Can income shocks polarize? Theory and evidence from natural resource windfalls*

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Abstract

We study the impact of income shocks on political polarization. Previous studies find that polarization increases during economic hardships. We present theory and evidence that point at an opposite perspective, vis-à-vis the case of natural resource windfalls. The latter provide a source of plausibly exogenous income effects that stimulate public debate. Our theoretical framework, based on a contest over public opinion, predicts that heightened exposure to public debates (connectivity) leads to elevated polarization by allowing extremists unbridled control over the discourse. We test the model's predictions by employing detailed individual-level data covering the period 1964-2020, in conjunction with plausibly exogenous differences in natural resource endowments, as well as in connectivity levels, across U.S. states. Our baseline estimates show that a one standard deviation of state resource windfalls increases individuals' average affective polarization by 4% in high-connectivity states. Our results shed light on the dynamics of polarization, as well as on hitherto overlooked adverse effects of natural resource abundance.

JEL classifications: Q32, D72, P18

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1 Introduction

Can income shocks polarize? Understanding the patterns of political polarization has been of perennial interest to economists and policymakers, in light of the steep increase in affective polarization and partisanship in recent decades, and the various adverse effects they inflict.[1] The literature so far indicates that political polarization increases at times of economic hardships.[2] We examine, theoretically and empirically, a new and opposite perspective vis-à-vis the case of natural resource windfalls, representing major, plausibly exogenous, income shocks emanating from oil and gas endowments (e.g., Arezki et al. (2017)). The political ramifications of natural resource windfalls have been studied extensively,[3] highlighting their significant impact on the development of political institutions, and macroeconomic outcomes, even within advanced democracies.[4] Little attention, however, was given to the potential impact of natural resource windfalls in shaping the distribution of political opinions, a cornerstone of democratic systems.

This paper endeavors to fill gaps in current research by examining the potential role of resource-induced income shocks in triggering public political debates that, in turn, contribute to polarization in societies with heightened interest in politics. We refer to the latter as the extent of *connectivity*, whereby close connectivity between the electorate and the political center amplifies the interest in and exposure to political debates. Such cases, as we illustrate, may ultimately grant extremists unchecked control over the discourse, and thus polarize opinions, even when facing income-increasing windfalls.

We hypothesize, and substantiate with U.S. data, that resource windfalls induce a divergent outcome on polarization, across the connectivity dimension. We find that state re-

[1]For instance, in the U.S. case, our focus in this study, it has been demonstrated that political elites have undergone significant partisan polarization over recent decades (see, e.g., Hetherington (2009) for a survey of the evidence). This, in turn, have been shown to induce adverse effects via various dimensions, including increased corruption (Melki and Pickering (2020)), inequality (Stewart et al. (2020)), conflict (Esteban and Ray (2011), Montalvo and Reynal-Querol (2005)), and poor government policies (Campos and Kuzeyev (2007)).

[2]See, e.g., Gidron et al. (2020) and Stewart et al. (2020) for cross-country and U.S.-based evidence on the polarizing effect of economic declines. We review the related literature in more detail in the next section.

[3]See Ades and Di Tella (1999); Armand et al. (2020); Brollo et al. (2013); Robinson et al. (2006); Tornell and Lane (1999), and references therein. van der Ploeg (2011), and Venables (2016) provide syntheses of the literature.

[4]See, e.g., Caselli and Tesei (2016); Caselli et al. (2015); James and Rivera (2022); Raveh and Tsur (2020a); van der Ploeg (2018), among others. The related literature is reviewed in more detail in the next section.

source windfalls increase the extent of various types of political polarization—primarily affective polarization—in a robust and economically meaningful way, while having no polarizing effect elsewhere. We introduce a novel mechanism linking the intensity of public debate and connectivity to polarization patterns. This theory not only explains the observed empirical phenomena, but also rationalizes previous empirical findings related to the exposure-polarization nexus (e.g., Waller and Anderson (2021)), including the rise in polarization in recent decades, and the polarizing effect of economic declines. Our findings contribute to a deeper understanding of the dynamics behind ideological and affective political polarization, and illuminate previously under-explored negative consequences of natural resource abundance.

Resource windfalls, such as increases in the international price of oil and gas, constitute a significant, plausibly exogenous source of income for economies with oil reserves (see, e.g., Harding et al. (2020), Perez-Sebastian et al. (2021), Raveh and Tsur (2020b), among others). Notably, such windfalls necessitate political decision-making regarding their allocation. In democratic societies, characterized by a diversity of viewpoints, this can ignite public debates whose intensity may correlate with the windfall's magnitude, elevating the stakes involved.[5] "It's Scotland's Oil", the widely publicized slogan used in the 1970s by the Scottish National Party following the discovery of oil in the North Sea, serves as one prominent example out of many. However, the influence of public debate is contingent upon the level of engagement it generates, which can be influenced by various factors, including interest in the topic at hand or broader exposure to political decision-making.

One example for induced interest may be the scope of media coverage of political matters (see, e.g., Lelkes et al. (2017)); a second one, as noted by Campante and Do (2014), may be the physical distance from the centroid of political turmoil, namely extent of connectivity. We conjecture that while stakes and connectivity are critical, they alone do not determine the distribution of public opinion. Together, however, they can lead to a polarization of opinions by allowing extremists to dominate the discourse.

To formalize our conjecture, we develop a model of public debate in which players possess

[5]Economic conditions, irrespective of being positive or negative, are weighed heavily in the ballot, as pointed by the evidence surveyed in Lewis-Beck and Stegmaier (2000).

private opinions that they express in public. The players' main goal is to control the discussion, in the sense that the governing opinion is similar to theirs. More formally, players exert costly efforts to manifest their opinions, and their payoffs decrease as a function of the distance between their individual opinions and those expressed publicly. That is, opposite opinions do not offset in the players' payoff functions, and they prefer other individuals, whose opinions are far from theirs, to remain silent.

Our first theoretical result establishes a foundation for the *silent majority* and *vocal minority* phenomena. It shows that moderate opinions remain mute in equilibrium (i.e., the silent majority), leaving the floor to more extreme viewpoints. This crowding-out effect stems from the disproportionate influence extremists have on the debate, driven by their willingness to undertake significant efforts to neutralize contrary opinions. This aggressive behaviour dilutes the impact of moderate players, leading to a self-reinforcing cycle where moderates increasingly disengage, further consolidating the extremists' control over the debate.

Expanding on this foundation, we extend the model to include player connectivity—reflecting their visibility and ability to monitor others——and debate intensity, which corresponds to the stakes involved. Employing the seminal polarization metric of Esteban and Ray (1994), adjusted to our context, we prove that polarization escalates as connectivity and debate intensity jointly increase. Leveraging these insights, we then present a novel, micro-founded adaptive-learning process, in which players repeatedly adjust their opinions according to the observed ones, thus bridging the gap between observable and affective polarization.

The model's predictions are corroborated by the empirical analysis. Focusing on the case of the U.S., we undertake an empirical investigation of the effect of state resource windfalls on individuals' extent of affective polarization (albeit also examining further forms of polarization), across states' degree of connectivity. An intra-U.S. perspective is appealing for various reasons. First, U.S. state governments are fiscally autonomous, and benefit from the natural resources located in their territories.[6] Second, there is ample cross-state variation in geologically-based

[6]These benefits are accrued regardless of whether the natural resources are located on state-owned or federal-owned lands. In the former case state-governments collect severance taxes and royalties. In the latter case they benefit from shared federal revenues that amount to approximately 50% (90% in the case of Alaska) of the royalties paid to the federal government for oil production undertaken on these lands.

natural endowments of crude oil and natural gas that are locally impactful, as well as in plausibly exogenous, predetermined, connectivity levels, and additional politico-economic factors, which are central to the analysis. Last, this setup provides a relatively homogeneous environment, in which detailed data is available for a prolonged period of time of several decades. These features closely follow the theoretical framework, and enable examining its main hypotheses.

The analysis is based on three key measures, namely resource windfalls, connectivity, and polarization. To measure resource windfalls, we use the state-level, time-varying resource abundance measure constructed in James (2015). In effect, this measure is an interaction of two plausibly exogenous measures: the cross-sectional difference in the geologically-based recoverable stocks of crude oil and natural gas, and the international prices of crude oil and natural gas. The usage of recoverable stocks provides relatively large cross-state variation; in addition, it is highly correlated with changes in oil production and revenues despite being geologically-based, as illustrated by James (2015). Our connectivity measure is based on the concept of isolated capital cities, introduced by Campante and Do (2014), who have shown that voters in states in which the capital city is isolated from the population have less interest in state politics. We reconstruct an inverse of their measure, pointing at the connectivity between the population and the state's political center (capital city), using population censuses up to 1960, which are predetermined to our analyzed sample period (commencing in 1964).[7]

As for polarization, we measure this via individual-level data from the American National Election Studies (henceforth, ANES), a comprehensive national survey of voters in the U.S. with standardized measures across waves (ANES (2022)). We construct a measure of affective ideological polarization, following the standard definition in the literature (e.g., Stewart et al. (2020)), vis-à-vis (absolute value) differences in reported warmth (thermometer) feelings, on a scale 1-100, concerning liberal and conservative views. This measure maps to the endogenous polarization metric introduced in the analytical framework as it reports the extent to which individuals identify with an ideology while concurrently disliking the other, eliminating moderate views. Importantly, the nature of this data enables considering a within-state framework, which

[7]Nonetheless, similar to Campante and Do (2014), we also examine specifications in which this measure in instrumented by measures with plausibly exogenous variation in the distance of capital cities from states' geographical centroid, based on historical records, as well as in the spatial distribution of arable land.

addresses concerns related to subjectivities in thermometer reports across geographic locations and time.

To that end, we assembled the data of respondents to the ANES, across the 48 continental U.S. states and over the period 1964-2020, limited by the availability of our baseline measures. Our data is at the respondent level, covering about 46,000 individuals. Our identification strategy throughout the analysis rests on the plausible exogeneity in the cross-sectional variation of (predetermined) connectivity levels, as well as in the variation of (geographically-entrenched) natural resource windfalls across states and time, undertaken via a within-state setup. Using a standard fixed-effects framework, we estimate the contemporaneous impact of resource windfalls on the extent of affective polarization across levels of connectivity in our sample of respondents.[8] In addition, we examine the role of a host of political, economic, as well as respondent level controls, and consider potential underlying mechanisms stemming from these controls as well as from other institutional differences.

We find that when facing a resource windfall, the extent of individuals' affective polarization increases significantly in high connectivity states, in an economically meaningful and robust magnitude that increases with the extent of connectivity. Specifically, our baseline estimates indicate that a one standard deviation of resource windfalls increases the average extent of affective polarization of individuals residing in states with above median level of connectivity by about 4%; conversely, the distribution of opinions of individuals residing in the remaining states is not affected. We show that the main result is robust to the inclusion of controls across various related dimensions, including measures at the state, respondent, and interview levels, as well as to different specifications, estimation methods, sample restrictions, different polarization, windfall, a connectivity measures, and demanding specifications that include additional fixed effects across the levels examined.

Testing for underlying potential mechanisms, via an heterogeneity analysis that considers the main controls and additional differences in political institutions, we find that the positive impact on polarization via resource windfalls intensifies in various respondents' characteristics, including income, turnout, age, education, right-wing political views, and male gender, and

[8] Albeit also examining the dynamic effects, over a 10-year horizon, later in the analysis.

diminishes in states with a larger upper chamber size, yet without affecting the main effect driven via connectivity. Last, examining the patterns over a longer horizon of 10 years, we find that the main effect lasts, under relatively consistent magnitude, over a course of about 6 years, after which it diminishes in magnitude and preciseness.

The next section reviews the related literature and places the current contribution within it. Section 3 presents a model that explains how resource windfalls may affect political sabotage. The data, empirical findings, and robustness tests are presented in Section 4. Section 5 concludes and the appendices present data, as well as technical details.

2 Related literature

The paper is related to number of literature strands. First, the literature on economic conditions and political polarization, which highlights the polarizing effects of economic downturns. Gidron et al. (2020) and López and Ramírez (2004) illustrate that increasing unemployment induces ideological and affective polarization. Eichengreen (2018) and Funke et al. (2016) find that economic downturns prompt the rise of radical populist parties, exacerbating ideological polarization. Mitrea et al. (2021) point at economic downward mobility as a determinant of polarization. Clarke et al. (1993) and Gilley (2006) show that weaker economic conditions decrease political trust and hence increase political polarization. Finally, Stewart et al. (2020) provide rationalization for the polarizing effect of economic declines. To our best knowledge, we are the first to point at an opposite perspective,[9] illustrating theoretically and empirically that resource-induced windfalls may polarize, despite increasing national income.

Second, the empirical literature on the link between exposure and polarization, which ranges from Economics and Political Science, exemplified by Lelkes et al. (2017), to Communication Studies, as discussed by Darr et al. (2018). Currently, there is a growing body of evidence showing that structural changes in connectivity facilitate exposure, which, in turn, fosters polarization. These structural changes take various forms. For example, Darr et al. (2018) argue that the closure of local newspapers contributes to political polarization by prompting higher

[9] An exception is Autor et al. (2020) who show that rising trade exposure polarizes; however, they do not consider the impact of an unexpected rise in income.

consumption of national news outlets, which tend to emphasize partisan differences. Another example is the access to broadband internet, which provides exposure to various opinions,[10] but eventually leads to higher polarization levels, as shown by Lelkes et al. (2017) and Melki and Sekeris (2019), and quantified by Waller and Anderson (2021). Our contribution to this literature is twofold. First, we offer a novel strategic explanation for these phenomena, illustrating the channel through which increased connectivity allows extreme opinions to marginalize moderate ones. This contribution spans both spatial and temporal dimensions, offering a theoretical framework that supports the well-documented evidence of increasing polarization in recent decades. Second, we consider a new determinant of polarization, namely income shocks vis-à-vis resource windfalls, examining how its manifested via connectivity.

Third, the literature on the effects of resource booms on development and economic growth, surveyed by van der Ploeg (2011), Venables (2016), and more recently by Van der Ploeg and Poelhekke (2016) who cover the local effects. Focusing on political perspectives, the literature highlights the key role of democratic institutions in manifesting the impact of resource windfalls, and in turn considers the potential impact of resource windfalls in shaping these institutions (e.g., Brückner et al. (2012); Haber and Menaldo (2011)), as surveyed in more detail by Deacon (2011). Further studies considered the impact of resource windfalls on processes relating to the electoral process itself, including their potential in giving rise to Petro-Populism (Matsen et al. (2016)), increase incumbent tenure (Andersen and Aslaksen (2013); Smith (2004)), and strengthen electoral participation (Andersen et al. (2014)). We contribute to this literature by pointing to a mechanism that has not yet been explored, namely the potential role of resource windfalls in raising the stakes of public debates and affecting the extent of polarization. Theoretically, we link resource windfalls to the extent of public interest in political matters (connectivity) and analyze how this may polarize public opinions. Empirically, we unravel a significant and robust positive impact of resource windfalls on the extent of polarization across the connectivity dimension.

