environmental bills proposed between 2009 and 2018. The U.S. has no landmark climate policy at the federal level, and leaves most of the policy-making at the states' discretion.

Party polarization affects environmental policy in four ways. First, the effect of polarization on environmental policy depends on the seat distribution of the legislature. Second, polarization moderates the environmental policy proposals by both parties when the seat distribution of the legislature is tight. Third, polarized legislatures are less likely to pass environmental legislation when the seat distribution of the legislature is tight. Fourth, parties reverse legislation when taking over a chamber; and the magnitude of this switch greater the more extreme is the status quo environmental policy is.

I rationalize these findings by developing a simple model of the legislature that incorporates the party distribution of seats. I find that polarization has a non-monotonic effect on policy. When polarization between parties is low, the preferences between both parties are overlapping and reaching an agreement is easy. On the other hand, the effect of high party polarization depends on the degree of control of the legislature. When the majority party's margin of votes is very narrow, bargaining between the two parties becomes too burdensome and a period of gridlock follows. Instead, when the majority party has a sufficient margin of control of the legislature, the response of policy will be towards extremism.

To understand the potential implications of party polarization in the long-run, I embed this mechanism into a simplified version of the IAM developed by Golosov et al. (2014). I show that polarization can harm economic growth. At the same time, the effects of polarization are mitigated by the exposure of the economy to climate change.

The findings in this paper open up a few important questions for future research. In the model, gridlock prevents polarized parties to approve proposals that would drive the carbon tax away from the optimal. This does not take into account the role of institutional factors that can require supermajorities (e.g. the fillibuster in the U.S. Senate). Supermajority requirements can also impede the approval of policies even when they are Pareto efficient. Similarly, the prevalence of gridlock in the legislature does not necessarily translate to policy stalemate. In fact, following gridlock in the U.S. Congress, executive policy making has taken off. The implications of this shift in power are substantial, since executive policy making is more prone to changes. Future chiefs of the executive power and legislatures can easily override rules established through executive orders.

Finally, the framework provided in this paper can be used for quantitative evaluation. It would be interesting to study, for example, whether the implementation of a carbon tax with a gradual updating to climate risks would be easier to approve. Estimating growth models with a climate module is usual in the macro-environmental literature (Hassler & Krusell, 2018; Hassler et al., 2016). Given its simplicity, incorporating the legislative bargaining game to standard models should be straightforward.

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1.A Additional Tables and Figures

Dependent Variable:	GDP Growth
Polarization	-3.157***
	(0.4091)
N	1001
State FE	Yes
Pseudo R^2	0.02893

Clustered (State) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 1.9: Results of regressing state’s real GDP growth on a measure of polarization from 1997 to 2018, with state fixed effects and standard errors clustered at the state level.

1.B Robustness of the Empirical Results

1.B.1 Results with Probit and Logit

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic House	0.506	0.236	0.164	0.101
	(0.526)	(0.295)	(0.550)	(0.291)
Polarization (Hou)	0.871	0.433	0.817	0.426
	(0.826)	(0.459)	(0.803)	(0.455)
Margin <5%			-0.810*	-0.388*
			(0.441)	(0.207)
Margin <5% $\times$ Polarization (Hou)			-0.452*	-0.220
			(0.273)	(0.135)
N	1226	1226	1226	1226
Method	Logit	Probit	Logit	Probit
Adjusted R2				

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.10: Results of estimating eq. (1.4) by OLS.

1.B.2 Restricting the Sample to Competitive Bills

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic House	0.562	1.145	0.494	1.254
	(0.524)	(0.860)	(0.458)	(0.761)
Polarization (Hou)	-0.423	1.012	-0.544	2.038
	(1.139)	(1.239)	(1.083)	(1.692)
Democratic House × Polarization (Hou)	0.0602	-0.436	-0.528	-2.486
	(0.367)	(0.386)	(1.437)	(1.632)
Democratic House × Margin <5% × Polarization (Hou)			-0.449**	-0.452*
			(0.197)	(0.241)
N	154	154	154	154
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.477	0.453	0.477	0.453

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.11: Results of estimating eq. (1.3) restricting the sample to competitive bills.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic House	0.688***	1.505***	0.689***	1.449***
	(0.209)	(0.267)	(0.203)	(0.277)
Polarization (Hou)	-0.572	-1.016	-0.557	-1.303*
	(0.840)	(0.643)	(0.918)	(0.659)
Margin <5%			0.196	-0.154
			(0.391)	(0.354)
Margin <5% × Polarization (Hou)			-0.0925	-0.0857
			(0.229)	(0.228)
N	154	154	154	154
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.272	0.321	0.259	0.314

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.12: Results of estimating eq. (1.4) restricting the sample to competitive bills.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	-0.423*	-0.959**	-0.848	-2.824
	(0.243)	(0.417)	(0.867)	(2.432)
Polarization (Hou)	-0.800	0.164	0.398	2.044
	(1.070)	(1.064)	(2.267)	(3.807)
Republican Take Over × Polarization (Hou)	-0.240	0.00566	-0.310	0.339
	(0.249)	(0.295)	(0.645)	(1.118)
Republican Take Over × Polarization (Hou) × EnvironmentalAvg			-1.189**	-2.214
			(0.514)	(1.279)
N	154	154	109	109
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.494	0.477	0.383	0.314

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.13: Results of estimating eq. (1.5) restricting the sample to competitive bills.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.0814	0.370	2.332	-6.013
	(0.426)	(0.803)	(1.923)	(8.073)
Polarization (Hou)	-0.179	0.698	0.310	0.726
	(1.110)	(1.236)	(1.249)	(2.529)
Democratic Take Over × Polarization (Hou)	0.708**	0.765	-0.274	5.242
	(0.322)	(0.495)	(1.174)	(5.369)
Democratic Take Over × Polarization (Hou) × EnvironmentalAvg			-0.956***	-0.849
			(0.300)	(0.842)
N	154	154	109	109
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.482	0.464	0.400	0.326

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.14: Results of estimating eq. (1.5) restricting the sample to competitive bills.

1.B.3 Sample Restricted to Swing States

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic House	0.303*	0.209	0.550***	0.420*
	(0.154)	(0.151)	(0.164)	(0.217)
Polarization (Hou)	-0.117	-0.0957	0.600	0.811*
	(0.340)	(0.322)	(0.545)	(0.472)
Democratic House × Polarization (Hou)	-0.107	-0.128	-0.323	-0.367*
	(0.190)	(0.172)	(0.210)	(0.189)
N	1267	1267	693	693
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.368	0.368	0.413	0.416

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.15: Results of estimating eq. (1.3) restricting the sample to bills produced in swing states.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Polarization (Hou)	-0.0181	0.0214	-0.264**	-0.284*
	(0.102)	(0.114)	(0.118)	(0.154)
Democratic House	0.0647	0.0617	0.0210	-0.0219
	(0.076)	(0.078)	(0.057)	(0.069)
N	1267	1267	721	721
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.156	0.163	0.154	0.150

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.16: Results of estimating eq. (1.4) restricting the sample to bills produced in swing states.

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Republican Take Over	-0.0837	-0.106	-0.210*	-0.307*
	(0.114)	(0.138)	(0.105)	(0.159)
Polarization (Hou)	-0.213	-0.121	0.00828	0.380
	(0.356)	(0.378)	(0.606)	(0.673)
Republican Take Over × Polarization (Hou)	-0.288**	-0.322**	-0.323**	-0.352**
	(0.142)	(0.145)	(0.141)	(0.135)
EnvironmentalAvg	-0.0864	-0.0872*	-0.159**	-0.217***
	(0.056)	(0.050)	(0.060)	(0.074)
Republican Take Over × EnvironmentalAvg	-0.0972	-0.126	-0.00406	-0.0636
	(0.102)	(0.104)	(0.101)	(0.137)
Polarization (Hou) × EnvironmentalAvg	0.0627	0.0293	-0.0937	-0.0788
	(0.044)	(0.044)	(0.080)	(0.093)
Republican Take Over × Polarization (Hou) × EnvironmentalAvg	-0.465***	-0.435***	-0.347*	-0.530***
	(0.139)	(0.137)	(0.182)	(0.176)
N	893	893	480	480
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.387	0.385	0.469	0.469

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.17: Results of estimating eq. (1.5) restricting the sample to bills produced in swing states.

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic Take Over	-0.473***	-0.359*	-0.314	-0.457**
	(0.167)	(0.197)	(0.199)	(0.203)
Polarization (Hou)	-0.252	-0.109	0.128	0.165
	(0.431)	(0.442)	(0.633)	(0.731)
Democratic Take Over × Polarization (Hou)	0.721***	0.646**	0.722**	0.694*
	(0.228)	(0.250)	(0.284)	(0.340)
EnvironmentalAvg	-0.0986	-0.0860	-0.156**	-0.225**
	(0.061)	(0.056)	(0.071)	(0.082)
Democratic Take Over × EnvironmentalAvg	0.684**	0.635*	0.681**	0.558
	(0.317)	(0.328)	(0.286)	(0.346)
Polarization (Hou) × EnvironmentalAvg	0.0791	0.0523	0.0289	0.0225
	(0.053)	(0.054)	(0.088)	(0.101)
Democratic Take Over × Polarization (Hou) × EnvironmentalAvg	-0.455**	-0.452**	-0.430**	-0.311
	(0.195)	(0.183)	(0.200)	(0.193)
N	893	893	480	480
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.385	0.383	0.466	0.461

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.18: Results of estimating eq. (1.5) restricting the sample to bills produced in swing states.

1.B.4 Sample Restricted to Proposals by the Majority Party

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic House	0.385**	0.314	0.357**	0.276
	(0.179)	(0.187)	(0.173)	(0.189)
Polarization (Hou)	-0.236	-0.323	-0.176	-0.240
	(0.256)	(0.287)	(0.286)	(0.309)
Democratic House $\times$ Polarization (Hou)	-0.156	-0.162	-0.104	-0.0573
	(0.217)	(0.237)	(0.212)	(0.218)
Democratic House $\times$ Margin $<5\%$ $\times$ Polarization (Hou)			-0.206	-0.312
			(0.275)	(0.289)
N	941	941	941	941
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Adjusted R2	0.382	0.380	0.382	0.380

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.19: Results of estimating eq. (1.3) restricting the sample to bills proposed by the majority party.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic House	0.0388	0.0488	0.00468	-0.0167
	(0.097)	(0.114)	(0.088)	(0.109)
Polarization (Hou)	-0.0684	-0.0797	-0.0380	-0.0281
	(0.130)	(0.149)	(0.138)	(0.159)
Margin $<5\%$			-0.171***	-0.197***
			(0.056)	(0.068)
Margin $<5\%$ $\times$ Polarization (Hou)			-0.0683	-0.101
			(0.063)	(0.073)
N	941	941	941	941
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method				
Adjusted R2	0.167	0.171	0.169	0.174

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.20: Results of estimating eq. (1.4) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	0.0281	0.0197	0.216	0.223
	(0.124)	(0.152)	(0.142)	(0.179)
Polarization (Hou)	-0.345	-0.383	-0.809*	-0.868
	(0.237)	(0.268)	(0.446)	(0.534)
Republican Take Over × Polarization (Hou)	-0.00656	0.0228	-0.0379	-0.105
	(0.245)	(0.273)	(0.294)	(0.322)
Republican Take Over × Polarization (Hou) × EnvironmentalAvg			-0.162	-0.112
			(0.344)	(0.362)
N	941	941	680	680
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Adjusted R2	0.378	0.378	0.401	0.396

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.21: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.215	0.133	-0.0728	-0.0294
	(0.151)	(0.167)	(0.131)	(0.180)
Polarization (Hou)	-0.418	-0.429	-0.909*	-1.006*
	(0.256)	(0.280)	(0.481)	(0.562)
Democratic Take Over × Polarization (Hou)	0.173	0.116	0.676***	0.671***
	(0.200)	(0.206)	(0.223)	(0.245)
Democratic Take Over × Polarization (Hou) × EnvironmentalAvg			-0.115	-0.141
			(0.113)	(0.115)
N	941	941	680	680
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Adjusted R2	0.381	0.379	0.407	0.402

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.22: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

1.B.5 Full Specification

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic House	0.303*	0.209	0.236	0.142
	(0.154)	(0.151)	(0.160)	(0.156)
Polarization (Hou)	-0.117	-0.0957	-0.0636	-0.0649
	(0.340)	(0.322)	(0.347)	(0.317)
Democratic House × Polarization (Hou)	-0.107	-0.128	-0.122	-0.140
	(0.190)	(0.172)	(0.226)	(0.199)
Margin <5%			-0.266	-0.302
			(0.219)	(0.202)
Democratic House × Margin <5%			0.123	0.0565
			(0.350)	(0.323)
Margin <5% × Polarization (Hou)			-0.0233	0.0445
			(0.242)	(0.238)
Democratic House × Margin <5% × Polarization (Hou)			-0.120	-0.181
			(0.298)	(0.287)
N	1267	1267	1267	1267
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.368	0.368	0.368	0.370

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.23: Results of estimating eq. (1.3) under the full specification.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Polarization (Hou)	-0.0181	0.0214	-0.00138	0.0243
	(0.102)	(0.114)	(0.103)	(0.113)
Democratic House	0.0647	0.0617	0.0407	0.0376
	(0.076)	(0.078)	(0.065)	(0.071)
Margin <5%			-0.115***	-0.101***
			(0.031)	(0.034)
Margin <5% × Polarization (Hou)			-0.0542**	-0.0452
			(0.025)	(0.032)
N	1267	1267	1267	1267
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.156	0.163	0.160	0.165

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.24: Results of estimating eq. (1.4) under the full specification.

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Republican Take Over	-0.158	-0.173	-0.0837	-0.106
	(0.098)	(0.121)	(0.114)	(0.138)
Polarization (Hou)	-0.162	-0.153	-0.213	-0.121
	(0.281)	(0.278)	(0.356)	(0.378)
Republican Take Over × Polarization (Hou)	-0.0564	-0.0269	-0.288**	-0.322**
	(0.132)	(0.133)	(0.142)	(0.145)
EnvironmentalAvg			-0.0864	-0.0872*
			(0.056)	(0.050)
Republican Take Over × EnvironmentalAvg			-0.0972	-0.126
			(0.102)	(0.104)
Polarization (Hou) × EnvironmentalAvg			0.0627	0.0293
			(0.044)	(0.044)
Republican Take Over × Polarization (Hou) × EnvironmentalAvg			-0.465***	-0.435***
			(0.139)	(0.137)
N	1267	1267	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.366	0.368	0.387	0.385

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.25: Results of estimating eq. (1.5) under the full specification.

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic Take Over	0.238*	0.185	-0.473***	-0.359*
	(0.120)	(0.121)	(0.167)	(0.197)
Polarization (Hou)	-0.203	-0.170	-0.252	-0.109
	(0.281)	(0.270)	(0.431)	(0.442)
Democratic Take Over × Polarization (Hou)	0.130	0.0797	0.721***	0.646**
	(0.111)	(0.113)	(0.228)	(0.250)
EnvironmentalAvg			-0.0986	-0.0860
			(0.061)	(0.056)
Democratic Take Over × EnvironmentalAvg			0.684**	0.635*
			(0.317)	(0.328)
Polarization (Hou) × EnvironmentalAvg			0.0791	0.0523
			(0.053)	(0.054)
Democratic Take Over × Polarization (Hou) × EnvironmentalAvg			-0.455**	-0.452**
			(0.195)	(0.183)
N	1267	1267	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.367	0.368	0.385	0.383

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.26: Results of estimating eq. (1.5) under the full specification.

1.B.6 Using Polarization in the Senate

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic Senate	0.119	0.0404	0.137	0.0443
	(0.160)	(0.176)	(0.164)	(0.183)
Polarization (Sen)	-0.126	-0.0127	-0.148	-0.0178
	(0.201)	(0.174)	(0.213)	(0.187)
Democratic Senate × Polarization (Sen)	0.0716	0.112	0.0857	0.119
	(0.133)	(0.141)	(0.170)	(0.159)
Democratic Senate × Margin <5% × Polarization (Sen)			0.0856	0.00194
			(0.120)	(0.105)
N	1240	1240	1240	1240
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.349	0.353	0.348	0.352

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.27: Results of estimating eq. (1.3) using the measures of polarization in the senate.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic Senate	0.0517	0.0524	0.0482	0.0369
	(0.045)	(0.047)	(0.048)	(0.049)
Polarization (Sen)	-0.0527	-0.0650	-0.0378	-0.0451
	(0.105)	(0.095)	(0.110)	(0.104)
Margin <5%			0.0380	0.0317
			(0.063)	(0.066)
Margin <5% × Polarization (Sen)			-0.0285	-0.0500
			(0.033)	(0.038)
N	1240	1240	1240	1240
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.162	0.171	0.161	0.170

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.28: Results of estimating eq. (1.4) using the measures of polarization in the senate.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	-0.155	-0.165	-0.0745	-0.110
	(0.096)	(0.121)	(0.130)	(0.140)
Polarization (Sen)	-0.0511	0.0815	0.0319	0.00993
	(0.190)	(0.173)	(0.321)	(0.320)
Republican Take Over × Polarization (Sen)	-0.112	-0.0752	-0.206	-0.227
	(0.095)	(0.097)	(0.137)	(0.140)
Republican Take Over × Polarization (Sen) × EnvironmentalAvg			-0.330*	-0.343*
			(0.194)	(0.192)
N	1240	1240	862	862
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.351	0.355	0.379	0.379

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.29: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.314**	0.206	0.0441	0.158
	(0.146)	(0.138)	(0.114)	(0.113)
Polarization (Sen)	-0.0616	0.0668	0.0450	0.0242
	(0.185)	(0.170)	(0.317)	(0.309)
Democratic Take Over × Polarization (Sen)	0.0409	0.0528	0.243	0.152
	(0.219)	(0.217)	(0.164)	(0.152)
Democratic Take Over × Polarization (Sen) × EnvironmentalAvg			-0.153	-0.176**
			(0.095)	(0.079)
N	1240	1240	862	862
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.352	0.354	0.377	0.377

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.30: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

1.B.7 Using a Party-Free Measure of Polarization (Average Distance)

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic House	0.357*	0.266	0.329*	0.249
	(0.178)	(0.192)	(0.176)	(0.193)
Polariz (Hou, PF)	0.694***	0.636***	0.757***	0.662***
	(0.218)	(0.231)	(0.229)	(0.243)
Democratic House × Polariz (Hou, PF)	-0.184	-0.175	-0.199	-0.157
	(0.188)	(0.177)	(0.195)	(0.190)
Democratic House × Margin <5% × Polariz (Hou, PF)			-0.229***	-0.237***
			(0.078)	(0.077)
N	1267	1267	1267	1267
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.373	0.371	0.374	0.373

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.31: Results of estimating eq. (1.3) using average distance between the legislators’ estimates as a measure of polarization.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic House	0.0637	0.0610	0.0433	0.0394
	(0.075)	(0.078)	(0.065)	(0.070)
Polariz (Hou, PF)	-0.0961	-0.0419	-0.0562	-0.0159
	(0.079)	(0.081)	(0.082)	(0.083)
Margin <5%			-0.0995***	-0.0904**
			(0.035)	(0.037)
Margin <5% × Polariz (Hou, PF)			-0.0480*	-0.0429
			(0.025)	(0.028)
N	1267	1267	1267	1267
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.157	0.163	0.160	0.165

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.32: Results of estimating eq. (1.4) using average distance between the legislators’ estimates as a measure of polarization.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	-0.201**	-0.197	-0.0879	-0.0746
	(0.099)	(0.128)	(0.111)	(0.130)
Polariz (Hou, PF)	0.670***	0.596***	0.765***	1.023***
	(0.198)	(0.214)	(0.282)	(0.253)
Republican Take Over × Polariz (Hou, PF)	-0.0867	-0.0719	-0.214*	-0.251**
	(0.102)	(0.107)	(0.112)	(0.106)
Republican Take Over × Polariz (Hou, PF) × EnvironmentalAvg			-0.465***	-0.459***
			(0.146)	(0.129)
N	1267	1267	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.373	0.372	0.392	0.395

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.33: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.301**	0.224	-0.0343	0.0567
	(0.146)	(0.143)	(0.131)	(0.163)
Polariz (Hou, PF)	0.574***	0.520**	0.815**	1.141***
	(0.201)	(0.230)	(0.303)	(0.302)
Democratic Take Over × Polariz (Hou, PF)	0.0151	0.00938	0.227*	0.222*
	(0.118)	(0.116)	(0.117)	(0.123)
Democratic Take Over × Polariz (Hou, PF) × EnvironmentalAvg			-0.100	-0.123**
			(0.067)	(0.058)
N	1267	1267	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.371	0.371	0.389	0.392

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.34: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

1.B.8 Using Polarization in the Senate and a Party-Free Measure of Polarization (Average Distance)

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic Senate	0.202	0.0670	0.183	0.0518
	(0.179)	(0.213)	(0.182)	(0.215)
Polariz (Sen, PF)	0.327	0.198	0.357	0.234
	(0.223)	(0.229)	(0.252)	(0.254)
Democratic Senate × Polariz (Sen, PF)	-0.0991	0.00300	-0.139	-0.0426
	(0.144)	(0.164)	(0.159)	(0.167)
Democratic Senate × Margin <5% × Polariz (Sen, PF)			0.0958	0.0505
			(0.119)	(0.099)
N	1240	1240	1240	1240
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.350	0.353	0.350	0.352

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.35: Results of estimating eq. (1.3) using average distance between the legislators' estimates in the senate as a measure of polarization.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic Senate	0.0507	0.0539	0.0434	0.0357
	(0.045)	(0.045)	(0.047)	(0.046)
Polariz (Sen, PF)	-0.113	-0.0846	-0.103	-0.0673
	(0.076)	(0.076)	(0.077)	(0.080)
Margin <5%			0.0610	0.0629
			(0.065)	(0.067)
Margin <5% × Polariz (Sen, PF)			-0.0468	-0.0688*
			(0.034)	(0.040)
N	1240	1240	1240	1240
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.164	0.171	0.163	0.171

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.36: Results of estimating eq. (1.4) using average distance between the legislators' estimates in the senate as a measure of polarization.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	-0.159*	-0.156	-0.0661	-0.0806
	(0.091)	(0.121)	(0.144)	(0.146)
Polariz (Sen, PF)	0.334	0.255	0.191	0.158
	(0.211)	(0.222)	(0.273)	(0.281)
Republican Take Over × Polariz (Sen, PF)	-0.152*	-0.111	-0.230*	-0.284**
	(0.080)	(0.088)	(0.115)	(0.110)
Republican Take Over × Polariz (Sen, PF) × EnvironmentalAvg			-0.304*	-0.339**
			(0.163)	(0.149)
N	1240	1240	862	862
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.354	0.356	0.381	0.381

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.37: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.340	0.217	0.0639	0.210
	(0.206)	(0.194)	(0.138)	(0.134)
Polariz (Sen, PF)	0.216	0.164	0.197	0.187
	(0.201)	(0.217)	(0.277)	(0.294)
Democratic Take Over × Polariz (Sen, PF)	-0.0245	-0.00649	0.132	0.0417
	(0.225)	(0.221)	(0.144)	(0.131)
Democratic Take Over × Polariz (Sen, PF) × EnvironmentalAvg			-0.171***	-0.185***
			(0.054)	(0.048)
N	1240	1240	862	862
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.352	0.354	0.378	0.377

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.38: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

1.B.9 Using a Party-Free Measure of Polarization (Standard Deviation)

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic House	0.334*	0.235	0.309*	0.215
	(0.170)	(0.183)	(0.167)	(0.184)
Polariz (Hou, STD)	0.758***	0.728***	0.794***	0.723**
	(0.251)	(0.265)	(0.258)	(0.272)
Democratic House × Polariz (Hou, STD)	-0.162	-0.153	-0.142	-0.0911
	(0.183)	(0.168)	(0.200)	(0.190)
Democratic House × Margin <5% × Polariz (Hou, STD)			-0.222***	-0.229***
			(0.082)	(0.080)
N	1267	1267	1267	1267
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.373	0.372	0.374	0.373

