On Conflict and Risk

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In memory of the fallen heroes
who have given their lives
to protect freedom and peace in Europe.

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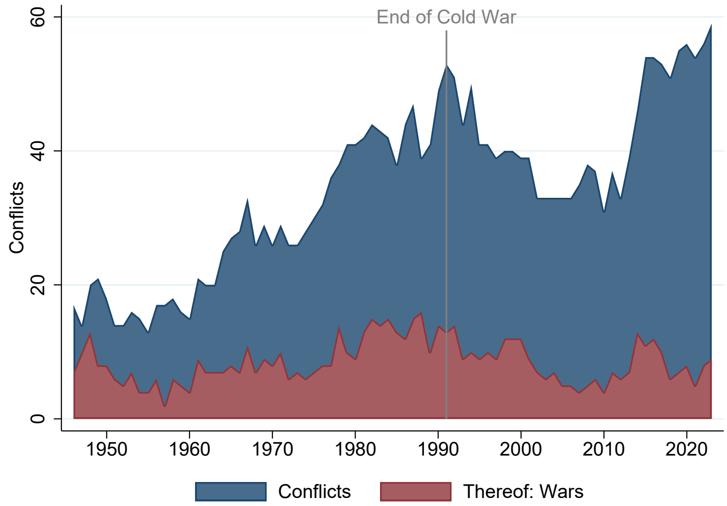
Preface

Human history has been a sequence of violence. Its worst century has just passed. The 20th century experienced a third of the 15 most deadly documented atrocities of history (Pinker, 2012). The horrors of the First and Second World War including the Holocaust, the famines and terror under Mao and Stalin, and the Russian Civil War are well documented and still seem so unimaginable. The bitter truth is: Even before this, humankind did not live a peaceful life either. Skeletons from archaeological sites around the world suggest that on average 15% of individuals in hunter-gatherer and tribal communities died through warfare (Pinker, 2012). This is five times more than during the war-torn 20th century. The expansion of nuclear stockpiles during the Cold War, however, marked an unprecedented point in human history. Embedded in a doctrine of mutually assured destruction, the competition between the Soviet Union and the United States had brought humanity to the brink of annihilation.

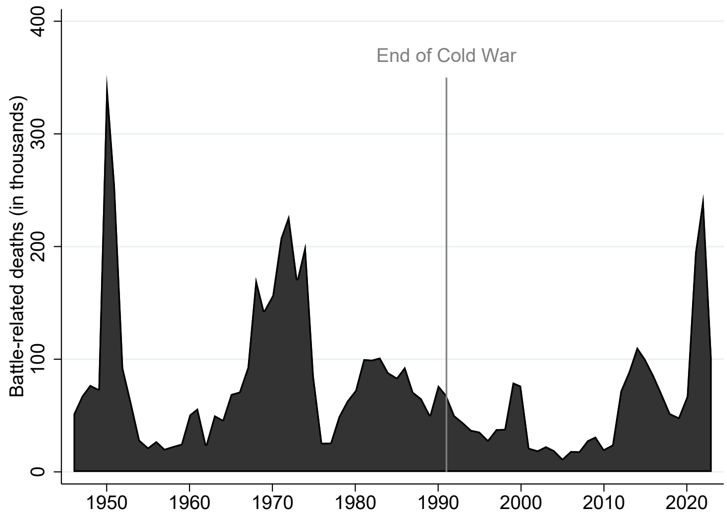
With the fall of the Iron Curtain in 1989 and the end of the Cold War in 1991, many contemporaries dreamed of a more peaceful future and some even of the 'end of history' (e.g., Fukuyama, 1989). The example of the Peaceful Revolution in East Germany in 1989 shows that there was reason for hope. The revolution led to the overthrow of the communist government, the withdrawal of Soviet troops, and German reunification - without any blood being spilled. More broadly, Figure 1a shows that the number of both state-based conflicts and wars declined after 1991 and remained at low levels for about twenty years. Battle-related deaths also decreased considerably. Conservative estimates suggest an average of 89,900 annual battle-related deaths during the Cold War, which dropped to 33,100 for the first twenty years after the end of the Cold War (see Figure 1b). During this relatively peaceful period, many countries reduced the size of their armed forces and collected a substantial peace dividend (Dorn et al., 2022, 2024). Beginning in 2013, however, the number of wars and battle-related deaths returned to levels observed during the Cold War. The most deadly conflicts were the Syrian and Yemeni civil wars, the rise of the Islamic State, the Taliban insurgency, and the Second Nagorno-Karabakh War.

Figure 1: DEVELOPMENT OF STATE-BASED CONFLICTS FROM 1946 TO 2023

(a) Number of conflicts



(b) Battle-related deaths

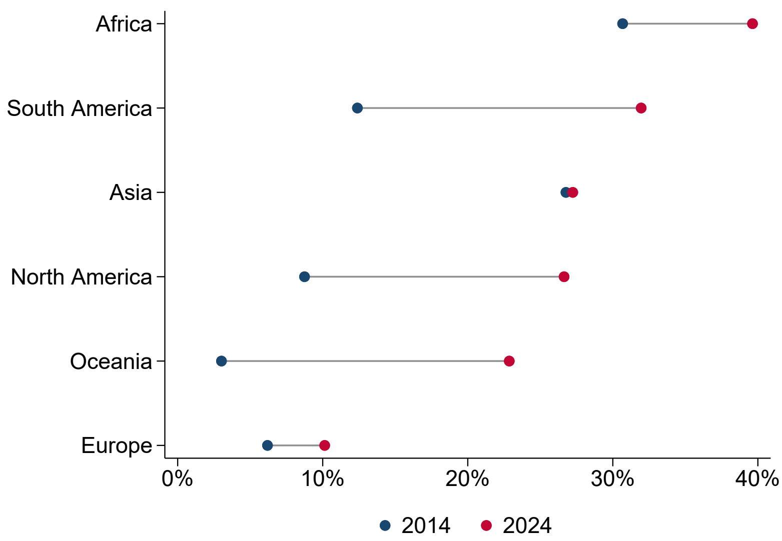


Notes: This figure shows the development of state-based conflicts and related fatalities between 1946 and 2023. The vertical line marks the end of the Cold War in 1991. Panel (a) shows the number of conflicts which meet the definition of at least 25 battle-related deaths per year. Red shows the share of these conflicts which meet the definition of war, i.e. 1,000 battle-related deaths per year. Panel (b) shows the total number of battle-related deaths. Battle-related deaths refer to both civilian and military deaths arising from combat, e.g. through fighting on the battlefield, guerrilla activities, or bombardments of military bases and cities. The overall number of lives lost due to war is much higher. The data is from the Uppsala Conflict Data Program (Davies et al., 2024). It is enriched with data on battle-related deaths between 1946 and 1988 from the Battle Deaths Dataset (Gleditsch et al., 2002). To allow for comparability, we employ the low estimate of battle-related deaths from both datasets.

In 2021, the globe experienced another acceleration in its move towards violence, war, and deaths (Rustad, 2024). In total, more than half a million battle-related deaths have been recorded in just the last three years. In fact, 2022 has been among the three most violent years since the end of the Second World War (WWII). The four wars driving the heavy death toll have been fought in countries dispersed over three continents - namely: in Ethiopia, Israel, Ukraine, and Yemen. The recent increase in conflict also casts its shadow ahead. Mueller et al. (2024) have developed a global measure of conflict risk over the next twelve months. Figure 2 shows that in summer 2024 five out of six continents face a substantially increased conflict risk compared to just a decade earlier. The average likelihood for a country to be involved in conflict over the next twelve months is estimated to be higher than 1:4 for five continents. Even though Europe is still facing a relatively low conflict risk, it has nearly doubled during the last decade. While ex-post many countries will be spared from conflict, ex-ante they are subject to a level of conflict risk which they have not experienced in recent years.

This thesis sets out to understand the economic costs arising from a world of insecurity. In Chapter 3, we will return to the era of the Cold War when a Third World War being fought on German territory was a realistic scenario. In this context, we will exploit a geographic discontinuity in war risk to capture its economic costs. We show that war risk distorts economic outcomes. While this single-authored chapter

Figure 2: RISE OF AVERAGE CONFLICT RISK ACROSS CONTINENTS



Notes: This figure shows the change of the average value of conflict risk over the next twelve months by continent from August 2014 to August 2024. It is based on the 175 countries covered in the monthly dataset provided by Mueller et al. (2024). They define conflict as an outbreak of violence that exceeds 0.5 fatalities per 1 million inhabitants of a country in a given month.

forms the core of the thesis, the remaining three chapters address questions of conflict and risk more broadly and, hence, widen the thesis' scope. In Chapter 1, we look at risk in the context of a political leadership selection. We theoretically derive and empirically show that politicians facing tough re-elections prefer more risky leadership candidates. They are even willing to trade off quality for risk. Chapter 2 remains centred on contemporary politics and focuses on elections as a peaceful mechanism to aggregate preferences over conflicting policy proposals. Employing an exogenous economic shock, we show that election precincts suffering higher income losses express stronger support for economically liberal policies and parties. Finally, in Chapter 4 we focus on reparations as a key element of post-conflict settlement. Assembling a new database on foreign investigations at German firms after WWII, we provide the first systematic and quantitative evidence on the large 'intellectual reparations' program conducted by the United Kingdom and the United States.

Chapter Preview

Chapter 1: Gambling for Re-election

There is a well-established intuition that risk-neutral agents sometimes behave as if they were risk-seeking when they do not bear all of the costs of a bad outcome. This behaviour is called 'gambling for resurrection' and has been documented in a wide range of settings. We show that gambling style behaviour is important in politics. Politicians 'gamble for re-election' in the context of a political leader selection. To overcome challenges arising from secret ballots, we exploit unique access to leaked information on individual decisions in a de facto vote for the 2021 leadership election of Germany's centre-right parties. We find that members of parliament are more likely to vote for a riskier candidate when faced with tougher re-election races in their constituency. Quantitatively, a 10 pp. decrease in the probability of being re-elected is associated with a 2.9 pp. increase in the likelihood to vote for the riskier candidate. These results match the predictions derived from our model of rational risk-taking. Gambling for re-election provides a new explanation for intra-party dissent and rationalises why parties may choose low-quality leaders. These findings contribute to three strands of literature covering gambling style behaviour, risk-taking in politics, and political selection.

Chapter 2: Economic Voting in Electoral Precincts

An extensive literature that spans several decades has found the state of the economy to be an incredibly robust predictor of electoral outcomes. A fundamental question is whether these correlations reflect causal links. We explore economic voting at the precinct-level, the most fine-grained administrative layer in elections. By unravelling the substantial variation in voting behaviour and in economic circumstances which exist in larger geographies, we can exploit the spatially heterogeneous shock caused by the Covid-19 pandemic in a shift-share setting. Linking a series of novel geospatial data collections to our granular cartography of electoral precincts, we explore how changes in income impact voting behaviour. We find that greater income loss at the precinct-level re-allocates votes from progressive to market-oriented parties. We estimate that the income loss caused by a one-standard-deviation decrease in the shift-share instrument increases the vote share of right-wing parties by 0.31 pp. between 2017 and 2021. Our findings connect to the extensive literature on economic voting and to the literature on the electoral effects of economic shocks. While recent studies suggest that parties are increasingly competing along socio-cultural lines, our estimates show that when facing a substantial income loss, economic voting re-emerges as a clear empirical pattern.

Chapter 3: Conflict's Spatial Echo

Growing geopolitical tension is exposing countries to an increasing risk of war. Economic theory suggests that rational agents adjust their behaviour when the probability of war rises. However, evidence on this is lacking as it remains an empirical challenge to disentangle the effects of war risk from the ones of war itself. We are the first to show that the mere risk of war (without any war happening) can lead to large distortions in economic outcomes. Using declassified information on a NATO defence line from the Cold War against a Warsaw Pact invasion, we exploit a geographic discontinuity in war risk within West Germany. While the area west of the defence line was treated with increased security, the area east of the defence line faced a higher risk of serving as a battlefield or being occupied by Warsaw Pact troops. Using a geographical regression discontinuity design, we provide causal evidence that the discontinuity in war risk has long-lasting effects on economic development. Monthly median income in 2019 is 155 Euro (4.2%) higher in municipality groups located west of the former NATO defence line. Our findings contribute firstly to the literature on the economic effects of insecurity and secondly to the literature on the long-run spatial effects of battle and occupation lines. The novelty of our approach is that we capture the isolated effects of war risk.

Chapter 4: Intellectual Reparations

During the Cold War, the United States and the Soviet Union competed for global leadership in military and industrial technology. Access to German science and technological know-how became a key tool in this race. Between 1945 and 1947, British and U.S. investigators visited firms and production sites across Germany to gather technological expertise that could benefit their private industries. One Washington official has called this 'the first orderly exploitation of an entire country's brainpower' (Walker, 1946, p.329). Based on a hand-collected dataset comprising close to all investigations of German firms, we provide the first systematic and quantitative analysis of this unprecedented program of 'intellectual reparations'. We contribute to a broad literature on industrial policy in post-war settings by studying intellectual reparations. In addition, we contribute to the literature on international technology diffusion by building a dataset that allows us to link the investigating U.S. firms and the investigated German firms, thus observing knowledge transfers directly.

Chapter 1

Gambling for Re-election

This chapter presents co-authored work with Alastair Langtry, Niklas Potrafke, and Timo Wochner (see Langtry et al., 2024). We would like to thank Toke Aidt, Elliot Ash, Daniel Bischof, Antoine Ferey, Jon Fiva, Klaus Gründler, Emanuel Hansen, Jakob Miethe, Massimo Morelli, Julieta Peveri, Panu Poutvaara, Helmut Rainer, Stephan Schneider, Janne Tukiainen, Taylor Watson, Kaspar Wüthrich, and participants of the Silvaplana Political Economy Workshop 2022, the 2022 Annual Congress of the International Institute of Public Finance (IIPF) in Linz, the 16th CESifo Workshop on Political Economy in 2022 in Dresden, the 6th Political Economy of Democracy and Dictatorship conference (PEDD) in Münster, the 2023 European Political Science Association (EPSA) meeting in Glasgow, the 2023 Verein for Socialpolitik (VfS) conference in Regensburg, the 2024 European Public Choice Society in Vienna, and seminars at the University of Cambridge, the BI Norwegian Business School, the ifo Institute, and the LMU Munich for excellent comments.

1.1 Introduction

Very few real-world decisions are risk-free. Huge bodies of work have been devoted to better understand how people respond to risk. Within this, there is a well-established intuition that risk-neutral agents sometimes behave as if they are risk-seeking when they do not bear all of the costs of a bad outcome. This behaviour is called 'gambling for resurrection', and has been documented in a wide range of settings. But there is a distinct lack of empirical evidence as to whether this intuition holds for political decision-making. Political decisions are high-stakes and risky, the outcomes are often judged discretely - as success or failure, victory or defeat - and have enormous welfare implications.

We provide novel empirical evidence that gambling-style behaviour is present in one of the most important political decisions: choosing political leaders. We do so in the context of the 2021 leadership election by the German centre-right parties. Specifically, we show that members of parliament (MPs) gamble for re-election. That is, MPs are more likely to vote for the risky leadership candidate when facing a lower chance of re-election.

Providing direct evidence of risk-taking behaviour in politics has proved difficult. When politicians' decisions are observable, analysis can be muddied by strong signalling motives - where politicians make decisions to send a signal to the public rather than make decisions in line with what they would do in private. It is theoretically well established that observability of decisions changes individuals' behaviour (Levy, 2007; Mattozzi and Nakaguma, 2023) - a finding that has also been empirically documented for important decision-makers (see, e.g., the evidence on Federal Open Market Committee members (Meade and Stasavage, 2008; Swank et al., 2008; Hansen et al., 2018)). Signalling motives and audience costs can therefore obscure the actual preferences of MPs when decisions are observed by voters. When decisions are not observed ('secret ballots'), data availability issues typically prevent empirical analysis.