Last, the literature on contests, which dates back to the seminal study of Tullock (1980).[11]

[10] According to Gentzkow and Shapiro (2011), internet access provides significantly lower ideological segregation, compared to face-to-face interactions with acquaintances and national newspapers.

[11] Later followed by Skaperdas (1996) and Baye and Hoppe (2003), among many others.

Within this set of games, there exists a specific class of *contests with externalities*, a concept initially inspired by Buchanan (1980) and further developed by Congleton (1989). This latter body of work delves into status-seeking contests where externalities impact non-strategic, outside individuals. In the past two decades, this research area expended in various directions,[12] and the study that is closest to our theoretical analysis is Esteban and Ray (1999), and specifically Section 5 therein. Our public-debate game extends theirs by generalizing the payoffs and groups of players (using the "linear alienation" given in Esteban and Ray (1994)). Evidently, our results give rise to additional conclusions, the obvious one being the silent-majority and vocal-minority phenomena, which are then utilized to assess the impact of exposure and debate intensity on polarization.

3 A game of public debate

The public-debate game is a complete-information contest in which players hold fixed individual opinions that they manifest in public. To do so, the players exert costly effort and are being rewarded according to the distance between the aggregate distribution of publicly observed opinions and their private ones. In equilibrium, players balance their individual cost of effort with the need to shift the public opinion towards their own.

Formally, fix $k \geq 2$ distinct values $O_1 < O_2 < \cdots < O_k$ in $\mathbb{R}$, that represent k different opinions. We shall refer to O_1 and O_k as the *extreme opinions*, and to all others as *moderate* ones.[13] Let $N = \{1, 2, \ldots, n\}$ be the set of players, and for every $i = 1, \ldots, k$, let N_i denote the non-empty set of players with a private opinion O_i, such that $n_i = |N_i| \geq 1$ and $n = \sum_i n_i$. We refer to the players in N_i as O_i-players.

The action set of every player is $\mathbb{R}_+$. An action $e_j \geq 0$ is the effort that player $j \in N_i$ exerts to publicly manifest opinion O_i. Given a non-zero action profile $\mathbf{e} = (e_1, \ldots, e_n) \in \mathbb{R}^n_+$, define

[12] See, e.g., Linster (1993), Chung (1996), Lee and Hyeong Kang (1998), Eggert and Kolmar (2006), Shaffer (2006), Konrad (2006), Lee (2007), Cohen et al. (2008), Chowdhury and Sheremeta (2011), Ahn et al. (2011), Moldovanu et al. (2012), Klose and Kovenock (2015), Park and Lee (2019), and Sela (2020) among many others.

[13] To facilitate the exposition, we sometimes relate to players with extreme/moderate opinions as extreme/moderate players, respectively.

the random variable $X_{\mathbf{e}}$ so that

$$\Pr(X_{\mathbf{e}} = O_i) = \frac{\sum_{j \in N_i} e_j}{\sum_{j=1}^{n} e_j} = \frac{E_i}{\sum_{j=1}^{k} E_j},$$

where $E_i = \sum_{j \in N_i} e_j$ is the sum of efforts of all O_i-players. Intuitively, $X_{\mathbf{e}}$ represents the distribution of publicly observed opinions, weighted according to the players' effort levels. If, for example, all O_i-players exert relatively high effort levels (on aggregate and compared to all other players combined), then their opinion would dominate the debate and $X_{\mathbf{e}}$ would be distributed accordingly.

The expected payoff of player $j \in N_i$, given a non-zero effort profile $\mathbf{e} \in \mathbb{R}^n_+$, is

$$U_j(\mathbf{e}|O_i) = -e_j - \mathbb{E}[d(O_i - X_{\mathbf{e}})], \tag{1}$$

where $d : \mathbb{R} \to \mathbb{R}_+$ is a convex and symmetric (with respect to zero) distance function with a strict minima $d(0) = 0$. The payoff function presents the classic tension in contest theory between the private cost of effort e_j and the need to govern the debate. The term $\mathbb{E}[d(O_i - X_{\mathbf{e}})]$ is the expected distance between opinion O_i and publicly observed opinions, given the players' effort levels $\mathbf{e}$. Thus, in case the distribution of publicly observed opinions $X_{\mathbf{e}}$ shifts towards O_i, then all O_i-players benefit from the reduced expected distance $\mathbb{E}[d(O_i - X_{\mathbf{e}})]$. Note that the expected distance is positive and taken point-wise, so opposing opinions (relative to O_i) do not offset. To eliminate trivial results of a null debate in which no player exerts positive effort (i.e., to exclude $e_0 = (0, 0, \ldots, 0)$ as an equilibrium), fix $U_j(e_0|O_i) = \inf_{\mathbf{e} \in \mathbb{R}^n_+ \setminus \{e_0\}} U_j(\mathbf{e}|O_i)$ for every opinion O_i and for every player j.[14]

3.1 The silent majority and the vocal minority

Our analysis commences with equilibria characterization. As detailed in Theorem 1 below, we outline the equilibria of the public-debate game, and in the process, uncover two key phenomena. The first phenomenon, termed the *silent majority*, suggests that all moderate players—those

[14] Nash equilibria are robust to affine payoff transformations, so if needed, one can adjust the payoff functions to get strictly positive payoffs under undominated strategies.

without extreme opinions—maintain silence in every equilibrium. The theorem explicitly stipulates that in each equilibrium, the effort level exerted by every moderate player is zero, so that the only players who exert positive effort levels are the extremists.[15]

The second phenomenon, which complements the first, is referred to as the *vocal minority.* Not only that the extreme opinions completely govern the public debate, the average expected effort of every individual in these groups is inversely related to theirs sizes. In other words, individuals from smaller extreme groups tend to be louder on average. This follows from the fact that the aggregate effort of each of these groups in equilibrium depends solely on the distance $d(O_1 - O_k)$. So if one group is smaller than the other, the average "vocality" of every individual in the smaller group is higher.

Theorem 1. *In every equilibrium, the effort level of every moderate player is zero, whereas the aggregate effort levels of all extreme players are* $E_1 = E_k = \frac{d(O_1 - O_k)}{4}$.

An immediate corollary, following Theorem 1, relates to the unique symmetric equilibrium in which every extreme player exerts the same level of effort as all other players sharing the same opinion. (The proof follows immediately from Theorem 1, thus omitted.)

Corollary 1. *There exists a unique symmetric equilibrium* $\mathbf{e}^{\text{sym}}$ *such that*

$$\mathbf{e}_j^{\text{sym}} = \begin{cases} 0, & \forall j \in N_i, i \neq 1, k, \\ \frac{d(O_1 - O_k)}{4n_i}, & \forall j \in N_i, i = 1, k, \end{cases}$$

and the expected payoff of every player j*, given* $\mathbf{e}^{\text{sym}}$*, is*

$$U_j(\mathbf{e}^{\text{sym}} | O_i) = -\frac{d(O_1 - O_k)}{2} \cdot \left[1 + \frac{1}{2n_i} \mathbb{1}_{\{i=1,k\}} \right].$$

The driving force and intuition behind this result is the *crowding-out* effect of extreme players over moderate ones in equilibrium. The impact of extreme players from both sides, one over the other, is significantly higher than their impact on moderate players (in proportion to

[15] We recognize that the majority could be rooted in the extremes. This terminology refers to the typical scenario wherein extremist groups are relatively small.

the distance between the different opinions). So extreme individuals naturally aim to mitigate the effect of other extreme players by increasing their effort levels. This joint "aggressive" behaviour dilutes all other opinions (note that the denominator in $P_{X_{\mathbf{e}}}(\cdot)$ becomes larger), so individuals with moderate opinions are less inclined to extract effort, thus producing a positive feedback loop which results in the stated equilibrium. The effect stabilizes once all moderate opinions withdraw from the public debate completely.

There are several additional conclusions that one can derive from Corollary 1: (i) The crowding-out effect is beneficial for moderate players who retain a strictly higher expected payoff, compared to the extremists. Moderate individuals actually increase their payoff by not participating in the public debate, whereas extreme players are bound to invest heavily in this contest; (ii) Free-riding may originate in equilibrium within each group of extreme players. The aggregate effort levels of extreme individuals are independent of the groups' sizes, so extreme players benefit from the participation of others extremists within the same group; and (iii) The equilibria of the game are independent of the relative position and of the number of moderate players. The relative position of the extreme groups is the key factor that "sets the tone" in the debate. Yet, we stress that this result may change if we divert from a linear cost function, specifically to either convex, or concave cost functions.

3.2 Limited connectivity and high intensity

The basic public-debate game builds on the premise of full monitoring, i.e., that individuals fully observe the opinions of all others. In reality, however, the connectivity among players vary, so one should consider the possibility of a partial-monitoring setting in which players have limited exposure to others' opinions. Such limitations often stem from structural impediments to information dissemination, such as physical distance from the centroid of political turmoil or localized news media, that constrain players' ability to fully observe diverse opinions. Another crucial aspect to consider in the basic game is the debate's intensity, namely its potential impact on the players' utility. As will be evident from our analysis, it is not only the connectivity that affects polarization, but also the potential impact of the debate over policy, i.e., its intensity.

This section is divided into three parts. In Sections 3.2.1 and 3.2.2, we explore the impact of limited connectivity (among players) and the intensity of the debate on observable polarization. Our findings suggest that increased exposure to contrasting opinions and higher intensity levels significantly exacerbate polarization.[16] Building upon these findings, in Section 3.2.3 we introduce the concept of dynamic opinions. Specifically, we utilize the updated game as a foundational framework for an adaptive-learning mechanism, which illustrates how observed perceptible polarization leads to affective polarization, as players modify their opinions in reaction to the equilibria of the debate.

3.2.1 A limited-connectivity game

To capture the notion of partial monitoring, we introduce a *connectivity level* $\delta \in (0,1]$ which limits the ability of players to observe distant opinions. More formally, consider the previously defined public-debate game, but assume that a fraction of the information that any O_l-player generates is discarded, by a factor of $\delta^{d(O_i - O_l)}$, until it reaches a O_i-player. Thus, the payoff function of every player $j \in N_i$ takes the following form

$$U_j(\mathbf{e}|O_i) \quad = \quad -e_j - \frac{\sum_{l=1}^{k} E_l \delta^{d(O_i - O_l)} d(O_l - O_i)}{\sum_{l=1}^{k} \delta^{|O_i - O_l|} E_l}.$$

In simple terms, the players' exposure to each other decreases as a function of the distance between their individual opinions.

Remark 1. *Before we elaborate on the polarization metric, let us clarify that the analysis throughout this section is confined to a symmetric set-up with three opinions, i.e.,* $k = 3$ *and* $d(O_1 - O_2) = d(O_2 - O_3) = \frac{1}{2} d(O_1 - O_3) = 1$. *This assumption is imposed for tractability, and the analysis of the general case, with any number of opinions and valuations, is left for future research.*

To measure polarization in public debates, we follow the seminal work of Esteban and Ray (1994) that axiomatically construct the following polarization metric for populations with various characteristics (see Theorem 1 and 2, as well as Section 5.1, therein). We adopt their

[16] Given that connectivity has grown over time, these results rationalize the increased polarization observed in recent decades, as noted by Hetherington (2009) and others.

metric by taking E_i to be the observed volume of opinion i, so that the effort profile $\mathbf{e} \in \mathbb{R}^n_+$ translates to a polarization value of

$$P(\mathbf{e}) = \frac{\sum_{i,j} E_i^2 E_j |O_i - O_j|}{\left[\sum_i E_i\right]^2}. \tag{2}$$

As evident from the theoretical foundations of Esteban and Ray (1994), polarization typically increases once masses are shifted towards the extremes (see Axioms 1–3 and Condition H therein), thus the result given in Theorem 1 supports the highest possible level of polarization. It is important to note that our polarization metric varies under re-scaling of effort levels, thus allowing us to account for the overall intensity of the debate. This consideration will contribute to our theoretical and empirical analysis in Sections 3.2.2 and 4, respectively.

Our main result in this subsection, given in Theorem 2, shows that the polarization level increases as a function of the game's connectivity level. Before we formally state the result, note that the polarization level $P(\mathbf{e})$ depends on the equilibrium-induced profile $\mathbf{e} \in \mathbb{R}^n_+$, which depends on the connectivity level δ. So, any discussion about polarization must first specify the equilibrium profile $\mathbf{e}$. For this purpose, we take the broad objective of considering the impact of the connectivity level on *all* possible equilibria. In other words, the result does not hinge on some equilibrium selection, but considers all possible equilibria of the limited-connectivity game.

Theorem 2. *Fix two connectivity levels $\delta_1 < \delta_2$. The polarization level $P(\mathbf{e}_2)$ in any equilibrium $\mathbf{e}_2$ given the higher connectivity level δ_2 is strictly higher than the polarization level $P(\mathbf{e}_1)$ in any equilibrium $\mathbf{e}_1$ given the lower connectivity level δ_1.*

The intuition behind this result lays in the augmented ability of extreme players to take control of the debate as a function of the connectivity level. Once connectivity increases, the relative impression of extreme players on all others becomes significant, leading them to manifest their opinions more strongly, thus diluting the impact of all moderate players, making the polarization evident. To the extent that the degree of connectivity increases over time, as indicated by observed technological progress and the societal penetration of social media, this is consistent with the documented increase in polarization in recent decades (e.g., Hetherington

(2009)).

To prove Theorem 2 we require the following supporting lemma which states that, in any equilibrium, moderate players become relatively less vocal once connectivity increases.

Lemma 1. *For any given connectivity level, the ratio between the aggregate effort level of moderate players and that of extreme players, in every equilibrium, is unique and strictly decreases in* δ*.*

The lemma implicitly proves that Theorem 2 could be easily extended to other polarization measures, at least in the symmetric 3-opinion set-up. Given that the setting is symmetric, any non-constant polarization metric would, to some degree, depend on the proportion of observable moderate opinions. Consequently, a strict decrease in the aggregate efforts levels of moderate players is likely to result in an increase in polarization across the board.

3.2.2 A high-stakes debate

In addition to the issue of connectivity, the potential outcomes of public debates, particularly the stakes involved, warrant consideration. Specifically, individuals may have significantly diverging opinions on topics where the potential repercussions are relatively minor, compared to issues with higher stakes. Take, for instance, the debate on municipal water fluoridation. In many communities, this issue may provoke varied opinions, but the stakes are generally perceived as low, primarily concerning local health concerns and individual preferences. In contrast, debates on climate change policies involve considerably higher stakes due to their global impact on the environment, economies, and public health. Consequently, the intensity and divergence of opinions regarding climate change are significantly higher, with discussions often encompassing a broad spectrum of perspectives on economic priorities, scientific interpretations, and policy approaches.