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.39: Results of estimating eq. (1.3) using standard deviation of the legislators’ estimates as a measure of polarization.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic House	0.0650	0.0621	0.0438	0.0398
	(0.076)	(0.078)	(0.066)	(0.071)
Polariz (Hou, STD)	-0.0679	-0.0155	-0.0357	0.00136
	(0.093)	(0.089)	(0.098)	(0.094)
Margin <5%			-0.107***	-0.0949**
			(0.034)	(0.036)
Margin <5% × Polariz (Hou, STD)			-0.0465*	-0.0412
			(0.023)	(0.027)
N	1267	1267	1267	1267
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.157	0.163	0.160	0.165

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.40: Results of estimating eq. (1.4) using standard deviation of the legislators’ estimates as a measure of polarization.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	-0.199**	-0.192	-0.0848	-0.0616
	(0.099)	(0.127)	(0.108)	(0.126)
Polariz (Hou, STD)	0.733***	0.684***	0.819**	1.098***
	(0.212)	(0.232)	(0.325)	(0.291)
Republican Take Over × Polariz (Hou, STD)	-0.0700	-0.0575	-0.195*	-0.220**
	(0.104)	(0.108)	(0.113)	(0.108)
Republican Take Over × Polariz (Hou, STD) × EnvironmentalAvg			-0.450***	-0.438***
			(0.149)	(0.137)
N	1267	1267	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.372	0.373	0.391	0.393

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.41: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.270**	0.198	-0.0372	0.0521
	(0.132)	(0.133)	(0.133)	(0.151)
Polariz (Hou, STD)	0.623***	0.613**	0.821**	1.158***
	(0.218)	(0.252)	(0.347)	(0.327)
Democratic Take Over × Polariz (Hou, STD)	0.0432	0.0316	0.208*	0.185
	(0.101)	(0.102)	(0.112)	(0.116)
Democratic Take Over × Polariz (Hou, STD) × EnvironmentalAvg			-0.108*	-0.130**
			(0.062)	(0.051)
N	1267	1267	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.371	0.371	0.388	0.391

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.42: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

1.B.10 Using Polarization in the Senate and a Party-Free Measure of Polarization (Standard Deviation)

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic Senate	0.172	0.0539	0.164	0.0444
	(0.172)	(0.201)	(0.175)	(0.204)
Polariz (Sen, STD)	0.172	0.111	0.193	0.140
	(0.224)	(0.214)	(0.264)	(0.246)
Democratic Senate × Polariz (Sen, STD)	-0.0640	0.0217	-0.0848	-0.00821
	(0.142)	(0.159)	(0.164)	(0.164)
Democratic Senate × Margin <5% × Polariz (Sen, STD)			0.0984	0.0444
			(0.130)	(0.106)
N	1240	1240	1240	1240
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.349	0.353	0.348	0.352

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.43: Results of estimating eq. (1.3) using standard deviation of the legislators' estimates in the senate as a measure of polarization.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic Senate	0.0491	0.0540	0.0424	0.0370
	(0.045)	(0.046)	(0.048)	(0.047)
Polariz (Sen, STD)	-0.139	-0.112	-0.128	-0.0952
	(0.092)	(0.084)	(0.094)	(0.088)
Margin <5%			0.0453	0.0459
			(0.064)	(0.066)
Margin <5% × Polariz (Sen, STD)			-0.0388	-0.0588
			(0.032)	(0.038)
N	1240	1240	1240	1240
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.164	0.172	0.163	0.171

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.44: Results of estimating eq. (1.4) using standard deviation of the legislators' estimates in the senate as a measure of polarization.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	-0.153	-0.155	-0.0814	-0.0937
	(0.093)	(0.123)	(0.140)	(0.143)
Polariz (Sen, STD)	0.183	0.166	0.268	0.186
	(0.209)	(0.211)	(0.250)	(0.271)
Republican Take Over × Polariz (Sen, STD)	-0.136	-0.0945	-0.211*	-0.256**
	(0.084)	(0.091)	(0.116)	(0.114)
Republican Take Over × Polariz (Sen, STD) × EnvironmentalAvg			-0.299*	-0.325**
			(0.163)	(0.153)
N	1240	1240	862	862
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.352	0.356	0.380	0.380

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.45: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.310^{*}	0.197	0.0847	0.211^{*}
	(0.177)	(0.170)	(0.134)	(0.124)
Polariz (Sen, STD)	0.0738	0.0838	0.248	0.207
	(0.201)	(0.205)	(0.257)	(0.280)
Democratic Take Over × Polariz (Sen, STD)	0.0331	0.0312	0.118	0.0406
	(0.205)	(0.203)	(0.133)	(0.125)
Democratic Take Over × Polariz (Sen, STD) × EnvironmentalAvg			-0.176^{***}	-0.187^{***}
			(0.054)	(0.048)
N	1240	1240	862	862
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.352	0.354	0.378	0.377

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.46: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

1.B.11 Using a Party-Free Measure of Polarization (Coefficient of Variation)

	(1) Environmental	(2) Environmental	(3) Environmental	(4) Environmental
Democratic House	0.379**	0.269	0.384**	0.277
	(0.170)	(0.172)	(0.177)	(0.178)
Polariz (Hou, CoV)	0.00360	0.00337	0.00344	0.00321
	(0.014)	(0.014)	(0.014)	(0.014)
Democratic House × Polariz (Hou, CoV)	0.0681	0.0365	0.0857	0.0595
	(0.089)	(0.105)	(0.082)	(0.091)
Democratic House × Margin <5% × Polariz (Hou, CoV)			-0.175	-0.245
			(0.584)	(0.569)
N	1275	1275	1275	1275
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.360	0.361	0.359	0.360

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.47: Results of estimating eq. (1.3) using the coefficient of variation of legislators’ estimates as a measure of polarization.

	(1) Enacted	(2) Enacted	(3) Enacted	(4) Enacted
Democratic House	0.0696	0.0665	0.0557	0.0492
	(0.070)	(0.074)	(0.062)	(0.068)
Polariz (Hou, CoV)	0.00814	0.0102	0.00889	0.0108
	(0.012)	(0.012)	(0.012)	(0.012)
Margin <5%			-0.122***	-0.104***
			(0.035)	(0.036)
Margin <5% × Polariz (Hou, CoV)			-0.116*	-0.129*
			(0.068)	(0.074)
N	1275	1275	1275	1275
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.158	0.164	0.160	0.166

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.48: Results of estimating eq. (1.4) using the coefficient of variation of legislators’ estimates as a measure of polarization.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Republican Take Over	-0.167*	-0.171	-0.0242	-0.0387
	(0.096)	(0.121)	(0.130)	(0.147)
Polariz (Hou, CoV)	0.115***	0.105***	0.127***	0.122***
	(0.034)	(0.034)	(0.047)	(0.043)
Republican Take Over × Polariz (Hou, CoV)	-0.127***	-0.115***	-0.205	-0.194
	(0.035)	(0.036)	(0.179)	(0.196)
Republican Take Over × Polariz (Hou, CoV) × EnvironmentalAvg			-0.0725	-0.0724
			(0.244)	(0.273)
N	1275	1275	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.358	0.362	0.382	0.380

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.49: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

	(1)	(2)	(3)	(4)
	Environmental	Environmental	Environmental	Environmental
Democratic Take Over	0.925***	0.779***	0.887***	0.836**
	(0.189)	(0.180)	(0.328)	(0.320)
Polariz (Hou, CoV)	0.00654	0.00548	-0.00432	-0.00222
	(0.017)	(0.016)	(0.014)	(0.014)
Democratic Take Over × Polariz (Hou, CoV)	4.979***	4.622***	6.888***	5.588**
	(1.359)	(1.449)	(2.523)	(2.662)
Democratic Take Over × Polariz (Hou, CoV) × EnvironmentalAvg			-2.097	-1.513
			(1.861)	(1.893)
N	1275	1275	893	893
State FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Method	OLS	OLS	OLS	OLS
Adjusted R2	0.360	0.362	0.383	0.381

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.50: Results of estimating eq. (1.5) restricting the sample to bills proposed by the majority party.

1.C Proofs & Derivations

1.C.1 Equilibrium Values

Substituting the normalization eqs. (1.11) and (1.18) into the relative labor demand, eq. (1.19), we obtain the equilibrium values of labor

$$N_d = \frac{(1-\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}} \tag{1.29}$$

$$N_c = \frac{(1+\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}} \tag{1.30}$$

where $\zeta \equiv (1-\varepsilon)(1-\alpha) < 0$ if $\varepsilon > 1$.

Substituting the equilibrium values of labor (eqs. (1.29) and (1.30)) and eq. (1.13) into eq. (1.18) gives the equilibrium values of prices

$$p_d = \frac{(1-\tau)^{\frac{\alpha}{\zeta-1}}}{\left[(1+\tau)^{\frac{\alpha(1-\varepsilon)}{\zeta-1}} + (1-\tau)^{\frac{\alpha(1-\varepsilon)}{\zeta-1}}\right]^{\frac{1}{1-\varepsilon}}} \tag{1.31}$$

$$p_c = \frac{(1+\tau)^{\frac{\alpha}{\zeta-1}}}{\left[(1+\tau)^{\frac{\alpha(1-\varepsilon)}{\zeta-1}} + (1-\tau)^{\frac{\alpha(1-\varepsilon)}{\zeta-1}}\right]^{\frac{1}{1-\varepsilon}}} \tag{1.32}$$

Substituting the equilibrium values of labor, eqs. (1.29) and (1.30), into eqs. (1.8) and (1.10) gives the equilibrium values of energy

$$E_d = \left(\frac{(1-\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}}\right)^{\alpha} \tag{1.33}$$

$$E_c = \left(\frac{(1+\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}} \right)^{\alpha} \tag{1.34}$$

$$E = \frac{\left((1+\tau)^{\frac{\alpha(1-\varepsilon)}{\zeta-1}} + (1-\tau)^{\frac{\alpha(1-\varepsilon)}{\zeta-1}} \right)^{\frac{\varepsilon}{\varepsilon-1}}}{\left((1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}} \right)^{\alpha}} \tag{1.35}$$

1.C.2 Proofs

Lemma 1. *If Assumption 1 holds, then*

(i) *Consumption decreases for any value $\tau \neq 0$.*

In addition, $\exists\, \varepsilon > 1$ such that the following statements hold:

(ii) *The profits of the clean sector are increasing in τ.*

(iii) *The profits of the dirty sector are decreasing in τ.*

Proof. We want to show that the following expressions hold

(i) $\frac{\partial C}{\partial \tau} \lesseqgtr 0 \Leftrightarrow \tau \gtreqless 0$

(ii) $\frac{\partial \Pi_d}{\partial \tau} < 0$

(iii) $\frac{\partial \Pi_c}{\partial \tau} > 0$

The signs of the derivatives depend on the equilibrium values of labor, prices, energy and output, eqs. (1.29) to (1.35). The derivatives of labor in both periods take the following form

$$\frac{\partial N_d}{\partial \tau} = \frac{\varepsilon N_d N_c}{\zeta - 1}\left[\frac{1}{1-\tau} + \frac{1}{1+\tau}\right] < 0 \tag{1.36}$$

$$\frac{\partial N_c}{\partial \tau} = \frac{\varepsilon N_d N_c}{1 - \zeta}\left[\frac{1}{1-\tau} + \frac{1}{1+\tau}\right] > 0 \tag{1.37}$$

because $\zeta < 0$ if $\varepsilon > 1$. The derivative of total energy produced is given by

$$\begin{aligned}\frac{\partial E}{\partial \tau} &= \frac{\partial N_d}{\partial \tau}\left[\frac{\partial E}{\partial E_d}\frac{\partial E_d}{\partial N_d} - \frac{\partial E}{\partial E_c}\frac{\partial E_c}{\partial N_c}\right] \\ &= E^{\frac{1}{\varepsilon}}\frac{\partial N_d}{\partial \tau}\left(\frac{E_d^{\frac{\varepsilon-1}{\varepsilon}}}{N_d} - \frac{E_c^{\frac{\varepsilon-1}{\varepsilon}}}{N_c}\right) \lesseqgtr 0 \Leftrightarrow \tau \gtreqless 0 \end{aligned} \tag{1.38}$$

where the first equality is implied by eq. (1.11)

$$\frac{\partial N_d}{\partial \tau} = -\frac{\partial N_c}{\partial \tau} \tag{1.39}$$

The sign of the derivative in eq. (1.38) is determined by the term in brackets

$$\begin{aligned}\frac{E_d^{\frac{\varepsilon-1}{\varepsilon}}}{N_d} - \frac{E_c^{\frac{\varepsilon-1}{\varepsilon}}}{N_c} &= \left(\frac{(1-\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}}\right)^{\frac{\zeta-1}{\varepsilon}} - \left(\frac{(1+\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}}\right)^{\frac{\zeta-1}{\varepsilon}} \\ &\propto (1-\tau)^{-1} - (1+\tau)^{-1} \gtreqless 0 \Leftrightarrow \tau \gtreqless 0 \end{aligned} \tag{1.40}$$

The derivative of output is given by

$$\begin{aligned}
\frac{\partial Y}{\partial \tau} &= Y\left[-\gamma \frac{\partial (S-\bar{S})}{\partial \tau} + \frac{1}{E}\frac{\partial E}{\partial \tau}\right] \\
&= \frac{\varepsilon N_d N_c Y}{\zeta - 1}\left(\frac{1}{1-\tau} + \frac{1}{1+\tau}\right)\left[E^{\frac{1}{\varepsilon}-1}\left(\frac{E_d^{\frac{\varepsilon-1}{\varepsilon}}}{N_d} - \frac{E_c^{\frac{\varepsilon-1}{\varepsilon}}}{N_c}\right) - \gamma\rho\frac{E_d}{N_d}\right]
\end{aligned}$$

where the second equality comes from

$$\frac{\partial (S-\bar{S})}{\partial \tau} = d\frac{\partial E_d}{\partial \tau} = \alpha d \frac{E_d}{N_d}\frac{\partial N_d}{\partial \tau}$$

From eq. (1.40), it follows that $\frac{\partial Y}{\partial \tau} > 0$ when $\tau < 0$. On the other hand, when $\tau > 0$,

$$\frac{\partial Y}{\partial \tau} < 0 \Leftrightarrow \left((1-\tau)^{-1} - (1+\tau)^{-1}\right)\frac{(1-\tau)^{\frac{\varepsilon(1-\alpha)}{1-\zeta}}\left((1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}\right)^{\alpha}}{\left((1+\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}} + (1-\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}}\right)} > \gamma\rho$$

Finally, it follows from the resource constraint $C = Y$ that

$$\frac{\partial C}{\partial \tau} = \frac{\partial Y}{\partial \tau}$$

which concludes the proof of the first part of the Lemma. The last two statements of the proof require the derivatives of prices, which are given by

$$\begin{aligned}
\frac{\partial p_d}{\partial \tau} &= p_d p_c^{1-\varepsilon}\frac{\alpha}{1-\zeta}\left[\frac{1}{1-\tau} + \frac{1}{1+\tau}\right] > 0 \\
\frac{\partial p_c}{\partial \tau} &= p_c p_d^{1-\varepsilon}\frac{\alpha}{\zeta-1}\left[\frac{1}{1-\tau} + \frac{1}{1+\tau}\right] < 0
\end{aligned}$$

Substituting the FOCs of the energy sectors, we obtain the equilibrium values of profits

$$\Pi_d = (1-\alpha)(1-\tau)p_d E_d$$
$$\Pi_c = (1-\alpha)(1+\tau)p_c E_c$$

These expressions can be used to obtain the sign of the derivatives of profits

$$\begin{aligned}\frac{\partial \Pi_d}{\partial \tau} &= \left[(1-\alpha)(1-\tau)\left(N_d^\alpha \frac{\partial p_d}{\partial \tau} + \alpha p_d N_d^{\alpha-1}\frac{\partial N_d}{\partial \tau}\right) - (1-\alpha)p_d N_d^\alpha\right] \\ &= \Pi_d\left[\frac{\alpha}{\zeta-1}\left(\frac{1}{1-\tau}+\frac{1}{1+\tau}\right)\left(\varepsilon N_c - p_c^{1-\varepsilon}\right) - \frac{1}{1-\tau}\right]\end{aligned}$$

will be negative if

$$\varepsilon > \left(\frac{1}{1+\tau}\right)\frac{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}} + (1-\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}}} \tag{1.41}$$

Similarly,

$$\begin{aligned}\frac{\partial \Pi_c}{\partial \tau} &= \left[(1-\alpha)(1+\tau)\left(N_c^\alpha \frac{\partial p_c}{\partial \tau} + \alpha p_c N_c^{\alpha-1}\frac{\partial N_c}{\partial \tau}\right) + (1-\alpha)p_c N_c^\alpha\right] \\ &= \Pi_c\left[\frac{\alpha}{1-\zeta}\left(\frac{1}{1-\tau}+\frac{1}{1+\tau}\right)\left(\varepsilon N_d - p_d^{1-\varepsilon}\right) + \frac{1}{1+\tau}\right]\end{aligned}$$

will be positive if

$$\varepsilon > \left(\frac{1}{1-\tau}\right)\frac{(1+\tau)^{\frac{\varepsilon}{1-\zeta}} + (1-\tau)^{\frac{\varepsilon}{1-\zeta}}}{(1+\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}} + (1-\tau)^{\frac{\alpha(\varepsilon-1)}{1-\zeta}}} \tag{1.42}$$

Lemma 2. *If Assumption 2 holds, then the threshold $\bar{\omega}(\tau, \bar{\tau}, \bar{S})$ is decreasing in τ.*

Proof. Taking the derivative of $\bar{\omega}$ gives

$$\frac{\partial \bar{\omega}}{\partial \tau} \propto \left(U_C' \frac{\partial C}{\partial \tau} + \frac{\partial \Pi_c}{\partial \tau} \right) \left(\Pi_c - \bar{\Pi}_c - (\Pi_d - \bar{\Pi}_d) \right) \\ - \left(\frac{\partial \Pi_c}{\partial \tau} - \frac{\partial \Pi_d}{\partial \tau} \right) \left(U(C) - U(\bar{C}) + \Pi_c - \bar{\Pi}_c \right)$$

We want to show that the sign of this derivative is negative,

$$\frac{\partial \bar{\omega}}{\partial \tau} < 0 \Leftrightarrow \frac{U_C' \frac{\partial C}{\partial \tau} + \frac{\partial \Pi_c}{\partial \tau}}{\frac{\partial \Pi_c}{\partial \tau} - \frac{\partial \Pi_d}{\partial \tau}} < \bar{\omega}$$

From Section 1.C.2, we know that $\frac{\partial \Pi_d}{\partial \tau} < 0$ and $\frac{\partial \Pi_c}{\partial \tau} > 0$. Then, the denominator

$$\frac{\partial \Pi_c}{\partial \tau} - \frac{\partial \Pi_d}{\partial \tau}$$

is positive when the agenda setter is planning to increase taxes, i.e. $\tau > \bar{\tau}$. Note that the numerator has to satisfy

$$U_{C_1}' \frac{\partial C}{\partial \tau} + \frac{\partial \Pi_c}{\partial \tau} \geq 0$$

Otherwise, the first-order condition of the agenda-setter in free rein case would be

$$U_C' \frac{\partial C}{\partial \tau} + \omega \frac{\partial \Pi_d}{\partial \tau} + (1 - \omega) \frac{\partial \Pi_c}{\partial \tau} < 0 \, \forall \, \omega \in [0, 1]$$

which would collapse to the case $\tau_D^u = \tau_R^u = -1$. □

Note that within the range $\tau \in (-1, 1)$, both eqs. (1.41) and (1.42) are well defined. Since acceptable values of ε lie in the set of positive real numbers, there will always exist a $\underline{\varepsilon}$ such that $\forall\, \varepsilon > \underline{\varepsilon}$, eqs. (1.41) and (1.42) will be satisfied. □

Lemma 3. *If* $\left|U_C' \frac{\partial^2 C}{\partial \tau^2}\right| > \left|\frac{\partial^2 \Pi_c}{\partial \tau^2}\right| \ \forall\, \tau$*, then* $\lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}(\tau_D^b, \bar{\tau}, \bar{S})$ *is decreasing in* $\bar{\tau}$*.*

Proof. By L'Hôpital's rule,

$$\lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}(\tau_D^b, \bar{\tau}, \bar{S}) = \lim_{\tau_D^b \to \bar{\tau}} \frac{U_C' \frac{\partial C}{\partial \tau} + \frac{\partial \Pi_c}{\partial \tau}}{\frac{\partial \Pi_c}{\partial \tau} - \frac{\partial \Pi_d}{\partial \tau}} = \left. \frac{U_C' \frac{\partial C}{\partial \tau} + \frac{\partial \Pi_c}{\partial \tau}}{\frac{\partial \Pi_c}{\partial \tau} - \frac{\partial \Pi_d}{\partial \tau}} \right|_{\tau = \bar{\tau}}$$

The derivative of this object will be proportional to

$$\left(U_C' \frac{\partial^2 C}{\partial \tau^2} + \frac{\partial^2 \Pi_c}{\partial \tau^2}\right)\left(\frac{\partial \Pi_c}{\partial \tau} - \frac{\partial \Pi_d}{\partial \tau}\right) - \left(\frac{\partial^2 \Pi_c}{\partial \tau^2} - \frac{\partial^2 \Pi_d}{\partial \tau^2}\right)\left(U_C' \frac{\partial C}{\partial \tau} + \frac{\partial \Pi_c}{\partial \tau}\right) < 0$$

will be negative if the assumption is satisfied. The statement follows from Lemma 1 and because C is concave, and Π_c, Π_d are convex in τ. □

Lemma 4. *If Assumption 1 and 2 hold, then the cross partial derivatives of* $U(C), \Pi_d, \Pi_c$ *have the same sign as the derivatives in Lemma 1.*

Proof. We need to show that the following expressions hold

$$\frac{\partial^2 U(C)}{\partial \bar{S} \partial \tau} < 0 \qquad \frac{\partial^2 \Pi_d}{\partial \bar{S} \partial \tau} \leq 0 \qquad \frac{\partial^2 \Pi_c}{\partial \bar{S} \partial \tau} \geq 0 \tag{1.43}$$

In order to obtain the cross partial derivatives, it is easier to start with the derivative with respect to $\bar{S}$. The derivative of the utility function is given by

$$\frac{\partial U(C)}{\partial \bar{S}} = U'_C \frac{\partial C}{\partial \bar{S}} \propto U'_C \frac{\partial Y}{\partial \bar{S}} = \gamma U'_C Y > 0$$

and the derivative of profits is given by

$$\frac{\partial \Pi_i}{\partial \bar{S}} = (1 - \tau_i)(1 - \alpha) E_{it} \frac{\partial p_i}{\partial \bar{S}} = 0 \text{ for } i = \{c, d\}$$

because

$$\frac{\partial p_i}{\partial \bar{S}} \propto \frac{\partial}{\partial \bar{S}} \left(\nu \frac{Y}{E} \right) = 0$$

The cross partial derivatives are then given by

$$\frac{\partial^2 U(C)}{\partial \bar{S} \partial \tau} \propto \frac{\partial}{\partial \tau} \left(\gamma U'_C \frac{\partial Y}{\partial \tau} \right) < 0 \qquad \frac{\partial^2 \Pi_i}{\partial \bar{S} \partial \tau} = 0 \text{ for } i = \{c, d\}$$

□

Theorem 2. *For any given status quo tax level $\bar{\tau}$, and if Assumption 2 holds, the threshold $\underline{\mu}_D(\hat{\tau})$ is weakly increasing in ψ_R.*

Proof. From eq. (1.26) and for $\psi'_R > \psi_R$ and slightly abusing notation by referring to $\bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right)$ as $\bar{\omega}$, we have that

$$\begin{aligned}
\frac{1}{2} &= \underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid \ell \leq \mu\right) + (1 - \underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid \ell > \mu\right) \\
&= \underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_D\right) + (1 - \underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_R\right) \\
&> \underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_D\right) + (1 - \underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_R'\right)
\end{aligned}$$