Unique access to a leak of internal party voting data from the 2021 leadership election held by Germany's centre-right parties allows us to overcome these difficulties. We can therefore take a rare peek behind the curtain of the secret ballot and study MPs' individual behaviour in leadership elections for the first time. While the process of the German centre-right parties choosing their leader does not include a formal vote, in this particular instance, signing a letter supporting one of the two candidates became a *de facto* vote. The existence of this letter became known to the public when it was leaked to a leading German newspaper. But even now, the identities of the signatories are not publicly known. Our empirical analysis is only possible because we have access to the identities of the signatories.

Our main finding is that MPs who (at the time of the leadership election) were predicted as *less* likely to win re-election in the upcoming German national elections were *more* likely to vote for the riskier leadership candidate. This relationship remains robust across a range of empirical specifications and to the inclusion of a wide battery of control variables on MP- and constituency-level as well as state fixed effects. The effect is sizeable: when MPs were 10 percentage points *less* likely to be re-elected, they were 2.9 percentage points *more* likely to vote for the riskier candidate. Notably, we only find this behaviour among MPs who are running for re-election. We are the first to document evidence of this type of risk-taking behaviour in intra-party selections, and in political decision-making more generally.

Our second finding is that ideological alignment with leadership candidates only influences MPs' decisions when they are *not* running for re-election. For MPs seeking re-election, ideological alignment does not play an important role. This is consistent with MPs being primarily - but not solely - re-election motivated.

The link between MPs' re-election prospects in national elections and their choices in the leadership election is in line with our model of rational risk-taking. Our model is a variant of the classic 'gambling for resurrection' models, adapted to the setting of political leader selection. In the model, there are two elections. First, MPs in one party elect a party leader. Second, voters elect MPs in national elections - and the quality of the party leader affects voters' preferences. MPs care about their leader's ideology and about their own re-election in upcoming national elections. Importantly, there is some uncertainty over a potential party leader's quality in the first election that has been resolved by the time of the second election. Voters have more information about the party leader's quality in the second election than MPs did in the first. Specifically, when there is a benefit to being re-elected regardless of the margin of loss/victory, the incentive structure implies that some MPs 'gamble for re-election'. MPs want to choose a higher risk option when their re-election prospects are poor, because there is a discontinuous jump in their payoff at the threshold of winning re-election. Politicians' behaviour is therefore equivalent to 'gambling for resurrection' by managers of firms, an idea first suggested by Jensen and Meckling (1976).

We take several steps to examine the scope for potential confounding. First, we show that our results are not sensitive to a particular specification of the regression model and survive a range of robustness tests. Second, we show that any selection on unobservables relative to selection on observables would have to be substantial to cancel out our results.

Third, we discuss some alternative stories that would generate similar empirical patterns, but would not reflect a causal effect running from MPs' electability to their choices in a leadership election. To address these possible endogeneity concerns, we conduct two empirical exercises. First, we re-estimate our empirical model using, as an alternative proxy for electability, MPs' pre-determined vote margins in the 2017 national elections as the main independent variable. We obtain qualitatively identical results: MPs with lower vote margins in the previous election were more likely to support the risky candidate. Second, we demonstrate that our results are robust to controlling for voters' preferences over leadership candidates, providing evidence that MPs are mostly influenced by their re-election probabilities rather than merely following their constituents' preferences.

Finally, we address any remaining endogeneity concerns via an established instrumental variables approach. Our instrument is based on CDU *party* vote shares in the 1990 national elections. In the same spirit as Svaleryd and Vlachos (2009) and Solé-Ollé and Viladecans-Marsal (2012), our instrument therefore leverages variation in local electoral competition arising from the persistence in voters' party preferences that is not tied to considerations about individual MPs. Changes in the constituency structure between 1990 and 2021 further reinforce this argument. The instrumental variable results strongly corroborate our OLS results and provide evidence for a causal interpretation of our results.

Our results have two important implications. First, MPs may be willing to choose the worse (in expected value terms) leadership candidate because they are willing to trade off expected quality against riskiness. This is akin to the 'asset substitution problem' in Corporate Finance, but with more severe consequences: even MPs who face good re-election prospects would be willing to choose the worse candidate if that candidate is less risky. This offers a complementary explanation to Carrillo and Mariotti (2001) and Mattozzi and Merlo (2015) as to why political parties sometimes choose mediocre candidates - despite the availability of better ones.

Second, our findings also shed light on how intra-party polarisation can emerge endogenously due to the incentives faced by individual MPs. In contrast, previous explanations are based on the idea that parties benefit from implementing competitive selection processes that involve *some* degree of intra-party polarisation. This is because competition can serve as a signal for the quality of the party platform and boosts candidates' incentives to provide individual effort (Caillaud and Tirole, 2002; Crutzen et al., 2010; Crutzen et al., 2020). Our results therefore suggest a new mechanism that can generate within-party disagreements.

Related literature. Our paper's core contribution is to provide novel empirical evidence of risk-taking behaviour by politicians. We show this in the important setting of a political leadership selection. As such, this paper relates to three strands of literature.

First, there is a vast literature on gambling style behaviour that follows Jensen and Meckling (1976). This behaviour has been shown to be important in a wide range of contexts, including banking, conflict, and government finance, among others.[1] We provide novel evidence within the realm of political decision-making.

Second, there is a literature on risk-taking in politics, both by politicians and by voters. Within this, Panunzi et al. (2024) and Bernecker et al. (2021) are closest in spirit to our paper. Panunzi et al. (2024) find that, when voters have reference-dependent preferences, those currently experiencing outcomes below their reference point can prefer riskier political parties/policies. This is due to the convexity of preferences below the reference point. They also provide survey evidence in support of this mechanism. In contrast, our paper presents evidence about the behaviour of professional politicians (rather than of voters). Furthermore, our mechanism does not rely on non-standard preferences. Rather, it stems from the inherent win-or-lose nature of elections.

Perhaps closer to our focus, Bernecker et al. (2021) find that US state governors with stronger electoral support are less likely to experiment with (risky) welfare reforms. This is similar in spirit to our headline finding that MPs with strong re-election chances opt for a lower risk leader. Beyond focusing on a different decision, we also have a setting where choices were not meant to be observable, and so decisions are likely freer from signalling motives.

The remainder of this literature is theoretical and largely focused on policy experimentation. Within it, one part considers the role of risk-preferences directly (Rose-Ackerman, 1980, 1991; Buisseret and Van Weelden, 2022), and the other part considers how experimentation allows learning about the efficacy of policies (Majumdar and Mukand, 2004; Callander, 2011; Callander and Harstad, 2015; Grunewald et al., 2020).

Finally, we add to the literature on political selection. The larger part of this strand focuses on how intra-party factors, such as internal resource allocation, ideological cohesion, or nomination systems, influence political selection (Cirone et al., 2021;

[1] See, for example, White (1989), Downs and Rocke (1994), Hellmann et al. (2000), Carrillo and Mariotti (2001), Majumdar and Mukand (2004), Albornoz and Hauk (2014), and Ben-David et al. (2019).

Hansen, 2022; Fiva et al., 2024; Matakos et al., 2024). Less work is dedicated to the selection of political leaders. Within this, existing work has mostly focused on innate characteristics of candidates (O'Brien, 2015; Jeffery et al., 2018; Yu and Jong-A-Pin, 2020), and on how parties create rules for selecting leaders (Kemahlioglu et al., 2009; Snyder and Ting, 2011). We examine a novel dimension: the role of risk. We show that risk is an important factor for political selection.

Furthermore, we are the first to present direct evidence on decision-making in political selections based on the actual voting behaviour of MPs. This is typically either prevented by 'candidate selection being a highly secretive procedure' (Besley, 2005, p.56), involving secret ballots and decisions behind closed doors, or by the signalling motives that accompany publicly observable votes. Our unique data and setting are able to overcome these constraints by allowing us to observe MPs' decisions despite the secret ballot.

Organisation. The remainder of this paper is organised as follows. Section 1.2 sets out our theoretical model and establishes key predictions. We describe our data and the setting of our empirical case in Section 1.3. Section 1.4 describes our empirical strategy and Section 1.5 presents the empirical results. Section 1.6 concludes.

1.2 Theory

1.2.1 Model

Agents. There are three types of agents: a unit mass of voters, indexed j, finitely many members of parliament (MPs), $m \in M = \{1, ..., \mathcal{M}\}$, and two leadership candidates, $\ell \in \{1, 2\}$. There is one MP per constituency (also indexed m), and each voter j is assigned to exactly one constituency.

Elections and strategies. There are two elections that happen sequentially. In the first, all MPs from party X vote for a leadership candidate. In the second, each MP $m \in M$ stands for election in a single constituency, and each voter j votes in her constituency. For clarity, we call the first (intra-party) *leadership election* and the second *national elections*. Abstentions are not allowed, and elections are by majority rule. For simplicity, we assume the national elections involve only two parties, the MPs' own party, X, and some other party, Y.

Each MP from party X can vote for leadership candidate 1 or 2. So strategies for MPs are $s_m \in \{1, 2\}$ for all m. Similarly, each voter can vote for party X or for party Y. So strategies for voters are $s_j \in \{X, Y\}$. We assume that agents naively vote for their most preferred choice in both leadership and national elections. This assumes that they never play a weakly dominated strategy.

Endowments and information. Each MP is endowed with an *electability*, $Q_m \in \mathbb{R}$, and each leadership candidate is endowed with an electability, $Q_\ell+\nu_\ell$, where $Q_\ell \in \mathbb{R}$ and ν_ℓ is a random draw from a uniform distribution on $[-\frac{1}{2}\lambda_\ell, \frac{1}{2}\lambda_\ell]$ with the Cumulative Distribution Function (CDF) denoted $F_\ell(\cdot)$.[2] For convenience, let $\lambda_1 = \lambda > 0$ and $\lambda_2 = \lambda + \phi$, and assume that $\phi > 0$. This assumes that candidate 2 is riskier in the sense that her eventual electability is more variable.[3] All of Q_m, Q_ℓ, and the uniform structure (λ and ϕ) are common knowledge, but ν_ℓ is only known by voters at the time of the national elections - *not* by MPs when electing a leader.

Each voter j is endowed with a preference for party X, ϵ_j, which is a random draw from a symmetric, mean zero distribution with CDF $G(\cdot)$. The CDF is common knowledge, but the value of ϵ_j is known only to voter j.

Preferences. Voter j in constituency m receives the following utility if the MP from party X wins:

$$u_j = Q_m + Q_\ell + \nu_\ell + \epsilon_j, \tag{1.1}$$

and we normalise her utility from party Y's MP winning to zero. Notice that we do not specify voters' preferences over election outcomes in other constituencies. This is because they can only vote in their own constituency.

MPs care about their own re-election and the ideology of their leader. Both of these are specific to the individual MP. For convenience, we assume the payoff from re-election does not depend on the identity of the leader. This gives preferences for MP m as:

$$u_m(\ell) = I_{\ell,m} + R_m \cdot Pr(\text{win}|m, \ell), \quad \text{for } \ell \in \{1, 2\}, \tag{1.2}$$

[2] This uniform distribution assumption is standard in probabilistic voting models. See, for example, Grossman and Helpman (1996) or Persson and Tabellini (1999).

[3] We rule out the less interesting case where both candidates are equally risky, but it is otherwise without loss.

where $I_{\ell,m}$ is the MP's ideological alignment with leadership candidate ℓ, $R_m \geq 0$ is the MP's re-election motivation, and $Pr(\text{win}|m, \ell)$ is the probability that she is elected given ℓ is the leader.

Interpreting parameters. The variable Q_m captures how 'electable' MP m is in her constituency. This covers a wide range of factors that affect the MP's popularity with voters from her constituency, for example; charisma, competence, name recognition, or ability to secure government spending for the constituency. Note that Q_m is specific to an MP-constituency pair, and so reflects how well matched the individual MP is to a particular constituency. Similarly, Q_ℓ and ν_ℓ capture how 'electable' leadership candidate ℓ is.[4] This could include the popularity of her policy platform, perceived competence, charisma, ability to raise campaign funds, etc.

What separates Q_ℓ and ν_ℓ is what is known at the time of the leadership election. Q_ℓ captures factors already known before the leadership election, and ν_ℓ captures things that happen or are learned between the leadership election and the national elections. For example, corrupt business dealings, extramarital affairs, or good crisis management may only come to light with greater scrutiny following the leadership election.

The λ_ℓ's capture how uncertain MPs are about candidate ℓ's 'true' electability at the time of the leadership election. A natural expectation is that an incumbent candidate (if there is one) will be lower risk, as she has already been subject to greater scrutiny by MPs, the media and the voting public. An incumbent will also have shown how well she manages activities at the core of an election campaign, such as speaking in public, interacting with voters, and presenting policy proposals. MPs have had more opportunities to learn about an incumbent's quality, reducing uncertainty.

The leader's electability appears in voters' preferences for two reasons. First, the leader may improve an MP's re-election campaign in the constituency, for example through a popularity spill-over or raising campaign funding. Then, $Q_\ell + \nu_\ell$ captures a popularity component which arises from the leader's campaign and benefits or harms all MPs from party X similarly. Second, voters may care directly about the leader of party X becoming head of government. Casting their vote, they take into account that voting for an MP from party X makes it more likely for its leader to become head of government. Here, $Q_\ell + \nu_\ell$ can be interpreted as the utility voters receive from the leader's policy platform, perceived competence or character attributes.

[4] Our assumptions restrict these to factors that affect all constituencies equally. We could relax this, but doing so would make the model less clean without affecting the insights.

Applicability. While we will test this model in the context of a specific leadership election among Germany's centre-right parties, the theory applies to majoritarian voting, closed and open lists, and mixed systems alike. In fact, the key mechanism applies far more widely. Gambling-style behaviour in politics may arise whenever politicians (1) choose between risky options and (2) care about the outcome being on one side of a threshold. This is the same as in the wider gambling-style literature that follows Jensen and Meckling (1976). Other political contexts where this will apply include, for example, choosing party manifestos, allocating public funds for research or voting on legislation.

Extension: Party list elections. In the model, voters elect a single MP for each constituency. But, in practice, German voters also cast a second vote - choosing a party at the national level. This second vote elects additional MPs from party lists. In the Appendix, we extend our model to include party list elections and to also allow voters to make different choices for their first and second vote. We show that adding these features does not affect qualitative behaviour (see Appendix 1.D).

1.2.2 Equilibrium and Theoretical Predictions

From their own point of view, voters' decisions are deterministic. Voter j votes for MP m from party X if and only if $u_j > 0$.[5] Whether an MP wins or loses in the national elections depends on the *median* voter in her constituency - who has $\epsilon_j = 0$ by construction.[6] So if ν_ℓ was known, then re-election would also be deterministic. But an MP does *not* observe ν_ℓ at the time she chooses her leader. So her *perceived* probability of winning is $F_\ell(Q_m + Q_\ell)$. This is the relevant probability when she is deciding which leadership candidate to support. An MP votes for leadership candidate 2 if and only if $u_m(2) - u_m(1) > 0$. Together these conditions characterise the equilibrium.

Proposition 1. *There exists a unique equilibrium where:*
(1) $s_j^* = X$ *if and only if* $u_j > 0$*, for all* j*,*
(2) $s_m^* = 2$ *if and only if* $F_2(Q_m + Q_2) - F_1(Q_m + Q_1) > \frac{1}{R_m}(I_{1,m} - I_{2,m})$.

[5] We assume that voter j votes for party Y when indifferent, but this is clearly not an important restriction.

[6] With infinitely many voters each taking random draws from a symmetric and mean-zero distribution, the median voter will have a value of ϵ arbitrarily close to zero.

Using the structure provided by the uniform distribution assumption,[7] we can express the condition for the MPs' choices as follows:

$$s_m^* = 2 \quad \Longleftrightarrow \quad \frac{1}{\lambda+\phi}Q_2 - \frac{1}{\lambda}Q_1 - \frac{\phi}{\lambda}\cdot\frac{1}{\lambda+\phi}Q_m > \frac{1}{R_m}(I_{1,m} - I_{2,m}). \tag{1.3}$$

Equation (1.3) shows that each MP has a threshold for voting for candidate 2 in terms of their *own* electability, Q_m. Note, however, that the threshold is specific to a given MP because both the ideological alignment with each leadership candidate and the strength of the re-election motivation differ across MPs. A simple, yet important, implication is that some MPs will support candidate 2, while others will support candidate 1.