To tackle this aspect, we can consider a small variation to the game, such that the payoff function of every player $j \in N_i$ takes the following form

$$U_j(\mathbf{e}|O_i) = -e_j - \alpha \cdot \frac{\sum_{l=1}^{k} E_l \delta^{d(O_i - O_l)} d(O_l - O_i)}{\sum_{l=1}^{k} \delta^{|O_i - O_l|} E_l},$$

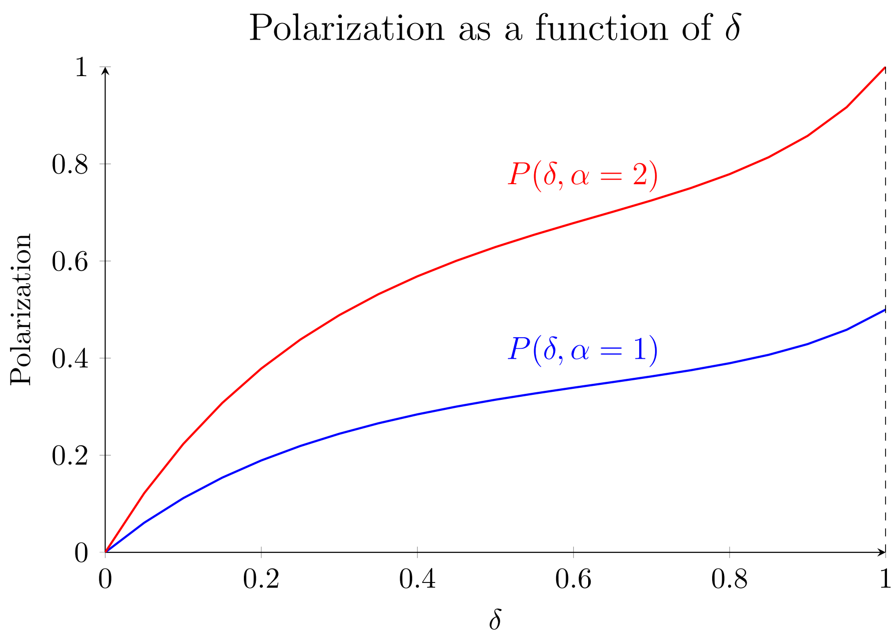

Figure 1: Polarization as a function of δ for $\alpha = 1$ and $\alpha = 2$.

where $\alpha > 0$ directly determines the relative reward (or, equivalently, the effective cost) for all players. One can think of α as the potential *impact/intensity* of the debate. Any upward shift in α increases the potential reward, as in the case of income shocks, thus extracting higher effort levels in equilibrium.[17]

It is straightforward to verify that any equilibrium profile $\mathbf{e}$ given in Theorem 2 and Lemma 1 extends to an equilibrium profile $\alpha \cdot \mathbf{e}$ in the updated version. That is, given the updated payoff function, all effort levels in equilibrium depend linearly on α. Thus, the same holds for the polarization metric given in Equation (2). Figure 1 illustrates this by depicting the polarization level as a function of the connectivity level δ for different intensity levels.

3.2.3 From observable to affective polarization

In this section, we leverage our basic framework as a micro-foundation to an novel adaptive-learning process, which outlines the evolution of opinions in accordance with the equilibrium of the public debate. Specifically, it is assumed that at every stage, players adjust their opinions

[17]Notably, α represents the stakes involved, which do not necessarily relate to a positive shock. In that sense, an increase in α may also be driven by major economic hardships, such as increased unemployment, so long as they provide high stakes for public debate.

according to the equilibrium-induced distribution of opinions observed in the previous stage. Doing so, the discussion transitions from observable to affective polarization, as players update their opinions accordingly.

More formally, for every $\delta \in (0,1]$ and for every stage $t \geq 0$, denote by $\mathbf{e}^t$ an equilibrium profile of the limited-connectivity game (assuming that all opinions are represented), and consider the 3×3 transition matrix Q^t with entries $Q^t_{i,j} = \Pr(X_{\mathbf{e}^t} = O_j | O_i)$. That is, $Q^t_{i,j}$ is the probability of observing opinion O_j from the position of person with opinion O_i. Explicitly,

$$Q^t = \begin{bmatrix} \frac{E_1}{E_1+\delta E_2+\delta^2 E_3} & \frac{\delta E_2}{E_1+\delta E_2+\delta^2 E_3} & \frac{\delta^2 E_3}{E_1+\delta E_2+\delta^2 E_3} \\ \frac{\delta E_1}{\delta E_1+E_2+\delta E_3} & \frac{E_2}{\delta E_1+E_2+\delta E_3} & \frac{\delta E_3}{\delta E_1+E_2+\delta E_3} \\ \frac{\delta^2 E_1}{\delta^2 E_1+\delta E_2+E_3} & \frac{\delta E_2}{\delta^2 E_1+\delta E_2+E_3} & \frac{E_3}{\delta^2 E_1+\delta E_2+E_3} \end{bmatrix}.$$

We use this matrix structure to define the following dynamic process. In stage $t = 0$, the players' opinions are fixed according to some initial distribution π_0 with full support. These players act according to an equilibrium profile $\mathbf{e}^0$. In stage $t = 1$, a new generation is formed (i.e., descendants) and their opinions are distributed according to $\pi_1 = \pi_0 Q^0$, where Q^0 is the previously defined transition matrix associated with $\mathbf{e}^0$. In simple terms, the generation in stage $t = 1$ observes the public opinion generated by the previous generation, which depends both on the equilibrium profile $\mathbf{e}^0$ and on the initial distribution π_0. Subsequently, in each stage $t \geq 1$, the newly formed generation adapts the opinion distribution π_t according to the following equation: $\pi_t = \pi_{t-1} Q^{t-1}$, where Q^{t-1} is the transition matrix associated with the equilibrium $\mathbf{e}^{t-1}$. This process continues indefinitely.[18]

This adaptive process builds on an inherent bias, as the previous distribution of opinions can significantly influence the subsequent one through the observed opinions. For instance, if the newly formed generation belongs to a population that is heavily skewed in favor of a particular opinion, say O_1, then their opinions would be significantly influenced by the equilibrium-viewpoints of their O_1-parents. Now, we can use the generic equilibrium profile given in the proof of Lemma 1 to explicitly present the transition matrix in every stage t.

[18] If π_t contains irrational values, it will not be feasible to implement it with a finite set of players. In such cases, one can use a sufficiently close approximation of π_t, which would also yield sufficiently close results. The notion of M-absorbing sets, as discussed in Lehrer and Shaiderman (2021), is helpful in this regard.

Observation 1. *The transition matrix in every stage t and in every equilibrium $\mathbf{e}^t$ (as given in the proof of* Lemma 1*) is*

$$Q^t = \begin{bmatrix} \frac{1}{1+\delta r^*+\delta^2} & \frac{\delta r^*}{1+\delta r^*+\delta^2} & \frac{\delta^2}{1+\delta r^*+\delta^2} \\ \frac{\delta}{2\delta+r^*} & \frac{r^*}{2\delta+r^*} & \frac{\delta}{2\delta+r^*} \\ \frac{\delta^2}{1+\delta r^*+\delta^2} & \frac{\delta r^*}{1+\delta r^*+\delta^2} & \frac{1}{1+\delta r^*+\delta^2} \end{bmatrix},$$

where $r^* = \frac{E_2}{E_1}$.

Note that this is a right centrosymmetric transition matrix, i.e., it is symmetric with respect to its center $Q^t_{2,2}$ and every row sums to one. Moreover, as long as all opinions are represented, the ratio $r^* = \frac{E_2}{E_1}$ is independent of the number of players holding each opinion. So, for every $\delta \in (0, 1)$, this irreducible and aperiodic transition matrix holds in every stage t and in every equilibrium $\mathbf{e}^t$. Thus, the convergence towards its unique, stationary, probability eigenvector π is guaranteed independently of the initial distribution of opinions. Specifically, its stationary distribution is

$$\pi = \left(\frac{\sqrt{\delta + \frac{1}{2}r^*}}{2\sqrt{\delta + \frac{1}{2}r^*} + r^*}, \frac{r^*}{2\sqrt{\delta + \frac{1}{2}r^*} + r^*}, \frac{\sqrt{\delta + \frac{1}{2}r^*}}{2\sqrt{\delta + \frac{1}{2}r^*} + r^*} \right).$$

Lemma 1 states that r^* is a decreasing function of δ, so one can easily prove that π_2 is decreasing in δ as well, thus establishing that the population becomes more polarized as δ increases.

3.2.4 Testable hypotheses

On its own, the impact of α on polarization is ambiguous. On the one hand, the transition probabilities are normalized by definition, so they do not directly depend on α. On the other hand, assuming that the public debate is rather mute, i.e., a relatively small α, people may not feel the need to shift opinions, so the entire process becomes rather futile. Moreover, the impact of α on polarization hinges significantly on the underlying levels of connectivity, as evident from Figure 1. As connectivity δ increases, the influence of α on polarization becomes more pronounced, suggesting a joint-positive impact between δ and α on polarization. Next, we examine these hypotheses empirically.

4 Empirical Analysis

The model above explains how debate intensity may increase polarization under greater connectivity. In this section we put this prediction into empirical testing, vis-à-vis the cases of resource windfalls and isolated capital cities. Specifically, we consider the potential impact of resource windfalls on the patterns of affective polarization in the U.S., accounting for the extent to which the population is connected to the political center.

We consider resource windfalls as a suitable proxy for major income shocks that spark public debate, mapping to α in the model. Resource windfalls induce significant economic implications for economies that are endowed with natural resource stocks, most notably at the regional level (Cust and Poelhekke (2015)). An increase in the value of natural resource stocks, namely the type of windfalls we examine, has been shown to trigger contemporaneous economic booms at the U.S. state level (e.g., Allcott and Keniston (2018); Raveh (2013); Perez-Sebastian and Raveh (2019)), and similar type of windfalls, such as oil discoveries, have been regarded as major news shocks worldwide (Arezki et al. (2017)). The state of the economy, in turn, has been shown to translate to electoral support and shape election outcomes (e.g., Brender and Drazen (2008)). Indeed, the wide evidence summarized in Lewis-Beck and Stegmaier (2000) indicate that voters weigh economic conditions more heavily than other issues, hence representing a central cause for public debate. Importantly, as we further note below, resource windfalls are primarily based on changes in international prices and geologically-entrenched endowments, and hence are plausibly exogenous.

The isolation of capital cities, in turn, proxy for connectivity. Campante and Do (2014) have shown, via various accountability mechanisms, that U.S. states with capital cities that are relatively isolated from the center of population exhibit less interest in political debates. We capitalize on this notion, which maps to the representation of δ in our theoretical framework by providing a predetermined, plausibly exogenous, structural element of exposure to public political debates, namely the spatial distribution of population relative to the capital.

We examine how these two measures interact to affect the extent of affective polarization.[19] We measure the latter via (the absolute value of) differences in respondents' responses in the ANES concerning their feelings towards liberal and conservative views.[20] This difference, as we further outline below, indicates the extent to which individuals empathize with an ideology while disliking the other, eliminating empathy for the moderate views, and hence mapping to the endogenous polarization concept introduced in the model. Focusing on the gubernatorial context enables undertaking within-state analyses, and thus mitigate concerns related to the extent of subjectivity in the reported views across states and time. Importantly, ANES surveys employ standardized measures across waves, making them ideal for examining polarization patterns over times.

The analysis is, therefore, undertaken at the respondent level, with a state level treatment. An intra-U.S., state-level, perspective is appealing for our purposes for several reasons. First, the intra-federal fiscally autonomous environment ensures that state governments benefit from their natural resource endowments to a considerable, and economically meaningful extent, via direct (severance) and indirect taxation. Second, the federal setup clearly distinguishes between state economies, matching resource windfalls to the consequent economic conditions and public debates within the state. Third, while presenting a relatively homogeneous environment, U.S. states provide significant cross-state variation in resource windfalls and connectivity, as we report below, in addition to variation in key aspects of the analysis including political institutions, and various politico-economic measures. Last, state-level indicators, including windfalls and connectivity, are exogenous to individuals' political opinions.[21] These features follow the framework studied in the theoretical analysis, and allow identifying the causal link running from resource booms to affective polarization via connectivity. Next, we describe the data and methodology in more detail.

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[19] Albeit examining, for robustness, additional types of political polarization.

[20] Following the definition of affective polarization outlined in Stewart et al. (2020).

[21] In other words, each individual, on his/her own, does not affect state level indicators, including those composing the treatment, namely windfalls and connectivity.

4.1 Data and methodology

We examine the data of respondents to the ANES,[22] across the 48 contiguous states, covering the period 1964-2020.[23] All variables are outlined in the Data Appendix. The analysis is based primarily on three key measures, namely resource windfalls, connectivity, and polarization. We outline each in detail.

4.1.1 Resource windfalls

To consider natural resource windfalls, we exploit the measure constructed in James (2015), and extend it to 2020. This measure is based on the interaction of two plausibly exogenous variables. The first is the cross-sectional difference in geologically-based recoverable stocks of crude oil and natural gas. This data is derived from the U.S. Geological Survey at the province level, which James (2015) aggregates to the state level.[24] The second is the international prices of crude oil and natural gas. Their interaction provides the (weighted) average state resource endowment, which is then normalized by states' land area.[25]

This measure is appealing for our purposes for various reasons. First, since it is based on geological features and prices that are set in international markets, it provides plausibly exogenous variation in resource windfalls across states as well as within them. Second, it provides ample cross-state variation; specifically, given the usage of recoverable stocks, only eight states have zero natural endowments (and hence no windfalls throughout the sample period).[26] The average natural endowment ranges from none (e.g., DE) to slightly below 0.005 (TX), in million USD per square mile, with a mean of 0.0006 and a standard deviation of 0.0011.[27] This is illustrated in Figure 2, which plots the average level of this measure across the

[22] The data is biennial (quadrennial) up to (post) 2004.

[23] The sample size and period are restricted by the availability of our baseline measures of resource windfalls, connectivity, and polarization, as we further explain below.

[24] This measure excludes AK and HI. Restricting the sample to the 48 continental states.

[25] Albeit adopting this measure for the baseline analysis, due to its appealing features, we also examine an additional output-based resource measure, later in the analysis.

[26] These states are CT, DE, MA, ME, NH, NJ, RI, VT. Nonetheless, several more states have positive, but close to zero natural endowments, as illustrated in Figure 2.

[27] Notably, the vast cross-state variation enables testing the impact of natural resource windfalls, regardless of their absolute levels. This approach follows the strand of literature that examines the effects of resource booms via the case of U.S. states (e.g., James (2015), Raveh (2013)). Related, we examine, later in the analysis, the

48 continental U.S. states. Last, despite being geologically-based, it is highly correlated with changes in oil production and revenues, as illustrated by James (2015).