Since $\underline{\mu}_D$ is defined at the limit $\tau_D^b \to \bar{\tau}$, $\bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right) \perp \psi_R$. Finally, $\exists\, \underline{\mu}_D' > \underline{\mu}_D$ such that

$$\begin{aligned}
&\underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_D\right) + (1 - \underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_R'\right) < \\
&\underline{\mu}_D'(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_D\right) + (1 - \underline{\mu}_D'(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_R'\right) = \frac{1}{2}
\end{aligned}$$

□

Corollary 1. *For any given status quo tax level $\bar{\tau}$, and if Assumption 2 holds, the bargaining tax level τ_D^b is weakly decreasing in ψ_R.*

Proof. For $\psi_R' > \psi_R$,

$$\begin{aligned}
\frac{1}{2} &= \mu Pr\left(\omega_\ell \leq \bar{\omega} \mid \ell \leq \mu\right) + (1 - \mu) Pr\left(\omega_\ell \leq \bar{\omega} \mid \ell > \mu\right) \\
&= \mu Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_D\right) + (1 - \mu) Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_R\right) \\
&> \mu Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_D\right) + (1 - \mu) Pr\left(\omega_\ell \leq \bar{\omega} \mid k, \psi_R'\right)
\end{aligned}$$

Furthermore, we have that $\forall\, \tilde{\omega}$ such that $\tilde{\omega} \geq \bar{\omega}\left(\hat{\tau}(\psi_R), \bar{\tau}, \bar{S}\right)$

$$\mu Pr\left(\omega_\ell \leq \tilde{\omega} \mid k, \psi_D\right) + (1-\mu) Pr\left(\omega_\ell \leq \tilde{\omega} \mid k, \psi'_R\right) \geq$$
$$\mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}(\psi_R), \bar{\tau}, \bar{S}\right) \mid k, \psi_D\right) + (1-\mu) Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}(\psi_R), \bar{\tau}, \bar{S}\right) \mid k, \psi'_R\right)$$

Then, $\exists\, \bar{\omega}\left(\hat{\tau}(\psi'_R), \bar{\tau}, \bar{S}\right) > \bar{\omega}\left(\hat{\tau}(\psi_R), \bar{\tau}, \bar{S}\right)$ such that

$$\mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}(\psi'_R), \bar{\tau}, \bar{S}\right) \mid k, \psi_D\right) + (1-\mu) Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}(\psi'_R), \bar{\tau}, \bar{S}\right) \mid k, \psi'_R\right) = \frac{1}{2}$$

From Lemma 2,

$$\bar{\omega}\left(\hat{\tau}(\psi'_R), \bar{\tau}, \bar{S}\right) > \bar{\omega}\left(\hat{\tau}(\psi_R), \bar{\tau}, \bar{S}\right) \Leftrightarrow \hat{\tau}(\psi'_R) < \hat{\tau}(\psi_R)$$

□

Corollary 2. *The unconstrained tax level τ_R^u (τ_D^u) is weakly increasing (decreasing) in $\bar{S}$.*

Proof. Consider two different pre-period levels of emissions, S^H, S^L with $S^H > S^L$. It then follows from Lemma 1 and the expressions in

Lemma 4 that

$$
\begin{aligned}
&U'_C \frac{\partial C}{\partial \tau}\bigg|_{\bar{S}=S^H} + \omega_{AR}\frac{\partial \Pi_d}{\partial \tau}\bigg|_{\bar{S}=S^H} + (1-\omega_{AR})\frac{\partial \Pi_c}{\partial \tau}\bigg|_{\bar{S}=S^H} \\
&< U'_C \frac{\partial C}{\partial \tau}\bigg|_{\bar{S}=S^L} + \omega_{AR}\frac{\partial \Pi_d}{\partial \tau}\bigg|_{\bar{S}=S^L} + (1-\omega_{AR})\frac{\partial \Pi_c}{\partial \tau}\bigg|_{\bar{S}=S^L} \\
&< U'_C \frac{\partial C}{\partial \tau}\bigg|_{\bar{S}=S^L} + \omega_{AD}\frac{\partial \Pi_d}{\partial \tau}\bigg|_{\bar{S}=S^L} + (1-\omega_{AD})\frac{\partial \Pi_c}{\partial \tau}\bigg|_{\bar{S}=S^L} \\
&< U'_C \frac{\partial C}{\partial \tau}\bigg|_{\bar{S}=S^H} + \omega_{AD}\frac{\partial \Pi_d}{\partial \tau}\bigg|_{\bar{S}=S^H} + (1-\omega_{AD})\frac{\partial \Pi_c}{\partial \tau}\bigg|_{\bar{S}=S^H}
\end{aligned}
$$

which implies that $\tau_R^u(S^H) > \tau_R^u(S^L) > \tau_D^u(S^L) > \tau_D^u(S^H)$. □

Corollary 3. *If Assumption 2 holds, then the threshold $\underline{\mu}_D(\hat{\tau})$ weakly decreases with a lower $\bar{S}$.*

Proof. Taking the derivative of $\bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right)$ gives

$$\frac{\partial}{\partial \bar{S}}\left(\bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right)\right) \propto \gamma \frac{\partial}{\partial \tau}\left(\bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right)\right) \tag{1.44}$$

which, following Lemma 2, is negative if $\left|U'_C \frac{\partial C}{\partial \tau}\right| < \left|\frac{\partial \Pi_c}{\partial \tau}\right|$. It then follows that for two different pre-period levels of emissions, S^H, S^L with $S^H > S^L$,

$$
\begin{aligned}
\frac{1}{2} &= \underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \le \bar{\omega}\left(\cdot, S^H\right) \mid \ell \le \mu\right) + (1-\underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \le \bar{\omega}\left(\cdot, S^H\right) \mid \ell > \mu\right) \\
&< \underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \le \bar{\omega}\left(\cdot, S^L\right) \mid \ell \le \mu\right) + (1-\underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \le \bar{\omega}\left(\cdot, S^L\right) \mid \ell > \mu\right)
\end{aligned}
$$

By the same logic as in Theorem 1, $\exists\, \underline{\mu}'_D < \underline{\mu}_D$ such that

$$\underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\cdot, S^L\right) \mid \ell \leq \mu\right) + (1 - \underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\cdot, S^L\right) \mid \ell > \mu\right) >$$
$$\underline{\mu}'_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\cdot, S^L\right) \mid \ell \leq \mu\right) + (1 - \underline{\mu}'_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\cdot, S^L\right) \mid \ell > \mu\right) = \frac{1}{2}$$

□

Corollary 4. *If* $\left|U'_C \frac{\partial^2 C}{\partial \tau^2}\right| > \left|\frac{\partial^2 \Pi_c}{\partial \tau^2}\right| \;\forall\; \tau$, *then the threshold* $\underline{\mu}_D(\bar{\tau})$ *is increasing in* $\bar{\tau}$.

Proof. From eq. (1.26) and for $\bar{\tau}' > \bar{\tau}$, we have that

$$\begin{aligned}
\frac{1}{2} &= \underline{\mu}_D(\bar{\tau}) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\cdot, \bar{\tau}\right) \mid \ell \leq \mu\right) + (1 - \underline{\mu}_D(\bar{\tau})) \lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\cdot, \bar{\tau}\right) \mid \ell > \mu\right) \\
&= \underline{\mu}_D(\bar{\tau}) Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}\left(\cdot, \bar{\tau}\right) \mid \ell \leq \mu\right) + (1 - \underline{\mu}_D(\bar{\tau})) Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}\left(\cdot, \bar{\tau}\right) \mid \ell > \mu\right) \\
&> \underline{\mu}_D(\bar{\tau}) Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}\left(\cdot, \bar{\tau}'\right) \mid \ell \leq \mu\right) + (1 - \underline{\mu}_D(\bar{\tau})) Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}\left(\cdot, \bar{\tau}'\right) \mid \ell > \mu\right)
\end{aligned}$$

where the equality follows from

$$\begin{aligned}
\lim_{\tau_D^b \to \bar{\tau}} Pr\left(\omega_\ell \leq \bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right)\right) &\equiv \lim_{\tau_D^b \to \bar{\tau}} \int_{-\infty}^{\bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right)} f_\omega(t) dt \\
&= \int_{-\infty}^{\lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right)} f_\omega(t) dt \\
&\equiv Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega}\left(\tau_D^b, \bar{\tau}, \bar{S}\right)\right)
\end{aligned}$$

and the inequality follows from Lemma 3.

By the same logic as in Theorem 1, $\exists\, \underline{\mu}'_D > \underline{\mu}_D$ such that

$$\underline{\mu}_D(\bar{\tau})Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega} \mid \ell \leq \mu\right) + (1-\underline{\mu}_D(\bar{\tau}))Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega} \mid \ell > \mu\right) <$$
$$\underline{\mu}'_D(\bar{\tau})Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega} \mid \ell \leq \mu\right) + (1-\underline{\mu}'_D(\bar{\tau}))Pr\left(\omega_\ell \leq \lim_{\tau_D^b \to \bar{\tau}} \bar{\omega} \mid \ell > \mu\right) = \frac{1}{2}$$

□

Corollary 5. *If* $\left|U'_C \frac{\partial^2 C}{\partial \tau^2}\right| > \left|\frac{\partial^2 \Pi_c}{\partial \tau^2}\right| \forall\, \tau$, *then the bargaining tax level* τ_D^b *is weakly decreasing in* $\bar{\tau}$.

Proof. For $\bar{\tau}' > \bar{\tau}$, and from Lemma 3,

$$\frac{1}{2} = \mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell \leq \mu\right) + (1-\mu)Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell > \mu\right)$$
$$< \mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}', \bar{S}\right) \mid \ell \leq \mu\right) + (1-\mu)Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}', \bar{S}\right) \mid \ell > \mu\right)$$

Furthermore, we have that $\forall\, \tilde{\omega}$ such that $\tilde{\omega} \geq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right)$

$$\mu Pr\left(\omega_\ell \leq \tilde{\omega} \mid \ell \leq \mu\right) + (1-\mu)Pr\left(\omega_\ell \leq \tilde{\omega} \mid \ell > \mu\right) \geq$$
$$\mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell \leq \mu\right) + (1-\mu)Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \mid \ell > \mu\right)$$

Finally, $\exists\, \bar{\omega}\left(\hat{\tau}', \bar{\tau}', \bar{S}\right) > \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right)$ such that

$$\mu Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}', \bar{\tau}, \bar{S}\right) \mid \ell \leq \mu\right) + (1-\mu)Pr\left(\omega_\ell \leq \bar{\omega}\left(\hat{\tau}', \bar{\tau}, \bar{S}\right) \mid \ell > \mu\right) = \frac{1}{2}$$

From Lemma 3, $\bar{\omega}\left(\hat{\tau}', \bar{\tau}', \bar{S}\right) > \bar{\omega}\left(\hat{\tau}, \bar{\tau}, \bar{S}\right) \Leftrightarrow \hat{\tau}' < \hat{\tau}$ □

Chapter 2

What’s on the News? Media and Economic Recessions

2.1 Introduction

The Great Recession of 2008 had a particularly long-lasting effect on economic growth. Since the beginning of the recession, some commentators were quick to point out the role of media in spreading panic (Crossley-Holland, 2008; Tett, 2007). In fact, as Schifferes and Roberts (2015) put it “throughout history, the media has been the lens through which the public have understood financial crises”. Content produced by media outlets plays a role in shaping not only public opinion, but also politics (Schudson, 2003). In spite of this, there are no formal business cycle theories that incorporate the role of media as an amplifying mechanism of economic shocks.

This paper documents that news outlets’ economic reporting becomes more coordinated when the economy is in a recession. To do so, I apply Latent Dirichlet Allocation (LDA) to uncover a structure of 40 topics discussed on the front page of newspapers published in the United States between 2007 and 2011. Five of these topics are related to economic issues, ranging from the stock market to the European Debt Crisis. I then define the economic content of newspapers as the proportion of economics-related topics on the front page of a given day. I find that the behavior of economic reporting during recessions changes in two ways: (i) it increases with respect to economic expansions; and (ii) it becomes more coordinated between outlets. In addition, several measures rule out the possibility that news outlets focus on reporting different economic events. Hence, content between outlets becomes more homogeneous. The empirical evidence then suggests that people jointly become more aware of economic conditions during recessions.

This observation gives mass media a central role in the business cycle. The response of the economy to a shock is affected by the degree to which it is perceived by agents in the economy (Woodford, 2001). Through an increase in awareness of economic conditions, the increasing correlation in economic reporting during recessions is bound to amplify the response of agents to an economic shock. If a sufficient amount of people pay attention to the news, this effect could potentially have a macroeconomic impact.[1] This poses the natural question of whether mass media could have contributed in deepening what could have been an otherwise mild recession.

Motivated by this evidence, I present a framework to explain the contribution of mass media in generating persistent economic downturns. The model rests on two key pillars. First, an investment model based on the global games literature (Morris & Shin, 2001) with a dynamic component. The model features non-linear dynamics in the form of multiple steady-states that can lead to persistent recessions. In addition, the global game approach guarantees uniqueness of equilibrium.[2] Second, the framework features news outlets modeled as a public signal structure with correlated noise. That is, each newspaper provides its own information to its readers, but there is a significant correlation with the content of other newspapers.

The latter ingredient allows me to isolate the role of varying common

[1]In 2022, up to 82% of U.S. citizens accessed the news on a regular basis (Pew, 2016).

[2]Because the framework allows for a clear distinction between multiplicity of equilibria and steady-states, a secondary contribution of this paper is to highlight the different forces behind both phenomena.

knowledge (i.e. perception) of a shock. The more correlated the noise between different sources is, the more common knowledge there is in the economy. More importantly, a higher correlation between the content provided by different newspapers will provide more information about what other people know, but it will give no additional information about the value of the fundamental. This modeling strategy will also be useful for the numerical exercise, since the correlation of noise between signals will find its real counterpart in the correlation of economic content measured in the empirical analysis.

News outlets are then potentially a key element to explain variations in the degree of common knowledge of a shock. This new stylized fact about economic reporting highlights the importance of fluctuations in imperfect common knowledge for the business cycle. If negative shocks are associated with higher degrees of common knowledge, the economy will naturally react more to a negative shock than to a positive shock of the same magnitude. In this setup, variations in common knowledge along the business cycle can create an asymmetry in the reaction of the economy to shocks. This asymmetric reaction can be used to explain the unprecedented slow recovery from the Great Recession.

Incorporating newspapers in a stylized investment model, I find that increases in common knowledge have a more-than-proportional effect on output. The more coordinated news outlets become, the more common knowledge the economic conditions become among firms. During a recession, the decision of firms not to invest is amplified because they are aware that other firms are also not willing to invest. Mass media then contribute to the business cycle by increasing awareness of the economic conditions. This increase in common knowledge can turn an otherwise mild recession into a persistent slump.

The global games approach is particularly suited to formalize the contribution of media to economic slumps. The reason is that this framework can embed the key elements needed to formalize this idea. First, a binary investment decision generates sufficient non-linearities to allow for multiple steady-states. Second, a set of public signals, which act as a coordination device for agents' beliefs about the state of the economy. Third, complementary decisions. Together with the public signals, complementarities ensure that correlation in beliefs translates into correlated actions. With agents acting all at once, the economy can suffer from small perturbations to the fundamental when it is "close to the edge" between two steady-states. Finally, persistent investment dynamics impede a quick rebound to the initial state of the economy.

To assess the quantitative relevance of the mechanism, I embed the signal structure of the newspapers into the model developed in Schaal and Taschereau-Dumouchel (2015). The model is a standard real business cycle model with monopolistic producers in which firms choose capacity utilization under uncertainty about a fundamental process. It features demand complementarities as firms' individual production decisions are done taking into account aggregate demand. In addition, firms' capacity utilization provides strong feedback between aggregate demand and production decisions. The combination of these two features gives rise to multiple equilibria, which are disciplined using a global game approach. In equilibrium, the final good behaves as if it were produced by a representative firm with an endogenous, non-linear component.

The results of the model confirm that the presence of mass media can have an amplifying effect in the economy. In the advent of an economic shock, the decision of firms not to invest is amplified by newspapers. Because newspapers coordinate in economic reporting, common knowledge of economic conditions increases as well. Firms' decision to invest decreases because they are aware that other firms are also not willing to invest. The resulting descent in entrant firms produces a decrease in output, consumption, and labor that is amplified just by the presence of newspapers and their role in disseminating common knowledge.

Literature Review

The primary contribution of this paper is the proposal of a new mechanism by which variations in common knowledge can generate persistent recessions. This contribution is embedded in the recent literature on business cycles with dispersed information. Removing the common knowledge assumption can help accommodate the notion of animal spirits that mainstream models cannot (e.g. Angeletos & La'O, 2013; Benhabib et al., 2015). The closest example to this paper within this class is Nimark (2014), which investigates the business cycle implications of a key aspect of news reporting: the fact that unusual events are more likely to be reported than commonplace ones (referred to as "man-bites-dog" signals). In particular, Bayesian agents updating to signals that are more likely to be available about unusual events can explain large changes in aggregate variables without an easily identifiable change in fundamentals.

This paper shares some similarities with the news shocks literature (Beaudry & Portier, 2004; Jaimovich & Rebelo, 2009; Lorenzoni, 2009). In this literature, business cycles are driven by difficulties encountered by agents in properly forecasting future productivity. Instead, I model news about the economy as a set of public signals with correlated noise. Productivity is still the main driver of the business cycle.

This paper also shares some similarities with the uncertainty shocks literature (Bloom, 2009; Bloom et al., 2018).[3] This literature posits that business cycle fluctuations can be accounted for variations in the standard deviation of the shocks that hit the economy (Fernández-Villaverde & Guerrón-Quintana, 2020). In this paper, I highlight the role of the uncertainty about what others know (i.e. a high-order uncertainty), instead of the uncertainty about the fundamental.

By applying this framework to media, I also contribute to the literature studying its economic impact. News outlets are known to have an impact on policy outcomes (Besley & Burgess, 2002; Eisensee & Strömberg, 2007; Strömberg, 2004), asset prices (Tetlock, 2007), and economic expectations (Boomgaarden et al., 2011). However, there have been few attempts to incorporate media into business cycle models. Chahrour et al. (2021) is a notable example. The authors show that media reporting about unrepresentative sectors of the economy coordinates firms' labor decisions. This creates the appearance of aggregate

[3] See Fernández-Villaverde and Guerrón-Quintana (2020) for a review of the literature.

shocks orthogonal to productivity, even though the only source of exogenous variation are sector-specific shocks.

In this paper, the presence of public information generates instability in the form of transitions between steady-states. Previous literature has emphasized the detrimental effects of public information. Morris and Shin (2002) explore the dual role of public signals both as a provider of information about the fundamental and as a coordination device. In setups with private information, excessive weight on the public signal can induce an excess of coordination, which can lead to higher volatility and lower welfare. This result is generalized in Angeletos and Pavan (2007). In a more applied setting, Angeletos et al. (2016) find that information can be welfare-deteriorating if the cycle is driven by distortionary (e.g. markup) shocks.

The modeling approach in this paper draws from the global games literature (Carlsson & Van Damme, 1993; Morris & Shin, 1998). In particular, I solve a dynamic version of the global game with public information present in Morris and Shin (2000). The dynamic link between periods leads to endogenous cycles in the equilibrium cutoff, as in Steiner (2008). Edmond (2013) applies global games to political regime changes with manipulated media. The author also highlights the importance of the regime's manipulation being common knowledge. Finally, global games have been used in the business cycle literature to discipline equilibrium selection in models with strong complementarities. Schaal and Taschereau-Dumouchel (2015) propose a theory of coordination failures driven by demand complementarities. I embed the signal structure in their model for the numerical illustration of Section 2.4.

2.2 Economic Reporting in the United States

In this section, I document that recessions are accompanied by an increase in the degree of common knowledge about the economic situation. In particular, I use Natural Language Processing (NLP) techniques to uncover the amount of economic content in the front page of newspapers. Economic content not only increases during recessions, it also becomes more coordinated and homogeneous across different newspapers.

2.2.1 Newspaper Data

The empirical analysis of this paper focuses on the period around the Great Recession going from January 2007 to December 2011. I use data from the Dow Jones Factiva database, which contains textual content from more than 30.000 sources.

Within the universe of content published in the U.S. during that period, I limit the sample to front page articles and cover stories published by four newspapers: USA Today, the Washington Post, the Wall Street Journal, and the New York Times.[4] Short articles, corrections, and recurring sections are also excluded.[5] The sample amounts to a total of

[4]Factiva's search engine tags each piece according to their own taxonomy (see Jones, n.d.). In this case, the articles selected are the ones tagged with code NPAG, corresponding to "Page One Stories".

[5]That is, articles tagged with codes NCRX, NCDig, and NSUM; corresponding to corrected items, corporate and news digests, respectively.

29.042 articles. From each of these, I use the headline and the lead paragraph. Table 2.1 provides an illustration of the article database.

2.2.2 Latent Dirichlet Allocation

Introduced in Blei et al. (2003), the Latent Dirichlet Allocation (LDA) is an unsupervised topic model that treats each document as a mixture of topics, and each topic as a cluster of words. Given a set of documents, the LDA model recovers the underlying topic structure.

Several properties of the LDA model make it particularly useful in the context of newspaper articles. First, due to its unsupervised nature, the model recovers the underlying topic structure from the data without any prior assumption about the topics. Second, because documents are defined as a mixture, they are not restricted to a single topic. For example, the LDA will find that the first snippet from Table 2.1 discusses two different topics: firm management and security. Finally, the decomposition of documents into a numerical vector provides an easy way to compare articles with each other.

Although the use of LDA models in economics is not as prevalent as in other fields, there are notable exceptions. Recently, Hansen et al. (2018) have used this method to analyze FOMC transcripts. Similarly, research at the Norges Bank has applied LDA to predict households' inflation expectations (Larsen & Thorsrud, 2019) and to quantify narratives relevant to the business cycle (Larsen et al., 2021).

Text Snippet	Publication	Date
Barclays in Sanctions Bust – U.K. Firm to Pay $298 Million to Settle Charges Involving Iran. Barclays PLC agreed to pay 298 million to settle charges by U.S. and New York prosecutors that the U.K. bank altered financial records for more than a decade...	WSJ	17/08/10
Denmark’s “flexicurity” blends welfare state, economic growth. Across Europe, nations such as France, Italy and Germany struggle with lackluster economic growth, high unemployment and high taxes...	USA Today	07/03/07
Iraq’s turbulent effort to reckon with the violence of its past took another macabre turn on Monday when the execution of Saddam Hussein’s half brother ended with...	NYT	16/01/07
Job Losses Worst Since ’74: 533.000 Shed in November. The U.S. lost half a million jobs in November, the largest one-month drop since 1974, as employers brace for a recession...	WSJ	06/12/08

Table 2.1: Sample articles from the newspaper database.

The LDA model works as follows.[6] Consider a set of D documents, each of length N_d, with an associated vocabulary list of size N. In the LDA framework, each document d is assumed to be generated as a mixture over a set of K latent topics. The latent structure of the model is given by the matrix of topic-document proportions, $\boldsymbol{\theta}$; the distribution of words over topic, $\boldsymbol{\beta}$; and the matrix assigning each word to a topic $\boldsymbol{z}$. The purpose of the LDA model is to recover this underlying structure using only the set of words $\boldsymbol{w}$. Figure 2.1 synthesizes the structure of the model in a simple diagram.

Given the set of words $\boldsymbol{w}$, the joint distribution of $\boldsymbol{\theta}, \boldsymbol{\beta}, \boldsymbol{z}$ can be approximated by

$$Pr\left(\boldsymbol{\theta}, \boldsymbol{\beta}, \boldsymbol{z} \,|\, \boldsymbol{w}\right) \propto \prod_{d=1}^{D} P\left(\theta_d\right) \prod_{k=1}^{K} P\left(\beta_k\right) \left(\prod_{n=1}^{N_d} P\left(w_{dn} \,|\, z_{dn}, \boldsymbol{\beta}\right) P\left(z_{dn} \,|\, \theta_d\right) \right) \tag{2.1}$$

where each column of the $D \times K$ matrix $\boldsymbol{\theta}$ is the topic proportion for document d, and each row of the $K \times N$ matrix $\boldsymbol{\beta}$ is the word distribution for topic k. The assignment to a topic of a word n in document d is given by z_{dn}.