The threshold condition illustrates the impact that a candidate's electability has on MPs' decisions: more MPs will vote for candidate ℓ if she becomes more electable (we mean 'more' in the set inclusion sense). This follows directly from Equation (1.3). In contrast, comparative statics regarding MPs' *own* electability are more nuanced.

Proposition 2. *Suppose that re-election is possible but not guaranteed under either candidate. When MPs become more electable (i.e. Q_m rises for some m), fewer MPs vote for the riskier candidate (candidate 2).*

This prediction is similar in spirit to corporate finance models of 'gambling for resurrection'. Within the confines of our model, MPs care about whether or not they win re-election, but not the vote share conditional on winning. So more variable, but symmetrically distributed, outcomes are good for an MP if she needs a sufficiently large positive shock (i.e. positive realisation of ν_ℓ) to win, but bad if she only needs 'not too large a negative shock' to win. In other words, an MP facing a tough re-election campaign finds higher risk attractive, but one in a commanding position prefers a less risky leadership candidate.

Were there no other differences in the two candidates (i.e. they were equally electable in expectation, $Q_1 = Q_2$, and equally ideologically appealing, $I_{1,m} = I_{2,m}$) then the switching point between preferring more vs less risk would happen exactly at the point where the MP's probability of re-election is 50 percent. When there are other differences between the two leadership candidates, then the switching point for an MP is less clean. But the core intuition remains unchanged. There is a threshold

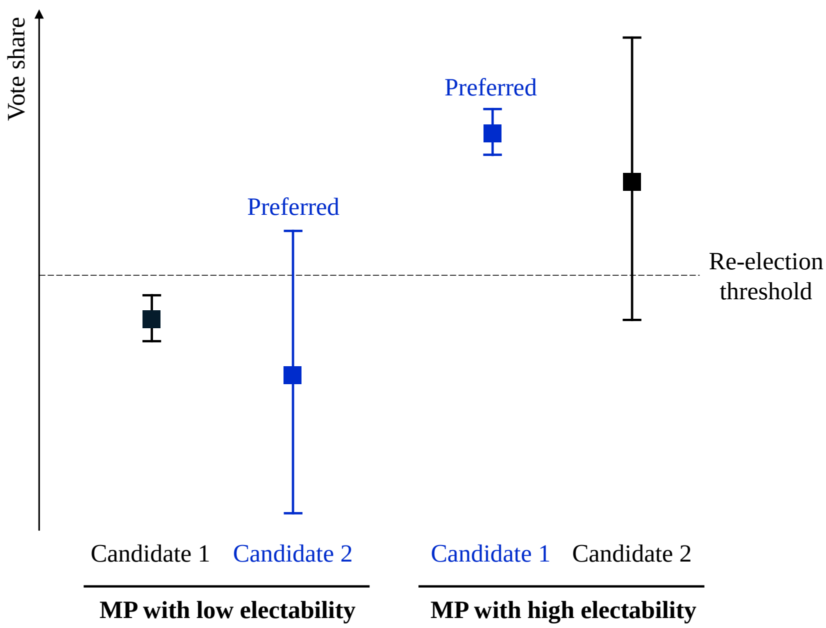
[7] The equation in Proposition 1(2) does not rely on the uniform distribution of ν_ℓ. It only requires symmetry and zero mean. But subsequent analysis is much cleaner with this uniform distribution assumption.

on her re-election probability: below the threshold she prefers the riskier candidate, and above the threshold she prefers the safer candidate.

An implication of Proposition 2 is that even though MPs are risk neutral, they are willing to trade off electability against riskiness. Importantly, the way MPs value risk depends on their own electability (and hence their probability of re-election). All else equal, MPs who have low electability prefer the riskier candidate, while MPs with high electability prefer the 'safer' candidate.

This implies that MPs with low electability may prefer the riskier candidate even when she is *worse* in terms of having lower expected electability than the less risky candidate. This is because MPs with low electability need a sufficiently large positive draw of ν_ℓ in order to win re-election - and a riskier candidate is by definition more likely to deliver this. The fact that a riskier candidate is also more likely to deliver a large negative draw does not matter to these MPs - as they lose with *any* negative draw, regardless of its size. Figure 1.1 shows this intuition graphically.

Figure 1.1: GAMBLING FOR RE-ELECTION BEHAVIOUR BY LOW ELECTABILITY MPS



Notes: This figure illustrates the range of potential vote shares under two leadership candidates for two MPs. The MP on the left has a lower re-election probability Q_m than the MP on the right. The leadership candidates differ both in electability and riskiness. A higher electability is illustrated by the solid square being further to the top and a higher riskiness is illustrated by a larger distance between the solid square and the whiskers. Here, candidate 1 is more electable ($Q_1 > Q_2$) and less risky ($\lambda_1 < \lambda_2$) than candidate 2. The MP with low electability gambles for re-election by choosing candidate 2 who compensates the lower electability with a high riskiness. The case where candidate 1 is less electable and less risky is shown in Appendix Figure 1.B.1.

The same gambling for re-election behaviour is possible for high electability MPs, but these MPs would prefer the *safer* candidate - even when that safer candidate is worse (see Appendix Figure 1.B.1).

We next consider the impact of MPs' ideological alignment with the leadership candidates. Intuitively, the result is very straightforward - MPs like to be ideologically aligned with a candidate, and so will be more inclined to vote for a candidate with whom they are more closely aligned.

Proposition 3. *If MPs become more ideologically aligned to candidate ℓ (i.e. $I_{\ell,m}$ rises for some m), more MPs vote for her.*

The intuition that politicians care about ideology is well established within political science. Closely related, the strength of re-election motives affects how much MPs care about ideology.

Proposition 4. *Suppose that some MPs $M' \subset M$ are more ideologically aligned with candidate ℓ. When these MPs care less about re-election (i.e. R_m falls for some $m \in M'$), weakly more MPs vote for candidate ℓ.*

If an MP is more ideologically aligned with candidate 2 (i.e. $I_{2,m} - I_{1,m} > 0$), then she becomes *more* inclined to vote for candidate 2, when she cares *less* about her own re-election (i.e. R_m rises). The intuition is straightforward: weaker re-election motivation makes the ideological differences between the candidates more important. So MPs who were not voting for candidate 2 due to being focused on re-election may switch to candidate 2 because the ideological preferences become relatively more important. The same holds symmetrically for candidate 1. In the most extreme scenario, an MP who has no re-election motivation at all (R_m=0) would only make a decision based on ideological alignment.

Propositions 2, 3, and 4 present the three key theoretical predictions that we take to the data: (#1) MPs are more inclined to vote for the riskier candidate when they face a lower probability of being re-elected in the national elections, (#2) MPs are more inclined to vote for the candidate with whom they are more ideologically aligned, and (#3) ideological alignment matters more when MPs are *not* motivated by re-election.

1.3 Institutional Background and Data

1.3.1 Setting

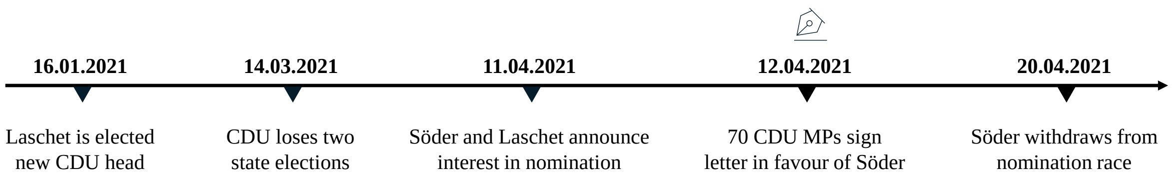
Our empirical setting is the April 2021 leadership election of the German centre-right sister parties. Angela Merkel's decision to step down as Chancellor required the formally independent parties Christian Democratic Union (CDU) and Christian Social Union (CSU) to select a joint Chancellor candidate.[8] Contested by Armin Laschet, Chairman of CDU, and Markus Söder, Chairman of CSU, the leadership election was held in the run-up to German national elections scheduled for 26 September 2021.

Four institutional details are important. First, the leadership election was not for a party leader. The elected candidate would become the German Chancellor (head of government) if CDU/CSU won the upcoming national elections.

Second, there is no predefined process for the leadership election between CDU and CSU.[9] But we are able to capture a crucial aspect of the decision-making process that acted as a *de facto* vote. Once both party chairmen had announced their interest in the chancellor candidacy, the CDU board unanimously backed its Chairman Armin Laschet. However, on 12 April 2021 (the day before a crucial party meeting), 70 out of 200 CDU MPs had signed an internal letter opposing their own party board. This was seen as an expression of support for a chancellor candidacy of the CSU candidate, Markus Söder (see, e.g., The Guardian, 2021; The Pioneer, 2021).

Figure 1.2 shows a timeline of the key events, and demonstrates the third important institutional feature: the CDU MPs had to decide whether to sign the letter within a very short time-frame, likely constraining any scope for coordination.

Figure 1.2: TIMELINE OF KEY EVENTS



[8]The CDU and CSU are legally two separate political parties with independent members, decision bodies, and chairmen. However, the parties do not compete in elections as the CSU only runs in the state of Bavaria, while the CDU runs outside of Bavaria. During the national election campaign, both parties unite behind one candidate for chancellor. Their MPs form a joint faction in the German parliament. Hence the two parties de facto operate as a single parliamentary party.

[9]The two previous occasions that required a leadership election took place in 1980 and 2002. Such long intervals prevented the establishment of a formal process.

The final institutional detail is that decisions taken by individual MPs were not observable. The letter was confidential. While it was leaked to the German newspaper FAZ, which reported on the existence of the letter, the identities of the signatories were *never* made public. We were able to obtain the identities directly from the FAZ; a critical step that allows analysis of this leadership election. The confidentiality is important for our analysis. As MPs made their choices unobserved, their vote only impacts the outcome of the contest, and does not serve as a signal to voters.

The letter played a key role. It allowed MPs both to enter the parties' selection process and to express their preferences over the two leadership candidates. Hence, we interpret an MP's decision of whether or not to sign the letter as a *de facto* vote.

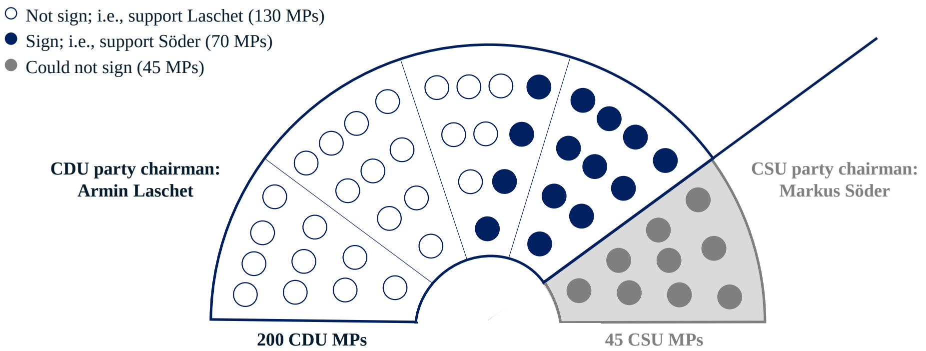
Media outlets conjectured that the signatories were afraid of an impending defeat in their constituency and hoped for an improvement in electoral support following the nomination of Markus Söder (FAZ, 2021). As Chairman of the larger party, Armin Laschet had generally been considered the natural Chancellor candidate (BBC, 2021). His position as a quasi-incumbent was weakened because, prior to the leadership election, the CDU had just lost two state elections and performed six percentage points below the 2017 national election result in opinion polls.

Equipped with stronger approval ratings, Markus Söder provided a viable alternative (InfratestDimap, 2021). However, selecting Söder as the joint Chancellor candidate was associated with higher risk - as is usual for a challenger (see, e.g., Panunzi et al., 2024). First, while Markus Söder was polling well in March 2021, the two previous CSU candidates had lost national elections despite initially favourable polls. Second, betraying their own Chairman and selecting a Chancellor candidate from the smaller sister party would have pushed the CDU into deep turmoil, with just a few months to the national elections. This argument demonstrates that voting for the challenger *per se* was a risky gamble as MPs went against their party board - potentially facing political repercussions. Third, the CSU Chairman had a reputation for being a 'political shape-shifter' whose political platform was unpredictable due to frequent flip-flopping (Financial Times, 2021).

A quote by the German newspaper Die Zeit (2021) captures well how the risk component from our theoretical model fits Söder's position in our empirical setting: '*Söder, the favorite in all the polls, who is willing to take risks in terms of content for the future leadership role, is the outsider. Armin Laschet, whom only a few trust with the top office, seems to be relying on reaching his goal without any innovative efforts, solely through the logic of the situation.*'

The 70 CDU MPs who opposed their own party Chairman were a minority. Even combined with the 45 CSU MPs, this group was not large enough to form a majority in the joint faction of 245 MPs (see Figure 1.3). Once the CDU board had renewed its support for CDU Chairman Armin Laschet on 19 April, his challenger Markus Söder from the CSU had to withdraw from the race.

Figure 1.3: SUPPORT FOR LEADERSHIP CANDIDATES WITHIN CDU/CSU PARLIAMENTARY FACTION



Notes: Dark blue dots denote MPs who signed the letter (i.e. voted for Söder). White dots denote MPs who did not sign the letter (i.e. voted for Laschet). Gray dots denote CSU MPs who were ineligible to sign the letter. One dot represents 5 MPs.

German national elections in 2021 and risk of defeat for CDU MPs. In German national elections, MPs can get elected through two routes. First, they can win a First-Past-The-Post election in their constituency. In 2021, 299 MPs (out of 736) were elected this way. Second, parties receive non-constituency seats, which are allocated to potential MPs through party lists on the state level.[10] The allocation of these seats follows a complex formula to ensure that each party's number of MPs is proportional to its vote share, for each of the 16 states. As the formula incorporates various factors which are difficult to forecast, both the size of parliament and the allocation of seats are highly uncertain (Vehrkamp, 2021).

CDU MPs are in general unlikely to get re-elected unless they win their constituency. In the 2017 national elections, 185 out of 200 of CDU MPs (92.5 %) were directly elected in their constituency. In ten out of 15 states, not a single CDU MP entered parliament through state lists - in the 16th state (Bavaria) the CDU does not run. At the time of the leadership election, the CDU was polling six percentage points below the previous election result in 2017, implying that the CDU would potentially lose a substantial share of their parliamentary seats. The 2021 national elections results show that this concern was well founded: the party lost 48 of their initial 200 mandates.

[10]National parties have state-level parties in all 16 German states. These state parties independently create the lists for MP candidates running in their state.

Even though one third of CDU MPs in 2021 were elected through state lists (54 out of 152), due to the complex allocation formula, eligibility for those seats could not be predicted around the time of the leadership election - this was not even the case in the weeks before the national elections (Der Spiegel, 2021; Johanssen+Kretschmer, 2021). The state party lists were also compiled between late April and June 2021, *after* the leadership election.[11] These features suggest that our model of constituency-based elections in Section 1.2.1 is a good fit for CDU MPs. The extended model in Appendix 1.D shows that incorporating second votes and party lists MPs does not change our results.

1.3.2 Data

All CDU MPs - but not CSU MPs - were eligible to sign the letter to the CDU board. We collect a rich dataset covering all 195 CDU MPs with a constituency sitting in the German parliament in April 2021.[12] The dataset is constructed from a wide range of sources. Summary statistics for all variables are shown in Appendix Table 1.C.1.

Leadership votes. Our dependent variable - how MPs voted in the leadership election - was obtained from the German newspaper FAZ. This is in the form of the names of the letter's signatories supporting the candidacy of the CSU Chairman, Markus Söder. There is ample variation in the support for Söder - also across states (see Appendix Figure 1.B.2).