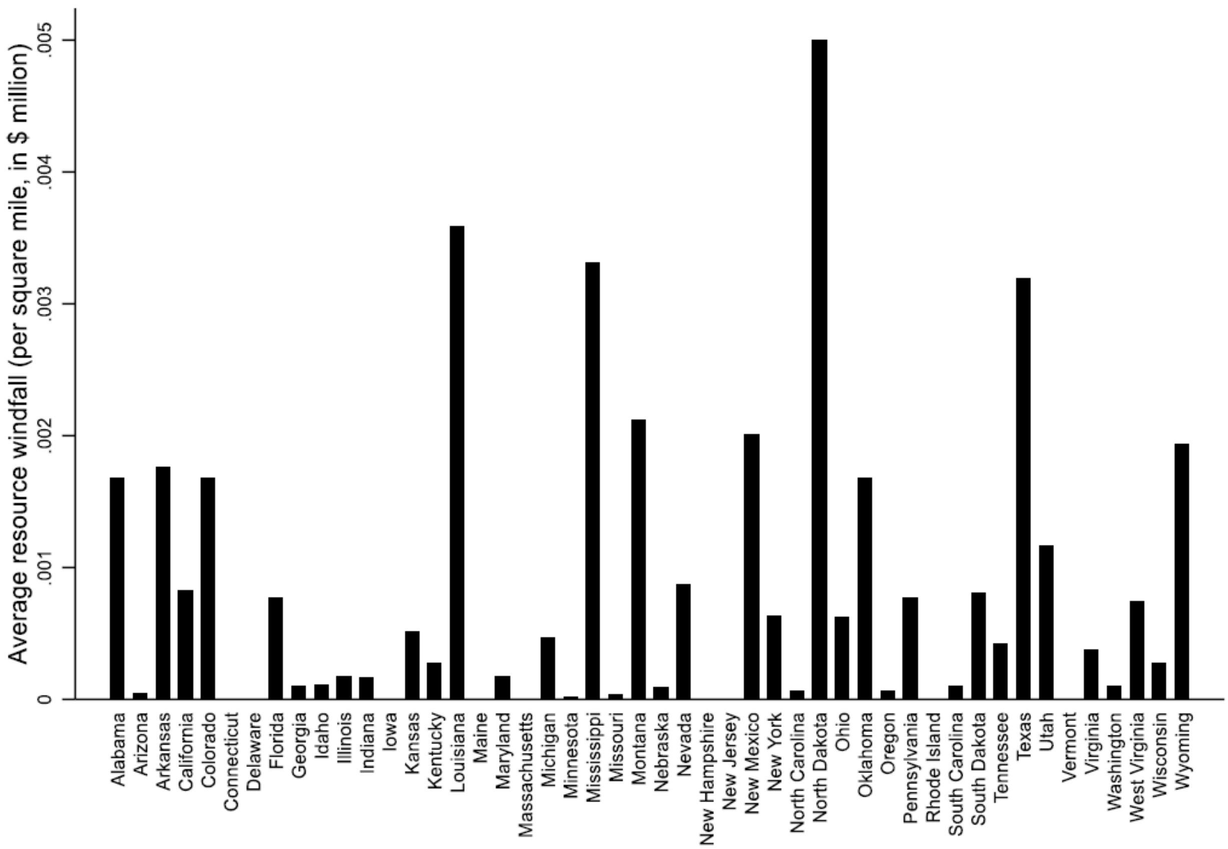

Figure 2: The figure presents the average resource windfall (in $ million) per square mile across the 48 contiguous U.S. states over the period 1964–2020.

4.1.2 Connectivity

We proxy for state connectivity based on the extent of isolation of states' capital cities.[28] In effect, we adopt a variant of the cross-sectional measure constructed in Campante and Do (2014). The latter employed historical U.S. Census data on population across counties, covering

robustness of our results to the exclusion of the most resource-rich states.

[28]We consider a state-level perspective, rather than an individual one, as it maps to the one adopted in the analytical framework, in which connectivity referred to the extent to which all participants are exposed to the debate.

the period 1920-2000, to compute the distance of population from the state's capital city, which is then averaged over counties and years to provide a cross-sectional measure at the state-level (for the 48 contiguous states). Their baseline measure, a variant of which we adopt in our main analysis, assumes linearly decreasing salience with distance from the capital city; an adjusted modification of their baseline measure, which we examine for robustness, accounts for states' size.

Campante and Do (2014) illustrated, via various mechanisms, that political debates gain less interest in states in which their capital states are more isolated. This observation maps to our notion of connectivity, as under isolation the electorate is, structurally, less exposed to the political turmoil undertaken at the capital.

While we emphasize the structural nature of this measure, the extent of isolation may be affected by population movements across time, potentially also polarization-driven ones. To mitigate related endogeneity concerns, we reconstruct Campante and Do's noted measure to account for population averages using the Population Censuses up to 1960. Restricting the underlying census data to 1960 yields a measure in which the extent of connectivity is predetermined, given that our analyzed sample begins in 1964 and the locations of capital cities are based on historical records and have not changed throughout the sample period.[29]

In addition, since our hypothesis addresses connectivity, rather than isolation, we consider the inverse of the above, such that the connectivity variable examined is in effect one minus the above-mentioned constructed measure, in which higher levels represent heightened connectivity. The distribution of our (cross-sectional) final measure across the 48 contiguous states is presented in Figure 3, illustrating the ample variation across states. Connectivity levels range from 0.16 (FL) to 0.58 (RI), with a mean level of 0.28, and a standard deviation of 0.09. Importantly, there is virtually zero correlation between cross-sectional levels of natural resource endowments and connectivity. Specifically, taking the ten most resource endowed states, as illustrated in Figure 2 (namely, AR, CO, LA, MI, MT, NM, ND, OK, TX, and WY), connectivity ranges

[29] Campante and Do (2014) in addition offer two instrumental variables to their baseline isolation measure. One examines variations between the location of capital cities and states' geographical centroids, based on historical records; the second considers the spatial distribution of arable land. Later in the analysis, we examine the robustness of our main results to instrumenting our connectivity measure via these two proposed instruments.

from 0.18 to 0.47, with a mean of 0.27, and a standard deviation of 0.08, hence distributing similarly as in the general sample of states. This, in turn, yields essential identifying variation across the two dimensions (resources and connectivity), exploited in the analysis.

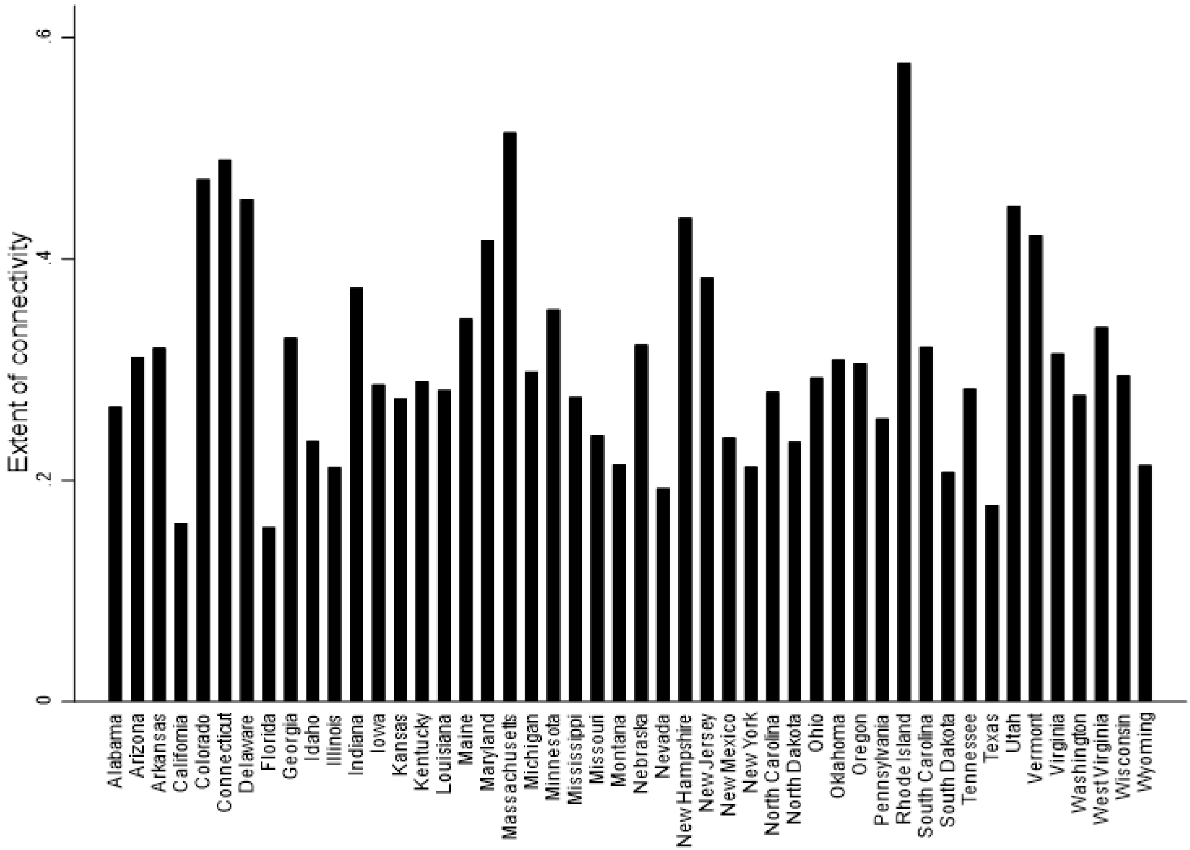

Figure 3: The figure presents the extent of connectivity across the 48 contiguous U.S. states.

4.1.3 Polarization

We measure polarization via data from the ANES (ANES (2022)). The latter is a comprehensive national survey of voters, undertaken biennially up to 2004 and quadrennially thereafter, on a representative sample of voting-legible U.S residents, before and/or after elections (Presidential or House/Senate, depending on the survey year), starting in 1948. We employ the ANES cumulative survey data which merges and standardizes survey variables across a pooled cross-section of survey waves. The analysis covers all years for which our main measures of interest (described below) are available, namely 1964-2020.

We consider affective polarization in ideology, in which individuals identify more strongly with an ideology while concurrently identifying less with the opposing views, mapping to the polarization criterion introduced in the analytical framework. Turning to ANES, we adopt the 'feelings thermometer' concerning liberals and conservative views, evaluated consistently over time. Feelings thermometers have long been a standard part of election surveys, and are administered on a 100 point scale, with 0 corresponding to strong negative feelings towards an ideology, and 100 corresponding to strong positive feelings. Intuitively, if an individual gives a high score to one ideology and a low score to another, this indicates a high degree of affective polarization i.e. a large net positive feeling towards a preferred ideology. Hence, our baseline measure of affective polarization considers the absolute value of the difference between individuals' thermometer values concerning liberal and conservative traits. Notably, thermometer responses concerning liberal-conservative values are recorded post-election in each wave, late in the year (noting that elections in the U.S. are held in November).[30]

Using the ANES presents several advantages for our hypotheses testing. First, the ANES is a central data source of political opinions in the U.S. across time, employed previously in several seminal studies (e.g., Kuziemko and Washington (2018), Shachar and Nalebuff (1999)), and is well suited for examining public opinions over time (ANES (2022)). Second, it provides a rich set of respondent-level measures, ranging from individuals' income to their party identification and voting turnout, essential to the analysis. Last, it also reports individuals' state of residence, covering the 48 continental states in our sample, and hence enables matching our (state-level) treatment and adding state fixed effects, thus undertaking a within-state analysis that addresses concerns related to the extent of subjectivity in thermometer values across states and time.

Our sample covers approximately 46,000 individuals. Figure 4 presents the cross-sectional distribution of our (baseline) polarization measure across U.S. states. As the figure illustrates, there is significant cross-state variation. The state averages range from 13 (Maine) to 36 (Montana). Overall, the average polarization level is about 23, with a standard deviation of 26, ranging from 0 to 99. The bias towards relatively small thermometer differences is clear;

[30]We account for the timing of interview, in terms of number of days post-election, within the analysis.

about 50% (3%) of the sample report differences in the lower (upper) 10% percentile (i.e., values between 0 to 10 (90 to 99)).

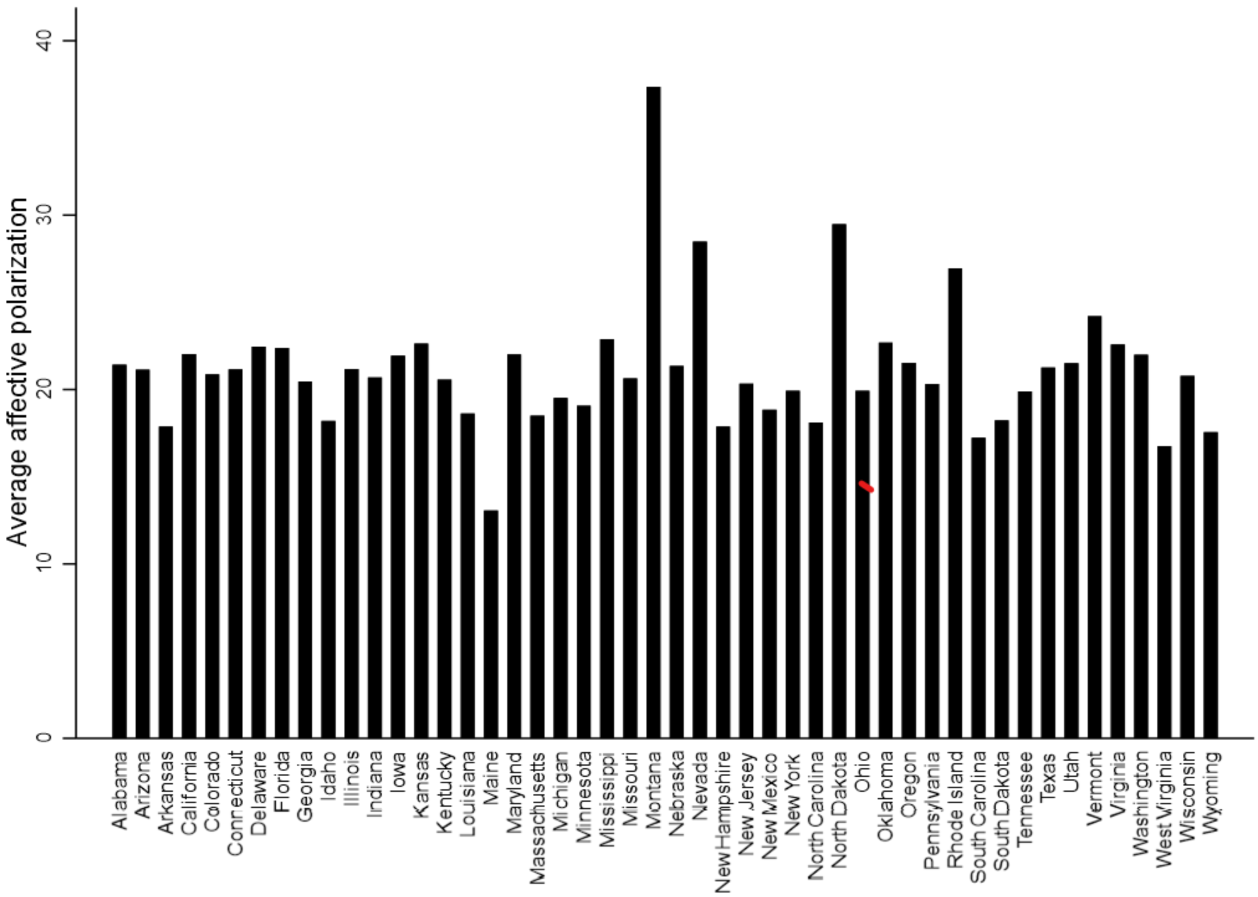

Figure 4: The figure presents the average affective polarization across the 48 contiguous U.S. states, over the period 1964-2020.