Maximizing the expression eq. (2.1) in order to estimate the underlying structure of the model requires advanced computational techniques. Fortunately, there are several routines available that implement the LDA. In what follows, I apply the Gibbs sampling algorithm developed by

[6] See Blei and Lafferty (2009) for a more detailed exposition of the LDA model.

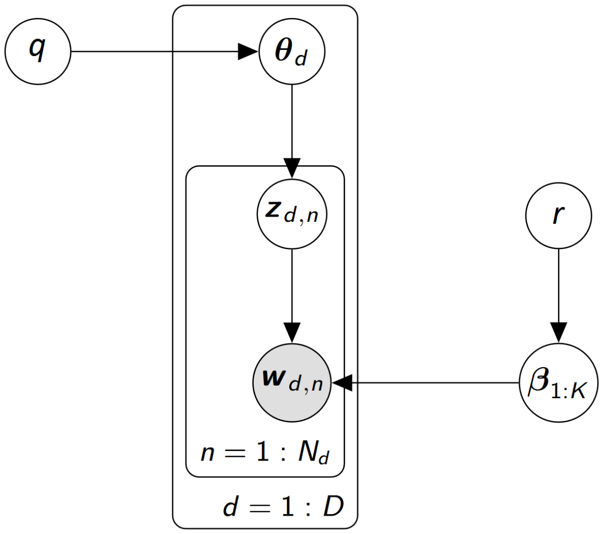

Figure 2.1: Plate Diagram of the Latent Dirichlet Allocation. Source: Blei et al. (2003).

McCallum (2002) for the choice of $K = 40$ topics.[7] I apply the LDA at the front page level. That is, I define document d as the union of articles published during the same day by a given newspaper.

2.2.3 Results of the LDA

The LDA produces two outputs of interest; the distribution of words per topic $\boldsymbol{\beta}$, and the distribution of topics per article $\boldsymbol{\theta}$. The first can be used to give an interpretation to the topics. Some topics are easy to interpret by looking at their high-probability words. Other topics require a closer

[7] Details about the choice of the number of topics and text preprocessing are described in Sections 2.A.1 and 2.A.2.

inspection to their most representative articles. Figure 2.2 presents a word cloud of the highest probability words for the economics-related topics, together with its label.[8]

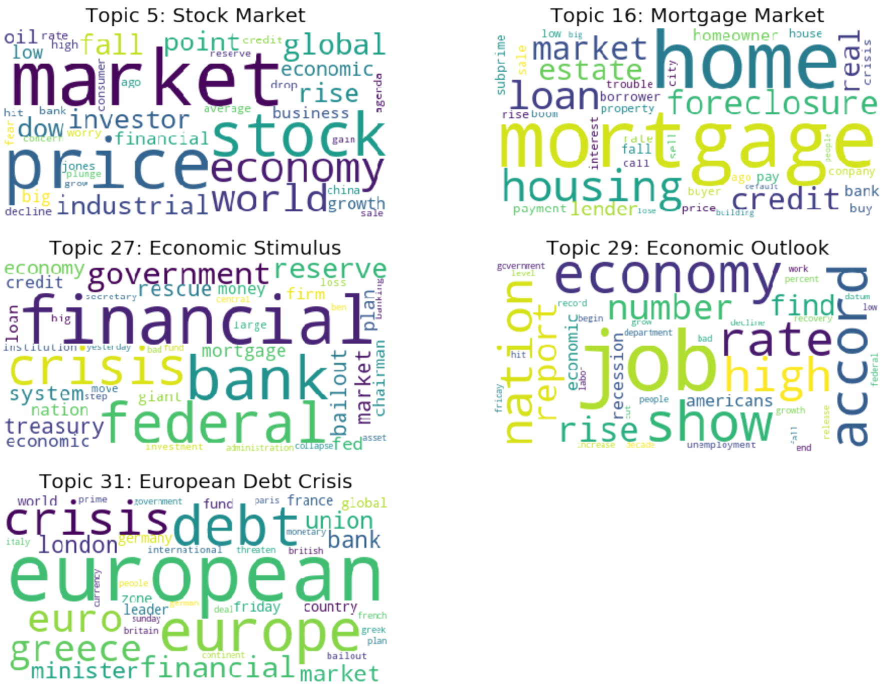

Figure 2.2: Word cloud of the economics-related topics. Each word cloud includes the highest-probability terms, its size weighted by their probability.

The topics discussed within the category of economics are related to the stock and the mortgage market (topics 5 and 16), the release of economic reports and forecasts (topic 29), the announcement of financial stimulus (topic 27), and the European Debt Crisis (topic 31). Non-economics-related topics fit into five broad categories: politics, war,

[8]For the remaining topics, see Tables 2.4 and 2.5 in Section 2.A.2.

international, science & environment, sectoral news, and soft news.[9]

The second output of the LDA is the distribution of topics per article $\boldsymbol{\theta}$. Each element θ_{dk} corresponds to the proportion of topic k in article d. Figure 2.3 plots the daily topic proportion of the six economics-related topics. The announcement of financial stimulus is the most prevalent topic during the sample. The banking system topic peaks during October 2008, coinciding with the bankruptcy of Lehman Brothers. Discussion about the European debt crisis initially peaks around May 2010, coinciding with the announcement of the first bailout of Greece. The topic proportion then increases steadily, closely following talks about a second bailout.

2.2.4 Measuring Economic Content

In order to show that newspapers coordinate in the way they report about the economy during recessions, I first need to define the economic content of the front page, d. In what follows, I denote the economic content of the front page as the sum of the proportion of economics-related topics. That is,

$$EconCont_d = \sum_{k \in Econ} \theta_{dk} \tag{2.2}$$

for all topics k belonging to the economics category. For example, the fourth article from Table 2.1 has an 86% of economic content, attributable almost entirely to the Economic Outlook topic.[10] On the other

[9]Sectoral news include news without economic content about different sectors such as health or education (topics 17 and 38). The term soft news refers to human-interest stories and commodity news (e.g. sports or entertainment).

[10]See Table 2.6 for more details about the topic proportions of articles in Table 2.1.

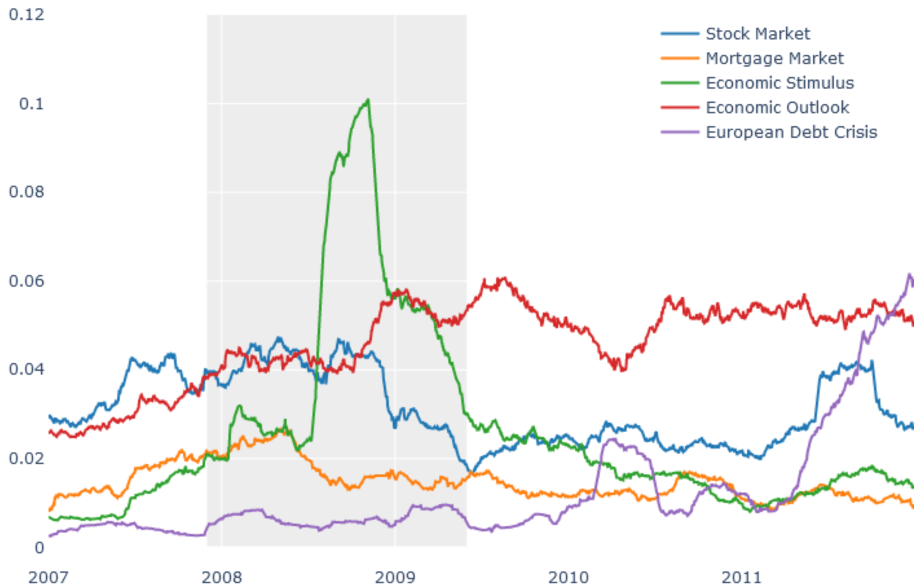

Figure 2.3: Mean topic proportion per day for the economic-related topics. The gray shaded area indicates a recession as defined by the NBER. The series have been smoothed with a two-sided rolling window of 4 months for illustrative purposes.

hand, the second article has a 81% of economic content distributed between three different topics: Economic Stimulus, the European Debt Crisis, and Economic Outlook.

Figure 2.4 plots the evolution of economic content in the front page for every newspaper. Economic content increased in the beginning of the recession and peaked around October 2008, coinciding with the bankruptcy of Lehman Brothers. From then on, it decreased to a higher level than prior to the recession. The Wall Street Journal was the newspaper with a higher economic content, followed by USA Today.

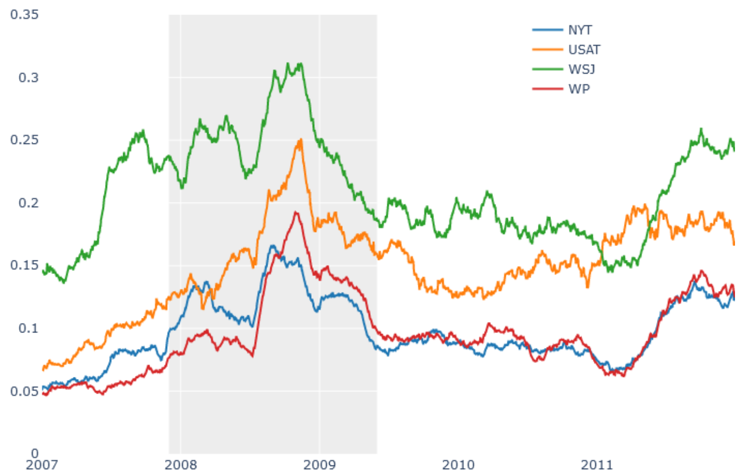

Figure 2.4: Daily mean of economic content per newspaper. The gray shaded area indicates a recession as defined by the NBER. The series have been smoothed with a two-sided rolling window of 4 months for illustrative purposes.

During the Great Recession newspapers not only increased their economic content, they did so in a more coordinated manner. Figure 2.5 plots the correlation of eq. (2.2) between all pairs of newspapers. Correlation in economic content also reaches its maximum around October 2008. To show more formally the relationship between the correlation of economic content and the business cycle, I estimate the following model,

$$Corr_{it} = \beta_0 + \beta_1 Recess_t + f_i + u_{it} \tag{2.3}$$

where $Corr_{it}$ is the correlation of economic content at day t for a newspaper pair i, $Recess_t$ is a dummy which equals to one if the economy was in a recession at day t, f_i are newspaper-pairs fixed effects and u_{it} is the error term. The first column of Table 2.2 presents the results of

	(1) CorrEconContent	(2) SpearmanRank	(3) CosineSimil	(4) Jaccard
Recession	0.166***	0.0552***	0.0266***	0.00880***
	(0.00263)	(0.0107)	(0.00761)	(0.00137)
_cons	0.104***	0.414***	0.494***	0.787***
	(0.00152)	(0.00616)	(0.00440)	(0.000790)
N	10956	8607	8607	8607
adj. R^2	0.267	0.002	0.001	0.004

Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.2: Results of estimating eqs. (2.3) and (2.4) by OLS.

the estimated model eq. (2.3). Correlation of economic content during economic expansions averages 0.1, and 0.26 during recessions. The difference is statistically significant at the 1% level. Although these results do not necessarily speak about causality, they show that recessions are associated with an increase in the correlation of economic content in newspapers.

As a robustness check, I also estimate eq. (2.3) using Spearman's rank correlation (see Figure 2.10). The measure of correlation is particularly useful in this setting, in which topics can be ranked by their propensity to appear on a given day's front page. The results are shown in the last two columns of Table 2.2. Correlation measured by Spearman's rank coefficient also increases during economic expansions. The difference is statistically significant at the 1% level.

The purpose of the previous analysis is to show that recessions are accompanied by an increasing degree of common knowledge about the

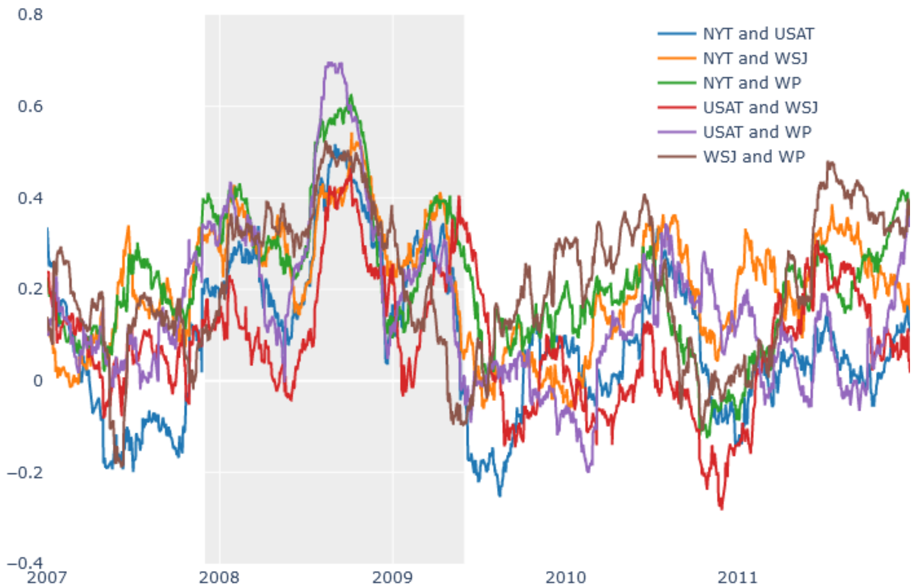

Figure 2.5: Correlation of the measure of economic content between newspapers. The gray shaded area indicates a recession as defined by the NBER. The series have been smoothed with a two-sided rolling window of 4 months for illustrative purposes.

economic situation. However, if newspapers provided different insights about the economic situation, this would not be the case. For this purpose, I also measure the similarity of content across news outlets. There exist several ways to measure the similarity between any two documents. Some of the most common measures used in textual data analysis are cosine similarity and the Jaccard index. Both measures are bounded in $[0, 1]$ and thus invariant to the number of topics estimated in the LDA, K.

The cosine similarity between two non-zero vectors of dimension n, A

and B, is defined as

$$CosineSimil = \frac{\mathbf{A}\cdot\mathbf{B}}{\|\mathbf{A}\|\|\mathbf{B}\|} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}}$$

where A_i, B_i are the i-th element of $\mathbf{A}$ and $\mathbf{B}$, respectively. In the context of text analysis, the vectors are topic proportions. In particular, I calculate the similarity between the topic proportions of the front page for each pair of newspapers, and for each day of the sample.

The Jaccard index is defined as the size of the intersection divided by the size of the union of two sets A and B,

$$J(A,B) = \frac{|A\cap B|}{|A\cup B|} = \frac{|A\cap B|}{|A|+|B|-|A\cap B|}$$

where $|\cdot|$ is the cardinality of a set. In the context of text analysis, the sets are bags of words. In particular, I calculate the Jaccard index between the sets of words published on the front page for each pair of newspapers, and for each day of the sample.

I then estimate the following model,

$$Simil_{it} = \beta_0 + \beta_1 Recess_t + f_i + u_{it} \tag{2.4}$$

where $Simil_{it}$ is either cosine similarity or the Jaccard index for a pair of newspapers i in day t. The last two columns of Table 2.2 present the results of estimating eq. (2.4). The point estimates of β_1 for both regressions are greater than zero, and significant at the 1% level. These results speak against the idea that newspapers discuss different topics during regressions, thus bringing further evidence for the case that common knowledge about economic conditions increases during recessions. These results are in line with a broad literature in political communication studying content homogeneity across Western media (see Boczkowski & De Santos, 2007; Entman, 2006)

To confirm that the results are not driven by the bankruptcy of Lehman Brothers, I repeat the estimation of eq. (2.3) excluding the observations corresponding to the period between September and November 2008. The results are presented in Table 2.8 in Section 2.B. Although the estimated increase of correlation is smaller, the results are still statistically significant at the 1% level.

2.3 The Benchmark Model

In the previous section, I established that economic conditions become more common knowledge during recessions. In this section, I formalize the mechanism by which mass media can contribute to the amplification of economic downturns. I begin by presenting a stylized model that only features the necessary ingredients. I present the simple version of the model in two steps. First, I develop a dynamic version of the global game with public noise present in Morris and Shin (2000). It will be useful to highlight the mechanism by which precise public signals can generate persistent falls in economic activity. I then introduce the notion of newspapers, modeled as a public signal structure with correlated noise. This particular information structure allows me to disentangle the role of common knowledge from that of uncertainty.

2.3.1 The Effect of Public Information

There is a unit mass of risk-neutral agents. Agents in the economy face an infinite-period investment problem. Each of them has an investment opportunity that can either be undertaken or not, $a_i = \{0, 1\}$. The project has an instantaneous payoff,

$$\pi_t = \theta_t + \beta m_t - c$$

where θ_t is the economic fundamental, m_t the mass of agents engaging in the investment opportunity, and c the cost of investment. The economy exhibits complementarities if $\beta > 0$.

The fundamental is distributed according to $\theta_t \overset{iid}{\sim} N(\theta_0, \sigma_0)$. The value of θ_t is unknown, but its mean θ_0 is known. In addition, every period agents receive a private signal $x_{it} = \theta_t + \varepsilon_{it}$, and a public signal $z_t = \theta_t + \eta_t$ with $\varepsilon_{it} \sim N(0, \sigma_\varepsilon)$ and $\eta_t \sim N(0, \sigma_\eta)$, respectively. Simple Bayesian updating leads to the following posterior about θ_t,

$$\theta_t|\{x_{it}, z_t\} \sim N\left(\frac{\frac{\theta_0}{\sigma_0^2} + \frac{x_{it}}{\sigma_\varepsilon^2} + \frac{z_t}{\sigma_\eta^2}}{\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}}, \left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right)^{-1}\right) \tag{2.5}$$

For simplicity, I will denote agent i's expected value of θ_t as $\bar{\theta}_{it}$.

The key difference from Morris and Shin (2000) is that now investment is persistent: if agents decide to invest, the project will extinguish the next period with probability α. Exiting agents are replaced by new ones, and a measure α of the inactive agents receive their own opportunity to invest. Therefore, the mass of investors evolves as follows

$$m_t = (1-\alpha)m_{t-1} + \alpha \int_0^1 a_{it} di \text{ with } \alpha \in [0,1] \tag{2.6}$$

Persistence is necessary because it will generate non-linearities in the form of multiple steady-states. These non-linearities are key to generate persistent downturns.

Proposition 1. *If agents are myopic, then investors will invest in the project if and only if*

$$\bar{\theta}_{it} \geq \kappa_t^*$$

That is, if the expected value of the project is greater or equal to the equilibrium cutoff, which is implicitly defined by

$$\begin{aligned} &\kappa_t^* - c + \beta(1-\alpha)m_{t-1} \\ &\quad + \beta\alpha\Phi\left(\zeta^{-\frac{1}{2}}\left[\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2} + \frac{z_t}{\sigma_\eta^2}\right) - \sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\eta^2}\right)\kappa_t^*\right]\right) = 0 \end{aligned} \tag{2.7}$$

In addition, the law of motion of m_t of the global game with public a public signal can be expressed in closed-form solution as

$$\begin{aligned} &m_t = (1-\alpha)m_{t-1} + \\ &\alpha\Phi\left(\frac{1}{\sqrt{\sigma_0^2 + \sigma_\varepsilon^2}}\left[\theta_t + \sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2} + \frac{z_t}{\sigma_\eta^2}\right) - \kappa_t^*\left(1 + \sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\eta^2}\right)\right)\right]\right) \end{aligned} \tag{2.8}$$

Proof. See Section 2.C.1. □

The resulting law of motion for m_t is the linear combination of the mass of previous investors m_{t-1} and the S-shaped term, $\Phi(\cdot)$. Therefore, it is possible to have multiple steady-states if the second term dominates. In this setup, transitions between steady-states are the key ingredient for public noise to disrupt the economy.[11]

Figure 2.6 plots the law of motion of m_t in an economy with and without a public signal for different values of the fundamental θ_t.[12] The main feature that stands out is the curvature of the law of motion in the case with public noise. This non-linearity generates multiple steady-states for values of the fundamental around its mean, θ_0.

There are two channels that explain the behavior of the law of motion. First, the equilibrium cutoff eq. (2.7). The equilibrium cutoff reacts more to the public signal z_t for lower values of the variance of aggregate noise σ_η^2 (see Figure 2.7). Second, the law of motion eq. (2.8). The mass of prospect investors is also more responsive to the cutoff for lower values of σ_η^2. The implications of this effect are important. Consider an economy with $\theta_{t-1} = \theta_0$ that has converged to its steady-state. Suppose that the fundamental is slightly perturbed, i.e. $\theta_t = \theta_0 - \varepsilon$ for some ε close to zero. In the absence of a public signal, the economy will converge to a lower steady-state. In the event of a recovery, the economy will go back to its previous steady-state. This can be seen in the upper panel of Figure 2.6. In this case, the economy would tran-

[11] The global game setup of the model guarantees uniqueness of equilibrium under well-defined conditions. For a clarification of the distinction between uniqueness of equilibrium and uniqueness of steady sates, see Section 2.C.2.

[12] Calibration of the parameters for the benchmark model is available in Section 2.C.4.

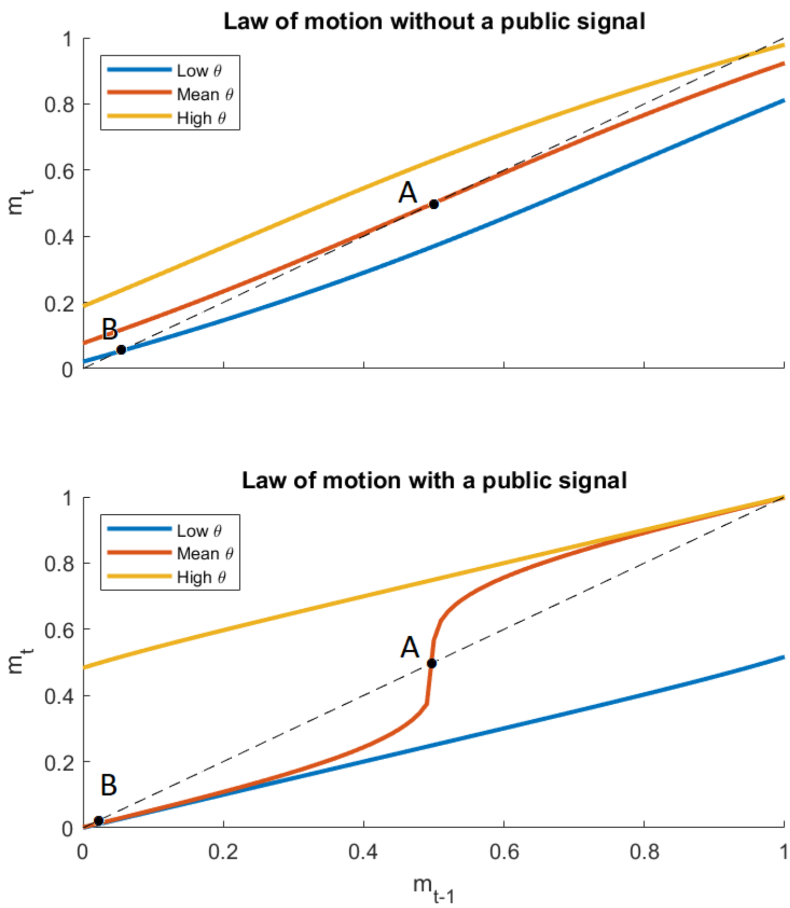

Figure 2.6: Law of motion of m_t for values of the fundamental, $\theta_t = \{\theta_0 - \sigma_0, \theta_0, \theta_0 + \sigma_0\}$, and for $\eta_t = 0$.

sition from Point A to B, and quickly return to A. This is not the case with a public signal. Upon the arrival of the shock, the economy will first experience a transition to a lower steady-state. However, the economy will be now trapped in a low steady-state even if the fundamental goes back to its initial value. It would take a disproportionately positive shock to restore the economy to its initial steady-state. This effect can be seen in the lower panel of Figure 2.6.