Electability. As a proxy for MPs' 'electability', we use re-election probabilities (on a 0-100% scale) calculated by *election.de* as of 9th April 2021 - a few days *before* the letter and *before* Laschet and Söder announced interest in the nomination.[13] They provide up-to-date information on the current status of the race within the constituency. This measure is highly predictive of actual outcomes: 93% of all constituency results were forecasted correctly for the 2017 national elections, and similar accuracy was achieved

[11] Three small states (totalling 16 CDU MPs) are an exception to this. Comparing the 2017 and 2021 state lists, we do not see any effect of whether an MP signed the letter either on her placement nor her movement on the state list. This is as expected because the state lists are compiled by state parties without interference by the national party or its Chairman Armin Laschet.

[12] 200 CDU MPs were elected in the 2017 national elections and all were assigned a constituency. Nine MPs resigned from parliament prior to April 2021. Only four of the nine replacements had been assigned a constituency.

[13] The predicted probability for winning the constituency is generated by a data-driven projection model which takes into account among others the candidates in the constituencies, current demoscopic trends, and the likely vote splitting (Moehl, 2021).

for two state elections in March 2021 (Moehl, 2021). MPs also consult the website. Politicians in one third of constituencies paid for a 'premium' version of *election.de* (FAZ, 2021; Lutz, 2021). Appendix Figure 1.B.3 shows how the variable is distributed across MPs.

Ideology. Various measures for ideology exist at the party level, but measuring ideology at the individual MP level is more difficult and hence much rarer.[14] We use a supervised machine learning model called 'Wordscores', which is an established tool in the political science literature for extracting political positions from text data (Laver et al., 2003; Lowe, 2008).[15] The model provides ideology scores based on similarities of texts of interest ('virgin texts') with a set of labelled texts ('reference texts'). Specifically, the method first estimates scores for each word that occurs in the reference texts and secondly employs these to generate a score for each virgin text. We use 2017 manifestos from all major German political parties as our set of reference texts. The labels are expert assessments of each manifesto's ideological positions, taken from Chapel Hill (Bakker et al., 2019). Our virgin texts are the parliamentary speeches made by each MP during the 19th parliamentary term (2017-2021). We validate the model's output in Appendix 1.E.1. For our empirical analysis, we only use the ideology scores for CDU MPs.[16] As ideology scores have no natural units, we normalise the scores to have a mean of zero and a standard deviation of one to aid interpretation.[17]

Re-election motivation. We determined whether MPs were seeking re-election based on local newspaper reporting. This process classified 42 MPs (22% of the sample) as either not seeking re-election or having lost their local party's nomination for re-election before the date of the leadership election. Hence we measure re-election motivations on the extensive margin.

[14]The DW-NOMINATE scores are an exception, which provide ideology scores for political actors in the US based on roll-call voting (Lewis et al., 2023). Deviations from the party line occur too rarely in Germany so as to follow their methodology.

[15]For a full discussion on the strengths and weaknesses of different text scaling approaches see Grimmer and Stewart (2013) and Egerod and Klemmensen (2020).

[16]We transform the raw ideology scores according to the method suggested by Martin and Vanberg (2008).

[17]Our theoretical model uses ideological alignment (i.e. a difference in ideology between an MP and a leadership candidate), while our data captures MPs' ideologies. Under a mild assumption, differences in ideological alignment are linear in MPs' ideology. So our measure of MPs' ideology is perfectly correlated with the theoretical object of interest. Appendix 1.E provides a more extensive discussion.

MP-level control variables. We obtained MPs' socio-economic characteristics, such as gender, education, religious affiliation, tenure, party or government positions from the Federal Returning Officer (2017) and MPs' personal webpages. We also use confidential information on MPs' membership in the largest partisan faction 'Parlamentskreis Mittelstand' (PKM) to capture potential network effects. Finally, we construct an indicator measuring the general tendency of individual MPs to rebel by calculating the share of roll-call votes in which the individual MPs deviated from the party line during the 19th parliamentary term.

Constituency-level control variables. We collect macro-economic variables on MPs' constituencies, including unemployment, income, and urbanisation. This data comes from the Regional Database Deutschland & Federal Employment Agency (2022). We also calculate the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD) as a proxy for right-wing pressure (Federal Returning Officer, 2017).

1.4 Empirical Analysis

1.4.1 Descriptive Analysis

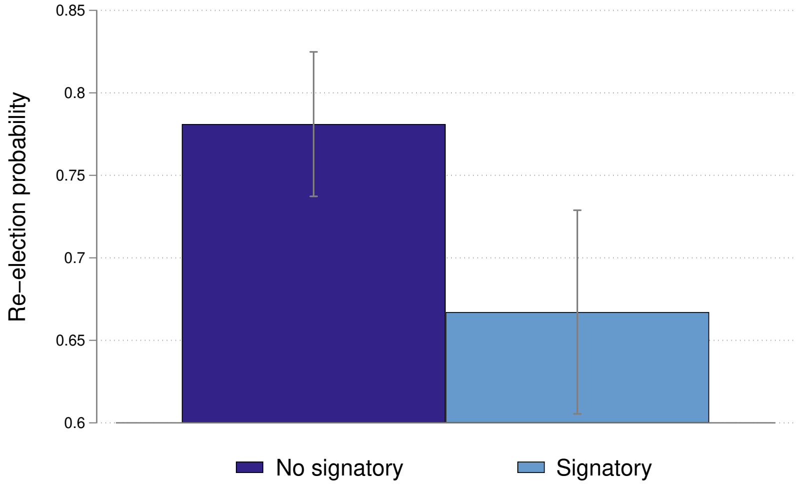
The raw data is suggestive of gambling for re-election behaviour by MPs. Figure 1.4 shows that MPs who voted for the risky challenger Markus Söder (i.e., who signed the letter) were predicted to be significantly less likely to win re-election than MPs who did not (by a 11 pp. difference).[18] This pattern cannot be explained by differences in the electability ('quality') of the leadership candidates. If MPs were to choose based solely on candidates' electability, there should be no relationship between MPs' choice of leadership candidate and their re-election probabilities. Figure 1.4, in contrast, suggests that risk matters for MPs.

1.4.2 Econometric Model

Our empirical framework follows the logic of our theoretical set-up very closely. The main variables each capture a key element from the theory model: electability (proxied

[18]Appendix Figure 1.B.6 demonstrates that MPs' decisions in the leadership election also relate to *realised* election outcomes. Among those MPs who were seeking re-election, MPs who signed the letter were 25 pp. (!) less likely to get re-elected than MPs who did not sign the letter. This illustrates that supporting the risky candidate, i.e. gambling, was a rational choice by MPs.

Figure 1.4: RE-ELECTION PROBABILITY AND SUPPORT FOR RISKIER CANDIDATE



Notes: This figure relates the predicted winning likelihoods of MPs to their decision to sign the letter (90% confidence intervals).

by re-election probability), ideological alignment (proxied by MPs' ideological positioning on a left-right scale), and importance of re-election motivation (proxied on the extensive margin by an indicator of whether or not an MP is running for re-election).[19] The equilibrium characterisation in Section 1.2.2 shows that the re-election motivation modulates the impact of electability and ideology (it appears multiplicatively, rather than additively; see Equation 1.3). It is therefore important to interact the re-election motivation with the other two key variables. Our specification allows us to examine how support for the risky candidate (Söder) depends on the factors highlighted by our theoretical model. Specifically, we estimate the following regression model:

$$\begin{aligned} Y_m = \alpha + \beta \ Poll_m + \gamma \ ID_m + \delta \ N\text{-}run_m + \zeta \ (Poll_m \times N\text{-}run_m) \\ + \eta \ (ID_m \times N\text{-}run_m) + \mathbf{X}_m \theta + \mathbf{B}_s \mu + \varepsilon_m. \end{aligned} \tag{1.4}$$

Y_m denotes whether CDU MP m signed the letter in support of Markus Söder. $Poll_m$ is the predicted probability of a CDU MP m winning her constituency. ID_m

[19] Our theoretical model also makes an intuitive prediction regarding the leadership candidates' electabilities: a candidate with higher electability will attract more votes. We cannot test this prediction empirically because the leadership candidates' electabilities are fixed across all MPs and therefore do not offer any identifying variation. This also implies that our empirical results cannot be explained by differences in leadership candidates' electabilities.

captures MPs' ideological leaning on a left-right-scale based on our supervised machine learning model. $N\text{-}run_m$ is a dummy that takes the value one for MPs who are not standing for re-election in the September 2021 national elections. The two interaction terms ($Poll_m \times N\text{-}run_m$ and $ID_m \times N\text{-}run_m$) are key parts following directly from the theoretical model. They allow us to test whether the effect of electability and ideology are conditional on the re-election motivation.

Beyond the factors highlighted by our theory model, our empirical specification includes a comprehensive battery of MP-specific and constituency-specific controls in the matrix $\mathbf{X}_m$. State- and geographic-specific factors are absorbed by state fixed-effects ($\mathbf{B}_s$).[20] This allows us to account for a wide range of other factors that might affect MPs' decisions. We estimate the model by OLS and use standard errors robust to arbitrary heteroskedasticity.

Identification strategy. While we control for a wide range of potential confounders, we cannot definitively rule out that the empirical model suffers from endogeneity issues. Indeed, in Section 1.5.2, we set out the three most natural alternative stories that would generate the relationship we see in Figure 1.4, but without low re-election probabilities *causing* MPs to back the riskier candidate. While we show that addressing these alternative stories directly does not alter our results, we also use an established instrumental variable strategy to rule out any remaining endogeneity issues. This allows us to more confidently attach a causal interpretation to our findings.

Specifically, we employ the CDU's constituency-level shares in *second* votes, i.e. the votes cast for the party as a whole rather than an MP personally, in the 1990 national elections (the first after Germany's reunification) as an instrument for MPs' re-election probabilities. The instrument leverages variation in local electoral competition arising from persistence in voters' party preferences, which are not tied to considerations about individual MPs (see, for example, (Becker et al., 2009; Svaleryd and Vlachos, 2009; Solé-Ollé and Viladecans-Marsal, 2012) for closely related empirical strategies).

Two convenient features make the instrument plausibly exogenous. First, in the same spirit as Svaleryd and Vlachos (2009), we benefit from the fact that the current constituency structure in Germany is not the same as it was in 1990. Several rezoning reforms changed which municipalities belong to which constituency. For 1990, we

[20]MP-specific controls include: tenure, education levels, gender, religious affiliation, general rebel tendency, faction membership, and party elite dummy. Constituency-specific controls include; unemployment rate, population density, average private households' income, and AfD second vote share in 2017. Some of the factors absorbed by state fixed effects include; state party ideology, state election schedule, and geographical proximity to the home states of the two leadership candidates (Bavaria and North Rhine-Westphalia).

geolocate the election results for all 16,110 German municipalities. Accounting for municipality mergers and rezoning reforms, we aggregate the historical municipality election results to the current constituency structure. Since only two MPs in our sample were running in 1990 and since the current constituency structure did not exist in 1990, our instrument leverages variation in the level of the current local electoral competition based on voters' stable ideological considerations.

Second, our instrument exploits the peculiarity of the federal electoral system in Germany that voters cast two votes simultaneously (one for an MP, one for a party). For our instrument, we employ the party preferences expressed in the second vote (see also the discussion in (Becker et al., 2009) on why this institutional feature makes the lagged share in second votes a well-suited instrument for local political competition). Both features ensure that the variation created by our instrument is not tied to considerations about individual MPs.

1.5 Results

1.5.1 Main Results

Table 1.1 reports our main regression results. Column (I) is parsimonious and includes only the MPs' predicted likelihood of winning, the re-election motivation, and the interaction of the two terms. Column (II) adds constituency- and MP-specific controls. Column (III) adds state fixed effects. In column (IV), we include MPs' ideology. Finally, column (V) adds the interaction term between ideology and the re-election motivation. This yields the full specification from Equation (1.4).

Gambling for re-election. The theory model's key prediction is that MPs are more likely to vote for the riskier candidate (in our setting, the challenger Markus Söder) if they themselves are less 'electable', i.e. have a lower expected probability of being re-elected (Proposition 2). In our empirical model, this implies a negative coefficient β. Table 1.1 shows that the data bear out this prediction. Throughout all specifications, the coefficients on the *Poll* variable are negative and statistically significant when MPs stood for re-election. In other words, MPs exhibit 'gambling for re-election' style behaviour.

Importantly, our point estimates suggest that this relationship is economically significant. A ten percentage points *decrease* in the predicted re-election probability for an MP is associated with a 2.9 percentage points *increase* in the probability that she

Table 1.1: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE: BASELINE REGRESSION RESULTS

Dependent variable: Support for Söder	(I) Parsimonious	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
Poll	-0.285**	-0.261*	-0.286*	-0.288*	-0.294*
	(0.128)	(0.139)	(0.168)	(0.170)	(0.167)
Not-run × Poll	0.042	0.035	0.150	0.147	0.077
	(0.290)	(0.273)	(0.309)	(0.308)	(0.307)
Ideology				0.009	-0.024
				(0.034)	(0.036)
Not-run × Ideology					0.175*
					(0.098)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195
R-squared	0.034	0.244	0.307	0.307	0.322

Notes: This table shows the results from estimating Equation (1.4). We show results from five specifications. We start with a parsimonious model that examines how MPs' electability (*Poll*), and the interaction of electability with the re-election motive, relate to MPs' leadership choices. We gradually augment this model by introducing MP- and constituency- controls (Column II), state fixed effects (Column III), ideology (Column IV) and the interaction term of ideology with the re-election motive (Column V). All specifications also include the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

supports the risky candidate. The point estimates stay remarkably constant across specifications, supporting the argument that the link between re-election probabilities and MPs' choices does not depend on control variables. Furthermore, we find this relationship only for MPs seeking re-election (i.e. who are re-election motivated) - exactly as predicted by our model. For MPs not seeking re-election, the marginal effect, i.e. the sum of coefficients of the *Poll* variable and the *Not-run* × *Poll* interaction, does not turn out to be statistically different from zero ($t = 0.71$ in the most comprehensive specification).

Result #1 *MPs gamble for re-election: A ten percentage points decrease in the predicted re-election probability for an MP is associated with a 2.9 percentage points increase in the probability of supporting the risky candidate.*

Ideology. The second theoretical prediction is that MPs who are more ideologically aligned with a candidate are more likely to vote for that candidate (Proposition 3). In the empirical application, this corresponds to the prediction that $\gamma > 0$. This is because Markus Söder (the CSU Chairman) is the more right-wing of the two candidates. The CSU is traditionally regarded as more conservative than the CDU, which is also reflected in the Chapel Hill rating (Bakker et al., 2019).

Our empirical results do *not* support this prediction. In both columns (IV) and (V), the point estimates on the *Ideology* variable are not statistically different from zero. Note that these coefficients are a precisely estimated zero and rule out even modest associations of ideology with MPs' choices. This suggests that MPs (at least those seeking re-election) are primarily motivated to choose a leader who will help them win re-election, rather than one who they find ideologically appealing.

Result #2 *For MPs seeking re-election, ideological alignment does not play an important role for their decision-making in a leadership election. This is consistent with MPs being primarily - but not solely - re-election motivated.*

The role of the re-election motive. A third important prediction from our model is that a reduced re-election motive makes ideology relatively more important for MPs' choice of leadership candidate - and consequently reduces the importance of their re-election probability (Proposition 4). In the extreme case, where MPs have no re-election motive at all, it is only ideology that matters. With our data, we test for extensive margin changes – whether or not MPs are seeking re-election at all - instead of 'marginal' changes in the re-election motive.