4.1.4 Methodology and identification

Using these primary measures, in addition to further respondent and state level controls noted below, as well as throughout the analysis, we estimate the impact of resource windfalls on the extent of polarization, across the connectivity dimension, over the period 1964-2020. Our identification strategy rests on the plausible exogeneity of the resource windfalls and connectivity measures, as the former is based on cross-sectional geological features and variations in international commodity prices over time, and the latter is based on historical, predetermined features.

The state-level perspective of both measures ensures that they are exogenous to individuals' political opinions. In addition, noting that the ANES data is composed of a pooled cross-section of individuals, identification is further based on the assumption that within state and years subjective differences in thermometer interpretations across individuals are similar over the opinion spectrum;[31] notably, other (cross-state and time) potential subjective differences are captured by the fixed effects, as further noted below.

Throughout the analysis we estimate models of the following type, for respondent i, state j, and year t:

$$polarization_{i,j,t} = \alpha + \beta(windfall)_{j,t} + \gamma(connectivity)_j + \theta(windfall * connectivity)_{j,t} + \delta(\mathbf{X})_{i,j,t} + \zeta_j + \nu_t + \epsilon_{i,j,t} \ , \quad (3)$$

where $polarization$, $windfall$, and $connectivity$ denote the polarization, resource windfalls, and connectivity measures outlined above. In addition, $\mathbf{X}$ is a vector of controls at the respondent-year and/or state-year level which varies across specifications and outlined across the analysis; ζ and ν are state and year fixed effects, respectively. The latter absorb $connectivity_j$, which is included in the estimated model for completeness. These fixed effects control for key factors. The within-state approach enables addressing regulatory impacts as well as effects of social political approaches related to, for instance, containment of partisanship and related phenomena. The time fixed effects absorb national impacts, ranging from business cycles to technological shocks. Importantly, both in addition control for subjective differences in thermometer reports across states and time.

Our focus throughout the analysis is on the characteristics of θ, namely its sign, magnitude and statistical preciseness, which give an estimate for the contemporaneous impact of resource

[31] In this case, individuals may differ in their thermometer interpretations; i.e., for some individuals a score of 50 may seem high, while others may interpret it as being low. Nonetheless, assuming that individuals apply their subjective interpretations similarly across the opinion spectrum, judging conservative and liberal views on the same subjective scale, the *difference* in thermometer values, which is what the outcome variable ultimately captures, is comparable across individuals and hence informative. Indeed, regressing the difference between individuals' Liberal Thermometer and the mean Liberal Thermometer within state and years, on the same difference using Conservative Thermometer values, yields a statistically precise positive estimate, indicating that deviations of individuals' opinions from the mean co-move across the opinion spectrum.

windfalls on polarization vis-à-vis the extent of connectivity. Considering the oil price, and hence windfalls, in levels, θ in effect compares between cases of low and high *non-negative* windfalls.[32] Our contemporaneous approach is driven by the timing of the survey parts pertaining to the analysis, which, as noted, are undertaken late in each given year.[33] Throughout the analysis we adopt a conservative clustering approach, in which the standard errors are clustered by states.

4.2 Results

This sub-section outlines the results of the empirical analysis. We start with the baseline results, and continue to additional examinations and robustness tests thereafter. In the last part we analyze the effects over longer terms.

4.2.1 Resource windfalls, connectivity, and polarization

We turn to the main analysis. We estimate various versions of Equation (3). Results appear in Table 1. Column 1 represents the initial specification, with *connectivity* and **X** excluded, in an attempt to estimate the direct impact of $windfall$. The non-significant estimated β indicates that on their own, resource windfalls are not associated with polarization, consistent with the ambiguous effect of α in the analytical analysis. Next, we account for the connectivity channel. Column 2 represents our baseline specification, in which *connectivity* and its interaction with $windfall$ are added. The estimated θ is positive and statistically significant. Resource windfalls increase polarization when connectivity is high, compared to when its extent is lower, consistent with the main prediction of the model. Furthermore, the magnitudes of θ and β indicate that the extent of this positive impact increases with the degree of connectivity, as illustrated theoretically in Figure 1.[34]

[32] The empirical setup does not consider negative windfalls. Hence, θ represents an empirical estimate for the patterns highlighted in Figure 1, thus mapping to the theoretical framework. Specifically, it estimates (referring to the model's notation) the impact of δ under cases of high relative to low α.

[33] Albeit we also present a dynamic analysis, over a 10-year horizon, later in the analysis.

[34] Considering a connectivity level of one standard deviation above the mean (0.0017), the magnitudes of θ and β indicate that even the minimum level of positive windfalls in our sample (0.0001) induces a positive impact on polarization, in a magnitude that increases with the extent of connectivity.

Table 1: Resource windfalls, polarization, and connectivity

Dependent variable: Polarization	(1) Windfall	(2) Baseline	(3) Distance	(4) Respondent characteristics	(5) Interview characteristics	(6) State characteristics
Windfall	-376.01	-1773.04***		-1878.28***	-1878.63***	-501.19
	(269.17)	(342.37)		(282.91)	(376.79)	(376.86)
Windfall X Connectivity		6289.43***		5494.01***	7055.7***	3720.49**
		(1380.34)		(1134.55)	(1511.96)	(1840.01)
Windfall X Close			817.58**			
			(375.48)			
Windfall X Far			-415.21			
			(257.56)			
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Respondent controls	No	No	No	Yes	No	No
Interview controls	No	No	No	No	Yes	No
State controls	No	No	No	No	No	Yes
R-squared	0.15	0.15	0.15	0.13	0.17	0.15
Observations	46423	46423	46423	40541	43546	26722

Notes: Standard errors are robust, clustered by state, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. The dependent variable is polarization. All regressions include state and year fixed effects, and an intercept. The complete sample includes respondents to the U.S. American National Elections Survey across the 48 contiguous states, covering the period 1964-2020. 'Windfall' is the baseline measure of resource windfalls, namely the interaction of the (cross-sectional) state recoverable stocks of oil and gas and the international prices of oil and gas, normalized by states' land area. 'Connectivity' is the measure of isolated capital cities. 'Close' is a dummy that captures states with capital cities that are within the 50th percentile of the least isolated ones; 'far' is a dummy that captures the remaining states. Respondent controls include: income, weight, turnout, party identification, education level, and marital status. Interview controls include: mode, language, and timing. State controls include: corruption, electoral competition, governor party affiliation, real GSP per capita, manufacturing/services employment shares, GSP share of government expenditures, inequality (Theil Index), state-year time trends. For further information on variables see data Appendix.

The magnitudes of the estimated β and θ further indicate, however, that the observed outcome is not merely a relative effect (noting that the minimum value of *connectivity* is 0.16); rather, they point at a divergent outcome across the connectivity dimension. This is illustrated in Column 3. Specifically, we examine whether the main outcome is the result of a relative effect (of respondents residing in states with high connectivity relative to others), or rather a direct one driven by polarizing-increasing impacts of resource windfalls in high connectivity locations, as hypothesized. To do so, we estimate the following version of Equation (3):

$$polarization_{i,j,t} \; = \; \alpha + \beta(windfall * close)_{j,t} + \gamma(windfall * far)_{j,t} + \zeta_j + \nu_t + \epsilon_{i,j,t} \;, \quad (4)$$

where *close* denotes states with capital cities that are within the 50th percentile of least isolated (higher connectivity), and far denotes the remaining states (lower connectivity), with $windfall$ excluded to enable identifying both effects concurrently. Such a specification enables observing the direct separate outcome on polarization in *close* and far states, by focusing on the estimated β and γ.

The results illustrate the divergent outcome. Specifically, β points at a positive and statistically significant impact of resource windfalls on polarization in states with high connectivity. Conversely, however, as the estimated negative and imprecise γ indicates, in the remaining states resource windfalls do not bear an observable polarizing impact. These outcomes not only clarify the source of the observed relative difference, but they also point at a distinct outcome, along the connectivity dimension, consistent with the analytical outcomes. The estimated β further indicates that in *close* cases, all (non-zero) windfalls in our sample, small or large, increases the extent of polarization. The magnitude is non-trivial. A one standard deviation of $windfall$ increases average *polarization* in *close* states by approximately 4%.[35]

The next columns include $\mathbf{X}$; each case addresses a different facet of the polarization reports examined.[36] We outline the controls considered in each case (referring to the Data Appendix for the complete description of each measure), which in turn alter sample sizes, depending on the measures' availability and coverage. In Column 4 we examine the role of respondent factors, as they may impact the extent of thermometer values reported. For instance, it has been shown that income may be associated with polarization (Gunderson (2022)), as well as turnout (Callander and Wilson (2007)), which may capture, for example, the extent of political knowledge. Hence, we add the following respondent controls: income level, voter turnout, party identification, education level, and marital status. In addition, we also account for respondent's observation weight, calculated by ANES, noting that methodologically some respondents may represent more, or less, than a single observation.

In Column 5 we account for the potential impact of interview characteristics. Specifically, we consider three measures, namely the mode, language, and timing of interview. The first measure considers whether the interview was held in person, over the phone, online, or through video; the second addresses the language in which the interview was held, including English,

[35]This is computed by multiplying a one standard deviation of $windfall$ (0.0011) by the estimated β (817.58), and dividing by the average *polarization* in *close* states (22.11).

[36]We distinguish between facets, rather than consider them jointly, as the latter option restricts the sample considerably.

Spanish, French, or other; the third reports the timing of the interview, measured as the number of days from the day of election (within the corresponding year). Each of these factors may affect respondents' reported measures; for instance, assuming that the interest in public debates peaks at, or around, election day, the farther the interview is from election day the subtler may be respondents' attitudes towards them.

In Column 6 we consider statewide politico-economic factors. First, states' non-windfall-driven economic situation and sectoral composition. Economic factors external to resource windfalls may induce political impacts in election years (e.g., Raveh and Tsur (2020b)), hence we include states' per capita Gross State Product (GSP), and the size of other major sectors, including manufacturing, services, and government.[37] Second, states' corruption level.[38] Corruption has been shown to be associated with polarization (Melki and Pickering (2020)). Therefore, we include a standard measure of state corruption, namely the *Corruption Convictions Index* (see, e.g., James and Rivera (2022)), which provides a measure of per capita federal convictions relating to corruption. Third, electoral competition. The latter enhances salience, and may affect polarization, as noted by Bassan-Nygate and Weiss (2022). To account for that, we include a measure of electoral competition; namely, a Ranney-Index based indicator (Ranney (1976)).[39] Fourth, governors' party affiliation. Governors have a potentially prime role in setting the tone of political intra-state political discussions, depending on their ideology, hence we consider their political affiliation. Last, income inequality. Previous studies noted that income and political polarization are associated (e.g., Stewart et al. (2020)), hence we control for income inequality via the standard Theil Index (Frank (2009)).

Columns 4-6 report the estimated β and θ.[40] Notably, the outcome in each case is reminiscent of that estimated under the baseline case (Column 2). Specifically, we note that θ

[37]Importantly, these factors also control for the transient impact of windfalls on the economy, hence strengthening our focus on the public debate channel.

[38]Consistent with the literature (e.g., Raveh and Tsur (2023)), we define corruption as "criminal abuses of public trust by government officials".

[39]This indicator takes the value 0 if both the state House and Senate have a majority affiliated with the same party, and 1 otherwise. The idea is that once neither party controls both houses, neither is particularly dominant, and the extent of electoral competition increases.

[40]The separate effects of the various key co-variates are reported and analyzed in the following sub-section which considers potential underlying mechanisms.

is positive and statistically precise, reaffirming the main outcome together with the relative magnitudes of β and θ which point, once again, at divergent paths across connectivity levels. Put together, we observe that the main observed patterns are robust to addressing the various noted co-variates.

4.2.2 Potential mechanisms

The baseline results indicate that, consistent with the theoretical analysis, resource windfalls increase the extent of polarization under high connectivity. Next, we consider various potential underlying mechanisms. To do so, we undertake an heterogeneity analysis with respect to the key controls considered in the baseline examinations, namely those related to respondent and state characteristics as well as additional ones related to state institutions. We examine each case separately. Hence, we estimate the following variation of Equation (3):

$$polarization_{i,j,t} = \alpha + \beta(windfall)_{j,t} + \gamma(z)_{\Theta\in((i,t),(j),(j,t))} + \theta(windfall * connectivity)_{j,t} + \delta(windfall * z)_{\chi\in((\Theta,t),(\Theta))} + \zeta_j + \nu_t + \epsilon_{i,j,t} \ , \quad (5)$$

where z is an alternating measure across specifications (in conjunction with corresponding alternations of Θ, depending on z's variation), outlined separately for each of the three cases (respondent, state, and institutional features). In each case we report the coefficients of interest, namely β, γ, θ, and δ.

Respondent characteristics: Examining heterogeneities across respondent-level measures, z in this case denotes one of the following respondent-level measures outlined above: income, turnout, age, education, party identification, and gender. Results appear in Table 2. We observe that income, turnout, age, and republican identification are associated with heightened polarization, also vis-à-vis resource windfalls; we also notice that, independent of windfalls, education and male gender are linked to higher polarization. Importantly, however, θ retains its characteristics, in terms of sign, magnitude, and significance; together with the estimated β, it points at patterns similar to the baseline case, including in Column 7 in which all the underlying channels are considered concurrently. The main outcome is, therefore, robust to the inclusion of the key respondent-level potential mechanisms.

Table 2: Potential mechanisms – Respondent characteristics

Dependent variable: Polarization	(1) Income	(2) Turnout	(3) Age	(4) Education	(5) Party	(6) Gender	(7) All
Windfall	-2181.39***	-2433.02***	-2798.96***	-1880.61***	-2668.79***	-2260.89***	-3371.27***
	(428.27)	(471.37)	(396.31)	(391.37)	(384.86)	(452.18)	(506.56)
Income	1.67***						0.36**
	(0.15)						(0.14)
Turnout		5.89***					5.17***
		(0.18)					(0.18)
Age			0.05***				0.05***
			(0.01)				(0.01)
Education				3.95***			2.54***
				(0.19)			(0.23)
Party					1.59***		1.36***
					(0.1)		(0.11)
Gender						-2.67***	-1.58***
						(0.29)	(0.31)
Windfall X Connectivity	6370.89***	5010.79***	6103.74***	5786.05***	6439.45***	6325.07***	4798.88***
	(1422.28)	(1174.51)	(1275.49)	(1478.12)	(1419.67)	(1368.43)	(1117.76)
Windfall X Income	151.29**						17.3
	(70.28)						(77.25)
Windfall X Turnout		378.4***					354.74**
		(140.4)					(170.78)
Windfall X Age			23.82***				10.03**
			(4.71)				(4.19)
Windfall X Education				116.41			-130.77
				(113.83)			(161.06)
Windfall X Party					222.21***		223.94***
					(57.01)		(58.73)
Windfall X Gender						308.84	83.61
						(199.01)	(160.64)
R-squared	0.16	0.22	0.15	0.17	0.17	0.15	0.25
Observations	44913	42051	46423	46423	46423	46423	40541

Notes: Standard errors are robust, clustered by state, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. The dependent variable is polarization. All regressions include state and year fixed effects, and an intercept. The complete sample includes respondents to the U.S. American National Elections Survey across the 48 contiguous states, covering the period 1964-2020. 'Windfall' is the baseline measure of resource windfalls, namely the interaction of the (cross-sectional) state recoverable stocks of oil and gas and the international prices of oil and gas, normalized by states' land area. 'Connectivity' is the measure of isolated capital cities. 'Income' is respondent's income level. 'Turnout' is respondent's voting turnout. 'Age' is respondent's age. 'Education' is respondent's education level. 'Party' is respondent's party identification. 'Gender' is respondent's gender. For further information on variables see data Appendix.