In this setting, public noise makes the economy more susceptible to falling into a low-activity regime. The key to this effect lies in the interaction between the dynamics of investment and the precision of the public signal. A precise public signal coordinates agents’ beliefs. Because investment is subject to strategic complementarities, coordinated beliefs translate into coordinated actions. When the fundamental is around its mean, the public signal groups agents’ beliefs near the value of the cut-off. Small perturbations to the fundamental drive the decision to invest or not invest in many agents at the same time. If investment is persistent enough, inertia will push the economy to an extreme steady-state. The more precise the public signal, the more intense this effect is. In the absence of a public signal, beliefs are dispersed and fewer agents react to small changes in the fundamental.

2.3.2 A Model with Newspapers

The previous model closely follows the global game with public noise presented in Morris and Shin (2000). The purpose of that model is to highlight the role of public noise as a coordination device in this economy, and to show how the interaction with the dynamics of investment can generate persistent recessions. However, the presence of a precise public signal confounds the role of public noise as a provider of common knowledge with its associated reduction in uncertainty.

To isolate the role of common knowledge, I rewrite the model with an alternative information structure. In this framework, I show how agents with the same beliefs, facing the same shock and the same uncertainty react differently when there are different levels of common knowledge.

For this purpose, I replace the notion of public signals with newspapers. Newspapers provide noisy information about the state of the fundamental to their readers. Each agent has access to only one newspaper. To keep the analysis tractable, I will consider the case in which there are only two. A fraction $\mu \in (0,1)$ of the population has access to newspaper A, and the remaining $(1-\mu)$ only reads newspaper B. Thus, newspapers are semi-public signals with the following structure

$$z_t^n = \theta_t + v_t^n \text{ for } n = \{A, B\} \text{ with } \mathbf{v_t} \sim N\left(\mathbf{0}, \begin{bmatrix} \sigma_\eta^2 & \hbar\sigma_\eta^2 \\ \hbar\sigma_\eta^2 & \sigma_\eta^2 \end{bmatrix}\right) \quad (2.9)$$

where $\hbar \in [0,1]$ varies the amount of common knowledge present in the economy. One interesting property of this structure is that agents face the same amount of uncertainty whatever the value of $\hbar$ is. A higher $\hbar$ provides more information about what the readers of the other newspaper know, but it gives no additional information about the value of fundamental.

Proposition 2. *If agents are myopic, then investors will invest in the project if and only if*

$$\bar{\theta}_{it} \geq \kappa_t^*$$

That is, if the expected value of the project is greater or equal to the *equilibrium cutoff, which is implicitly defined by*

$$\begin{aligned}
&\kappa_t^{A*} + \beta(1-\alpha)m_{t-1} - c \\
&\quad + \beta\alpha\mu\Phi\left(\zeta^{-\frac{1}{2}}\left[\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^A}{\sigma_\eta^2}\right)-\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\kappa_t^{A*}\right]\right) \\
&\quad + \beta\alpha(1-\mu)\Phi\left(\zeta_2^{-\frac{1}{2}}\left[\frac{\theta_0}{\sigma_0^2}+\left(\kappa_t^{A*}-\kappa_t^{B*}\right)\left(\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}\right)-\frac{\kappa_t^{B*}}{\sigma_0^2}+\hbar\frac{\left(z_t^A-\kappa_t^{A*}\right)}{\sigma_\eta^2}\right]\right)=0
\end{aligned} \tag{2.10}$$

and an analog condition for newspaper B readers. In addition, the law of motion of m_t of the global game with newspapers can be expressed in closed-form solution as

$$\begin{aligned}
&m_t = (1-\alpha)m_{t-1} \\
&\quad + \alpha\mu\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t+\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^A}{\sigma_\eta^2}\right)-\kappa_t^{A*}\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right) \\
&\quad + \alpha(1-\mu)\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t+\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^B}{\sigma_\eta^2}\right)-\kappa_t^{B*}\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right)
\end{aligned} \tag{2.11}$$

Proof. See Section 2.C.1. □

The resulting law of motion is the weighted average of the mass of new investors in each population. Figure 2.8 plots the law of motion of m_t in an economy for different values of the correlation of noise $\hbar$. An increase in $\hbar$ has the same effect as a decrease in the variance of aggregate noise, σ_η^2. The effect, however, is less marked because in this case only one channel is operating. In the previous case, a decrease in σ_η^2 operates through the equilibrium cutoff eq. (2.7) and through the mass of new investors eq. (2.8). In this case, variations in $\hbar$ have an effect only through the equilibrium cutoff, eq. (2.28).

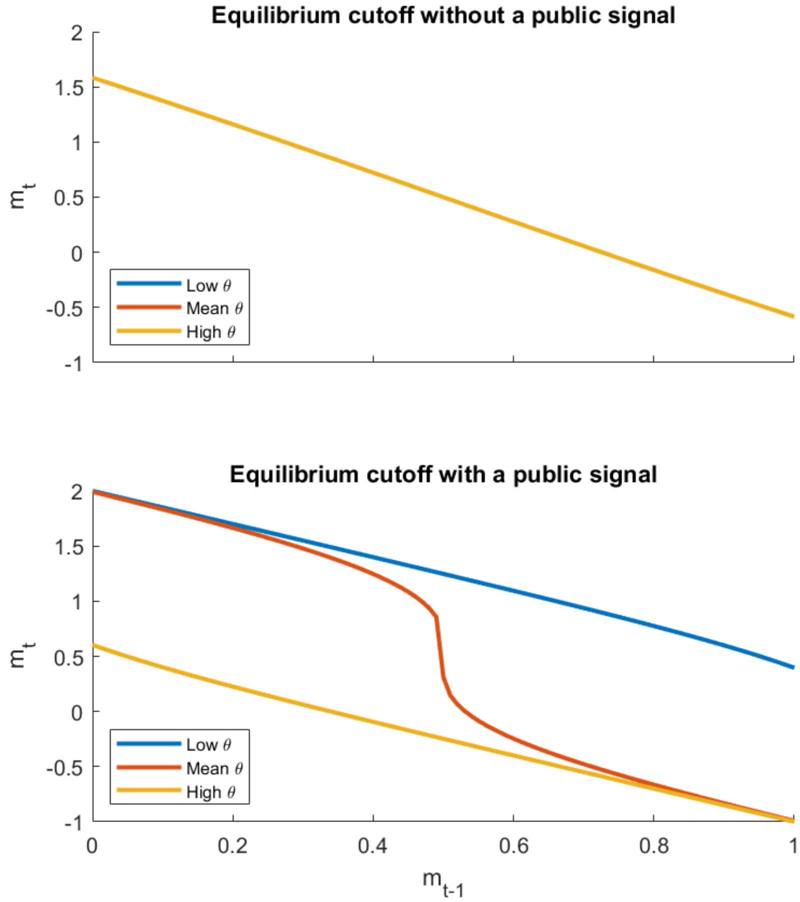

Figure 2.7: Evolution of the equilibrium cutoff κ_t^* for values of the fundamental, $\theta_t = \{\theta_0 - \sigma_0, \theta_0, \theta_0 + \sigma_0\}$, and for $\eta_t = 0$.

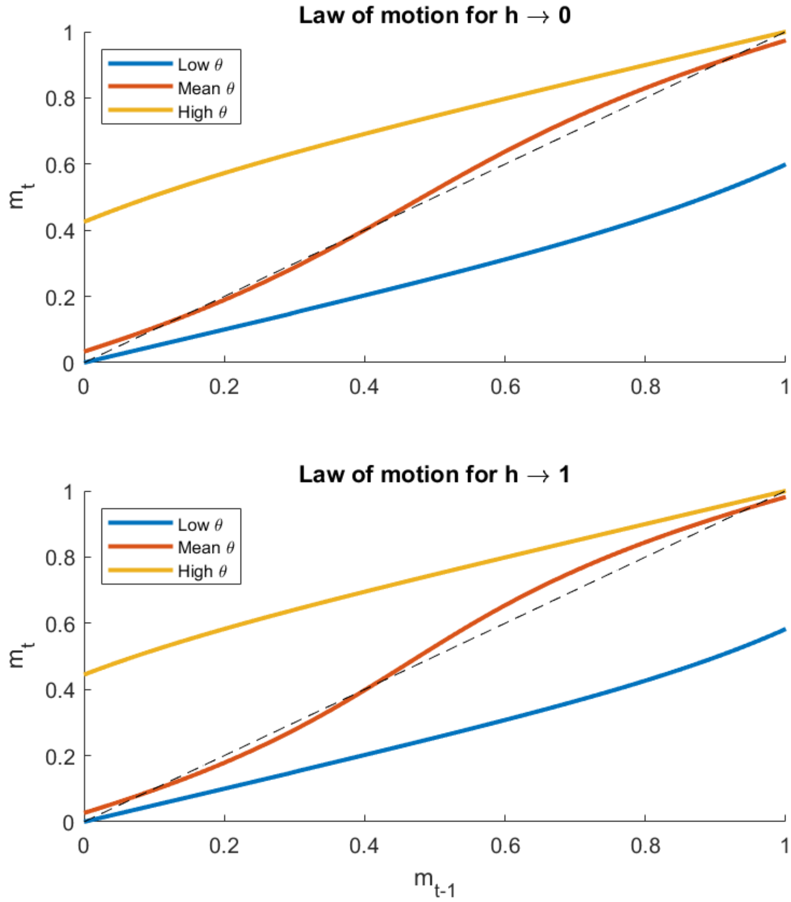

Figure 2.8: Law of motion of m_t for values of the fundamental, $\theta_t = \{\theta_0 - \sigma_0, \theta_0, \theta_0 + \sigma_0\}$, and for $\eta_t = 0$.

2.4 Numerical Illustration

To illustrate the importance of variations in common knowledge, I embed the mechanism into a general equilibrium model. For this purpose, I add the information structure of the previous section to the business cycle model in Schaal and Taschereau-Dumouchel (2015). In addition, this model allows me to restore rational expectations. The model features the same key elements as the one in Section 2.3. Agents imperfectly observe the fundamental through a signal structure, eq. (2.9), and face a binary decision – capacity utilization, in this case. Persistence is ensured by the presence of capital.

2.4.1 Environment

Time is discrete and goes on forever. The economy consists of a representative household, a final good sector, and an intermediate good sector. The final good is produced by a representative firm, and can be used both for consumption and investment. The intermediate goods are produced by a continuum of monopolists, and are solely used to produce the final good.

Households and Preferences

The representative household maximizes lifetime utility

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t U(C_t, L_t) \tag{2.12}$$

where $\beta \in (0,1)$ is the discount factor, $C_t \geq 0$ is the amount of the final good consumed and $L_t \geq 0$ is labor. The period utility of the household is given by GHH preferences (Greenwood et al., 1988)

$$U(C_t, L_t) = \frac{1}{1-\gamma}\left(C_t - \left(\frac{L_t^{1+\nu}}{1+\nu}\right)^{1-\gamma}\right) \text{ with } \gamma > 0, \nu > 0 \quad (2.13)$$

The representative household owns the final good and the intermediate good firms. It also supplies capital K_t and labor L_t in perfectly competitive markets. Every period, the representative household faces the following budget constraint

$$P_t \left(C_t + K_{t+1} - (1-\delta)K_t\right) \leq W_t L_t + R_t K_t + \Pi_t \quad (2.14)$$

where P_t is the price of the final good, W_t the wage rate, R_t the rental rate of capital and Π_t the profits of the firms. Capital depreciates at a rate $0 < \delta < 1$.

Final Good Producer

The final good is produced by a representative firm in a perfectly competitive market. The final good producer aggregates the output of the intermediate sector monopolists using a Dixit-Stiglitz (1980) aggregator

$$Y_t = \left(\int_0^1 Y_{it}^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}} \quad (2.15)$$

where $\sigma > 1$ is the elasticity of substitution between varieties, Y_t is the amount of the final good produced and Y_{it} is the input of intermediate good i. Profit maximization, taking prices as given, results in the following demand curve for every intermediate good i,

$$Y_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\sigma} \text{ with } P_t = \left(\int_0^1 P_{it}^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{2.16}$$

Intermediate Good Producers

Intermediate goods producers have access to the following constant returns to scale production technology

$$Y_{it} = Ae^{\theta_t} u_{it} K_{it}^{\alpha} L_{it}^{1-\alpha} \tag{2.17}$$

where $\alpha \in (0,1)$ is the capital share, K_{it} and L_{it} are capital and labor, and u_{it} is capacity utilization. Productivity depends on a constant scaling factor A and on a fundamental θ_t which follows an AR(1) process,

$$\theta_t = \rho\theta_{t-1} + \xi_t \tag{2.18}$$

where $\xi_t \sim N(0, \sigma_\xi)$.

Capacity utilization can either be low, $u_l = 1$, or high, $u_h = \omega > 1$. Production at high capacity requires a fixed cost $c > 0$. For a given choice of capacity utilization, intermediate producers solve the following production problem:

$$\Pi_{it} = \max_{Y_{it}, P_{it}, K_{it}, L_{it}} P_{it}Y_{it} - R_t K_{it} - W_t L_{it} \tag{2.19}$$

subject to the demand curve, eq. (2.16), and to the production technology, eq. (2.17). Intermediate producers take the rental rate of capital R_t

and the wage W_t as given.

Information and Timing

Each period t is divided in two stages. In the first stage, intermediate producers choose their capacity decision u_{it} under incomplete information about the fundamental θ_t. As in the baseline model, firms imperfectly observe the fundamental θ_t through a private signal x_{it} and a newspaper z_t^n for $n = \{A, B\}$. In addition, agents know all past realizations of the fundamental. Since productivity shocks follow an AR(1) process, the ex-ante beliefs about current productivity are given by $\theta_t|\theta_{t-1} \sim N\left(\rho\theta_{t-1}, \sigma_0\right)$. After observing the private signal and the newspapers, firms update their beliefs as follows

$$\theta_t|\{\theta_{t-1}, x_{it}, z_t^n\} \sim N\left(\frac{\frac{\theta_{t-1}}{\sigma_0^2} + \frac{x_{it}}{\sigma_\varepsilon^2} + \frac{z_t^n}{\sigma_\eta^2}}{\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}}, \left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right)^{-1}\right) \quad (2.20)$$

In the second stage, the value of the fundamental is revealed. Households make consumption-savings decisions, firms make production decisions, and markets clear.

Characterization

I will briefly characterize some of the results of the model.[13] There are two aspects that simplify the solution of this model. First, because of the GHH preferences, the household's labor and consumption-savings decisions are independent. Thus the household's problem is still char-

[13] See Schaal and Taschereau-Dumouchel (2015) for more details.

acterized by the standard conditions:

$$U_C(C_t, L_t) = \beta\mathbb{E}\left[(R_{t+1} + 1 - \delta)U_C(C_{t+1}, L_{t+1})\right] \tag{2.21}$$

$$L_t^{\nu} = \frac{W_t}{P_t} \tag{2.22}$$

In addition, because the fundamental is revealed in the second stage of the problem, production decisions can be solved by the standard first-order conditions, taking the level of capacity decision as given. The optimal level capacity utilization for every firm is given by

$$u_{it} = \begin{cases} u_h \text{ if } \Delta\Pi(K_t, \theta_{t-1}, m_t, z_t^n, x_{it}) > 0 \\ u_l \text{ if } \Delta\Pi(K_t, \theta_{t-1}, m_t, z_t^n, x_{it}) \leq 0 \end{cases} \tag{2.23}$$

where $\Delta\Pi(K_t, \theta_{t-1}, m_t, z_t^n, x_{it}) \equiv \mathbb{E}\left[(\Pi_{ht} - \Pi_{lt})(K_t, \theta_t, m_t) - c|\theta_{t-1}, z_t^n, x_{it}\right]$ is the expected surplus of choosing a high capacity utilization.

Under imperfect information, the mass of firms operating at high capacity, m_t, will be pinned down endogenously. Because the economy is populated by heterogeneous firms producing at possibly different capacities, the production of the final good will be as follows

$$\begin{aligned} Y_t &= \left(m_t Y_{ht}^{\frac{\sigma-1}{\sigma}} + (1 - m_t) Y_{lt}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \\ &= \bar{A}(\theta_t, m_t) K_t^{\alpha} L_t^{(1-\alpha)} \end{aligned} \tag{2.24}$$

where $\bar{A}(\theta_t, m_t) \equiv \left(m_t(A\omega e^{\theta_t})^{\sigma-1} + (1 - m_t)(Ae^{\theta_t})^{\frac{\sigma-1}{\sigma}}\right)^{\sigma-1}$. That is, in equilibrium the economy behaves as if it were populated by a representative firm with an endogenous TFP, $\bar{A}$.

2.4.2 Calibration

The calibration of the model can be found in Tables 2.10 and 2.11. The calibration of the model resembles that of Schaal and Taschereau-Dumouchel (2015), except for the correlation of newspapers, $\hbar$. I calibrate $\hbar$ using the results from Section 2.2. In particular, recall that the correlation of economic content in U.S. newspapers averages 0.1 during periods of growth, and 0.26 during recessions. In that spirit, I calibrate the correlation of newspapers as $\hbar = 0.10$ when the economy is in a high activity regime (i.e. $m_t = 1$), and $\hbar = 0.26$ when the economy is in a low activity regime (i.e. $m_t = 0$).

2.4.3 Macroeconomic Effects of Mass Media

Figure 2.9 plots the impulse responses of the model to a productivity shock in the case both with and without newspapers. Both in the case with and without newspapers, the mass of entrants in the market decreases after the shock. Productivity naturally decreases, since it is a combination of both the fundamental and the mass of active firms (eq. 2.24). As productivity decreases, so do the real variables of the model, i.e. output, consumption, and labor. The economy goes back to its original steady-state as the fundamental reverts to its mean.

As discussed in Section 2.3, newspapers act as an amplification mechanism. The channel through which this amplification takes place is the mass of entrants. In the advent of an economic shock, the decision of firms not to invest is amplified because they are aware that other firms are also not willing to invest. Productivity then decreases more than in the baseline case with no newspapers. In turn, the response of output, consumption, and labor is also amplified with respect to the baseline case.

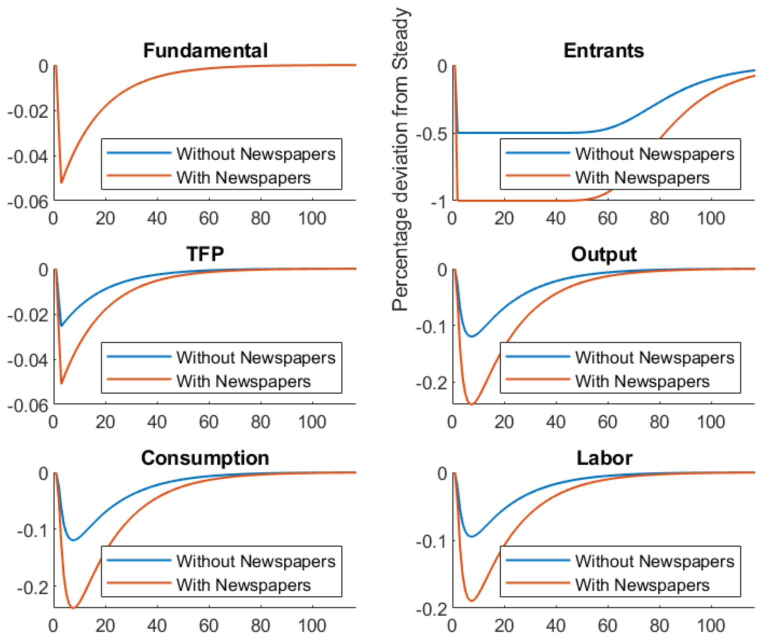

Figure 2.9: Impulse response function to a fundamental shock with and without newspapers.

2.5 Conclusion

In this paper, I document the behavior of newspapers' economic reporting during recessions. To do so, I apply Latent Dirichlet Allocation

(LDA) to uncover a structure of 40 topics discussed on the front page of newspapers published in the United States between 2007 and 2011. Five of these topics are related to economic issues, ranging from the stock market to the European Debt Crisis. I then define the economic content of newspapers as the proportion of economics-related topics on the front page of a given day. I find that the behavior of economic reporting during recessions changes in two ways: (i) it increases with respect to economic expansions; and (ii) it becomes more coordinated between outlets. In addition, several measures rule out the possibility that news outlets focus on reporting different economic events. Hence, content between outlets becomes more homogeneous. The empirical evidence then suggests that people jointly become more aware of economic conditions during recessions.

Despite the notion that mass media contribute to spreading financial panic is commonplace (Crossley-Holland, 2008; Tett, 2007), to this day there are no formal business cycle theories incorporating the role of media as an amplifying mechanism of economic shocks. Motivated by the empirical evidence, I formulate a model in which mass media contribute to recessions by making economic conditions more common knowledge. During a recession, mass media become more coordinated, and economic conditions become more common knowledge among firms. Then, the decision of firms not to invest is amplified because they are aware that other firms are also not willing to invest. Mass media then contribute to the business cycle by increasing awareness of the economic conditions.

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2.A Technical Details of the LDA

2.A.1 Preprocessing Text

A proper cleaning of the textual data is key to obtaining easy-to-interpret results. Although idiosyncrasies present in every set of documents make the preprocessing of texts almost a matter of craftsmanship, several procedures are common when working with LDA.

The first step is removing *stop words* and punctuation. Stop words refer to terms that are widely used in a language (e.g. "the", "is", "at"). These terms usually provide no substantive meaning and hinder the interpretation of topics. There exists no unique list of stop words. I use the stop word list provided in Python's Natural Language ToolKit package developed by Bird (2002). Punctuation needs also be removed, as it provides no meaning in the context of LDA.

The second step is *lemmatization*. Lemmatization is the act of grouping together the inflected forms of a word for analysis as a single item. In many languages, words are inflected. In the context of LDA, inflection can be problematic. For example, LDA considers the words "walk" and "walks" as different, even though they share the same lemma and convey the same meaning. Lemmatization is thus a procedure used to avoid losses in LDA due to the breaking up of the same lemma into different terms. I use the lemmatization algorithm provided in Python's spaCy package developed by Honnibal and Montani (2017).

The last step is *trimming*. In the context of reporting, there are several

K	20	30	40	50
Coherence	0.640	0.658	0.671	0.662

Table 2.3: Coherence of the LDA model for different choices of K.

words relative to time (e.g. “today”, “week”) and verbs (e.g. “say”, “take”, “make”) that convey no meaning but are not included in the stop word list. I thus trim words appearing in either more than half or less than 5 of the articles.

2.A.2 LDA: Specification, Choice of K, and Results

As mentioned in Section 2.2, I apply the Gibbs sampling algorithm developed by McCallum (2002). Originally programmed in Java, the gensim package provides a wrapper that allows to use this algorithm in Python (Řehuřek, Sojka, et al., 2011). The key choice when using LDA models is the number of topics K. Given the unsupervised nature of the model, there is no *correct* choice of K. However, there exist semantic measures of coherence that can be used to measure the meaningfulness of topics (Chang et al., 2009).

The gensim package includes a routine to calculate the coherence of a model given K. I thus run the LDA for $K = \{20, 30, 40, 50\}$. Table 2.3 shows the coherence for each K. The highest value of coherence corresponds with $K = 40$. Finally, Tables 2.4 and 2.5 present the topics estimated by the LDA, together with its label.