Within our empirical framework, this amounts to the prediction that for MPs who are not seeking re-election, ideology matters for their choice *and* that their re-election probability does not. In other words, the marginal effect of the *Poll* variable is zero, while the marginal effect of *Ideology* is non-zero. This is exactly what we find in our regression results. Column (V) shows that the coefficient on the interaction term between the re-election motive and MPs' ideology is positive and statistically significant (the marginal effect of ideology for MPs not seeking re-election yields a t-statistic of 1.67). Among MPs not seeking re-election, more conservative MPs were more likely (all else equal) to support Markus Söder. This matches our view that Markus Söder is the more conservative of the two candidates. In contrast, our previous finding showed that for those MPs not seeking re-election, the marginal effect of the *Poll* variable is not statistically different from zero. More conservative MPs were thus more likely to support the more conservative CSU Chairman, but *only* when they were not seeking re-election.

This result is suggestive that our inability to find a relation between ideological alignment and MPs' choices in the full sample of MPs (Result #2) may be because the risk channel dominates the ideology motive, rather than because the ideology motive does not exist at all. It also demonstrates the importance of the interaction between re-election motivation and ideological alignment highlighted by the theoretical model.

Result #3 *Importance of the risk channel: risk preferences of MPs dominate the importance of ideological alignment for MPs selecting a political leader. MPs only care about ideological alignment when not seeking re-election.*

Robustness

Next, we demonstrate that our empirical results survive a wide range of robustness checks. For briefness, data tables are relegated to the Appendix.

Functional form and sample restrictions. Our results are not driven by the use of an OLS model: changing to a Probit Model has no impact on inferences (see Appendix Table 1.C.2). The results are also not driven by outliers or by the inclusion of state fixed effects - both of which could be a concern given our modest sample size. Jack-knife regressions, which exclude one MP at a time, show that results do not rely on individual MPs (see Appendix Figure 1.B.7). Inferences do not change when we account for cultural and geographical differences with an East-Germany dummy, rather than full state fixed effects (see Appendix Table 1.C.3).

Testing our key variables. The polls and ideology variables are the most important in our analysis. Our measure of ideology is derived from MPs' speeches, and so is likely noisy (i.e. it may suffer from measurement error). To address any resulting attenuation bias, we include the standard errors of the ideology variable as an additional control. Inferences stay qualitatively the same (see Appendix Table 1.C.4). Even though our polling data is a very accurate predictor of election outcomes (see Section 1.3.2), the variable might still suffer from measurement error. As we do not observe the exact data generating process, we cannot account for it by bootstrapping our regressor. However, we will show that our results are not driven by this particular choice of proxy, and that we obtain qualitatively identical results when using pre-determined vote margins.

COVID-19. The leadership election took place amid the COVID-19 pandemic. We rule out that geographical differences in the severity of the pandemic situation, and hence potentially different policy preferences of MPs, influence our results. Controlling for constituency-level infection cases (relative to the population), either cumulatively to 12 April 2021 (the day the letter was sent), or just in the seven days prior to 12 April 2021, does not change our results (see Appendix Table 1.C.5).

Second route into parliament - the state list. Finally, we show that controlling for whether MPs were placed on the 2017 state lists (*ex-ante*) or the 2021 state lists (*ex-post*) does not change inferences (see Appendix Table 1.C.6). This is in line with the arguments in Section 1.3.1.

Selection on unobservables. While we have controlled for a wide range of potential confounders, we cannot completely rule out the possibility that there is some selection on unobservables. We therefore use the Oster (2019) test to estimate how large the selection on unobservables would have to be in order to drive the estimated effects on the *Poll* variable. We find that selection on unobservables would have to be substantial - 1.9 times larger than the selection on controls and state fixed effects - to cancel out our estimated effects.

1.5.2 Alternative Explanations

The empirical results confirm our model's predictions about gambling style behaviour. However, a natural concern is that the results might be driven by some other mechanism, which would generate the same empirical patterns, but without re-election chances having a *causal* effect on MPs' leadership decisions. We consider three leading alternatives and show that addressing them does not alter our results.

Reverse causality: support for Markus Söder *caused* lower poll numbers. A first alternative story is that MPs' support for Markus Söder entered voters' preferences directly. That is, voters punished CDU MPs for backing the non-CDU leadership candidate. This would create a negative association between MPs' choice of leader and their probability of re-election; but one where their choice of leader *causes* their re-election probability.

This possible explanation is immediately weakened by the fact that, (1) the re-election probabilities (the *Poll* variable) are taken from one week *before* MPs voted for the leadership candidate, and (2) MPs' votes were secret (and in spite of the leak of the letter, are still not publicly available).

An omitted variable: party reliance. A second alternative story is that CDU MPs receive assistance from their party leader, Armin Laschet, and that this assistance drives both their re-election chances and their inclination to vote for Laschet. Such assistance might take the form of channelling party or donor funds to MPs, more frequent visits by senior politicians to the constituencies, or extra government spending in the constituencies - factors that could make MPs receiving the assistance more electable. Receiving this assistance would also likely make MPs more reliant on Armin Laschet and hence would create a spurious correlation between MPs' choice of leader and their probability of re-election.

Misspecified preferences. A third alternative story is that MPs do not care about re-election and the ideology of their leader (which are both assumed in our model), but instead follow their constituents' preferences over the two leadership candidates. If this were the case, then voters' preferences for a party/MP and for a leadership candidate would generate a corresponding association between MPs' re-election chances and their choice of leadership candidate.

Assessing the alternative explanations

Reverse causality & omitted variable. The reverse causality and omitted variable stories share a common feature: the potential factor driving the relationship between MPs' re-election probabilities and leadership decisions could only arise *after* Armin Laschet became Chairman of the CDU (which took place in January 2021). In the party reliance story, MPs could only have reasonably become reliant on Laschet after he became Chairman of the CDU. In the reverse causality story, support for Markus Söder could not have influenced re-election probabilities from before a leadership election between Laschet and Söder was anticipated.

In contrast, our risk model relies on underlying MP 'electability', which we assume is stable over time (or at least persistent). Therefore, if our risk model is in fact the correct story, the relationship between polling/voting data and support for Markus Söder should be present when using older polling/voting data as a proxy for 'electability'.

We therefore re-estimate Equation 1.4 using MPs' vote margins in the 2017 national elections as an alternative proxy for electability. The 2017 election took place long before Armin Laschet became Chairman of the CDU and before a contest between Laschet and Söder was foreseeable. Therefore, MPs' vote margins cannot be driven by MPs' reliance on Laschet or voters' preferences for Markus Söder.

Table 1.2: VOTE MARGINS AND CANDIDATE CHOICE: REGRESSION RESULTS

Dependent variable: Support for Söder	(I) Parsimonious	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
Vote margin	-1.287***	-0.869*	-1.109**	-1.112**	-1.206**
	(0.402)	(0.452)	(0.499)	(0.501)	(0.500)
	(0.140)	(0.133)	(0.134)	(0.137)	(0.134)
Not-run × Vote margin	0.829	0.628	1.060	1.052	0.930
	(0.911)	(0.887)	(0.947)	(0.948)	(0.948)
Ideology				0.007	-0.026
				(0.034)	(0.036)
Not-run × Ideology					0.183*
					(0.096)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195
R-squared	0.051	0.243	0.314	0.314	0.331

Notes: This table shows the results from re-estimating Equation 1.4 using the 2017 vote margin for CDU MPs as main independent variable. The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

We obtain qualitatively identical results when estimating our baseline model with MPs' vote margins as the main independent variable (see Table 1.2). MPs with a lower vote margin in 2017 ('tougher re-election races') were significantly more likely to support the risky candidate. This shows that the reverse causality and party reliance stories are not driving our qualitative results.

Quantitatively, the estimates imply that MPs with a 1 pp. lower vote margin in 2017 were 1.2 pp. more likely to support the risky candidate. In standardised terms, the coefficient on the vote margins is slightly larger than our baseline coefficient on the Polls variable: a one standard deviation increase in the vote margin (predicted winning likelihood) is associated with a 11.1 (9.0) pp. increase in the likelihood to vote for the riskier candidate.

Misspecified preferences. To address the possibility of misspecified preferences, we disentangle voters' preferences over leadership candidates from MPs' preferences. We measure voters' preferences using high-quality, geo-referenced, and representative household survey data from Infratest Dimap (2022). The geo-referencing is critical - it allows us to aggregate these preferences to the constituency level. The data captures two measures of voters' feelings towards Markus Söder: (1) satisfaction with the quality of his political work (on a 1 to 4 scale), and (2) perceptions of Söder as a suitable Chancellor.[21] If MPs base their leadership decisions not on own objectives but simply followed their constituents' preferences, then it should be these measures, and not the *Polls* variable, that have predictive power.

Adding both variables to our empirical model has no impact on our results (see Appendix Table 1.C.7). The point estimates on the pre-existing variables remain stable. Furthermore, the coefficients on the voters' preference variables are close to zero and not statistically significant. We also obtain qualitatively identical results if we include the variables separately, construct the variables using only up-to-date answers from January to April 2021, or construct the variables using only answers from declared CDU-voters. Combined, this presents strong evidence that MPs' decisions are reflective of risk-taking behaviour and are not merely based on their constituents' preferences.

1.5.3 Instrumental Variable Results

While we have demonstrated that it is unlikely that other alternative stories to the gambling for re-election mechanism are driving our empirical results, we cannot fully rule out that there might be some other source of bias. We therefore use an established instrumental variables approach to address 'residual' endogeneity concerns. Our instrument is based on CDU party vote shares in the 1990 national elections, creating variation in local electoral competition that is not tied to considerations about individual MPs (see the discussion in Section 1.4.2). This helps attach a stronger causal interpretation to our results.

Table 1.3 presents the 2SLS-results for our instrumental variable approach. Panel A shows results when using the *Polls* variable. The first stage results show that our instrument is a relevant and strong predictor for local electoral competition. A one pp. increase in the CDU's 1990 vote share at the constituency-level relates to a 1.9 pp. increase in the predicted (personalised) re-election likelihood for CDU MPs in 2021.

[21] The exact wording of the questions is *'How satisfied are you with Markus Söder's political work?'* and *'The next general election will take place in September. The CDU/CSU candidates for Chancellor are Markus Söder and Armin Laschet. What do you think: Would Markus Söder be a good candidate for chancellor or not a good candidate for chancellor of the CDU/CSU?'*. We pool all seven waves of the survey containing these two questions (from 2019 to April 2021), yielding 10,913 observations for the first question, and 6,233 observations for the second question. Appendix Figure 1.B.8 shows that there is ample variation in both measures across constituencies.

Table 1.3: ELECTABILITY AND CANDIDATE CHOICE: INSTRUMENTAL VARIABLE REGRESSION RESULTS

Dependent variable: Support for Söder	(I) Parsi.	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
	Panel A: Results using *Polls* proxy				
	First Stage Regression Results				
$Vote\ share_{1990}$	2.014***	1.868***	1.916***	1.910***	1.910***
	(0.323)	(0.340)	(0.326)	(0.322)	(0.322)
	Second Stage Regression Results				
Poll	-0.719***	-0.619**	-1.042***	-1.056***	-1.057***
	(0.256)	(0.296)	(0.332)	(0.336)	(0.326)
Ideology				0.018	-0.019
				(0.036)	(0.038)
Not-run × Ideology					0.201**
					(0.093)
Kleibergen-Paap F-statistic	38.8	30.2	34.6	35.2	34.7
Anderson-Rubin p-val	0.00	0.01	0.00	0.00	0.00
	Panel B: Results using *Vote margins* proxy				
	First Stage Regression Results				
$Vote\ share_{1990}$	0.933***	0.766***	0.972***	0.973***	0.973***
	(0.075)	(0.085)	(0.081)	(0.081)	(0.081)
	Second Stage Regression Results				
Vote margin	-1.550***	-1.510**	-2.054***	-2.073***	-2.074***
	(0.529)	(0.730)	(0.635)	(0.644)	(0.619)
Ideology				0.012	-0.027
				(0.032)	(0.034)
Not-run × Ideology					0.207**
					(0.091)
Kleibergen-Paap F-statistic	156.7	81.7	145.7	143.4	143.0
Anderson-Rubin p-val	0.00	0.03	0.00	0.00	0.00
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195

Notes: This table shows the instrumental variable results using the CDU's party vote share in the 1990 national elections as an instrument. Panel A shows results when using the Polls variable as proxy for MPs' electability, Panel B shows results when using 2017 vote margins as proxy. The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

The second stage results strongly corroborate our OLS results throughout all specifications: MPs with lower electability were more likely to support the riskier candidate, and ideological alignment only matters for MPs who are not seeking re-election. These results are highly statistically significant; also reflected by the low p-values of the Anderson-Rubin test.[22]

Panel B shows results when alternatively using MPs' vote margins in the 2017 national elections as proxy for MPs' electability. The results are qualitatively identical across both proxies and provide strong evidence that the relationship between MPs' electability and their risk-taking behaviour is likely causal.

The point estimates obtained via the 2SLS-approach are markedly larger than the OLS estimates.[23] The relative gap in the OLS-IV estimates is larger for the *Polls* variable than for the vote margins. This is consistent with the *Polls* variable being likely more noisily measured than the vote margins.

For both proxies we perform the state-of-the art decomposition proposed by Ishimaru (2024), which decomposes the OLS-IV gap into a covariate weight difference component, a treatment-level weight difference component, and the marginal effect difference component. Appendix Table 1.C.8 shows that most of the OLS-IV gap is indeed explained by the marginal effect difference component.

Extended Results: Instrumenting the interaction. Table 1.3 shows results when we instrument the (potentially endogenous) re-election probabilities with the 1990 vote shares and control for the base effect of the re-election motive ($Not\text{-}run$), but do not include the interaction term between the re-election probabilities and the re-election motive - a factor highlighted by our theory model. This is to facilitate exposition and interpretation of the instrumental variable approach. To make our instrumental variable results fully comparable to our OLS approach, we additionally use the CDU's vote shares in 1990 *and* their interaction with the re-election motive as instruments for the re-election probabilities and their interaction with the re-election motive. The qualitative results are unchanged, and the coefficients on the interaction terms confirm that the re-election motive plays an important role in our ideology and risk-taking findings (see Appendix Table 1.C.9).

[22]The results are not an artefact reflecting our choice of using the 1990 national election results for our instrument. In line with the idea of ideological persistence, we obtain very similar estimates when using the 1994 national election results.

[23]Note that this does not contradict the result from our Oster (2019) test, showing that selection on unobservables would need to be large to *cancel out* our estimated effects.

1.6 Conclusion

Politicians often have to choose between riskier and safer options. And, as in the case of selecting political leaders, the stakes are often high. But insights into risk-taking behaviour in politics are difficult for one of two reasons. First, when behaviour is publicly observable, politicians may be concerned about public perceptions, which can affect their decisions. This makes it difficult to disentangle signalling incentives to voters from inherent risk preferences. Second, when behaviour is not observable, there are clear data availability issues. In the case of selecting political leaders, secret ballots have proved the key barrier - they do not reveal individual decisions. We overcome these issues through unique access to a leak of party-internal data, allowing us to observe MPs' decisions in a *de facto* vote for the first time.

We set out a theoretical model of rational risk-taking by MPs, and derive predictions on the factors that drive MPs' decisions in leadership elections. Our main prediction is that MPs 'gamble for re-election'. That is, they value the degree of uncertainty over the leadership candidates' electability differently. MPs predicted to fall short of re-election prefer a riskier candidate, while MPs above the margin for re-election prefer a candidate with lower risk. More generally, the situation can make MPs behave *as if* they are risk-averse or risk-loving - even if they have risk-neutral preferences.

We document exactly this 'gambling for re-election' behaviour in the leadership competition of the German centre-right parties before the 2021 national elections. We show that - even after accounting for a battery of potential confounders - MPs with a lower predicted re-election probability were more likely to support the riskier candidate. Specifically, a 10 percentage points reduction in the re-election probability is associated with a 2.9 percentage points increase in the likelihood of voting for the riskier candidate. We find this behaviour only for MPs who are running for re-election. We also show evidence that risk preferences dominate ideological alignment when MPs select political leaders. Ideological alignment with leadership candidates only matters for those MPs who are not running for re-election. We obtain these results both in OLS regressions and confirm them via an instrumental variable approach that induces plausibly exogenous variation in MPs' re-election probabilities.