State characteristics: Undertaking similar analysis for the key state-level measures, z in this case represents one of the following state-level measures outlined above: GSP, electoral competition, governor's party, corruption, government size, and inequality. The results, which appear in Table 3, indicate that affective polarization is not robustly associated with any of the key state characteristics, independently or via resource windfalls, with the exception of connectivity. The main observed patterns remain to hold under the consideration of the different state-level channels, also when all of them are considered jointly in Column 7.

Table 3: Potential mechanisms – State characteristics

Dependent variable: Polarization	(1) GSP	(2) Electoral competition	(3) Governor's party	(4) Corruption	(5) Government	(6) Inequality	(7) All
Windfall	-1706.54	-1731.34***	-1262.86***	-1676.16***	-863.23**	-1273.83	2169.19
	(1132.08)	(324.38)	(295.54)	(598.28)	(429.34)	(1618.79)	(2741.03)
GSP	-0.0001						-0.0001
	(0.0001)						(0.0001)
Electoral competition		0.22					0.29
		(0.27)					(0.43)
Governor's party			0.13				-0.08
			(0.37)				(0.41)
Corruption				-0.21*			-0.3***
				(0.11)			(0.11)
Government					0.01		-0.21
					(0.24)		(0.33)
Inequality						-4.92**	-3.32
						(2.32)	(2.99)
Windfall X Connectivity	5810.91***	6278.08***	4945.62***	5252.4***	6497.25***	4559.96***	3753.18**
	(1294.61)	(1425.25)	(1354.97)	(1751.79)	(1640.32)	(1572.16)	(1577.13)
Windfall X GSP	0.001						-0.01
	(0.02)						(0.03)
Windfall X Electoral_competition		-15.9					46.11
		(168.73)					(270.94)
Windfall X Governor's party			-16.34				14.78
			(309.43)				(369.38)
Windfall X Corruption				69.07			148.85**
				(60.26)			(70.43)
Windfall X Government					-76.33		-121.72
					(55.32)		(86.43)
Windfall X Inequality						-30.27	-1657.78
						(1360.87)	(1780.86)
R-squared	0.15	0.15	0.12	0.17	0.12	0.15	0.14
Observations	46305	46070	37078	31118	37078	41663	26722

Notes: Standard errors are robust, clustered by state, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. The dependent variable is polarization. All regressions include state and year fixed effects, and an intercept. The complete sample includes respondents to the U.S. American National Elections Survey across the 48 contiguous states, covering the period 1964-2020. 'Windfall' is the baseline measure of resource windfalls, namely the interaction of the (cross-sectional) state recoverable stocks of oil and gas and the international prices of oil and gas, normalized by states' land area. 'Connectivity' is the measure of isolated capital cities. 'GSP' is the per capita Gross State Product. 'Corruption' is the Corruption Convictions Index. 'Electoral competition' is a Ranney-Index based measure of state electoral competition. 'Governor's party' is the party with which the governor is affiliated. 'Government' is the GSP share of government expenditures. 'Inequality' is the Theil Index. For further information on variables see data Appendix.

Institutional characteristics: Additional potential political mechanisms relate to cross-state institutional differences. U.S. states present various institutional differences that may be pivotal for our analysis, as they relate to incumbent behavior, which may crucially affect various aspects of public debates. We, hence, consider cross-sectional differences in the institutional settings that have been reported in previous research to affect states' incumbent behavior (see, e.g., Raveh and Tsur (2023)). While such differences are captured via the state fixed effects, we look into the role of their interaction with $windfall$, to better identify the impact manifested via connectivity. In this case z represents an indicator for one of the examined institutional features. The descriptions and cross-sectional state divisions of each of the institutional differences mentioned below are outlined in the Data Appendix, together with their sources.

We examine the roles of the following cross-state institutional differences: baseline budgeting rules; biennial budgeting; debt limitations; direct democracy; line item veto; party strength; rules of the budget stabilization fund; tax and expenditure limitations; state upper chamber size; combined tax and spending committees in the legislature; gubernatorial and/or legislature term limits. Results appear in Columns 1-12, of Table 4, examining each of these cases, respectively, in addition to Column 13 in which they are considered jointly. The estimates indicate that with the exception of upper chamber size, via which windfalls decrease polarization, the examined institutional differences do not transmit the impact of resource windfalls to polarization. Connectivity, on the other hand, retains its role as a transmission mechanism of resource windfalls in all cases, including in the one that considers all institutional differences concurrently. Our main outcome is, thus, robust to considering major state institutional differences.

Table 4: Potential mechanisms – State institutions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable: Polarization	Baseline budget	Biennial budget	Debt limit	Direct democracy	Line item veto	Party strength	Stablization fund	Tax and spending limits	Chamber size	Combined committees	Term limits	All
Windfall	-1688.2***	-2422.61**	-1233.21**	-1950.57***	-2685.97	-1747.76***	-1321.48**	-2314.2***	-93.64	-1722.22***	-1779.06***	-1735.78
	(540.59)	(925.3)	(584.47)	(490.61)	(8822.78)	(323.42)	(589.38)	(593.89)	(693.61)	(310.97)	(607.39)	(9844.73)
Windfall X Connectivity	5856.3**	7911.65***	5368.06***	7245.18***	6290.61***	6226.07***	5994.56***	6991.51***	8115.82***	6097.3***	6331.78**	12406.86**
	(2744.01)	(2339.78)	(1645.9)	(2212.09)	(1386.59)	(1306.26)	(1407.54)	(1554.58)	(2245.72)	(1383.49)	(3010.9)	(5736.52)
Windfall X Baseline	166.64											-1871.49
	(813.22)											(1512.9)
Windfall X Biennial		429.38										1322.68
		(503.32)										(1478.04)
Windfall X DebtLimit			-431.65									-463.62
			(373.72)									(367.98)
Windfall X DirDem				-434.78								-600.73
				(598.88)								(1084.23)
Windfall X Veto					906.79							2009.89
					(8743.29)							(8755.81)
Windfall X ParStrength						756.98						2456***
						(1320.35)						(704.61)
Windfall X StabFund							-429.03					42.08
							(493.7)					(985.98)
Windfall X TaxLimit								450.51				-78.11
								(428.03)				(578.67)
Windfall X Chamber									-60.73***			-126.49***
									(22.47)			(42.7)
Windfall X Combined										-396.08		463.77
										(624.47)		(1187.87)
Windfall X TL											-9.12	1681.79*
											(568.91)	(982.82)
R-squared	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Observations	46423	46423	46423	46423	46423	46423	46423	46423	46423	46423	46423	46423

Notes: Standard errors are robust, clustered by state, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. The dependent variable is polarization. All regressions include state and year fixed effects, and an intercept. The complete sample includes respondents to the U.S. American National Elections Survey across the 48 contiguous states, covering the period 1964-2020. 'Windfall' is the baseline measure of resource windfalls, namely the interaction of the (cross-sectional) state recoverable stocks of oil and gas and the international prices of oil and gas, normalized by states' land area. 'Connectivity' is the measure of isolated capital cities. The various institutional heterogeneities (interacted with 'Windfall') are absorbed by the state fixed effects and hence not reported separately. State institutional heterogeneities include: 'Baseline': baseline budgeting rules; 'Biennial': semi-annual budget; 'DebtLimit': debt limitations; 'DirDem': direct democracy (voter initiative); 'Veto': line item veto. 'ParStrength': party strength; 'StabFund': rules of the budget stabilization fund; 'TaxLimit': tax and expenditure limitations; 'Chamber': chamber size of the state Senate; 'Combined': combined tax and spending committees in the legislature; 'TL': The existence of gubernatorial and/or legislature term limits over the sample period. For further information on variables see data Appendix.

4.2.3 Different measures

The baseline analysis employed specific *polarization*, *windfall* and *connectivity* measures. In this sub-section we examine the robustness of the results to the adoption of various alternatives. Results appear in Table 5, and follow the baseline specification (Column 2 of Table 1), yet with the examined alternative in lieu of either the baseline measure noted. Starting with *polarization*, we examine three alternative measures, each at the state level. Considering the latter enables examining standard measures, used previously in the literature, and considering more explicitly the silent majority and vocal minority hypothesis by mapping the outcome to the treatment level.[41] This mapping, in turn, also enables more generally to test the main hypothesis under a complete state-level perspective in which both the treatment and outcome variables are aggregated to the same level.

The first measure considers ideological polarization, presenting a standard view of political polarization, by summing population shares of individuals who identify as political conservatives and those who identify as political liberals, as constructed by Enns and Koch (2013). The second measure, constructed also by Enns and Koch (2013), examines the extent of an additional standard polarization measure, namely partisanship, by similarly summing population shares of individuals who identify as Democrats and those who identify as Republicans. The third measure examines polarization in opinions concerning environmental issues, testing the hypothesis that the impact of resource windfalls and connectivity are also relevant to public debates over issues related directly to resource windfalls. In effect, this measure provides the sum of average pro-environmental public opinion, and average anti-environmental public opinion, as constructed by Eun Kim and Urpelainen (2018). Notably, unlike the baseline measure, the state-level ones are available annually (albeit for different periods, as outlined in the appendix).[42]

Next, we examine an alternative *windfall* measure, mining output per capita. The mining sector includes the oil and gas industries, and hence provides a different, yet more direct,

[41] An aggregation considers the mean across the population, relevant to reflecting the voice of vocalists, as opposed to a survey-level perspective which accounts for the opinion of all sampled individuals.

[42] In these cases, since the outcome variable is at the state level, we also include a basic control for state heterogeneity, namely real per capita GSP.

measure of resource windfalls. Last, we consider an alternative for *connectivity*. In the main analysis we employed a measure which is based on the baseline measurement of isolated capital cities in which Campante and Do (2014) assumed salience decreases linearly with distance from the capital city. In an adjusted measure, they account for states' size, assuming that salience drops to zero at the border. We construct an alternative connectivity measure based on their adjusted variant, accounting for the population censuses up to 1960, as described in the benchmark case.

Each of these cases appear in Columns 1-5, in the order described, respectively. Notably, in all cases the impact of our interaction term of interest remains positive and significant, similar to the baseline analysis, and together with the estimated β, the main outcome is reaffirmed and robust to the examination of alternative measures.

Table 5: Different measures

	(1)	(2)	(3)	(4)	(5)
	State-level analysis			Respondent analysis	
Dependent variable:	Ideological polarization	Partisanship	Environmental polarization	Polarization	Polarization
Windfall	-195.36*	-421.32**	-6.05***		-1309.17***
	(113.32)	(202.78)	(1.91)		(469.5)
Windfall X Connectivity	1137.27**	2094.09**	33.1***		
	(526.49)	(946.16)	(9.18)		
Mining output				-1427.85***	
				(457.78)	
Mining X Connectivity				5227.99**	
				(2127.13)	
Windfall X Connectivity_adjusted					5152.64***
					(1851.59)
State fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
R-squared, within	0.92	0.81	0.89	0.12	0.15
Observations	1672	2296	1912	39960	46423

Notes: Standard errors are robust, clustered by state, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. The dependent variable is respondent polarization (Columns 4-5); ideological polarization/partisanship/environmental polarization (Columns 1/2/3, respectively). All regressions include an intercept (and real GSP per capita in Columns 1-3). The complete sample includes respondents to the U.S. American National Elections Survey across the 48 contiguous states covering the period 1964-2020 (Columns 4-5), or the 48 contiguous states covering the period 1960-2010 (Columns 1-3). 'Windfall' is the baseline measure of resource windfalls, namely the interaction of the (cross-sectional) state recoverable stocks of oil and gas and the international prices of oil and gas, normalized by states' land area. 'Connectivity' ('Connectivity_adjusted') is the (adjusted) measure of isolated capital cities. 'Mining output' is state per capita output in the mining sector. For further information on variables see data Appendix.

4.2.4 Additional tests

We undertake additional robustness tests to the main specification. All cases follow the baseline specification (Column 2 of Table 1), with case-specific modifications as noted below. Results of this sub-section appear in Table 6. First, we examine three restricted samples. In Column 1 we exclude the resource-richest states, as observed in Figure 2, namely Louisiana, Mississippi, North Dakota, Texas, and Wyoming. This exclusion enables examining the extent to which the main results are driven by the states with significant resource windfalls, or whether the main result is also apparent even in low-level variations. In Column 2 we exclude New Hampshire and Vermont, which have local elections every two years, to fix government durability, as it may affect the electorate's attitudes towards the government. In Column 3 we exclude California, and New York, to test the robustness of the key results to the exclusion of the largest states. This restriction addresses the concern that the main results may be driven by the dominant states. The estimated γ in either of the cases indicates that the main result is robust to these restrictions.

Second, we test different clustering levels. The baseline analysis follows a conservative clustering approach at the state level. However, the basic structure of the data enables assuming standard error correlations across multiple groups. We examine two such cases, under two-way clustering; clustering by state and year, and by respondent and year. The results, which appear in Column 4-5, respectively, indicate that the main effect is robust to these modifications.

Third, we examine additional specifications. In the first case, appearing in Column 6, we test a dynamic version of the baseline specification, in which we also control for lagged variable of the dependent variable. This specification is, in effect, equivalent to one in which the dependent variable is examined in changes; it addresses the dynamic aspects of the process portrayed in the analytical framework. In the second case, appearing in Column 7, we estimate a demanding specification in which the categorical, non-continuous, controls of those examined in the baseline analysis, enter the analysis as fixed effects. Specifically, in this specification we have the following fixed effects (in addition to the standard state and year ones): respondent's voting turnout, respondent's party identification, respondent's marital status, language of interview, mode of interview, timing of interview, state electoral competition, governor's party affiliation, and respondent's age. The estimates in both cases indicate that the main result is robust to these examinations.

Fourth, we further address endogeneity concerns related to the connectivity measure, following the approach undertaken in Campante and Do (2014). The latter offered two instruments for their baseline measure of isolated capital cities. The first pertains to the distance between capital cities and the geographical centroid of the state, based on historical records of the former; the second considers the spatial distribution of arable land, to the extent that it provides geographical-based motives for the distribution of population across the state. We adopt both measures to instrument for our measure of connectivity, via the methodology set in Wooldridge (2002) for instrumentation of interaction terms. Specifically, we first regress *connectivity* on the two proposed instruments, and the take the predicted values (PV).[43] Thereafter, in the second stage, PV is included in the specification, in lieu of *connectivity*. The results in Column 8 indicate that the observed patterns are robust to this estimation method.