Label	**Top Words**
Retail	store retailer sale consumer shopper buy shopping holiday mart wal chain
Firm Management	company big firm executive business bank deal group investor financial sell
Russia	russia russian moscow putin vladimir soviet georgia venezuela kremlin chavez
Local	county yesterday virginia prince maryland district george area school fairfax
Shooting	shoot kill shooting police virginia wound tech student hood gunman fort
Stocks	*market price stock economy world global fall investor industrial rise point*
Traffic	car driver road traffic vehicle drive highway gas transportation mile metro
-	page article correction incorrectly publish amplification front space mine
BP	oil gulf mexico spill company coast drilling rig offshore gas water disaster
Natural Disasters	hurricane storm earthquake people katrina coast haiti water city port prince
Obamacare	health care obama insurance system bill overhaul coverage plan debate
Automotive	auto general company car detroit motors industry chrysler bankruptcy
Judicial	court supreme justice law rule decision judge case federal state ruling
Arab Spring	libya force government protest egypt protester cairo power leader military
Federal	official department bush accord yesterday agency federal report investigation
Terrorism	pakistan qaeda attack official pakistani kill intelligence american militant
Mortgage	*mortgage home housing loan foreclosure market credit estate real lender*
Health	drug health medical doctor patient study disease find hospital cancer
Campaing	barack presidential clinton john hillary democratic obama campaign senator
Food	food grow farm eat farmer china crop restaurant corn product chinese field

Table 2.4: Estimated LDA topics (0 - 19): label and high-probability words. In italics, economics-related topics.

Label	**Top Words**
Immigration	immigrant illegal mexico immigration drug border mexican law country
GOP	republican election party candidate voter campaign presidential race political
Middle East	israel israeli palestinian gaza middle minister hamas saudi arab prime
States	gov governor state albany sarah palin mayor tuesday alaska city andrew
Entertainment	show game los star angeles team play good season big sunday fan
Trials	*case charge federal court prison prosecutor crime suspect trial criminal*
Technology	company internet web online computer site technology google phone
Stimulus	*financial bank federal crisis government reserve treasury rescue market bailout*
Air Travel	flight air airport plane airline passenger security fly jet travel safety airlines
Econ Outlook	*job economy show accord rate nation high number report rise find americans*
War	afghanistan military troop war afghan taliban force army iraq commander
European Debt	*european europe debt crisis euro greece financial union minister london*
Diplomacy	obama official administration government country united states begin nation
Pensions	government state pay money cut federal tax budget plan program dollar cost
Iraq	iraq baghdad iraqi troop american bush military war shiite security force iraqis
Environment	plant climate power gas japan energy global nuclear environmental warming
Legislative	house senate democrats republican leader congress republicans vote bill
Profiles	home man family city long leave work call find house run hour begin
Education	school student high university college teacher education church class
Nuclear	iran nuclear iranian weapon tehran korea north program country sanction korean

Table 2.5: Estimated LDA topics (20 - 39): label and high-probability words. In italics, economics-related topics.

Text Snippet	**1st Topic**	**2nd Topic**
Barclays in Sanctions Bust – U.K. Firm to Pay $298 Million to Settle Charges Involving Iran. Barclays PLC agreed to pay 298 million to settle charges by U.S. and New York prosecutors that the U.K. bank altered financial records for more than a decade...	Firm Mgmt T1: 0.47	Federal T14: 0.21
Denmark’s “flexicurity” blends welfare state, economic growth. Across Europe, nations such as France, Italy and Germany struggle with lackluster economic growth, high unemployment and high taxes...	European Debt T31: 0.48	Economic Outlook T29: 0.20
Iraq’s turbulent effort to reckon with the violence of its past took another macabre turn on Monday when the execution of Saddam Hussein’s half brother ended with...	Profiles T37: 0.43	Middle East T22: 0.30
Job Losses Worst Since ’74: 533,000 Shed in November. The U.S. lost half a million jobs in November, the largest one-month drop since 1974, as employers brace for a recession...	Economic Outlook T29: 0.86	-

Table 2.6: Top 2 topics (and their proportions) of the sample articles from Table 2.1.

Text Snippet	**T12**	**T28**	**T40**	**T42**	**T43**	**T48**
Barclays in Sanctions Bust – U.K. Firm to Pay $298 Million to Settle Charges Involving Iran. Barclays PLC agreed to pay 298 million to settle charges by U.S. and New York prosecutors that the U.K. bank altered financial records for more than a decade...	0.000	0.039	0.000	0.000	0.001	0.000
Denmark's "flexicurity" blends welfare state, economic growth. Across Europe, nations such as France, Italy and Germany struggle with lackluster economic growth, high unemployment and high taxes...	0.487	0.000	0.001	0.124	0.001	0.205
Iraq's turbulent effort to reckon with the violence of its past took another macabre turn on Monday when the execution of Saddam Hussein's half brother ended with...	0.000	0.000	0.000	0.000	0.000	0.000
Job Losses Worst Since '74: 533,000 Shed in November. The U.S. lost half a million jobs in November, the largest one-month drop since 1974, as employers brace for a recession...	0.000	0.000	0.001	0.001	0.001	0.864

Table 2.7: Proportion of economic topics in the sample articles.

2.B Robustness of the Empirical Results

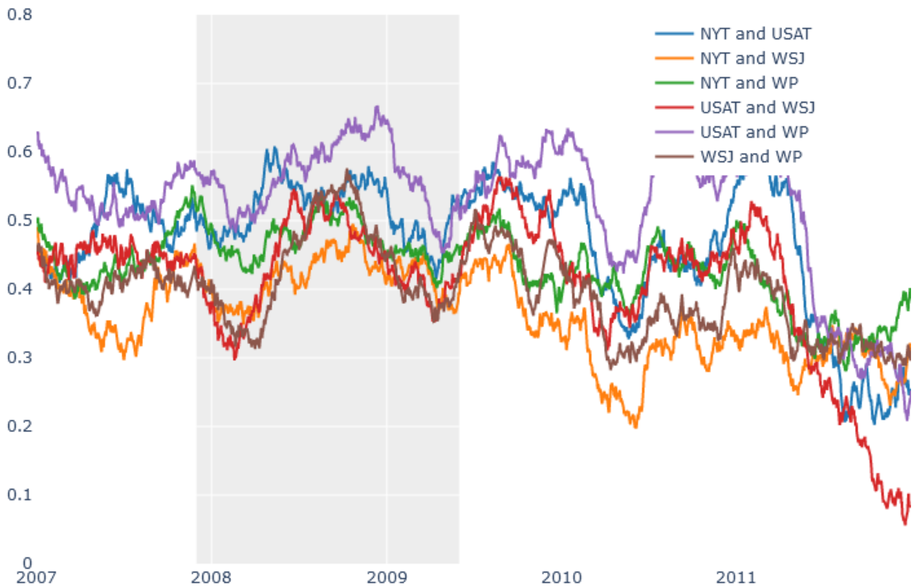

Figure 2.10: Spearman's rank correlation of the measure of economic content between newspapers. The gray shaded area indicates a recession as defined by the NBER. The series have been smoothed with a two-sided rolling window of 4 months for illustrative purposes.

	(1)	(2)	(3)	(4)
	CorrEconContent	SpearmanRank	CosineSimil	Jaccard
Recession	0.135***	0.0372**	0.00588	0.00748***
	(0.00264)	(0.0113)	(0.00800)	(0.00145)
_cons	0.104***	0.414***	0.494***	0.787***
	(0.00144)	(0.00620)	(0.00437)	(0.000795)
N	10422	8180	8180	8180
adj. R^2	0.199	0.001	-0.001	0.002

Standard errors in parentheses.

These results exclude the obsevations between September and November 2008.

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

Table 2.8: Results of estimating eqs. (2.3) and (2.4) excluding the period September - November 2008.

2.C Proofs and Additional Results

2.C.1 Proofs

Proposition 1. *If agents are myopic, then investors will invest in the project if and only if*

$$\bar{\theta}_{it} \geq \kappa_t^*$$

That is, if the expected value of the project is greater or equal to the equilibrium cutoff, which is implicitly defined by

$$\begin{aligned} &\kappa_t^* - c + \beta(1-\alpha)m_{t-1} \\ &\quad + \beta\alpha\Phi\left(\zeta^{-\frac{1}{2}}\left[\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2} + \frac{z_t}{\sigma_\eta^2}\right) - \sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\eta^2}\right)\kappa_t^*\right]\right) = 0 \end{aligned} \tag{2.7}$$

In addition, the law of motion of m_t of the global game with public a public signal can be expressed in closed-form solution as

$$m_t = (1-\alpha)m_{t-1} + \alpha\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t + \sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t}{\sigma_\eta^2}\right) - \kappa_t^*\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right) \tag{2.8}$$

Proof. Following Morris and Shin (2000), the equilibrium of this model can be solved by assuming and then verifying a cutoff strategy such that any agent i invests if and only if

$$\bar{\theta}_{it} \geq \kappa_t \tag{2.25}$$

That is, investment takes place if and only if the expected value of the fundamental, θ_t, exceeds a certain threshold, κ_t. Since the economy is dynamic, the cutoff value is not necessarily constant over time.

Substituting the expected value of the fundamental θ_t into eq. (2.25), this inequality can also be expressed in terms of the private signal x_{it},

$$x_{it} \geq \sigma_\varepsilon^2\left(\kappa_t\left(\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right) - \left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t}{\sigma_\eta^2}\right)\right) \tag{2.26}$$

For simplicity, agents are myopic. That is, they only focus on the instantaneous payoff of investing when taking their decision, disregarding possible payoffs thereafter. This simplification is done for illustrative purposes. I will restore rational expectations in the numerical version of the model in Section 2.4.

To solve for the equilibrium strategy, consider an agent i who believes all other players will follow a cutoff strategy in their investment decision. In any given period t, agent i will invest if and only if their expected payoff is greater than zero. That is, if the following condition holds

$$\begin{aligned} &\mathbb{E}\left(\theta_t + \beta m_t - c \middle| \{x_{it}, z_t\}\right) \geq 0 \Leftrightarrow \\ &\bar{\theta}_{it} + \beta(1-\alpha)m_{t-1} + \beta\alpha\mathbb{E}\left(\int_0^1 a_{jt} dj \middle| \{x_{it}, z_t\}\right) - c \geq 0 \end{aligned} \tag{2.27}$$

where the second inequality follows from substituting the expression for the mass of investors, eq. (2.6). The expected mass of new investors is equivalent to the probability any other agent j decides to invest. That is,

$$\mathbb{E}\left(\int_0^1 a_{jt} dj \middle| \{x_{it}, z_t\}\right) = Pr\left(\bar{\theta}_{jt} \geq \kappa_t \middle| \{x_{it}, z_t\}\right)$$

Agent i knows that any other agent's private signal will be equal to θ_t plus a noise term. By standard properties of the normal distribution, the posterior that agent i has about any other agent j's beliefs is the following

$$x_{jt} | \{x_{it}, z_t\} \sim N\left(\bar{\theta}_{it}, \frac{2 + \sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\eta^2}\right)}{\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}}\right)$$

For simplicity, I will denote the posterior variance of this equation as ζ. Following the cutoff strategy, agent i believes any other agent j will invest if their private signal x_{jt} satisfies the inequality eq. (2.26).

Therefore, the probability agent i assigns to any other agent investing is given by

$$Pr\left(x_{jt} \geq \sigma_\varepsilon^2\left(\kappa_t\left(\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)-\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t}{\sigma_\eta^2}\right)\right)\Big|\{x_{it}, z_t\}\right) =$$
$$\Phi\left(\zeta^{-\frac{1}{2}}\left[\bar{\theta}_{it}+\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t}{\sigma_\eta^2}\right)-\kappa_t\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right)$$

where $\Phi(\cdot)$ denotes the CDF of the standard normal distribution. The equality follows from standardizing x_{jt} with its posterior distribution, ζ.

The equilibrium cutoff is a function $\kappa_t^*(m_{t-1}, z_t)$ implicitly defined by the payoff of the marginal investor. Slightly abusing notation, I will denote the equilibrium cutoff $\kappa_t^*(m_{t-1}, z_t)$ as κ_t^*. The marginal investor is the agent whose expected value of θ_t is equal to the cutoff κ_t and is therefore indifferent between investing or not. As a result, the equilibrium cutoff is the value that solves

$$\kappa_t^* - c + \beta(1-\alpha)m_{t-1} + \beta\alpha\Phi\left(\zeta^{-\frac{1}{2}}\left[\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t}{\sigma_\eta^2}\right)-\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\kappa_t^*\right]\right) = 0$$

To find the expression for the law of motion of m_t, we still need an expression for the mass of new investors, $\int_0^1 a_{it}di$. The actual mass of new investors is equal to the unconditional probability that an agent's expected value is greater that the cutoff,

$$Pr\left(\bar{\theta}_{it} \geq \kappa_t^*\right) =$$
$$\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t+\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t}{\sigma_\eta^2}\right)-\kappa_t^*\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right)$$

Therefore, the law of motion of m_t can be expressed as

$$m_t = (1-\alpha)m_{t-1} + \\ \alpha\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t + \sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t}{\sigma_\eta^2}\right) - \kappa_t^*\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right)$$

□

Proposition 2. *If agents are myopic, then investors will invest in the project if and only if*

$$\bar{\theta}_{it} \geq \kappa_t^*$$

That is, if the expected value of the project is greater or equal to the equilibrium cutoff, which is implicitly defined by

$$\begin{aligned}&\kappa_t^{A*} + \beta(1-\alpha)m_{t-1} - c \\ &\quad + \beta\alpha\mu\Phi\left(\zeta^{-\frac{1}{2}}\left[\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^A}{\sigma_\eta^2}\right) - \sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\kappa_t^{A*}\right]\right) \\ &\quad + \beta\alpha(1-\mu)\Phi\left(\zeta_2^{-\frac{1}{2}}\left[\frac{\theta_0}{\sigma_0^2} + \left(\kappa_t^{A*}-\kappa_t^{B*}\right)\left(\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}\right) - \frac{\kappa_t^{B*}}{\sigma_0^2} + \hbar\frac{\left(z_t^A-\kappa_t^{A*}\right)}{\sigma_\eta^2}\right]\right) = 0\end{aligned} \tag{2.10}$$

and an analog condition for newspaper B readers. In addition, the law of motion of m_t of the global game with newspapers can be expressed in closed-form solution as

$$\begin{aligned}m_t &= (1-\alpha)m_{t-1} \\ &\quad + \alpha\mu\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t + \sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^A}{\sigma_\eta^2}\right) - \kappa_t^{A*}\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right) \\ &\quad + \alpha(1-\mu)\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t + \sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^B}{\sigma_\eta^2}\right) - \kappa_t^{B*}\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right)\end{aligned} \tag{2.11}$$

Proof. Overall, the model is solved in following the same procedure as in Section 2.3.1. However, an important aspect changes with respect to the benchmark model. Since the population is partitioned, each fraction of the population will have their own cutoff. Assume WLOG that agent i is a newspaper A reader. Following the cutoff strategy eq. (2.25), agent i will decide to invest if and only if

$$\bar{\theta}_{it}^{A} + \beta(1-\alpha)m_{t-1} + \beta\alpha\mathbb{E}\left(\int_0^1 a_{jt}dj\middle|\{x_{it}, z_t^A\}\right) - c \geq 0$$

where $\bar{\theta}_{it}^{A}$ is the expected value of the fundamental conditional on $\{x_{it}, z_t^A\}$. The expected mass of new investors is now given by

$$\begin{aligned}\mathbb{E}\left(\int_0^1 a_{jt}dj\middle|\{x_{it}, z_t^A\}\right) = \mu Pr\left(\bar{\theta}_{jt}^{A} \geq \kappa_t^A|\{x_{it}, z_t^A\}\right)\\ + (1-\mu)Pr\left(\bar{\theta}_{jt}^{B} \geq \kappa_t^B|\{x_{it}, z_t^A\}\right)\end{aligned}$$

Agent i's problem when calculating the first term of this expected values is exactly the same as in the previous section. The reason is that newspaper A readers share common information, z_t^A. This is not the case with the second term. To see why, notice that

$$Pr\left(\bar{\theta}_{jt}^{B} \geq \kappa_t^B|\{x_{it}, z_t^A\}\right) = Pr\left(\frac{\frac{\theta_0}{\sigma_0^2} + \frac{x_{it}}{\sigma_\varepsilon^2} + \frac{z_t^B}{\sigma_\eta^2}}{\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}} \geq \kappa_t^B|\{x_{it}, z_t^A\}\right)$$

where z_t^B is unobserved by a newspaper A reader. Thus, agent i expects newspaper B readers to invest if their signals satisfy

$$\frac{x_{jt}}{\sigma_\varepsilon^2} + \frac{z_t^B}{\sigma_\eta^2} \geq \kappa_t^B\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right) - \frac{\theta_0}{\sigma_0^2}$$

To newspaper A readers, z_t^B is unobserved and thus a second unknown. However, even if newspaper A readers cannot observe the value z_t^B, they can still learn from it through their own newspaper as long as the correlation of noise $\hbar \neq 0$. This correlated information between the partitioned population will act as an amplification mechanism.

Any newspaper A reader has the following posterior over newspaper B

$$z_t^B|\{x_{it}, z_t^A\} \sim N\left(\psi_0\theta_0 + \psi_x x_{it} + \psi_z z_t^A, (1-\hbar)\sigma_\eta^2\left(1 + \frac{\frac{1}{\sigma_\eta^2} + \hbar\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2}\right)}{\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}}\right)\right)$$

where ψ_0, ψ_x, ψ_z are the weights agents give to the prior, their private signal and their newspaper, respectively[14]

$$\psi_0 \equiv \left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right)^{-1}\left(\frac{1-\hbar}{\sigma_0^2}\right)$$
$$\psi_x \equiv \left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right)^{-1}\left(\frac{1-\hbar}{\sigma_\varepsilon^2}\right)$$
$$\psi_z \equiv \left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right)^{-1}\left(\frac{1}{\sigma_\eta^2} + \hbar\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2}\right)\right)$$

Naturally, the higher the degree of common knowledge $\hbar$, the more relative weight attributed to z_t^A. Similarly, the higher the degree of common knowledge $\hbar$, the less uncertainty regarding the other population's information.

Consequently, the probability agent i assigns to any newspaper B reader

[14] See Section 2.C.3 for the full derivation.

investing is given by

$$Pr\left(\frac{x_{jt}}{\sigma_\varepsilon^2}+\frac{z_t^B}{\sigma_\eta^2}\geq\kappa_t^B\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}\right)-\frac{\theta_0}{\sigma_0^2}\middle|\{x_{it},z_t^A\}\right)=$$
$$\Phi\left(\zeta_2^{-\frac{1}{2}}\left[\frac{\theta_0-\kappa_t^B}{\sigma_0^2}+\left(\bar{\theta}_{it}-\kappa_t^B\right)\left(\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}\right)+\frac{\frac{\hbar}{\sigma_\eta^2}\left(z_t^A\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\varepsilon^2}\right)-\frac{x_{it}}{\sigma_\varepsilon^2}-\frac{\theta_0}{\sigma_0^2}\right)}{\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}}\right]\right)$$

where the equality follows from standardizing the variable

$$\frac{x_{jt}}{\sigma_\varepsilon^2}+\frac{z_t^B}{\sigma_\eta^2}\middle|\{x_{it},z_t^A\}$$

with its posterior distribution.[15]

Finally, as in the the case without newspapers, the cutoff for a newspaper A reader is implicitly defined by the marginal investor

$$\begin{aligned}&\kappa_t^{A*}+\beta(1-\alpha)m_{t-1}-c\\&\quad+\beta\alpha\mu\Phi\left(\zeta^{-\frac{1}{2}}\left[\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^A}{\sigma_\eta^2}\right)-\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\kappa_t^{A*}\right]\right)\\&\quad+\beta\alpha(1-\mu)\Phi\left(\zeta_2^{-\frac{1}{2}}\left[\frac{\theta_0}{\sigma_0^2}+\left(\kappa_t^{A*}-\kappa_t^{B*}\right)\left(\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}\right)-\frac{\kappa_t^{B*}}{\sigma_0^2}+\hbar\frac{\left(z_t^A-\kappa_t^{A*}\right)}{\sigma_\eta^2}\right]\right)=0\end{aligned}\tag{2.28}$$

Together with the analogue expression for a Newspaper B reader, this condition gives rise to the equilibrium cutoffs $\kappa_t^{A*}(m_{t-1},z_t^A,\kappa_t^{B*})$ and $\kappa_t^{B*}(m_{t-1},z_t^B,\kappa_t^{A*})$. Slightly abusing notation, I will denote the equilibrium cutoffs as κ_t^{A*} and κ_t^{B*}, respectively. Notice that when $\hbar>0$, newspaper A readers use their own cutoff to estimate the proportion of newspaper B readers that are going to invest. The resulting law of

[15]See Section 2.C.3 for more details.

motion is the weighted average of the mass of new investors in every population

$$\begin{aligned}
m_t &= (1-\alpha)m_{t-1} \\
&+ \alpha\mu\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t+\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^A}{\sigma_\eta^2}\right)-\kappa_t^{A*}\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right) \\
&+ \alpha(1-\mu)\Phi\left(\frac{1}{\sqrt{\sigma_0^2+\sigma_\varepsilon^2}}\left[\theta_t+\sigma_\varepsilon^2\left(\frac{\theta_0}{\sigma_0^2}+\frac{z_t^B}{\sigma_\eta^2}\right)-\kappa_t^{B*}\left(1+\sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\eta^2}\right)\right)\right]\right)
\end{aligned}$$

□

2.C.2 Decoupling Equilibrium and steady-state

One interesting feature of this framework is that allows to make a clear distinction between multiplicity of equilibria and of steady-states, thus highlighting the different forces behind both phenomena.

Proposition 3. *A sufficient condition that guarantees uniqueness of the equilibrium cutoff is given by*

$$\left(\frac{2+\sigma_\varepsilon^2\left(\frac{1}{\sigma^2}+\frac{1}{\sigma_\eta^2}\right)}{\frac{1}{\sigma^2}+\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}}\right)^{-\frac{1}{2}}\sigma_\varepsilon^2\left(\frac{1}{\sigma^2}+\frac{1}{\sigma_\eta^2}\right) > \frac{\alpha\beta}{\sqrt{2\pi}} \tag{2.29}$$

where

$$\tau_E \equiv \left(\frac{2+\sigma_\varepsilon^2\left(\frac{1}{\sigma^2}+\frac{1}{\sigma_\eta^2}\right)}{\frac{1}{\sigma^2}+\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}}\right)^{-\frac{1}{2}}\sigma_\varepsilon^2\left(\frac{1}{\sigma^2}+\frac{1}{\sigma_\eta^2}\right)$$

is the expected response of investment to a marginal increase in κ_t^*.[16]

Proof. Follows from Appendix A in Morris and Shin (2000). □

The interpretation of the equilibrium uniqueness condition in this setup is very similar to previous results form the global games literature[17]. The equilibrium will be unique if *contemporaneous* complementarities ($\alpha\beta$) are weak; or if the *expected* response of investment to a marginal increase in the equilibrium cutoff (i.e. proposition 3) is strong. Alternatively, the second condition can also be interpreted as the requirement that private information be precise relative to public.

Corollary 6. *If agents' actions exhibit complementarities (*$\beta > 0$*), and Proposition 3 is satisfied, then the equilibrium cutoff at time t is decreasing in the previous mass of investors,* m_{t-1}.

Proof. By implicitly differentiating the payoff function eq. (2.27), a sufficient condition for the cutoff to be decreasing in m_{t-1} if

$$\frac{\partial \kappa_t^*}{\partial m_{t-1}} = -\frac{\beta(1-\alpha)}{\left[1-\sqrt{2\pi}\alpha\beta\sigma_\varepsilon^2\left(\frac{1}{\sigma^2}+\frac{1}{\sigma_\eta^2}\right)\gamma^{-\frac{1}{2}}\right]} \leq 0$$

which is negative if $\beta < 0$ and proposition 3 is satisfied. □

[16]This expression results from taking the derivative of an agent's *expected* – conditional on her information – proportion of new investors, $Pr\left(\bar{\theta}_{jt} \geq \kappa_t^* | \mathcal{I}_{it}\right)$, with respect to the equilibrium cutoff κ_t^*.

[17]In fact, when the public signal is diffuse, i.e. $\sigma_\eta^2 \to \infty$, this condition converges to Proposition 3.1 in Morris and Shin (2000).