This gambling-style behaviour by politicians is similar to the behaviour of company managers who make a high-stakes decision in the context of a potential insolvency. Managers might choose riskier, but also objectively worse, investments when facing a potential insolvency because they benefit from the investments' success but do not bear the costs of failure ('gambling for resurrection'). From a welfare perspective, such behaviour is worrisome because managers do not consider the costs of bankruptcy to debt-holders. Similarly, a majority of MPs may prefer a candidate who they all expect to be of lower 'quality', as long as that candidate is sufficiently risky, i.e., performing either very poorly or being a political superstar. The consequences are even more severe in the political context: even MPs who are predicted to very likely win re-election may prefer a worse candidate - as long as that candidate comes with sufficiently low risk.

Our results imply that MPs' individually rational choices could seriously undermine their party's success. The behaviour also explains why MPs support different candidates - and hence provides a new explanation for the emergence of intra-party polarisation. In the same spirit, many commentators argued that the fierce competition between the two candidates and the subsequent divide within the party were important factors in the CDU/CSU performing poorly in the 2021 national elections.

Finally, our results raise the possibility that political parties select low-quality leaders, as MPs are willing to trade off leaders' expected quality for riskiness. Understanding the implications this has for policy-making and voters' welfare remains a promising avenue for future research.

Appendix to Chapter 1

This Appendix contains the following information:

- Section 1.A provides proofs for the propositions in the theory section.
- Section 1.B provides additional figures.
- Section 1.C provides additional tables.
- Section 1.D provides an extension by modelling party list elections.
- Section 1.E provides details on the employed ideology scores.

1.A Proofs

Proof of Proposition 1. **Part (1)** Follows trivially from the assumptions of the model. **Part (2)** m wins if and only if the *median* voter chooses party X. Because there are a mass of voters, the median voter has $\epsilon_j(\text{median}) = 0$. Therefore $Pr(\text{win}|m,\ell) = Pr(u_j > 0|m,\ell,\epsilon_j = 0)$. Which in turn equals $Pr(Q_m + Q_\ell + \nu_\ell > 0)$. Straightforward algebra yields $Pr(\text{win}|m,\ell) = F_\ell(Q_m+Q_\ell)$.[24] Therefore $u_m(\ell) = I_{\ell,m}+R_m \cdot F_\ell(Q_m+Q_\ell)$. By assumption, $s^*_m = 2$ if and only if $u_m(2) > u_m(1)$. Straightforward rearranging then yields the result.[25] □

Equation 3. Assuming interior solutions, $F_2(Q_m + Q_2) = \frac{Q_m+Q_2}{\lambda+\phi} + \frac{1}{2}$ and $F_1(Q_m + Q_1) = \frac{Q_m+Q_1}{\lambda} + \frac{1}{2}$. Substituting these expressions into the equation in Proposition 1 and rearranging immediately yields the result.

Proof of Proposition 2. The assumption that re-election is not guaranteed under either candidate ensures that $0 < F_\ell(Q_m + Q_\ell) < 1$ for $\ell \in \{1, 2\}$. Therefore $\frac{\partial U_m}{\partial Q_m} = R_m \left(\frac{1}{\lambda+\phi} - \frac{1}{\lambda}\right) < 0$. So an increase in Q_m can only induce MPs to switch towards candidate 2. □

Proof of Proposition 3. Define the *net* utility of voting for candidate 2: $U_m = u_m(2) - u_m(1)$. Trivially m votes for candidate 2 if and only if $U_m > 0$. From Proposition 1, we can write $U_m = R_m(F_2(Q_m + Q_2) - F_1(Q_m + Q_1)) + I_{2,m} - I_{1,m}$. It is also clear that $\frac{\partial U_m}{\partial I_2} > 0$ and $\frac{\partial U_m}{\partial I_1} < 0$. So an increase in I_2 [resp. I_1] can only induce MPs to switch towards [resp. away from] candidate 2. □

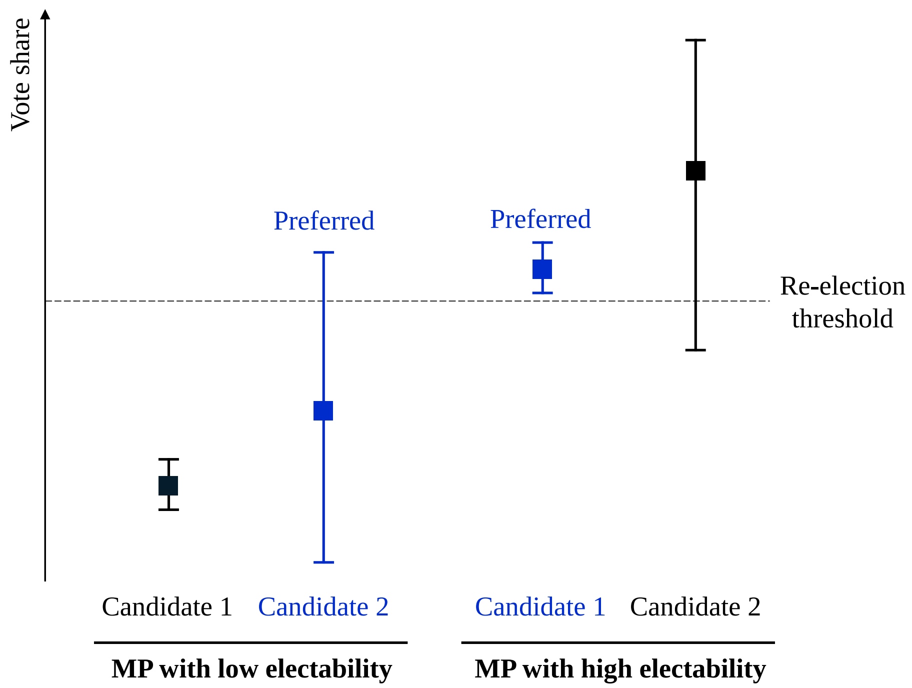
Proof of Proposition 4. From Proposition 1, an MP votes for candidate 2 if and only if in Equation (1.3) $LHS > RHS$. If MPs $m \in M'$ find candidate 1 more ideologically appealing, then $I_{1,m} - I_{2,m} > 0$. So an increase in R_m decreases RHS of Equation (1.3). This must weakly increase the number of MPs who vote for candidate 2. Conversely, if MPs $m \in M'$ find candidate 1 more ideologically appealing, then $I_{1,m} - I_{2,m} < 0$. So an increase in R_m increases RHS of Equation (1.3). This must weakly decrease the number of MPs who vote for candidate 2. □

[24] To see this: $Pr(Q_m+Q_\ell+\nu_\ell > 0) = 1-Pr(\nu_\ell < -Q_m-Q_\ell) = 1-F_\ell(-Q_m-Q_\ell) = F_\ell(Q_m+Q_\ell)$ using the fact that $F_\ell(-x) = 1 - F_\ell(x)$ by the symmetry of the distribution.

[25] $u_m(2) > u_m(1)$ is equivalent to $I_{2,m} + R_m \cdot F_2(Q_m + Q_2) > I_{1,m} + R_m \cdot F_1(Q_m + Q_1)$, which easily rearranges to the result.

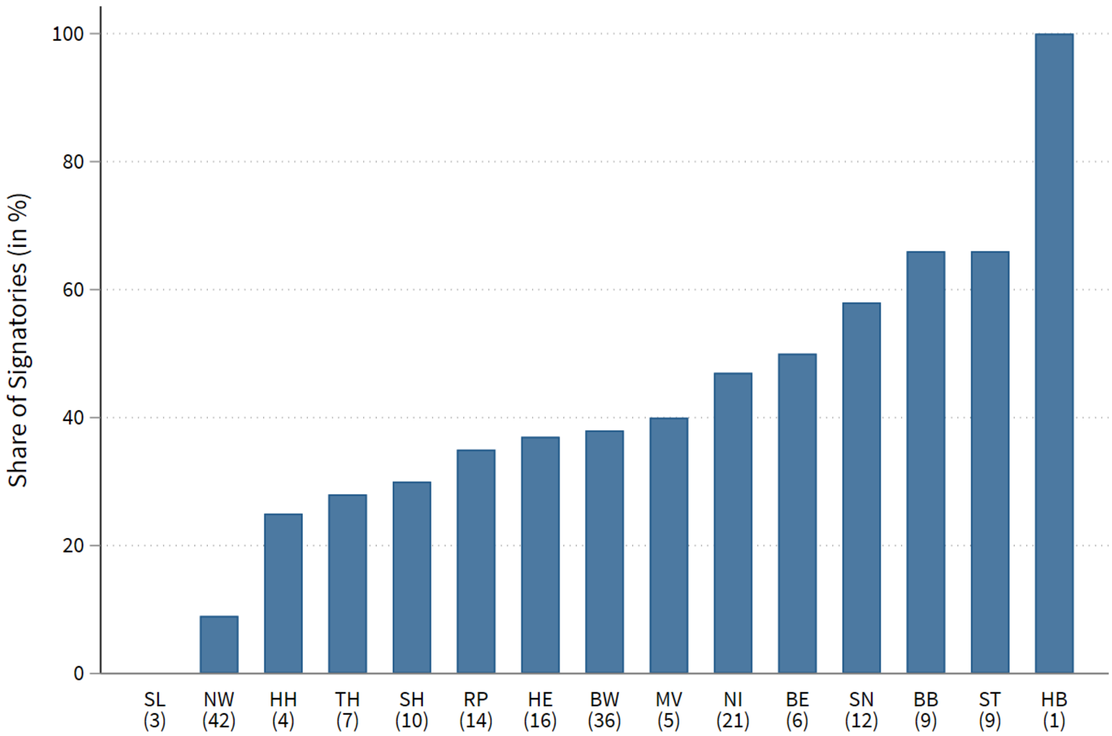
1.B Supplementary Figures

Figure 1.B.1: GAMBLING FOR RE-ELECTION BEHAVIOUR BY HIGH ELECTABILITY MPS



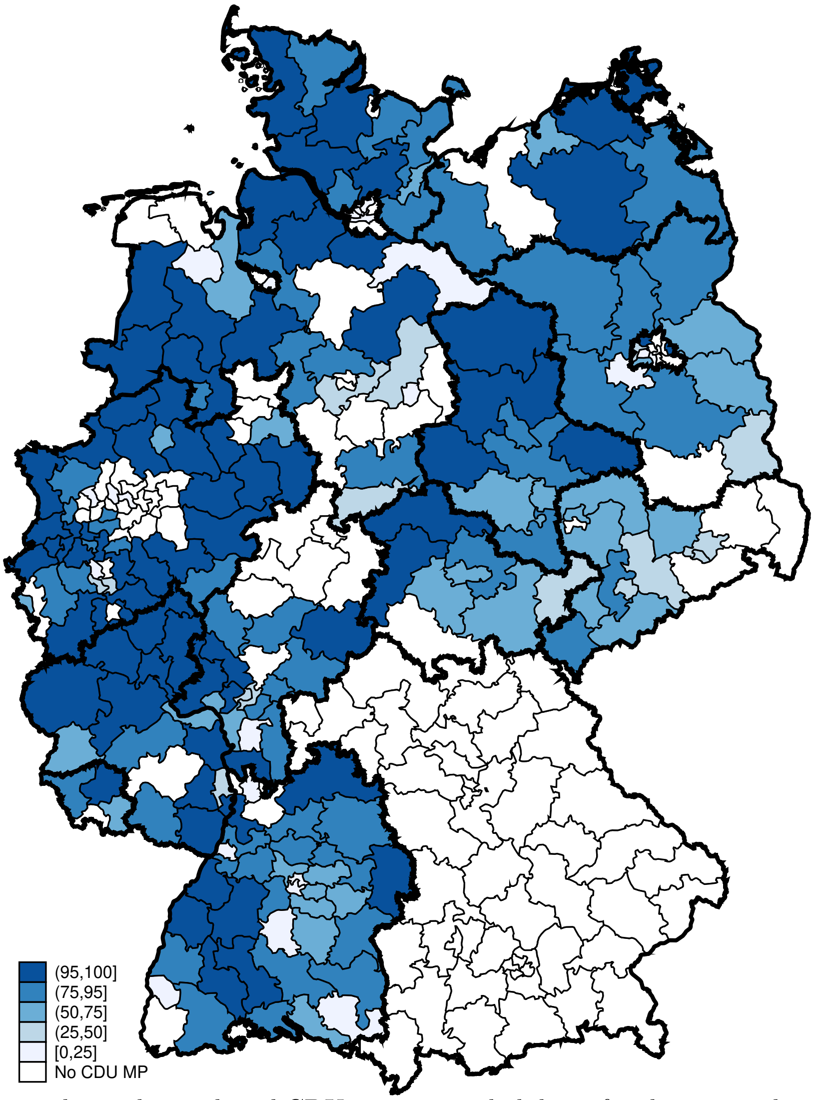
Notes: This figure illustrates for two MPs the range of potential vote shares under two leadership candidates. The MP on the left has a lower re-election probability Q_m than the MP on the right. The leadership candidates differ both in electability and riskiness. A higher electability is illustrated by the solid square being further to the top and a higher riskiness is illustrated by a larger distance between the solid square and the whiskers. Here, candidate 1 is less electable ($Q_1 < Q_2$) and less risky ($\lambda_1 < \lambda_2$) than candidate 2. The MP with high electability gambles for re-election by choosing candidate 1 who compensates the lower electability with lower riskiness. The case where candidate 1 is more electable, but less risky is shown in Figure 1.1.

Figure 1.B.2: SHARE OF SÖDER SUPPORTERS IN GERMAN STATES



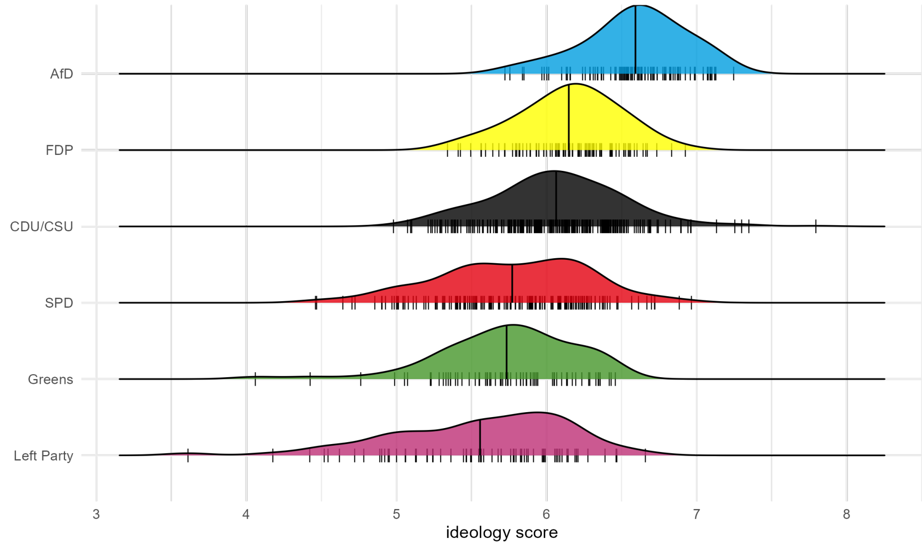
Notes: This figure shows the share of CDU MPs who signed the letter in the 15 German states (excluding Bavaria). The number in parentheses shows the total number of CDU MPs in the states. Data comes from the FAZ. SL: Saarland, NW: North Rhine-Westphalia, HH: Hamburg, TH: Thuringia, SH: Schleswig-Holstein, RP: Rhineland-Palatinate, HE: Hesse, BW: Baden-Württemberg, MV: Mecklenburg-Vorpommern, NI: Lower Saxony, BE: Berlin, SN: Saxony, BB: Brandenburg, ST: Saxony-Anhalt, HB: Bremen.

Figure 1.B.3: PREDICTED WINNING PROBABILITIES OF CDU MPS



Notes: This figure shows the predicted CDU winning probabilities for the personalised vote in each constituency from *election.de* on 9th April 2021. Constituencies shaded in white indicate that no elected CDU MP had been running there. CSU MPs (Bavaria) are excluded. The highlighted lines represent state boundaries.