Last, we examine sample restrictions related to the time period examined. Column 9 examines the case of up to 2000, whereas Column 10 considers the remaining, post-2000 sample period. This division serves to examine the validity of the main patterns across different periods. However, in addition, it also addresses the concern that the relation of isolated capital cities to connectivity may diminish across time given the rise of digital media. Interestingly, we observe that the main effect is apparent in both cases, yet in a slightly increased magnitude in the post-2000 case, compared to the precedent period, as well as relative to the benchmark case.

4.2.5 Longer-term analysis

Our focus has been on the contemporaneous effects of resource windfalls and connectivity, noting that public debates tend to relate to contemporary issues. Nonetheless, the impact on the characteristics of public debates and opinions may last longer, in case of high stakes debates, such as those potentially triggered by resource windfalls. To test that, we estimate and present the dynamic heterogeneous effects of resource windfalls across states with different levels of connectivity over the course of 10 years. We employ the method of local projections of Jorda (2005).

[43] Note that, consistent with the analysis undertaken in Campante and Do (2014), the first stage exhibits a large F-statistic of well above 1000.

Table 6: Additional tests

Dependent variable: Polarization	(1) Resource-rich excluded	(2) NH, and VT excluded	(3) CA, and NY excluded	(4) Clustering by state and year	(5) Clustering by respondent and year	(6) Dynamic specification	(7) Additional fixed effects	(8) Instrumenting connectivity	(9) Up to 2000	(10) Post 2000
Windfall	-2459.38**	-1812.16***	-1601.34***	-1773.04***	-1773.04***	-1165.39***	-1250.69***	-1411.43***	-1651.67***	-2157.06***
	(1213.52)	(347.74)	(312.51)	(379.15)	(452.99)	(399.56)	(300.69)	(407.1)	(554.21)	(744.18)
Windfall X Connectivity	8067.26***	6483.52***	5689.28***	6289.43***	6289.43***	4914.72***	4465.96***		5606.79**	6398.2**
	(2894.43)	(1395.76)	(1370.26)	(1117.39)	(1562.12)	(1184.86)	(1253.53)		(2760.8)	(2490.13)
Polarization_[t-1]						-0.06***				
						(0.01)				
Windfall X PV								4943.65**		
								(2243.97)		
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Additional fixed effects	No	No	No	No	No	No	Yes	No	No	Yes
R-squared	0.16	0.15	0.17	0.15	0.15	0.13	0.21	0.15	0.14	0.39
Observations	41377	46081	38628	46423	46423	30694	29994	46423	32048	12680

Notes: Notes: Standard errors are robust, clustered by state (state and year in Column 4; respondent and year in Column 5), and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. The dependent variable is polarization. All regressions include state and year fixed effects, and an intercept. The complete sample includes respondents to the U.S. American National Elections Survey across the 48 contiguous states (LA, MS, ND, WY, and TX are excluded in Column 1; NH, and VT are excluded in Column 2; CA, and NY are excluded in Column 3), covering the period 1964-2020 (up to 2000 in Column 9; post-2000 in Column 10). 'Windfall' is the baseline measure of resource windfalls, namely the interaction of the (cross-sectional) state recoverable stocks of oil and gas and the international prices of oil and gas, normalized by states' land area. 'Connectivity' is the measure of isolated capital cities. Additional fixed effects include: respondent's voting turnout, respondent's party identification, respondent's marital status, language of interview, mode of interview, timing of interview, state electoral competition (Ranney-Index based measure of state electoral competition), governor's party affiliation, respondent's age. 'PV' represents the predicted values from regressing 'Connectivity' on the distribution of arable lands and the distance of the capital city from the state's geographical centroid. For further information on variables see data Appendix.

The method of local projections gives us estimates of impulse response functions via separate regressions for each lead over the forecast horizon. The effect of $windfalls * connectivity$ at $t+h$ with $h = 0, 1, \ldots, 10$ is estimated by regressing dependent variables at $t+h$ on shocks and covariates at time t. Responses thus do not rely on nonlinear transformations of reduced-form parameters as in VARs. We define $\Delta_{t-1} x_{i,j,t+h} \equiv x_{i,j,t+h} - x_{i,j,t-1}$ and estimate the sequential equations

$$\Delta_{t-1}(polarization)_{i,j,t+h} = \alpha^h + \beta^h (polarization)_{i,j,t-1} + \gamma^h (windfall)_{j,t} + \delta^h (connectivity)_j + \theta^h (windfall * connectivity)_{j,t} + \zeta_j^h + \nu_t^h + \epsilon_{i,j,t+h}. \quad (6)$$

The dependent variable is the cumulative growth of the $polarization$ variable, $\Delta_{t-1}(polarization)_{i,j,t+h}$, for different values of h. Our main coefficients of interest are the ones on the $windfall * connectivity$ interaction variable, i.e., θ^h for the contemporaneous effect $h = 0$ and the different leads $h = 1, \ldots, 10$. These 10 parameters shape the impulse response function, and hence enable us to trace the time profile of the effect of resource windfalls across connectivity levels. Note that in this case we employ a dynamic version of the baseline case, due to the dynamic nature of the analysis. Given this, we consider the state level data, specifically

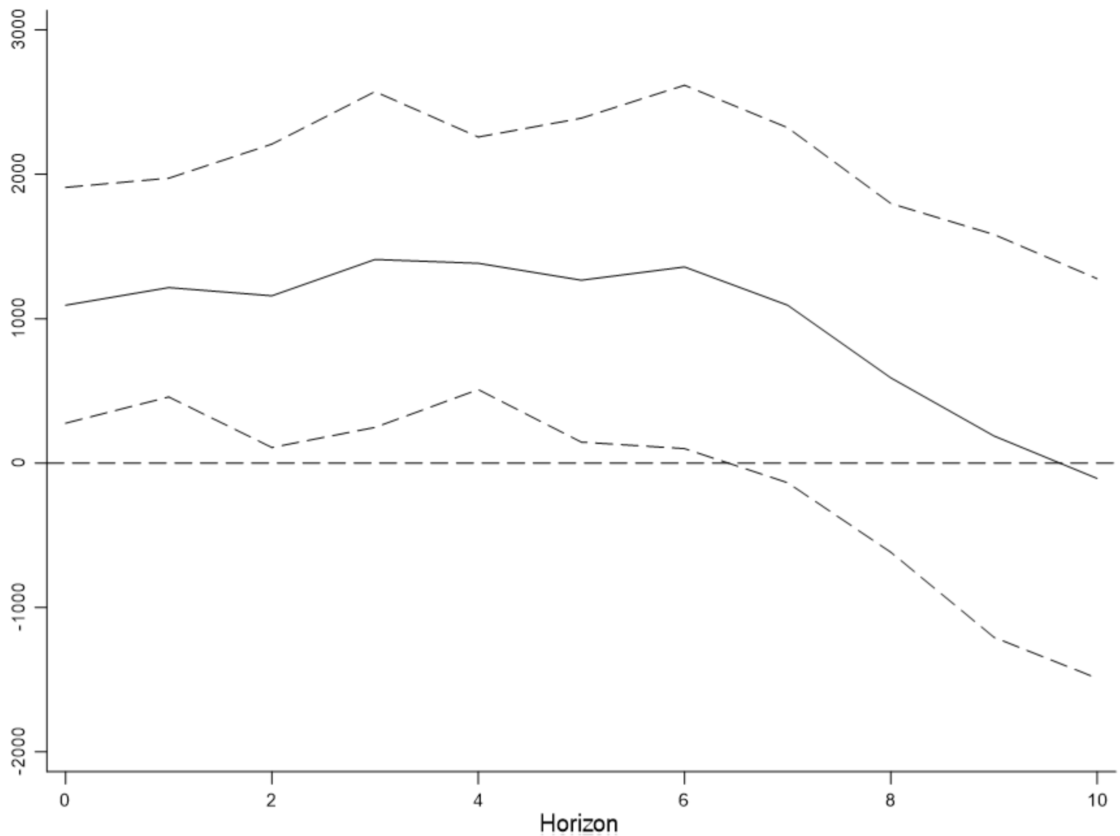

Figure 5: The figure presents the impact of resource windfalls interacted with connectivity on state ideological polarization over a 10-year horizon, following the local projections methodology (Jorda, 2005). The sample includes the 48 continental U.S. states and covers the period of 1976-2010.

via the standard ideological polarization measure introduced previously, as it is based on annual-level panel data, covering the period 1976-2010, and hence more suitable for a dynamic analysis over a 10-year period, relative to the baseline data which is biennial or quadrennial.

Figure 5 plots the impulse response functions for our polarization measure, together with 95% confidence intervals. As illustrated in the figure, θ^h is positive contemporaneously, consistent with the main outcome; however, this effect continues, in constant magnitude, until the sixth year. In the seventh year statistical preciseness diminishes, and the magnitude gradually decreases until the last (10th) year in the examined period. These patterns indicate that the impact of resource windfalls on polarization, via connectivity, extend beyond the short-term, and remain applicable over a period of several years.

5 Conclusion

This work examined, both theoretically and empirically, how resource-induced income shocks influence the degree of polarization, depending on the extent to which the population is connected to the political center. We offered a model of public debate in which players compete for control over the discussion, illustrating that extremists may exert greater effort in muting opposite opinions. The analysis indicated that when the stakes are high and players are engaged in the debate, extremists are able to control the discourse, leading to an adaptive-learning process in which the distribution of opinions in the population is polarized.

The model's predictions have been empirically tested using comprehensive panel data of respondents to the ANES, covering the period 1964-2020, in conjunction with plausibly exogenous state connectivity levels and resource windfalls, measuring the degrees of engagement in and stakes of state public debate, respectively. We examined the impact of the interaction of resource windfalls and connectivity, on the extent of individual affective polarization, measured as differences in warmth levels of opposing ideologies, under a setup that maps to the analytical framework, and enables considering a within-state perspective.

Consistent with the theoretical predictions, the empirical estimates pointed to a positive, significant, and robust relative effect of resource windfalls on the extent of polarization, when connectivity is high, in a magnitude that increases with the extent of connectivity. We illustrated that this result is apparent under a battery of examinations, including various respondent, state and interview level controls, and tests of different measures, sample restrictions, estimation methods, and specifications. Testing for possible underlying channels further illustrated the robustness of the main result, and pointed to additional personal and institutional characteristics that may manifest the impact of windfalls on polarization. Last, we showed that the main effect goes beyond the contemporaneous impact, and is applicable over a longer horizon of about 6 six years.

The results highlight the role of income shocks in inducing polarization, and more specifically, shed light on the potential adverse effects of resource windfalls in advanced democracies, most notably in relation to understanding their role in affecting the distribution of public opinions. These insights point at the need to consider policies that promote transparency and certainty in the management of unexpected income, such as resource windfalls, in an attempt to reduce their potential in sparking public debate, most notably in politically-engaged locations.

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A Data

We use a pooled cross-section of respondents to the American National Election Studies (ANES, 2022), covering the period 1964-2020 (biennial-based up to 2004, and quadrennial-based afterwards), and the 48 contiguous states. Specifically, the data is derived from ANES' time-series cumulative data, which merges and standardizes survey variables across years. Additional standard state variables are derived from the U.S. Bureau of Economic Analysis (BEA). Variables in monetary-values are in current $USD. Descriptive statistics of the key variables are presented in Table A1.

Table A1: Descriptive statistics

	Mean	Std. Dev.	Min.	Max.
Polarization (respondent)	22.92	26.12	0	99
Windfall (state; in $million; per square mile)	0.0006	0.0011	0	0.0087
Connectivity (state)	0.28	0.09	0.16	0.58
Connectivity_adjusted (state)	0.20	0.07	0.08	0.41
Age (respondent)	46.46	18.01	17	99
Education (respondent)	2.57	1.01	1	4
Income (respondent)	2.68	1.32	1	5
Turnout (respondent)	2.31	1.04	1	3
Party identification (respondent)	3.59	2.13	1	7
Marital status (respondent)	2.10	1.74	1	7
Gender (respondent)	1.55	0.50	1	3
Mode of interview (respondent)	1.13	1.72	0	5
Language of interview (respondent)	0.50	2.04	0	7
Timing of interview (respondent)	26.13	25.28	0	99
Ideological polarization (state)	53.79	7.75	36.70	74.03
Partisanship (state)	66.18	8.96	38.96	93.92
Environmental polarization (state)	0.64	0.07	0.44	0.81
Corruption (state)	2.74	2.10	0	20.27
Mining output per capita (state; in $million)	0.0004	0.0012	0	0.0105
Gross State Product per capita (state)	26020.93	18549.11	2018.74	83245.73
Electoral competition (state)	0.50	0.50	0	1
Governor's party affiliation (state)	0.52	0.50	0	1
Manufacturing employment share (state)	0.10	0.04	0.02	0.19
Services employment share (state)	0.15	0.005	0.14	0.17
Government expenditure GSP share (state)	0.09	0.02	0.03	0.19
Inequality (state)	0.64	0.27	0.29	1.50

Notes: See Appendix for detailed description of variables.

Respondent-related variable definitions (source: ANES)[44]

Polarization: The absolute value of the difference between Liberals' thermometer (variable VCF0211 in the survey) and Conservatives' thermometer (variable VCF0212 in the survey),

[44] Variables in this group are at the respondent-level.

each reporting the respondent's feelings towards the corresponding group, on a scale between 0 and 100.

Age: Respondent's age (variable VCF0101 in the survey).

Education: Respondent's education level (variable VCF0110 in the survey), taking the values 1-4, each representing the following education groups: 1. Grade school or less; 2. High school (12 grades or fewer, incl. non-college training if applicable); 3. Some college (13 grades or more but no degree; 4. College or advanced degree.

Income: Respondent's income level (variable VCF0114 in the survey), taking the values 1-5, each representing the following income groups, which classify ranking in the population's income distribution: 1. 0 to 16 percentile; 2. 17 to 33 percentile; 3. 34 to 67 percentile; 4. 68 to 95 percentile; 5. 96 to 100 percentile.

Turnout: Respondent's registration and voting status (variable VCF0703 in the survey) in the elections within the given year (presidential, or house/senate races), taking the values 1-3, each representing the following options: 1. Not registered, and did not vote; 2. Registered, but did not vote; 3. Voted (registered).

Party identification: Respondent's party identification (variable VCF0301 in the survey, taking the values 1-7 according to the following classifications: 1. Strong Democrat; 2. Weak Democrat; 3. Independent - Democrat; 4. Independent - Independent; 5. Independent - Republican; 6. Weak Republican; 7. Strong Republican.

Gender: Respondent's gender (variable VCF0104 in the survey), taking the values 1-3 according to the following categories: 1. Male; 2. Female; 3. Other.

Martial status: Respondent's marital status (variable VCF0147 in the survey), taking the values 1-7 1. Married; 2. Never married; 3. Divorced; 4. Separated; 5. Widowed; 7. Partners.

Mode of interview: Respondent's mode of interview (variable VCF0017 in the survey), taking the values 0-5 according to the following categories: 0. Personal; 1-2. Telephone (partial, for different parts); 3. All telephone; 4. All internet; 5. All video (2020 only).

Language of interview: Respondent's language of interview (variable VCF0018b in the survey), taking the values 0-7 according to the following categories: 0. English; 1. Spanish; 3. French; 4. Either Spanish or French; 5. Non-English language other than Spanish or French; 7. Non-English language but NA which language.