Conjecture 1. *If the inequality*

$$(1-\alpha)\beta\left(\frac{1+\sigma_{\varepsilon}^{2}\left(\frac{1}{\sigma^{2}}+\frac{1}{\sigma_{\eta}^{2}}\right)}{\sqrt{\sigma^{2}+\sigma_{\varepsilon}^{2}}}\right)>\left(\sqrt{2\pi}-\alpha\beta\xi^{E}\right) \tag{2.30}$$

holds, where

$$\tau_{A}\equiv\frac{1+\sigma_{\varepsilon}^{2}\left(\frac{1}{\sigma^{2}}+\frac{1}{\sigma_{\eta}^{2}}\right)}{\sqrt{\sigma^{2}+\sigma_{\varepsilon}^{2}}}$$

is the actual response of investment to a marginal increase in κ_t^*; then there exists (at least one) value of the fundamental for which the economy exhibits multiple steady-states.[18]

Conjecture 1 essentially states that to have multiple steady-states either *past* complementarities ($(1-\alpha)\beta$) are strong; or the *actual* response of investment to a marginal increase in the equilibrium cutoff is weak.

The two propositions provide analogue conditions related to the strength of complementarities and the response of investment. However, there are some subtle differences between both of them worth discussing. In general, strong complementarities generate multiple equilibria and, inevitably, multiple steady-states. The contrary is not true. Multiple steady-states can be present in a model with a unique equilibrium (e.g. Fajgelbaum et al., 2017).

The results from Proposition 3 and Conjecture 1 highlight that the roots of both phenomena are not the same. Multiplicity of equilibria has a

[18] This expression results from taking the derivative of an the *actual* proportion of investors, $Pr\left(\bar{\theta}_{jt}\geq\kappa_t^*\right)$, with respect to the cutoff κ_t^*.

forward-looking origin – contemporaneous in this setup, because of the myopic agents assumption –, linked to the decisions of prospect investors. On the other hand, multiplicity of steady-states is a backward-looking phenomenon, related to the decision of previous investors.

To sustain a unique equilibrium, complementarities in the investment decisions by new investors should not be too strong, whereas expectations have to react strongly to changes in the cutoff. Otherwise, fundamental values by themselves will not be enough to pin down the equilibrium. To sustain multiple steady-states, past investment decisions have to exert a strong complementarity on current ones. There is thus a trade off between past and contemporaneous complementarities. In addition, the response of investment to changes in the cutoff has to be weak to ensure the existence of transition dynamics between steady-states, and not simply jumps from one to another.

The precision of public noise has an effect on the reaction of investment (expected or actual) to a change in the cutoff, but not on complementarities. In particular, the more precise the public signal, the stronger the reaction of (expected or actual) investment

$$\frac{\partial \tau^E}{\partial \sigma_\eta^2} < 0 \text{ and } \frac{\partial \tau^A}{\partial \sigma_\eta^2} < 0$$

That is, a more precise public signal relaxes the conditions to obtain steady-state. However, too much precision can eventually restore equilibrium multiplicity. This means that the transition between uniqueness and indeterminacy regions is not direct. Instead, there is now an intermediate region characterized by a unique equilibrium but multiple steady-states.

2.C.3 Newspaper A reader's posterior of Newspaper B

The private signals and the two newspapers are three random variables distributed as follows

$$\begin{bmatrix} x_{it} \\ z_t^A \\ z_t^B \end{bmatrix} \sim N\left(\theta_{\mathbf{0}}, \begin{bmatrix} \sigma_0^2+\sigma_\varepsilon^2 & \sigma_0^2 & \sigma_0^2 \\ \sigma_0^2 & \sigma_0^2+\sigma_\eta^2 & \sigma_0^2+\hbar\sigma_\eta^2 \\ \sigma_0^2 & \sigma_0^2+\hbar\sigma_\eta^2 & \sigma_0^2+\sigma_\eta^2 \end{bmatrix}\right)$$

The problem for any newspaper A reader is to find the posterior of z_t^B with their own information $\{x_{it}, z_t^A\}$. By standard properties of the normal distribution,

$$\begin{aligned} \mathbb{E}(z_t^B|x_{it}, z_t^A) &= \theta_0 + \begin{bmatrix} \sigma_0^2 & \sigma_0^2+\hbar\sigma_\eta^2 \end{bmatrix} \begin{bmatrix} \sigma_0^2+\sigma_\varepsilon^2 & \sigma_0^2 \\ \sigma_0^2 & \sigma_0^2+\sigma_\eta^2 \end{bmatrix}^{-1} \begin{bmatrix} x_{it}-\theta_0 \\ z_t^A-\theta_0 \end{bmatrix} \\ &= \left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}\right)^{-1}\left[\theta_0\left(\frac{1-\hbar}{\sigma_0^2}\right)+x_{it}\left(\frac{1-\hbar}{\sigma_\varepsilon^2}\right)+z_t^A\left(\frac{1}{\sigma_\eta^2}+\hbar\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\varepsilon^2}\right)\right)\right] \end{aligned}$$

and

$$\begin{aligned} &\mathbb{V}(z_t^B|x_{it}, z_t^A) = \\ &\quad = \sigma_0^2+\sigma_\eta^2 - \begin{bmatrix} \sigma_0^2 & \sigma_0^2+\hbar\sigma_\eta^2 \end{bmatrix} \begin{bmatrix} \sigma_0^2+\sigma_\varepsilon^2 & \sigma_0^2 \\ \sigma_0^2 & \sigma_0^2+\sigma_\eta^2 \end{bmatrix}^{-1} \begin{bmatrix} \sigma_0^2 \\ \sigma_0^2+\hbar\sigma_\eta^2 \end{bmatrix} \\ &\quad = (1-\hbar)\sigma_\eta^2\left(1+\frac{\frac{1}{\sigma_\eta^2}+\hbar\left(\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\varepsilon^2}\right)}{\frac{1}{\sigma_0^2}+\frac{1}{\sigma_\varepsilon^2}+\frac{1}{\sigma_\eta^2}}\right) \end{aligned}$$

Then, the random variable

$$\frac{x_{jt}}{\sigma_\varepsilon^2} + \frac{z_t^B}{\sigma_\eta^2}\bigg|\{x_{it}, z_t^A\}$$

has the following mean

$$\begin{aligned}\bar{\mu}(x_{it}, z_t^A) \equiv \left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right)^{-1} \Bigg[& \frac{\theta_0}{\sigma_0^2}\left(\frac{1}{\sigma_\varepsilon^2} + \frac{1-\hbar}{\sigma_\eta^2}\right) \\ & + \frac{x_{it}}{\sigma_\varepsilon^2}\left(\frac{1}{\sigma_\varepsilon^2} + \frac{1-\hbar}{\sigma_\eta^2}\right) \\ & + \frac{z_t^A}{\sigma_\eta^2}\left(\frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2} + \hbar\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2}\right)\right)\Bigg]\end{aligned}$$

and the following variance

$$\begin{aligned}\zeta_2 \equiv \left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2} + \frac{1}{\sigma_\eta^2}\right)^{-1} \Bigg[& \frac{1}{\sigma_\varepsilon^4}\left(2 + \sigma_\varepsilon^2\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\eta^2}\right)\right) \\ & + \frac{1}{\sigma_\eta^4}(1-\hbar)\left(\frac{2}{\sigma_\eta^2} + \sigma_\eta^2(1+\hbar)\left(\frac{1}{\sigma_0^2} + \frac{1}{\sigma_\varepsilon^2}\right)\right)\Bigg] + \frac{2\sigma_0^2}{\sigma_\varepsilon^2\sigma_\eta^2}\end{aligned}$$

2.C.4 Calibration

Table 2.9 shows the calibrated parameters for the benchmark model. I set the scaling factor β such that there are multiple equilibria in the presence of perfect information. I set the rest of the parameters such that the economy has a unique steady-state when there is no public signal, but it has a unique equilibrium with multiple steady-states when the signal is more precise.

Investment		
α	Persistence probability	0.5
β	Complementarity	3
c	Cost	2
Fundamental		
θ_0	Mean	0.5
σ_0	Variance	1.5
Signal variances		
σ_ε	Private	1.5
σ_η	Public	1.1

Table 2.9: Parameter values for the benchmark model.

2.D Calibration of the Numerical Model

Firms		
A	Productivity scaler	2.6
α	Capital share	0.3
δ	Depreciation rate	$1 - 0.9^{1/4}$
σ	Elasticity of substitution	3
c	Fixed cost of high capacity	0.021
ω	TFP gain from high capacity	1.0182

Household		
β	Discount factor	$0.95^{1/4}$
γ	Risk aversion	1
ν	Elasticity of labor supply	0.3

Table 2.10: Parameter values for the quantitative model.

Signals		
ρ_0	Persistence of θ	0.94
σ_0	Long-run standard deviation of θ	0.027
σ_ε	Standard deviation of private signal	0.001
σ_η	Standard deviation of newspapers	0.001
$\hbar$	Correlation between newspapers (recessions)	0.26
$\hbar$	Correlation between newspapers (expansions)	0.1

Table 2.11: Parameter values for the quantitative model (cont.).

Chapter 3

Does Polarization Foster Complex Laws?

3.1 Introduction

The increase in polarization in U.S. politics has been extensively documented and discussed. The ideological gap between the Democratic and Republican parties has widened substantially starting from the 1970s. This evolution, depicted in Figure 3.1, has formed the basis of many political science studies on the causes of polarization, with the aim of either finding drivers of polarization (for instance see Voorheis et al., 2015, on income inequality as a driver of polarization) or ruling out popular explanations (see Barber et al., 2015, for a survey of that literature).

While much attention has been afforded to the potential causes of polarization, the literature is still building a clear picture of its policy consequences. Perhaps the best-understood consequence of polarization is that it reduces legislative output, i.e. the number of that bills can be passed through the legislature (Binder, 1999; McCarty, 2011). Polarization restricts the set of coalitions that can be built by essentially shutting down bipartisan alliances. This leads to gridlock in legislative production. Yet, some bills do pass, and there is little quantitative evidence on how polarization may shape their contents or quality. Analyzing the impact of polarization on the quality of legislative output is a notoriously difficult task (Barber et al., 2013).

Case studies from legislative activity in the U.S. Congress suggest that polarization has led to worse quality legislative outcomes (Barber et al., 2013). In this paper, we propose one channel through which this relationship may emerge, and we provide quantitative evidence for its existence. Using data from U.S. state legislatures, we show that polarization increases the complexity of legislation. This relationship holds for various common measures of textual complexity. We also show that the relationship is causal by employing an instrumental variable strategy, where we exploit variation in polarization in the U.S. Congress affecting state-level polarization.

We choose to focus on complexity for several reasons. First, in the legislative context, recent empirical work points to higher complexity being associated with lower quality legislation (Gratton et al., 2021). While other proxies for quality may be plagued by the concerns of subjective coding, we can rely on several quantitative measures of textual complexity. Second, complexity itself has been linked to higher implementation costs of laws and regulations (Epstein, 1995). Therefore, the increase in complexity itself has negative effects on the quality of policy-making implementation. Finally, higher complexity may be linked to the quality of policy-making more broadly. A channel highlighted by Epstein and O'Halloran (1999) is that polarization increases the reticence of legislators to delegate policy-making authority to agencies. An implication of this channel is more complexity in legislation, as bills must specify more constraints and directives for agencies.

We show that party polarization increases the complexity of legal documents. In our preferred specification, our results imply that if the level of polarization of a state legislature were to increase from the level of Rhode Island (least polarized state) to that of California (most polarized), the complexity of proposals would increase by almost half a standard deviation. This result is masked by party differences within legislature. That is, within states parties propose legislation with varying levels of complexity.

An important challenge to identifying the effect of polarization is its potential endogeneity to complexity. To address this concern, we employ the identification strategy developed in the first chapter of this thesis that exploits the heterogeneity in the response to aggregate trends in polarization. In particular, we instrument polarization at the state level using polarization at the U.S. Congress interacted with state fixed effects. The results remain both qualitatively and quantitatively similar under this IV strategy. In addition, our results are also robust to different ways to measure polarization and complexity.

Finally, one may wonder through which mechanism can polarization increase complexity. We propose the following. Ideological polarization increases the cost of adding opposition party members to a supporting coalition for a bill. This effectively reduces the number of potential coalition partners to members of one's party only. The smaller pool of potential coalition partners in turn increases the bargaining power of each partner. A bill proposer must make more concessions to each partner. Reaching agreement on any bill thus requires adding into the bill more elements demanded by coalition members. The result is an increasing complexity of bills, as they contain more provisions and contingencies to address the demands of all coalition members. The mechanism we propose is consistent with the evidence discussed by Mansbridge and Martin (2013) on the changes to the quality of deliberation and negotiations induced by polarization in Congress.

Literature Review

This paper studies the consequences of party polarization on legislative complexity. Although less explored than the causes of polarization, the political science literature has documented several of them. For example, party polarization has been associated with a reduction in legislative productivity (McCarty, 2011) and for increasing gridlock (Binder, 1999) in the U.S. Congress. Polarization can also have effects on the other two branches of policy-making by decreasing delegation to the executive branch (Epstein & O’Halloran, 1999; Farhang, 2010) or delaying the nomination of Supreme Court nominees (Binder & Maltzman, 2009; McCarty & Razaghian, 1999). Party polarization is also suspected to be behind the deterioration of welfare policies (Hacker, 2004; McCarty et al., 2016). Relative to this literature, we take a quantitative approach and focus on the impact of polarization on legislative quality.

This paper also contributes to the literature on complexity. There is rich theoretical literature studying how complexity is used in financial products to obfuscate prices (see Ellison, 2016, for a review). However, the absence of data has complicated the possibility to establish a common framework (Colliard & Georg, 2023) that can be used to test the predictions from these models. There are also examples incorporating complexity in the field of political economy (Ash et al., 2021; Epstein, 2004; Epstein, 1995; Foarta & Morelli, 2021; Gratton et al., 2021; Kawai et al., 2018; McCarty, 2017), even though these are less prevalent than in finance. More importantly, some of these examples use text analysis to test the predictions of the theory. For example, Ash et al. (2021) find that more complex legislation contributes to economic growth combining a shift-share design for identification with topic modeling applied to U.S. state laws. Similarly, Gratton et al. (2021) test the validity of their model of Kafkaesque bureaucracy estimating the quality of laws issued by the Italian parliament. To the best of our knowledge, this is the first paper to link the complexity of legal documents to party polarization.

Finally, this paper also contributes to the legislative bargaining literature that originated from Baron and Ferejohn (1989). There is a large political science literature that explores the causes of gridlock in the United States in particular. Legislative gridlock in the United States has been increasing since the last decades of the 20th century, and this literature has focused on finding the root cause of this phenomenon. The standard partisan explanation is the divided government hypothesis (Fiorina, 1996), whose empirical support has been mixed at best (Mayhew, 1991). Alternative theories also highlight the role of the bicameral system (see Binder, 2004). Scholars have also explored non-partisan explanations for gridlock (Brady & Volden, 2005; Krehbiel, 1996, 1998). Relative to the literature, the bargaining process of our proposed mechanism has an impact on the quality of the proposed legislation, as well as on the quantity.

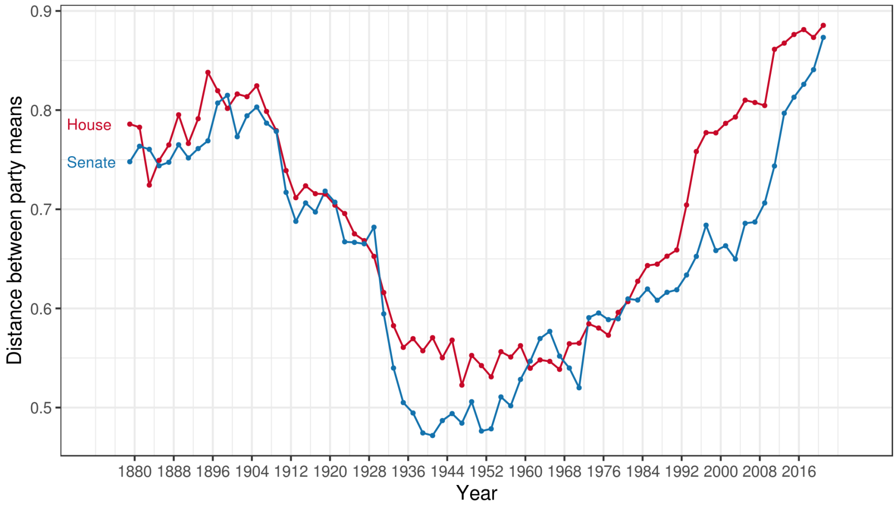

Figure 3.1: Party mean differences on the left-right axis over time in the U.S. Congress by chamber. *Source: voteview.com*

3.2 Empirical Evidence

3.2.1 Complexity Data

To obtain a measure of complexity for states we use data from LegiScan. LegiScan is a nonpartisan organization that provides access to bills proposed in all U.S. state legislatures since 2008. We focus our analysis on a sample of 10.000 bills proposed in all U.S. state legislatures from 2008 to 2019. Following Al-Ubaydli and McLaughlin (2017), we measure complexity of the legal documents in three different ways. First, a measure counting the length in lines of the document, once the preamble of the bill is removed. Second, a measure counting the number of conditional terms in the document, normalized by its length and expressed in percentage terms.[1] Finally, the last measure is the entropy of the document, which is calculated as

$$-\sum_{w=1}^{W} p_w ln(p_w)$$

where p_w is the relative frequency of word $w \in \{1, \ldots, W\}$ in a document.[2] Intuitively, entropy measures the predictability of the document.

3.2.2 Polarization Data

The data for polarization comes from Shor and McCarty (2011). The political science literature has a tradition of estimating politicians' ideal points using roll call data (Poole & Rosenthal, 2000). Intuitively, the procedure of these models is the following. Consider a chamber with only one legislator i voting on R roll calls. Let $x_i \in (-1, 1)$ be legislator i's coordinate on the left-right axis. The points z_{rY} and z_{rN} are the outcome coordinates of voting Y or N, respectively, on a roll call r. The model uses the random utility framework to determine a legislator's choices. That is, legislator i will vote Y with probability

$$Pr(U_{irY} > U_{irN}) = Pr(\varepsilon_{irN} - \varepsilon_{irY} < u_{irY} - u_{irN})$$

where the deterministic part of the utility, u, depends on some distance between the ideal point of the legislator, x_i, and the outcome of the roll call, z_{rY}, z_{rN}.

[1]The list of conditional terms includes *if, but, except, provided, when, where, whenever, unless, notwithstanding*.

[2]Entropy is measured in *nats*.

Different procedures are characterized by particular assumptions on both the deterministic and stochastic terms of the utility. Suppose error terms are normally distributed and $u_{iY} = (x_i - z_{rY})^2$. Then legislator i will vote Y with probability $\Phi(\beta_0 + \beta_1 x_i)$, where β_0, β_1 are both a function of z_{rY}, z_{rN}. The likelihood of the model is given by

$$L = \left[\Phi(\beta_0 + \beta_1 x_i)^{C_{irY}} (1 - \Phi(\beta_0 + \beta_1 x_i))^{C_{irN}}\right]$$

where $C_{irY} = 1$ if i votes Y on roll call r. Given this structure, the parameters of the model can be recovered from the roll call data using an iterative procedure. Shor and McCarty (2011) apply a similar methodology to state legislators.[3]

Figure 3.2 illustrates the ideological estimates from Shor and McCarty (2011) for the legislatures of Washington State and Rhode Island, two states known for being among the most and least polarized in the U.S., respectively. Legislators in the two states are clearly divided along party lines. However, there are some key differences. For example, while the clusters of legislators are very close in ideological terms in Rhode Island, there is a substantial gap in the Washington legislature. In fact, an extreme legislator in the Rhode Island legislature from either party would be considered a moderate in Washington.

[3] The dynamic component of Poole and Rosenthal (2000)'s DW-NOMINATE measure relies on legislators that served several legislatures. These legislators are used to "glue" different Congresses, in order to allow for comparison between the scores of congress members that did not serve together. A similar procedure is not possible for state legislators at the cross-sectional level. Shor and McCarty (2011) use a procedure based on standardized surveys as a way to "glue" different states.

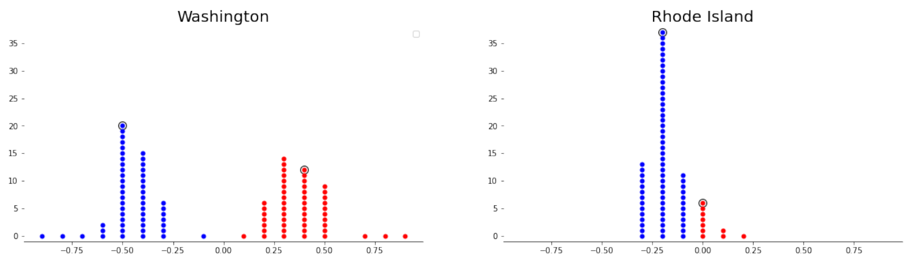

Figure 3.2: Distribution of ideological estimates in the 2017 legislatures. The marker indicates the party median. Blue (red) indicates Democratic (Republican) legislators.

The usual measure of polarization is the difference between the estimate of the median Democratic and Republican legislators in each chamber (the circled points in Figure 3.2). Alternative measures of polarization include the standard deviation of the estimates of *all* legislators, or the standard deviation of the estimates of the legislators in the majority party. Polarization data at the state level is available for all legislatures from 1993 to 2018.

3.2.3 Descriptive Statistics

The range of data available in this paper – from 2009 to 2018 – is a potential concern, since party polarization is a slow-moving phenomenon. Despite worries about gridlock in the U.S. Congress reaching the general public recently, party polarization is a long-term phenomenon that has been increasing during the last six decades (see Figure 3.1). Thus, the lack of within-state variation of polarization might be potentially problematic in our subsequent analyses. However, Figure 3.3 illustrates that our main measure of polarization – party differences – seems to exhibit enough variation within states. Moreover, our results will be robust to different measures of polarization, given the strong correlation between them (see Table 3.1).

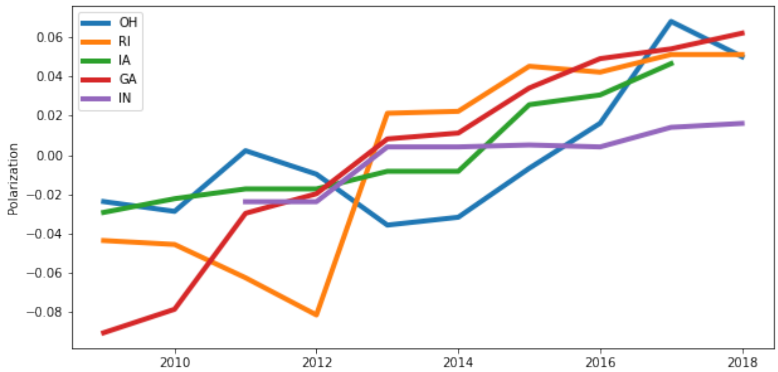

Figure 3.3: Evolution of polarization for selected states. *Note: the mean has been normalized for illustrative purposes.*

	Party Differences	Chamber Heterog	Majority Heterog
Party Differences	1		
Chamber Heterog	0.966***	1	
Majority Heterog	0.390***	0.429***	1

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.1: Correlation table of the different measures of polarization.

On the other hand, the descriptive statistics and the correlation between the different measures of complexity (see Tables 3.2 and 3.3) suggest that these measures capture different dimensions of complexity (Colliard & Georg, 2023). However, our results will be robust to different specifications.

	Line Length	Conditional Count	Shannon Entropy
Line Length	1		
Conditional Count	0.106***	1	
Shannon Entropy	0.244***	0.257***	1

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.2: Correlation table of the different measures of complexity.

	Mean	Sd	Max
Line Length	173.14	591.41	24458.00
Conditional Count	0.52	0.61	6.41
Shannon Entropy	6.63	1.59	10.18

Table 3.3: Descriptive statistics of the different measures of complexity.