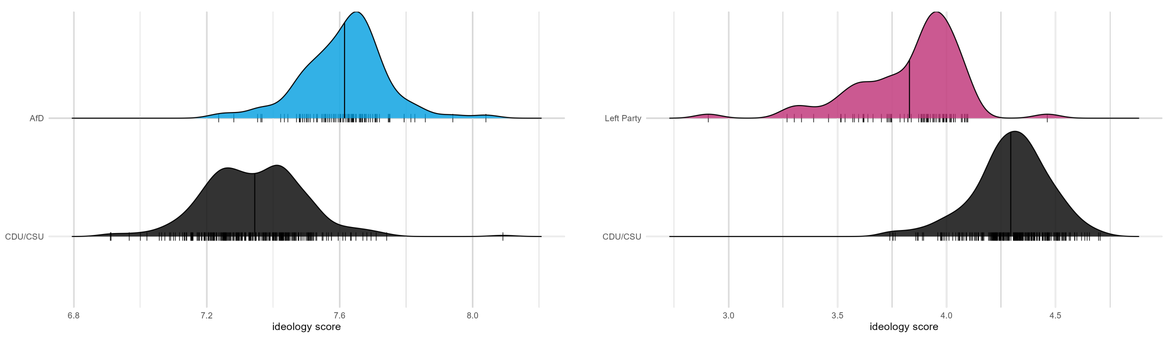
Figure 1.B.4: FACE VALIDITY: VISUALISATION OF IDEOLOGY ESTIMATES



Notes: This figure visualises the raw ideology scores for all MPs in the 19th legislative period derived from our supervised machine learning model. The figure highlights that the model accurately captures ideology across parties. The distributions of left-wing parties (Left party, Greens, SPD) are to the left of the spectrum, while more right-wing parties (CDU/CSU, FDP, AfD) are to the right of the spectrum.

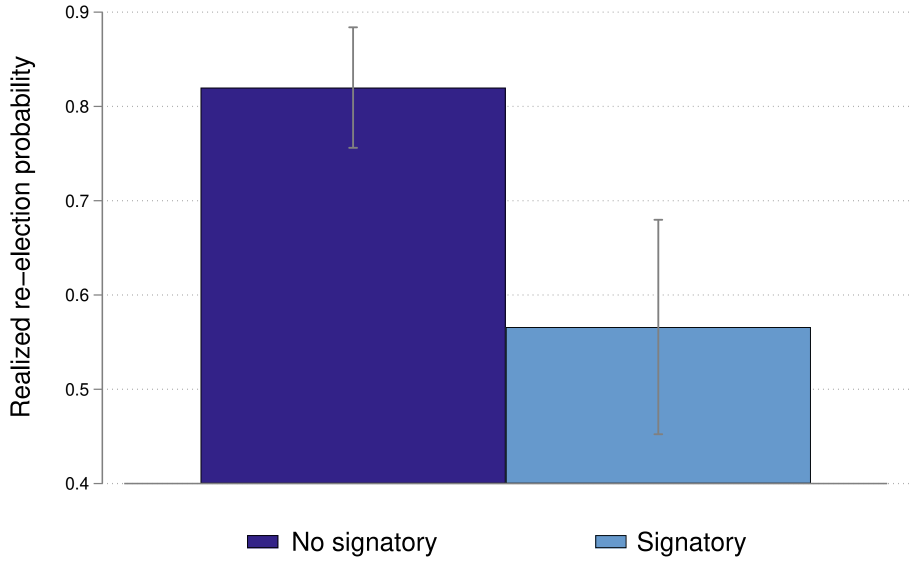
Figure 1.B.5: VALIDATION EXERCISE: PARTY PAIRWISE COMPARISONS

(a) CDU/CSU MPs versus AfD MPs (b) CDU/CSU MPs versus Left MPs



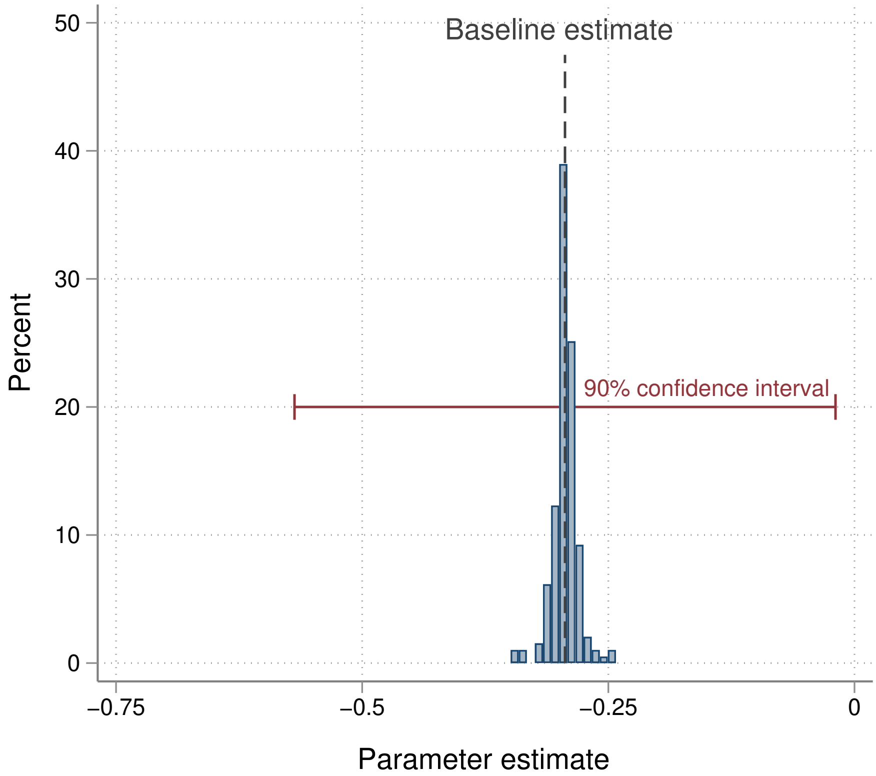
Notes: This figure visualises our validation exercise, in which we restrict the sample in Panel (a) to MPs from the CSU/CDU and the AfD and in Panel (b) to MPs from the CSU/CDU and the Left party. The resulting distributions show that the model can meaningfully differentiate between MPs from the respective two parties.

Figure 1.B.6: REALISED ELECTION OUTCOMES AND SUPPORT FOR RISKIER CANDIDATE



Notes: This figure shows the average likelihood to getting re-elected in the 2021 national elections (ex-post) depending on MPs' support for the riskier candidate.

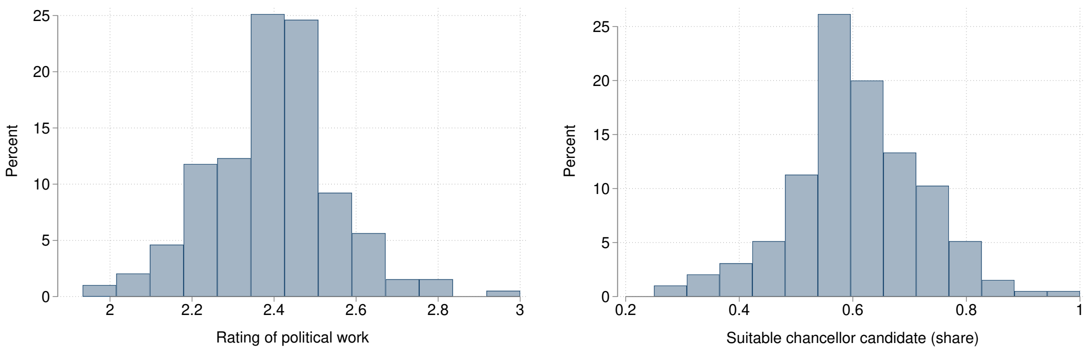
Figure 1.B.7: HISTOGRAM OF PARAMETER ESTIMATES USING JACK-KNIFE REGRESSIONS



Notes: This figure shows a histogram of parameter estimates on the *Polls* variable using jack-knife regressions, where we exclude one MP at a time ('leave-one-out'). The dotted vertical line represents our baseline estimate in Table 1.1, Column (V). All parameter estimates are well within the 90% confidence interval of the baseline estimate.

Figure 1.B.8: DISTRIBUTION OF VOTERS' PREFERENCES ACROSS CONSTITUENCIES

(a) Quality of political work (b) Suitability as chancellor



Notes: This figure shows distributions of our two measurements of voters' preferences. Subfigure (a) displays the distribution of the average rating of the quality of Markus Söder's political work (on a 1-4 scale). Lower values reflect better ratings. Subfigure (b) displays the distribution of the share of survey participants within a constituency who view Markus Söder as a suitable chancellor candidate.

1.C Supplementary Tables

Table 1.C.1: DESCRIPTIVE STATISTICS

Variable	Observations	Mean	Std. dev.	Min	Max
Signatory	195	0.359	0.481	0	1
Poll	195	0.740	0.306	0	1
Ideology	195	0	1	-2.276	4.102
Not-run	195	0.215	0.412	0	1
Vote margin in 2017	195	0.118	0.092	-0.177	0.373
CDU vote share in 1990 (IV)	195	0.441	0.068	0.251	0.700
	MP-level controls:				
Tenure	195	11.581	7.246	1.4	48.4
$Education_{low}$	195	0.154	0.361	0	1
$Education_{high}$	195	0.661	0.475	0	1
$Education_{PhD}$	195	0.185	0.389	0	1
Female	195	0.221	0.416	0	1
Party elite	195	0.164	0.371	0	1
PKM faction member	195	0.662	0.474	0	1
Religious affiliation (1=protestant)	195	0.452	0.499	0	1
Roll-call vote share against party line (in %)	195	0.843	1.243	0	7.477
	Constituency-level controls:				
AfD sec. vote share in 2017	195	0.128	0.058	0.049	0.329
Unemployment rate (in %)	195	6.3	2.0	2.9	15.8
Population density	195	747	1,092	36.8	6,476
Avg. private HHs' income	195	22,654	2,296	16,450	32,099
Political rating	195	2.396	0.160	1.933	3
Chancellor suitability rating (share)	195	0.607	0.115	0.250	1

Notes: This table shows descriptive statistics of the variables used in our empirical analysis. The dummy for the party elite takes the value of one for members of the government (cabinet and parliamentary state secretaries) and for members of the CDU board.

Table 1.C.2: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE - REGRESSION RESULTS ROBUSTNESS: PROBIT MODEL

Dependent variable: Support for Söder	(I) Parsi.	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
	Panel A: Probit Regression Results				
Poll	-0.760**	-1.004**	-1.018*	-1.019*	-1.095**
	(0.336)	(0.450)	(0.547)	(0.551)	(0.536)
$Not\text{-}run \times Poll$	0.132	0.407	1.051	1.045	0.668
	(0.749)	(0.877)	(1.032)	(1.030)	(1.031)
Ideology				0.027	-0.159
				(0.134)	(0.151)
$Not\text{-}run \times Ideology$					0.802*
					(0.413)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195
Pseudo R-squared	0.026	0.228	0.291	0.291	0.313
	Panel B: Marginal Effects				
$Poll_{Running}$	-0.273**	-0.283**	-0.264*	-0.264*	-0.280**
	(0.115)	(0.123)	(0.139)	(0.140)	(0.135)
$Poll_{Not\ running}$	-0.237	-0.179	0.009	0.007	-0.106
	(0.242)	(0.255)	(0.277)	(0.277)	(0.262)
Ideology				0.007	
				(0.035)	
$Ideology_{Running}$					-0.041
					(0.038)
$Ideology_{Not\ running}$					0.160*
					(0.087)
Equal. (p-val)	0.75	0.39	0.01	0.01	0.19

Notes: This table shows the results from estimating Equation (1.4) with a Probit model. The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of $Not\text{-}run$. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD). 'Equal. (p-val)' reports p-values on a Wald test for equality of the estimated marginal effect of $Poll_{Running}$ and the marginal effect of $Poll_{Not\ running}$. Robust standard errors (adjusted for arbitrary heteroskedasticity) are reported in parentheses.

Table 1.C.3: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE - REGRESSION RESULTS ROBUSTNESS: EAST-WEST DUMMY

Dependent variable: Support for Söder					
	(I) Parsimonious	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
Poll	-0.285**	-0.261*	-0.266*	-0.268*	-0.273*
	(0.128)	(0.139)	(0.139)	(0.141)	(0.140)
	(0.229)	(0.210)	(0.215)	(0.214)	(0.213)
Not-run × Poll	0.042	0.035	0.064	0.063	0.013
	(0.290)	(0.273)	(0.280)	(0.277)	(0.270)
Ideology				0.018	-0.010
				(0.031)	(0.031)
Not-run × Ideology					0.160
					(0.098)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
East-Dummy	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195
R-squared	0.034	0.244	0.247	0.249	0.262

Notes: This table shows the results from estimating Equation (1.4) when, instead of using state fixed effects, we control for geographical and cultural differences via a dummy whether the MPs run in East- or West-Germany. The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

Table 1.C.4: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE: MEASUREMENT ROBUSTNESS

Dependent variable: Support for Söder					
	(I) Parsimonious	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
Poll	-0.280**	-0.256*	-0.286*	-0.286*	-0.291*
	(0.129)	(0.140)	(0.169)	(0.169)	(0.166)
Not-run × Poll	0.039	0.041	0.162	0.163	0.094
	(0.286)	(0.272)	(0.309)	(0.310)	(0.309)
Ideology				-0.002	-0.039
				(0.038)	(0.039)
Not-run × Ideology					0.185*
					(0.098)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195
R-squared	0.039	0.247	0.310	0.310	0.327

Notes: This table shows the results from estimating Equation (1.4) when we additionally include the standard deviation of our ideology measurement. The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

Table 1.C.5: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE: ROBUSTNESS COVID-19

Dependent variable: Support for Söder	(I) Parsimonious	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
Poll	-0.275**	-0.281**	-0.293*	-0.294*	-0.299*
	(0.131)	(0.138)	(0.169)	(0.171)	(0.168)
Not-run × Poll	0.039	0.071	0.169	0.165	0.093
	(0.290)	(0.275)	(0.307)	(0.306)	(0.305)
Ideology				0.008	-0.024
				(0.034)	(0.036)
Not-run × Ideology					0.174*
					(0.099)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195
R-squared	0.037	0.252	0.308	0.308	0.323

Notes: This table shows the results from estimating Equation (1.4) when we additionally include measurements for the levels of COVID-19 cases in the constituencies. The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

Table 1.C.6: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE - REGRESSION RESULTS ROBUSTNESS: STATE LIST

Dependent variable: Support for Söder	(I) Parsi.	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
	Panel A: Controlling for 2017 state lists placement				
Poll	-0.285**	-0.260*	-0.301*	-0.302*	-0.306*
	(0.128)	(0.139)	(0.166)	(0.168)	(0.164)
Not-run × Poll	0.042	0.031	0.138	0.135	0.068
	(0.290)	(0.272)	(0.307)	(0.306)	(0.305)
Ideology				0.006	-0.025
				(0.035)	(0.037)
Not-run × Ideology					0.171*
					(0.099)
	Panel B: Controlling for 2021 state lists placement				
Poll	-0.285**	-0.264*	-0.285*	-0.287*	-0.291*
	(0.128)	(0.140)	(0.170)	(0.172)	(0.168)
Not-run × Poll	0.042	0.031	0.149	0.146	0.073
	(0.290)	(0.273)	(0.309)	(0.308)	(0.308)
Ideology				0.009	-0.024
				(0.034)	(0.036)
Not-run × Ideology					0.176*
					(0.098)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
List dummy	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195

Notes: This table shows the results from estimating Equation (1.4) when additionally controlling for whether MPs were placed on state lists in 2017 (Panel A) or in 2021 (Panel B). The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

Table 1.C.7: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE: ACCOUNTING FOR VOTERS' PREFERENCES

Dependent variable: Support for Söder					
	(I) Parsim.	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
Poll	-0.285**	-0.252*	-0.291*	-0.293*	-0.306*
	(0.128)	(0.142)	(0.172)	(0.174)	(0.171)
Not-run × Poll	0.042	0.033	0.152	0.148	0.080
	(0.290)	(0.273)	(0.313)	(0.312)	(0.312)
Ideology				0.010	-0.023
				(0.034)	(0.036)
Not-run × Ideology					0.180*
					(0.099)
Rating Pol. Work		-0.127	-0.013	-0.014	0.033
		(0.197)	(0.196)	(0.195)	(0.196)
Suitable Chancellor		-0.059	0.089	0.095	0.164
		(0.266)	(0.286)	(0.284)	(0.290)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Observations	195	195	195	195	195
R-squared	0.034	0.246	0.307	0.308	0.324

Notes: This table shows the results from estimating Equation (1.4) when accounting for voters' preferences by including (1) voters' rating of Markus Söder political work (lower values reflect more positive ratings) and (2) the share of voters who consider Markus Söder to be a suitable chancellor candidate. The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

Table 1.C.8: DECOMPOSITION OF THE IV-OLS GAP

	Coefficients			Decomposition		
	OLS	IV	IV-OLS	Δ_{cw}	Δ_{tw}	Δ_{me}
Polls	-0.284	-1.057	-0.773	0.220	-0.178	-0.815
	(0.160)	(0.326)	(0.313)	(0.151)	(0.137)	(0.288)
Vote margins	-1.089	-2.074	-0.985	0.010	0.052	-1.047
	(0.489)	(0.619)	(0.513)	(0.281)	(0.072)	(0.480)

Notes: The first column reports the OLS estimate, the second column reports the IV estimate, and the third the OLS-IV gap. The next three columns report the estimates of the covariate weight difference, the treatment-level weight difference, and the marginal effect difference components. By construction, these three components sum to the IV–OLS gap. For computational details on the decomposition see Ishimaru (2024).