Timing of interview: Respondent's timing of interview (variable VCF1016 in the survey) measured as the number of days from day of election (presidential or House/Senate races, depending on the year).

State-related variable definitions[45]

Connectivity (mean/adjusted): The extent of connected capital cities, which is one minus the (mean or adjusted) measure of isolated capital cities derived from Campante and Do (2014).

Ideological polarization: The sum of shares of surveyed individuals who identify as political liberals and those who identify as political conservatives, as constructed in Enns and Koch (2013). Available annually, 1976-2010.

Partisanship: The sum of shares of surveyed individuals who identify as Democrats and those who identify as Republicans, as constructed in Enns and Koch (2013). Available annually, 1960-2010. *Environmental polarization*: The sum of average pro-environmental public opinion,

[45] Variables in this group are at the U.S. state level.

and average anti-environmental public opinion, as constructed in Eun Kim and Urpelainen (2018). Available annually, 1973-2012.

Resource windfall: The baseline measure of resource windfalls, constructed as the interaction of the cross-sectional state recoverable stocks of oil and natural gas (AK and HI excluded) and the international prices of crude oil and natural gas, normalized by states' land area. In the computations, the oil and gas recoverable stocks were interacted separately with their respective prices, and then added, prior to normalization. Source of the underlying cross-sectional measure: James (2015).

Mining output per capita: State output in the mining sector, normalized by state population. Source: BEA.

GSP per capita: Gross State Product, normalized by state population. Source: BEA.

Corruption: The Corruption Convictions Index, which provides a measure of per capita federal convictions relating to corruption ("criminal abuses of public trust by government officials"). Source: Institute for Corruption Studies, Department of Economics, Illinois State University.

Electoral competition: A binary indicator that takes the value 0 if both the state House and Senate have a majority affiliated with the same party, and 1 otherwise. Source: Grossmann et al. (2021).

Manufacturing share: The GSP share of manufacturing output. Source: BEA.

Services share: The GSP share of services output. Source: BEA.

Government share: The GSP share of government expenditures. Source: BEA.

State political institutions

Baseline budgeting rules: States are divided based on a binary variable that is 1 for states that use current services baseline, and 0 if they use last year's dollar budget as a baseline. The former group includes: AR, AZ, CT, CO, DE, HI, ME, MA, NV, NC, OH, PA, VT, VA, WV, WY. Source: Crain and Crain (1998).

Biennial budget: States are divided based on a binary variable that is 1 for states that have an annual budget, and 0 if they have a biennial budget. The former group includes: AR, HI, IN, KY, ME, MN, MT, NE, NV, NH, NC, ND, OH, OR, TX, VA, WA, WI, WY. Source: Kearns (1994).

Debt limitations: States are divided based on a binary variable that is 1 for states that have debt limitations, and 0 otherwise. The latter group includes: AR, CT, DE, FL, HI, IL, LA, MA, MD, MI, MT, NC, NH, NY, NV, OK, PA, TN, VT. Source: ACIR (1987).

Direct democracy: States are divided based on a binary variable that is 1 for states that have voter initiatives, and 0 otherwise. The former group includes: AK, AR, AZ, CA, CO, FL, ID, IL, MA, ME, MI, MO, MT, NE, NV, ND, OH, OK, OR, SD, UT, WA, WY. Source: Matsusaka (1995).

Line item veto: States are divided based on a binary variable that is 1 for states that have gubernatorial line item veto, and 0 otherwise. The latter group includes: HI, IN, ME, NC, NH, NV, RI, VT. Source: ACIR (1987).

Party strength: States are divided based on a binary variable that is 1 for states with relatively stronger parties based on the Mayhew Index (Mayhew (1986)), and 0 otherwise. The latter group includes: CT, DE, IL, KY, MD, MO, NJ, NY, OH, PA, RI, WV. Source: Primo and Snyder (2010).

Rules of the budget stabilization fund: States are divided based on an indicator that is 0 for states that have no stabilization fund, 1 for states that have such a fund with relatively lax rules, 2 for states that have such a fund with relatively strict rules (strict deposit and withdrawal rules). The first group includes: AL, AR, MT, OR. The latter group includes: AZ, IN, MI, VA. Source: Wagner and Elder (2005).

Tax and expenditure limitations: States are divided based on a binary variable that is 1 for states that have tax and expenditure limitations, and 0 otherwise. The former group includes: AK, AZ, CA, CO, HI, ID, LA, MI, MT, NV, OR, RI, SC, TN, TX, UT, WA. Source: ACIR (1987).

Chamber size: Cross-sectional measure of states' upper chamber size. Source: National Conference of State Legislatures.

Combined committees: States are divided based on a binary variable that is 1 for states that have combined tax and expenditure committees, and 0 otherwise. The former group includes: AK, AL, CA, FL, HI, KS, KY, MA, ME, NJ, NY, OK, SC, TN, WI, WV. Source: ACIR (1987).

Term limits: States are divided based on a binary variable that is 1 for states that had gubernatorial and/or legislature term limits over the sample period, and 0 otherwise. The former group includes: AK, AL, AR, AZ, CA, CO, DE, FL, GA, HI, ID, IN, KS, KY, LA, MA, MD, ME, MI, MO, MS, MT, NC, NE, NJ, NM, NV, OH, OK, OR, PA, RI, SC, SD, TN, UT, VA, WA, WV, WY. Source: National Governors Association.

B Proofs

B.1 Proof of Theorem 1

Proof. Assume there are at least three opinions, $k \geq 3$. The zero vector is not an equilibrium, so fix a non-zero profile $\mathbf{e} \in \mathbb{R}^n_+$, and define the function

$$H(t) = \sum_{l=1}^{k} E_l d(t - O_l).$$

Note that H is convex as, for every $t_1 < t_2$ and $\lambda \in (0,1)$, we get

$$\begin{aligned} H(\lambda t_1 + (1-\lambda)t_2) &= \sum_{l=1}^{k} E_l d(\lambda t_1 + (1-\lambda)t_2 - O_l) \\ &= \sum_{l=1}^{k} E_l d(\lambda(t_1 - O_l) + (1-\lambda)(t_2 - O_l)) \\ &\leq \sum_{l=1}^{k} E_l \left[\lambda d(t_1 - O_l) + (1-\lambda) d(t_2 - O_l)\right] = \lambda H(t_1) + (1-\lambda) H(t_2). \end{aligned}$$

Using the fact that $d(\cdot)$ is convex and symmetric with a strict minima at zero, we note that the inequality above is strict if there exists an opinion O_i where $E_i > 0$ and $t_1 - O_i < 0 < t_2 - O_i$.

Consider the payoff function of player $j \in N_i$,

$$\begin{aligned} U_j(e_j, e_{-j}|O_i) &= -e_j - \frac{\sum_{l=1}^{k} \sum_{r \in N_l} e_r d(O_i - O_l)}{\sum_{r=1}^{n} e_r} \\ &= -e_j - \frac{\sum_{l=1}^{k} E_l d(O_i - O_l)}{\sum_{l=1}^{k} E_l} \\ &= -e_j - \frac{H(O_i)}{\sum_{l=1}^{k} E_l}. \end{aligned}$$

The function $U_j(\cdot, e_{-j}|O_i)$ is differentiable and concave in e_j, so the maximum is reached either at the boundary $e_j = 0$ (effort levels are unbounded from above), or when the following FOC is satisfied:

$$\frac{\partial U_j(e_j, e_{-j}|O_i)}{\partial e_j} = -1 + \frac{H(O_i)}{\left[\sum_{l=1}^{k} E_l\right]^2} = 0, \quad \forall j = 1, \ldots, n.$$

Now assume, by contradiction, that there exists an opinion O_i such that $1 < i < k$ and $E_i > 0$. Thus, the FOC $\frac{\partial U_j(e_j, e_{-j}|O_i)}{\partial e_j} = -1 + \frac{H(O_i)}{\left[\sum_{l=1}^{k} E_l\right]^2} = 0$ is satisfied for such players. Fix $\lambda \in (0,1)$ where $O_i = \lambda O_1 + (1-\lambda) O_k$ and note that

$$H(O_i) = H(\lambda O_1 + (1-\lambda) O_k) < \lambda H(O_1) + (1-\lambda) H(O_k),$$

by the strict convexity above. Assume, w.l.o.g., that $H(O_1) > H(O_i)$. Hence, there exists an extreme player with opinion O_1 with a strictly profitable deviation

$$\frac{\partial U_j(e_j, e_{-j}|O_1)}{\partial e_j} = -1 + \frac{H(O_1)}{\left[\sum_{l=1}^{k} E_l\right]^2} > -1 + \frac{H(O_i)}{\left[\sum_{l=1}^{k} E_l\right]^2} = 0.$$

We thus conclude that, in every equilibrium, $E_i = 0$ for every moderate opinion O_i. Therefore, we are left with the following FOCs for the extreme opinions

$$E_i d(O_1 - O_k) = [E_1 + E_k]^2, \text{ where } i = 1, k.$$

Solving for E_1 and E_k, we get the unique solution (other than the zero-effort profile) of $E_1 = E_k = \frac{d(O_1 - O_k)}{4}$, as needed. □

B.2 Proof of Theorem 2

Proof. Consider an equilibrium profile $\mathbf{e} \in \mathbb{R}^n_+$. It follows from the proof of Lemma 1 that $E_1 = E_3$, so the polarization level translates to

$$P(\mathbf{e}) \;=\; \frac{2E_1E_2^2 + 2E_1^2E_2 + 4E_1^3}{[2E_1 + E_2]^3} = \frac{W^2 + \frac{1}{2}W + \frac{1}{2}}{[1+W]^3} = \frac{1}{1+W} - \frac{1}{2(1+W)^2} - \frac{W}{(1+W)^3},$$

where $W = \frac{E_2}{2E_1}$. According to Lemma 1, W is strictly decreasing in δ, so it is left to prove that $P(\mathbf{e})$ is strictly decreasing w.r.t. $W \geq 0$. Evidently,

$$\frac{dP}{dW} = -\frac{1}{(1+W)^2} + \frac{3W}{(1+W)^4} = \frac{-W^2 + W - 1}{(1+W)^4} < 0,$$

for every $W \geq 0$, as needed. □

B.3 Proof of Lemma 1

Proof. Fix $\delta \in (0,1)$ and consider the FOCs of every player $j \in N_i$ given a non-zero profile e,

$$\sum_{l=1}^{3} E_l \delta^{|i-l|} |O_l - O_i| = \left[\sum_{l=1}^{3} \delta^{|i-l|} E_l\right]^2,$$

where $E_l = \sum_{r \in N_l} e_r$ for $1 \leq l \leq 3$. Stated explicitly for every opinion, we get

$$\begin{aligned}
\text{for } j \in N_1 &: \quad E_2\delta + 2E_3\delta^2 = \left[E_1 + E_2\delta + E_3\delta^2\right]^2, \\
\text{for } j \in N_2 &: \quad E_1\delta + E_3\delta = \left[E_1\delta + E_2 + E_3\delta\right]^2, \\
\text{for } j \in N_3 &: \quad 2E_1\delta^2 + E_2\delta = \left[E_1\delta^2 + E_2\delta + E_3\right]^2.
\end{aligned}$$

Define $X = E_1 + E_2\delta + E_3\delta^2$, $Y = E_1\delta + E_2 + E_3\delta$, and $Z = E_1\delta^2 + E_2\delta + E_3$. So,

$$\begin{aligned}
X - E_1 + \delta^2 E_3 &= X^2, \\
Y - E_2 &= Y^2, \\
Z - E_3 + \delta^2 E_1 &= Z^2.
\end{aligned}$$

and

$$\begin{aligned}
X - \delta Y = E_1(1-\delta^2) \quad &\Rightarrow \quad E_1 = \frac{X - \delta Y}{1-\delta^2}, \\
Z - \delta Y = E_3(1-\delta^2) \quad &\Rightarrow \quad E_3 = \frac{Z - \delta Y}{1-\delta^2}.
\end{aligned}$$

Plug this in the previous equations to get

$$X^2 = X - \frac{X - \delta Y}{1-\delta^2} + \delta^2 \frac{Z - \delta Y}{1-\delta^2} = \;\Rightarrow\; X^2(1-\delta^2) = (Z-X)\delta^2 + \delta(1-\delta^2)Y,$$
$$Z^2 = Z - \frac{Z - \delta Y}{1-\delta^2} + \delta^2 \frac{X - \delta Y}{1-\delta^2} \;\Rightarrow\; Z^2(1-\delta^2) = (X-Z)\delta^2 + \delta(1-\delta^2)Y.$$

Subtracting both equations yields $(X^2 - Z^2)(1-\delta^2) + 2(X-Z)\delta^2 = 0$. Hence, we conclude that $X = Z$ is the unique solution and $E_1 = E_3$. Moreover, if $E_i = 0$ for some $i = 1, 2, 3$, then all other aggregate effort levels are zero, which cannot be an equilibrium.

So, the FOCs revert to

$$2\delta^2 + 2\delta W = E_1 \left[1 + \delta^2 + 2\delta W\right]^2,$$
$$2\delta = E_1 \left[2\delta + 2W\right]^2,$$

where $W = E_2/(2E_1)$. Divide the first equation by the second to get

$$\delta + W = \left[\frac{1 + \delta^2 + 2\delta W}{2(\delta + W)}\right]^2 \quad \Leftrightarrow \quad 4(\delta+W)^3 = \left[1 + \delta^2 + 2\delta W\right]^2.$$

Define the function $Q(W,\delta) = 4(\delta+W)^3 - \left[1+\delta^2+2\delta W\right]^2$ and note that $Q(0,\delta) < 0$ and $Q(1,\delta) > 0$, for every $\delta \in (0,1]$. By the Intermediate Value Theorem, there exists a solution for $Q(W(\delta),\delta) = 0$. Note that

$$\begin{aligned} \frac{\partial Q}{\partial W} &= 12(\delta+W)^2 - 4W[1+\delta^2+2\delta W] \\ &\geq 12(\delta+W)^2 - 4(W+\delta)[1+\delta^2+2\delta W] = \frac{\partial Q}{\partial \delta}, \end{aligned}$$

and by substituting $[1+\delta^2+2\delta W] = 2(\delta+W)^{3/2}$ we get

$$\begin{aligned} \frac{\partial Q}{\partial \delta} &= 12(\delta+W)^2 - 4[1+\delta^2+2\delta W](\delta+W) \\ &= 12(\delta+W)^2 - 8(\delta+W)^{5/2} \\ &= 8(\delta+W)^2(1.5 - \sqrt{\delta+W}) > 0, \quad \forall (\delta, W) \in (0,1]^2. \end{aligned}$$

Hence, both partial derivatives are strictly positive, and the solution $W(\delta)$ to $Q(W,\delta) = 0$ is unique. By the Implicit Function Theorem, we get

$$\frac{\partial W(\delta)}{\partial \delta} = -\frac{\frac{\partial Q}{\partial \delta}}{\frac{\partial Q}{\partial W}} < 0,$$

implying that $W = \frac{E_2}{E_1+E_3}$ is decreasing w.r.t. δ in equilibrium. $\square$