3.2.4 Empirical Specification

To measure the impact of polarization on environmental policy proposals, we estimate the following equation

$$\begin{aligned} Complexity_{ist} &= \beta_0 + \beta_1 Polarization_{st} \\ &+ \boldsymbol{\gamma X} + \sum_{k=1}^{K-1} \alpha_k \mathbb{1}(Topic_{ist} = k) + \alpha_t + \varepsilon_{ist} \end{aligned} \tag{3.1}$$

where $Complexity_{ijt}$ is the measure of complexity for a bill i proposed in state s and year t, $Polarization_{st}$ is the measure of polarization in state s, and α_k, α_t are topic and presidential cycle fixed effects, respectively.[4] Finally, the vector $\boldsymbol{X}$ includes a series of control variables (see Table 1.4) including legislature and state characteristics. Note the absence of state fixed effects in this specification. Currently, because there are less than 250 observations per state, we have deemed the statistical power to be too weak in order to include state fixed effects.[5]

Table 3.4 presents the results of this estimation using conditional count as the measure of complexity, and party differences as the measure of polarization as our preferred specification. The estimates are positive and associate an increase in polarization to an increase in complexity as measured by the percentage of conditional terms, although the estimates are not statistically significant. Nevertheless, these results are qualitatively similar when using other measures of complexity and polarization

[4] Allocation of bills to topics is the result of applying a Latent Dirichlet Allocation (LDA) to the documents. Bills were clustered into 10 different topics (see Table 3.9). For an introduction to LDA, see Blei and Lafferty (2009).

[5] In future iterations of this paper, we plan to increase the number of observations.

(see Section 3.B). However, the non-significance of the results might be

	(1) Complexity	(2) Complexity
Polarization	0.0525	0.0339
	(0.049)	(0.044)
Constant	-1.723	-1.305
	(1.069)	(0.960)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.0124	0.0445

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.4: Results of estimating eq. (3.1) by OLS.

hiding opposing effects between Democratic and Republican legislators within a given chambers. There is ample evidence that the complexity of U.S. politicians' speech patterns differ by ideology (Cichocka et al., 2016; Schoonvelde et al., 2019). The evidence regarding actual legislative output is mixed (Shaffer, 2022), but there is substantial evidence from the U.S. Supreme Court judges that several aspects of decision-making – including complexity – are affected by ideology (Gruenfeld, 1995). For this purpose, we now estimate the following equation

$$\begin{aligned} Complexity_{ist} = \beta_0 + \beta_1 Polarization_{st} + \beta_2 D_{st} \\ + \beta_3 Polarization_{st} \times D_{st} \\ + \boldsymbol{\gamma} \boldsymbol{X} + \sum_{k=1}^{K-1} \alpha_k \mathbb{1}(Topic_{ist} = k) + \alpha_t + \varepsilon_{ist} \end{aligned} \tag{3.2}$$

where D_{st} is a dummy equal to one if a legislative body (either the House/Assembly or the Senate) in state s is controlled by the Democratic Party. Table 3.5 presents the results of this estimation. The co-

	(1) Complexity	(2) Complexity
Polarization	0.136**	0.119**
	(0.060)	(0.055)
Democratic House	0.338**	0.331**
	(0.165)	(0.152)
Democratic House=1 × Polarization	-0.173*	-0.175**
	(0.089)	(0.082)
Constant	-1.888*	-1.393
	(1.040)	(0.920)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.0151	0.0470

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.5: Results of estimating eq. (3.2) by OLS.

efficients are now statistically significant at the 5% level. The results from Table 3.4 were masking differences by party. Polarization is thus associated with an increase in the complexity of legal text. In terms of magnitude, these results imply that in high-polarization states (such as California), the count of conditionals is expected to be 0.22 percentage points higher than in low-polarization states (such as Rhode Island) were to become.[6] On the other hand, Democratic chambers produce on average more complex legal documents. However, this gap between parties closes the more polarized the chambers become, as indicated by the interaction term, β_3. These results are also robust to alternative measures of polarization and complexity (see Section 3.B)

3.2.5 Heterogeneous Impact of Polarization

The previous analysis included the full sample of bills available. However, we expect the impact of polarization to be stronger in some topics than in others. For example, one would not expect bills dealing with regulations to be affected by party polarization the way other contentious topics would, such as immigration or abortion.

The different columns of Table 3.6 present the results of estimating eq. (3.2) individually for each topic. The effect of polarization on complexity is markedly different depending on the topic of the bill. In particular, it seems that the effect found in Table 3.5 is mainly driven by three types of bills: "resolution", "traffic" and "corporate" bills. Bills in the "resolution" category correspond to symbolic statements proposed

[6] Rhode Island and California's value of party differences equals 0.5 and 2.5, respectively.

by legislators, whereas "corporate" bills deal with topics related to corporate law (see Table 3.7).

The magnitude of the coefficients for these three type of bills more than doubles with respect to the full sample. In addition, the coefficients are significant at the 1% level, despite the smaller size of the sample. To confirm that the magnitude of these statistics is different from the full sample, we perform a Chow test for each of the regressions. Under the null hypothesis that these bills react to polarization just like the rest, our test statistics follow an F-distribution with 26 and 7629 degrees of freedom. The critical value to reject the null hypothesis for $\alpha = 0.01$ is 2.13.

The F-statistics for the Chow test are available in Table 3.6. With these statistics, we can reject the null hypothesis with a 99% confidence level. Thus symbolic bills, bills dealing with corporate issues and with traffic regulation are more sensitive to party polarization than the average bill present in the U.S. state legislature.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Complexity	Complexity	Complexity	Complexity	Complexity	Complexity	Complexity	Complexity	Complexity
Polarization	0.245^{***}	0.338^{***}	0.0322	0.0561	0.151^{*}	0.224^{***}	0.0769	0.124	0.0987
	(0.085)	(0.113)	(0.063)	(0.084)	(0.080)	(0.080)	(0.097)	(0.098)	(0.103)
Democratic House	0.602^{***}	0.441^{*}	-0.0291	0.327	0.643^{***}	0.488^{**}	0.559^{*}	-0.0897	0.181
	(0.186)	(0.231)	(0.208)	(0.218)	(0.184)	(0.211)	(0.292)	(0.253)	(0.212)
Democratic House=1 × Polarization	-0.384^{***}	-0.318^{***}	0.0368	-0.203^{*}	-0.331^{***}	-0.216^{*}	-0.378^{**}	0.0669	-0.0926
	(0.112)	(0.118)	(0.110)	(0.118)	(0.104)	(0.124)	(0.147)	(0.140)	(0.142)
Constant	-0.547	-1.018	-3.732^{***}	-1.944	-3.402^{**}	-0.574	0.522	0.179	4.423^{***}
	(1.304)	(1.929)	(1.344)	(1.402)	(1.597)	(1.500)	(1.849)	(1.569)	(1.498)
N	966	602	887	1232	1140	672	529	985	606
Presidential Cycle FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Topic Subsample	Resolutions	Traffic	Health	Elections	Appropriations	Corporate	Fiscal	Projects	Criminal
Chow Test	11.16	2.454	1.712	1.462	3.674	1.553	3.100	3.322	3.072
Adjusted R2	0.124	0.0282	0.0316	0.0167	0.0492	0.0331	0.0460	0.0577	0.0431

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.6: Results of estimating eq. (3.2) by OLS for bills under specific topics.

3.2.6 Endogeneity and Instrumental Variable

An important challenge to identifying the effect of polarization is its potential endogeneity to complexity. As we have argued before, the

Resolutions	**Corporate**
The members of the House of Representatives of the 131st General Assembly of Ohio are pleased to congratulate the Fisher Catholic High School boys golf team on winning the 2015 Division III State Championship;	An act relating to land trusts; [...] revising provisions relating to vesting of ownership in a trustee; revising rights, liabilities, and duties of land trust beneficiaries; providing exclusion and applicability; [...]
A concurrent resolution congratulating the Fort Wayne Carroll High School girls cross country team on winning the 2018 Indiana High School Athletic Association.	An Act adopting the Alaska Entity Transactions Act; relating to changing the form of entities, including corporations, partnerships, limited liability companies, business trusts, and other organizations.

Table 3.7: Most representative bills of the topics "resolutions" and "corporate".

evidence regarding the relationship between ideology and complexity is not clear. Common factors could be driving both measures. One such factor could be economic growth. Postwar economic growth has been linked to increasing trends in inequality. Currently, political scientists cite economic inequality as the main driving factor of party polarization in the last six decades (McCarty et al., 2016). At the same time, this period of growth could have required more complex legislation (Ash et al., 2021). It is also possible that the relationship between polarization could be driven by reverse causality.

To this effect, we estimate again eq. (3.2) employing an identification strategy based on the fixed-effect instrumental variable (FE-IV) approach from Murtazashvili and Wooldridge (2008) to control for polarization. In this setup, the application of this approach follows from the observation that states are affected differently by trends of polarization in the U.S. Congress. This approach consists in instrumenting for polarization at the state level using polarization in the U.S. Congress interacted with a state dummy (see Nakamura & Steinsson, 2014). Consider the reduced model $Complex_{ist} = \beta Pol_{st} + \varepsilon_{ist}$ where Pol_{st} is our potentially endogenous independent variable, and the instrument $z_{st} = f_s Pol_t$, where Pol_t denotes polarization in the U.S. Congress. In this setup, the moment conditions necessary for identification are

$$\mathbb{E}\left(f_s Pol_t \varepsilon_{ist}\right) = 0 \;\forall\; t$$

That is, a state’s response to polarization in the U.S. Congress is exogenous to the unobserved factors affecting the complexity of a bill.

Table 3.8 presents the 2SLS estimates of eq. (3.2). The results from the IV regression are both qualitatively and quantitatively similar to those of Table 3.6. In this case, these results imply that if the level of polarization of Rhode Island were to increase as that of California, the count of conditionals would increase by 0.24 percentage points, or equivalently half a standard deviation (see Table 3.3). The suitability of this approach is confirmed by the first-stage regressions (see Table 3.10), and by the value of the Cragg-Donald F-Statistic for weak instruments (see Table 3.8).

	(1) Complexity
Polarization	0.129***
	(0.033)
Polarization × Democratic House	-0.192***
	(0.050)
Democratic House	0.360***
	(0.089)
Constant	-1.612***
	(0.480)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Cragg-Donald F-stat	238.6
Adjusted R2	0.0470

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.8: Results of estimating eq. (3.2) by 2SLS.

3.3 Conclusion

The increase in polarization in U.S. politics has been extensively documented and discussed. While much attention has been afforded to the potential causes of polarization, the literature is still building a clear picture of its policy consequences. In this paper, we have applied the empirical framework of the first chapter of this thesis to study the impact of party polarization on the complexity of bills proposed in the U.S. legislatures. We find that party polarization increases the complexity of legal documents. In our preferred specification, our results imply that if the level of polarization of a state legislature were to increase from the level of Rhode Island (least polarized state) to that of California (most polarized), the complexity of proposals would increase by almost half a standard deviation.

We propose the following mechanism to explain these results. Ideological polarization increases the cost of adding opposition party members to a supporting coalition for a bill. This effectively reduces the number of potential coalition partners to members of one's party only. The smaller pool of potential coalition partners in turn increases the bargaining power of each partner. A bill proposer must make more concessions to each partner. Reaching agreement on any bill thus requires adding into the bill more elements demanded by coalition members. The result is an increasing complexity of bills, as they contain more provisions and contingencies to address the demands of all coalition members. The mechanism we propose is consistent with evidence discussed by Mansbridge and Martin (2013) on the changes to the quality of deliberation and negotiations induced by polarization in Congress.

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3.A Additional Tables

topic 0	topic 1	topic 2	topic 3	topic 4	topic 5	topic 6	topic 7	topic 8	topic 9
bill	licens	health	elect	school	person	tax	block	depart	court
unit	vehicl	servic	counti	fund	properti	year	underscor	project	person
state	person	provid	board	appropri	requir	amount	materi	fund	child
repres	applic	care	offic	educ	interest	credit	dakota	public	order
secretari	sale	insur	member	program	corpor	employ	delet	bond	law
po	motor	medic	vote	provid	record	subsect	mexico	construct	provid
sfmt	fee	plan	public	year	author	incom	tract	author	nrs
jkt	oper	requir	general	general	chapter	employe	group	facil	pursuant
frm	permit	board	voter	fiscal	busi	fund	south	plan	subsect
fmt	depart	licens	amend	student	provid	retir	origin	provid	amend
verdat	requir	depart	appoint	depart	file	revenu	bracket	develop	parent
prod	product	includ	ic	servic	law	provid	rs	water	offens
nation	provid	individu	day	public	notic	percent	hls	general	offend
defens	issu	chapter	law	board	subsect	member	parish	land	crimin
forc	manufactur	benefit	provid	charter	includ	payment	struck	cost	violat
Resolutions	Regulation	Health	Elections	Appropiations	Corporate	Employment	-	Projects	Criminal Justice

Table 3.9: Highest probability word in each topic and their interpretation.

	(1) Polarization	(2) Polarization × Democratic House
Response to Polariz (ST 1)	0.409***	0.395***
	(0.049)	(0.100)
Response to Polariz (ST 2)	0.200***	-0.230*
	(0.060)	(0.122)
Response to Polariz (ST 3)	1.536***	0.365***
	(0.054)	(0.111)
Response to Polariz (ST 4)	0.233***	0.273***
	(0.050)	(0.103)
Response to Polariz (ST 5)	0.443***	2.299***
	(0.141)	(0.287)
Response to Polariz (ST 6)	1.892***	1.655***
	(0.048)	(0.098)
Response to Polariz (ST 7)	0.353***	0.0949
	(0.057)	(0.116)
Response to Polariz (ST 8)	0.0830	-0.309**
	(0.072)	(0.147)

Response to Polariz (ST 9)	-0.0647	0.127
	(0.077)	(0.158)
Response to Polariz (ST 10)	0.446***	0.863***
	(0.052)	(0.106)
Response to Polariz (ST 11)	-0.961***	-1.277***
	(0.064)	(0.132)
Response to Polariz (ST 12)	0.953***	0.365***
	(0.051)	(0.105)
Response to Polariz (ST 13)	0.119**	0.416***
	(0.056)	(0.114)
Response to Polariz (ST 14)	0.764***	1.025***
	(0.049)	(0.101)
Response to Polariz (ST 15)	0.737***	0.461***
	(0.052)	(0.107)
Response to Polariz (ST 16)	0.719***	0.582***
	(0.045)	(0.092)
Response to Polariz (ST 17)	0.287***	0.600***

	(0.051)	(0.104)
Response to Polariz (ST 18)	0.197***	0.702***
	(0.051)	(0.105)
Response to Polariz (ST 19)	0.846***	0.357***
	(0.060)	(0.122)
Response to Polariz (ST 20)	0.807***	0.749***
	(0.054)	(0.111)
Response to Polariz (ST 21)	0.211***	0.280**
	(0.066)	(0.134)
Response to Polariz (ST 22)	0.600***	0.762***
	(0.051)	(0.105)
Response to Polariz (ST 23)	1.436***	0.963***
	(0.047)	(0.095)
Response to Polariz (ST 24)	0.255***	0.347***
	(0.056)	(0.114)
Response to Polariz (ST 25)	1.383***	0.688***
	(0.045)	(0.093)

Response to Polariz (ST 26)	1.336***	0.0993
	(0.067)	(0.138)
Response to Polariz (ST 27)	0	0
	(.)	(.)
Response to Polariz (ST 28)	0.197**	0.581***
	(0.087)	(0.179)
Response to Polariz (ST 29)	0.991***	0.462***
	(0.057)	(0.116)
Response to Polariz (ST 30)	-0.0973*	0.0888
	(0.058)	(0.118)
Response to Polariz (ST 31)	0.959***	0.544***
	(0.053)	(0.109)
Response to Polariz (ST 32)	-0.315***	0.378**
	(0.079)	(0.161)
Response to Polariz (ST 33)	0.502***	0.865***
	(0.049)	(0.100)
Response to Polariz (ST 34)	0.00658	-0.325**

	(0.063)	(0.129)
Response to Polariz (ST 35)	0.421***	0.704***
	(0.053)	(0.108)
Response to Polariz (ST 36)	0.175***	0.244**
	(0.049)	(0.099)
Response to Polariz (ST 37)	1.206***	1.117***
	(0.048)	(0.097)
Response to Polariz (ST 38)	-0.0389	0.567***
	(0.060)	(0.122)
Response to Polariz (ST 39)	-0.464***	-0.866***
	(0.070)	(0.143)
Response to Polariz (ST 40)	0.543***	0.549***
	(0.055)	(0.113)
Response to Polariz (ST 41)	0.0566	-0.0341
	(0.071)	(0.144)
Response to Polariz (ST 42)	0.563***	0.720***
	(0.049)	(0.100)

Response to Polariz (ST 43)	0.486***	0.764***
	(0.096)	(0.196)
Response to Polariz (ST 44)	1.344***	0.943***
	(0.046)	(0.094)
Response to Polariz (ST 45)	0.728***	0.154
	(0.073)	(0.150)
Response to Polariz (ST 46)	0.493***	0.643***
	(0.052)	(0.107)
Response to Polariz (ST 47)	1.405***	1.715***
	(0.048)	(0.098)
Response to Polariz (ST 48)	0.00635	-0.173
	(0.059)	(0.121)
Response to Polariz (ST 49)	1.215***	0.752***
	(0.047)	(0.095)
Response to Polariz (ST 50)	0.147**	-0.180
	(0.074)	(0.151)
Democratic House	-0.0237***	1.602***

	(0.003)	(0.007)
Constant	3.907***	1.380***
	(0.235)	(0.481)
N	7679	7679
Adjusted R2		

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.10: First-stage results of estimating eq. (3.2) by 2SLS.

3.B Robustness of the Empirical Results

	(1) Complexity	(2) Complexity
Polarization	0.705***	0.656***
	(0.238)	(0.227)
Democratic House	0.289**	0.287**
	(0.120)	(0.110)
Democratic House × Polarization	-0.916**	-0.932**
	(0.378)	(0.351)
Constant	-1.810*	-1.332
	(1.014)	(0.907)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.0175	0.0494

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.11: Results of estimating eq. (3.2) by OLS using *Majority Heterogeneity*.

	(1) Complexity	(2) Complexity
Polarization	0.219*	0.199*
	(0.122)	(0.114)
Democratic House	0.343*	0.337**
	(0.178)	(0.165)
Democratic House × Polarization	-0.332*	-0.337*
	(0.182)	(0.169)
Constant	-1.991*	-1.501
	(1.044)	(0.925)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.0145	0.0468

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.12: Results of estimating eq. (3.2) by OLS using *Chamber Heterogeneity*.

	(1) Complexity	(2) Complexity
Polarization	0.442	0.435
	(0.407)	(0.410)
Democratic House	1.491	1.484
	(1.113)	(1.106)
Democratic House × Polarization	-0.844	-0.840
	(0.590)	(0.588)
Constant	7.119**	7.243**
	(2.998)	(2.921)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.113	0.122

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.13: Results of estimating eq. (3.2) by OLS using *Shannon Entropy*.

	(1) Complexity	(2) Complexity
Polarization	4.422*	4.354*
	(2.480)	(2.473)
Democratic House	0.995	1.003
	(0.818)	(0.814)
Democratic House × Polarization	-3.979	-3.978
	(2.527)	(2.520)
Constant	6.358*	6.453**
	(3.234)	(3.189)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.144	0.152

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.14: Results of estimating eq. (3.2) by OLS using *Shannon Entropy* and *Majority Heterogeneity*.

	(1) Complexity	(2) Complexity
Polarization	1.122	1.120
	(0.928)	(0.935)
Democratic House	1.714	1.712
	(1.228)	(1.222)
Democratic House × Polarization	-1.848	-1.846
	(1.244)	(1.241)
Constant	6.197*	6.312*
	(3.317)	(3.237)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.117	0.126

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.15: Results of estimating eq. (3.2) by OLS using *Shannon Entropy* and *Chamber Heterogeneity*.

	(1) Complexity	(2) Complexity
Polarization	20.99	20.04
	(31.214)	(30.300)
Democratic House	94.59	92.45
	(77.380)	(73.461)
Democratic House × Polarization	-45.23	-47.44
	(44.945)	(42.805)
Constant	-1941.6***	-1779.2***
	(614.791)	(603.595)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.0149	0.0194

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.16: Results of estimating eq. (3.2) by OLS using *Line Length*.

	(1) Complexity	(2) Complexity
Polarization	313.7***	291.5**
	(114.894)	(114.524)
Democratic House	37.90	39.91
	(43.668)	(42.598)
Democratic House × Polarization	-141.5	-159.8
	(132.966)	(132.411)
Constant	-2052.1***	-1883.3***
	(611.529)	(593.800)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.0160	0.0202

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.17: Results of estimating eq. (3.2) by OLS using *Line Length* and *Majority Heterogeneity*.

	(1) Complexity	(2) Complexity
Polarization	45.94	43.36
	(64.568)	(62.857)
Democratic House	101.6	99.31
	(80.686)	(76.753)
Democratic House × Polarization	-92.98	-96.76
	(87.479)	(83.700)
Constant	-1979.1***	-1816.0***
	(625.576)	(612.376)
N	7679	7679
Presidential Cycle FE	Yes	Yes
Topic FE	No	Yes
Adjusted R2	0.0149	0.0194

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.18: Results of estimating eq. (3.2) by OLS using *Line Length* and *Chamber Heterogeneity*.

	(1)
Majority Heterog	0.852***
	(0.218)
Polarization × Democratic House	-1.312***
	(0.346)
Democratic House	0.396***
	(0.110)
Constant	-1.479*
	(0.877)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.0487

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.19: Results of estimating eq. (3.2) by 2SLS using *Majority Heterogeneity*.

	(1)
Chamber Heterog	0.241*
	(0.129)
Polarization × Democratic House	-0.398*
	(0.214)
Democratic House	0.393*
	(0.209)
Constant	-1.753*
	(0.906)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.0467

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.20: Results of estimating eq. (3.2) by 2SLS using *Chamber Heterogeneity*.

	(1)
Party Differences	0.308
	(0.489)
Polarization × Democratic House	-0.561
	(0.730)
Democratic House	1.002
	(1.378)
Constant	6.756**
	(2.941)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.121

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.21: Results of estimating eq. (3.2) by 2SLS using *Shannon Entropy*.

	(1)
Majority Heterog	5.830**
	(2.618)
Polarization × Democratic House	-6.029**
	(2.574)
Democratic House	1.562*
	(0.808)
Constant	6.453*
	(3.375)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.146

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.22: Results of estimating eq. (3.2) by 2SLS using *Shannon Entropy* and *Majority Heterogeneity*.

	(1)
Chamber Heterog	0.991
	(1.144)
Polarization × Democratic House	-1.446
	(1.517)
Democratic House	1.341
	(1.497)
Constant	5.934*
	(3.409)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.126

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.23: Results of estimating eq. (3.2) by 2SLS using *Shannon Entropy* and *Chamber Heterogeneity*.

	(1)
Party Differences	6.202
	(33.537)
Polarization × Democratic House	-23.83
	(59.532)
Democratic House	51.83
	(102.764)
Constant	-1864.5***
	(598.627)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.0193

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.24: Results of estimating eq. (3.2) by 2SLS using *Line Length*.

	(1)
Majority Heterog	320.0**
	(126.485)
Polarization × Democratic House	-199.0
	(161.498)
Democratic House	50.58
	(50.278)
Constant	-1948.2***
	(592.633)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.0202

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.25: Results of estimating eq. (3.2) by 2SLS using *Line Length* and *Majority Heterogeneity*.

	(1)
Chamber Heterog	4.618
	(68.014)
Polarization × Democratic House	-33.52
	(114.008)
Democratic House	41.92
	(106.334)
Constant	-1875.6***
	(607.297)
N	7679
Presidential Cycle FE	Yes
Topic FE	Yes
Adjusted R2	0.0193

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3.26: Results of estimating eq. (3.2) by 2SLS using *Line Entropy* and *Chamber Heterogeneity*.