Table 1.C.9: PREDICTED WINNING LIKELIHOOD AND CANDIDATE CHOICE: EXTENDED INSTRUMENTAL VARIABLE REGRESSION RESULTS

Dependent variable: Support for Söder					
	(I) Parsi.	(II) + Controls	(III) + State f.e.	(IV) + Ideology	(V) + Ideology Int.
	Panel A: First Stage Regression Results (Poll)				
$Vote\ share_{1990}$	1.923***	1.768***	1.862***	1.852***	1.850***
	(0.363)	(0.368)	(0.336)	(0.331)	(0.333)
	Panel B: First Stage Regression Results (Not-run × Poll)				
$Not\text{-}run \times Vote\ share_{1990}$	2.465***	2.545***	2.211***	2.251***	2.283***
	(0.626)	(0.600)	(0.535)	(0.524)	(0.520)
	Panel C: Second Stage Regression Results				
Poll	-0.874***	-0.695**	-1.146***	-1.157***	-1.162***
	(0.296)	(0.309)	(0.345)	(0.348)	(0.343)
Not-run × Poll	0.759	0.480	1.010	1.031	1.079
	(0.600)	(0.552)	(0.721)	(0.710)	(0.697)
Ideology				0.012	-0.018
				(0.037)	(0.040)
Not-run × Ideology					0.158*
					(0.096)
Constituency controls	No	Yes	Yes	Yes	Yes
MP controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Kleibergen-Paap F-statistic	14.0	12.9	13.7	14.2	14.2
Anderson-Rubin p-val	0.00	0.07	0.00	0.00	0.00
Observations	195	195	195	195	195

Notes: This table shows the instrumental variable results when estimating Equation 1.4 using the CDU's party vote shares in the 1990 national elections and their interaction with the re-election motive as instruments for the re-election probabilities (Poll, Panel A) and their interaction with the re-election motive (Non-run × Poll, Panel B). The specifications in Columns (I)-(V) follow the structure in Table 1.1, and control for the base effect of *Not-run*. MP controls include MPs' tenure, education levels, religious affiliation, general rebel tendencies, gender, PKM faction membership, and a dummy whether an MP has a leading party position (value of one for members of the government and members of the CDU board). Constituency controls include the unemployment rate, households' average income, and the urbanisation rate, and the share of second votes in the previous 2017 national election for the populist right-wing party 'Alternative für Deutschland' (AfD).

1.D Extension: Party List Elections

An institutional feature of the German electoral system is that voters have two votes. The first vote is to elect an MP in their constituency on a First-Past-The-Post basis. The second vote is for a political party at the national level. These second votes are then used to elect MPs from party lists. In Germany, these lists are created at the state level (so we call them 'state lists' in the main text). MPs are chosen so that the proportion of MPs a political party has in parliament is the same as the proportion of second votes it received nationally. With party lists, voters do not choose a specific person: if party X wins n seats through the second vote, then the top n people on its party list are elected as MPs.

We abstract away from state-level party lists and consider a single party list at the national level. We also assume that an MP stands for election *either* in a constituency *or* through the party list. Both are merely simplifications that help to keep the model clean. Allowing both routes simultaneously would make the model more complex without adding insight.[26] This extended model incorporates two new features. Voters now have two votes - the first for the constituency's MP and the second on national party lists. In addition, MPs can either run in a constituency or through a party list. We contend that these features are a useful first-order approximation of the German electoral system.

Agents. There are four types of agents: a unit mass of voters, indexed j, finitely many *First-Past-The-Post* (FPTP) members of parliament (FPTP MPs), $m \in M = \{1, ..., \mathcal{M}\}$, finitely many *party list* members of parliament (list MPs), $n \in N = \{1, ..., \mathcal{N}\}$ and two leadership candidates, $\ell \in \{1, 2\}$. There is one FPTP MP per constituency (also indexed m), and each voter j is assigned to exactly one constituency. For clarity, we will use $i \in M \cup N$ to refer to an MP where separating FPTP and list MPs is not necessary.

Elections and strategies. There are two elections that happen sequentially. In the first, all MPs (both FPTP and list) from party X vote for a leadership candidate. We call this the *leadership election*. In the second, each FPTP MP $m \in M$ stands for election in a single constituency, each list MP $n \in N$ stands for election on the party list, and each voter j casts two votes in her constituency. One is for a FPTP MP

[26]We will see later in this section that MPs' behaviour does not depend on whether they stand for election in a constituency or through the party list. This is at least suggestive that their behaviour would not change much if they were to stand through both routes simultaneously.

(which we call a *first vote*) and one for a national party (which we call a *second vote*). Combined, they form *national elections*. Abstentions are not allowed, and elections for FPTP MPs are by majority rule. Each national party receives a number of list MPs proportional to the share of second votes it received. List MPs are chosen according to the party list, from the top downwards. For simplicity, assume the national elections involve only two parties, the MPs' own party (X) and some other party (Y). Each MP from party X can vote for leadership candidate 1 or leadership candidate 2. So strategies for MPs are $s_m = \{1, 2\}$ for all m. Similarly, each voter can vote for party X, or for party Y in both the first vote and in the second vote. So strategies for voters are $s_j = \{X, Y\} \times \{X, Y\}$. We assume that agents naively vote for their most preferred choice in both leadership and national elections.[27]

Endowments and information. Exactly as in Section 1.2.1 (with all parameters endowed to MPs in Section 1.2.1 being endowed to both FPTP and list MPs), with the following addition: each list MP is endowed with a position on the party list equal to her index. This party list position then induces a threshold $T_n \in [0, 1)$, such that a list MP n is elected if and only if the vote share of party X is strictly larger than T_n.

Preferences. Voter j in constituency m receives the following utility if the MP from party X wins:

$$u_j = Q_m + Q_\ell + \nu_\ell + \epsilon_j, \tag{1.5}$$

and we normalise her utility from the MP from party Y winning to be zero. The rationale for the appearance of Q_m is as in Section 1.2.1. Voter j also receives the following utility if party X wins the overall election:

$$u_j^p = Q_\ell + \nu_\ell + \epsilon_j, \tag{1.6}$$

MPs care about their own re-election and the ideology of their leader. Both of these are specific to individual MPs.[28] But for convenience, we assume the payoff from re-election does not depend on the identity of the leader. This gives preferences:

$$u_i(\ell) = I_{\ell,i} + R_i \cdot Pr(\text{win}|i, \ell), \quad \text{for } \ell \in \{1, 2\}, \tag{1.7}$$

[27] As is standard, this assumes that they never play a weakly dominated strategy.

[28] Note that the electability of individual list MPs does not appear in u_j^p because the voter does not know which MP their vote will help elect.

where R_i is the MP's re-election motivation, $I_{\ell,i}$ the MP's ideological preference for leadership candidate ℓ, and $Pr(\text{win})$ is the probability that she is elected.

1.D.1 Results

As in the main text, voters' decisions are deterministic from their own point of view. Voter j casts her first vote for party X (i.e. for MP m) if and only if $u_j > 0$. And she cases her second vote for party X if and only if $u_j^p > 0$. An obvious implication is that a voter may cast her two votes for different parties.

Whether or not a FPTP MP m wins or loses in the national elections depends on the *median* voter in her constituency - who has $\epsilon_j = 0$ by construction. For a list MP n the problem turns out to be similar. Whether or not a list MP $n \in N$ wins re-election depends on whether the *fraction* of voters who cast their second vote for party X is greater than T_n. Therefore it is the voter at the T_n-th percentile (rather than at the median) who is critical for the list MP. And recall that the CDF of ϵ, $G(\cdot)$ is common knowledge. So the critical voter for list MP $n \in N$ has $\epsilon_j = G^{-1}(T_n)$.

Therefore if ν_ℓ is known, then re-election is deterministic for both types of MPs (FPTP and list). But remember that an MP does not observe ν_ℓ at the point she chooses her leader. So the *perceived* probability of winning for a FPTP MP is $F_\ell(Q_m + Q_\ell)$. And for a list MP it is $F_\ell(-G^{-1}(T_n) + Q_\ell)$. This is the only difference between the types of MPs. Consequently, they make qualitatively identical decisions - the only difference being that a FPTP MP cares about her own electability, Q_m, while a list MP cares about her election threshold T_n. They play identical roles. The following result formalises this discussion.

Proposition 5. *There exists a unique equilibrium where:*
(1) $s_j^* = \{\mathcal{X}(u_j), \mathcal{X}(u_j^p)\}$ *where* $\mathcal{X}(u) = X$ *if* $u > 0$ *and* $\mathcal{X}(u) = Y$ *if* $u \leq 0$,
(2) $s_m^* = 2$ *if and only if* $F_2(Q_m + Q_2) - F_1(Q_m + Q_1) > \frac{1}{R_m}(I_{1,m} - I_{2,m})$,
(3) $s_n^* = 2$ *if and only if* $F_2(-G^{-1}(T_n) + Q_2) - F_1(-G^{-1}(T_n) + Q_1) > \frac{1}{R_n}(I_{1,n} - I_{2,n})$.

Proof. **Part (1)** follows trivially from the assumptions of the model. **Part (2)** is identical to Proposition 1. **Part (3)** Party X's vote share is equal to the probability that a randomly chosen voter j casts her second vote for party X: Vote share$(X) = Pr(Q_\ell + \nu_\ell + \epsilon_j > 0)$. Straightforward algebra yields Vote share$(X) = G(Q_\ell + \nu_\ell)$.[29] This means that list MP n is elected if and only if $G(Q_\ell + \nu_\ell) > T_n$. So $Pr(\text{win}|n, \ell) =$

[29] To see this: $Pr(Q_\ell + \nu_\ell + \epsilon_j > 0) = 1 - Pr(\epsilon_j < -Q_\ell - \nu_\ell) = 1 - G(-Q_\ell - \nu_\ell) = G(Q_\ell + \nu_\ell)$, using the fact that $G(-x) = 1 - G(x)$ by the symmetry of the distribution.

$Pr(T_m < G(Q_\ell + \nu_\ell))$, which rearranges to $Pr(\text{win}|m, \ell) = F_\ell(Q_\ell - G^{-1}(T_n))$. Therefore $u_n(\ell) = I_{n,\ell} + R_n \cdot F_\ell(Q_\ell - G^{-1}(T_n))$. By assumption $s^*_n = 2$ if and only if $u_n(2) > u_n(1)$. Straightforward rearranging then yields the result. □

The similarity between parts (2) and (3) is immediate. The behaviour of list MPs is identical to that of FPTP MPs except that $-G^{-1}(T_n)$ replaces Q_m. Therefore all subsequent results from Section 1.2.2 will apply unchanged. The only thing to note is that $G^{-1}(\cdot)$ is an increasing function (so $-G^{-1}(\cdot)$ is a decreasing function), so comparative statics found for Q_m will be flipped when considering T_n. This is intuitive. A higher threshold for election (due to a lower position on the party list) makes an MP harder to elect: in other words, less electable.

1.E Ideology

1.E.1 Validation of the Ideology Scores

We conduct two exercises to validate the ideology scores derived from our text scaling model. First, we estimate the model for all MPs across all parties. The model accurately captures ideology across parties: the score distributions of MPs from left-wing parties (Left party, Greens, and the SPD) are to the left of the spectrum, while the score distributions of MPs from more right-wing parties (CDU/CSU, FDP, and the AfD) are to the right of the spectrum (see Figure 1.B.4). Second, we perform pairwise comparisons by including label and reference texts only from the CDU/CSU in combination with the Left party or the AfD (both extremes of the ideological spectrum). Even though we reduce the available information, the model continues to meaningfully differentiate between MPs from the two respective parties (see Figure 1.B.5). Further, the correlation of ideology scores for CDU MPs in our baseline model and the pairwise comparisons is strong (0.74 and 0.43). This shows that our model consistently predicts individual ideology scores.

1.E.2 Ideological Alignment: Taking the Model to Data

The model in Section 1.2 works with ideological *alignment* between an MP m and a leadership candidate ℓ, $I_{\ell,m}$. It then finds that the *difference* in ideological alignment, $I_{1,m} - I_{2,m}$, is what matters for MPs' voting behaviour. Working directly with ideological alignment, rather than raw ideology of MPs and leadership candidates separately, is more parsimonious and helps us state the theoretical predictions more cleanly. But only raw ideology, *not* ideological alignment, is available in the data.

Here, we show the one-to-one mapping between raw ideology and the difference in ideological alignment. This demonstrates that using a measure of raw ideology (as we do in Section 1.4) is in fact appropriate given our model.

Let an MP m have a raw ideology $\tilde{I}_m$, and a candidate ℓ have a raw ideology $\hat{I}_\ell$. Then let ideological alignment be defined as $I_{\ell,m} = -(\tilde{I}_m - \hat{I}_\ell)^2$. This gives the difference in ideological alignment as.

$$I_{1,m} - I_{2,m} = -(\tilde{I}_m - \hat{I}_1)^2 + (\tilde{I}_m - \hat{I}_2)^2. \tag{1.8}$$

This shows that the difference in ideological alignment - the object of interest in the theoretical model - is linear in an MP's raw ideology. To see this, simply notice that

$$\frac{d(I_{1,m} - I_{2,m})}{d\tilde{I}_m} = 2(\hat{I}_1 - \hat{I}_2). \tag{1.9}$$

It is clear that this argument extends to any function $I_{\ell,m} = -h(\tilde{I}_m - \hat{I}_\ell)$ that is strictly convex and symmetric about zero. However, in this more general case the difference in ideological alignment will be strictly increasing in $\tilde{I}_m$, but not necessarily linear.

Chapter 2

Economic Voting in Electoral Precincts: Evidence from a Granular Cartography of German Cities

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2.1 Introduction

An extensive literature that spans several decades has found the state of the economy to be an incredibly robust predictor of electoral outcomes. A fundamental question is whether these correlations reflect causal links. Previous evidence mostly comes from two classes of empirical models. The *survey-based* literature uses self-reported information on economic circumstances and voting behaviour to establish a link between the economy and individuals' votes. The *macro-based* literature, instead, relies on observational data aggregated over countries, states, or municipalities. While survey-based approaches are increasingly viewed with scepticism due to biases caused by misreporting, partisan preferences, and other factors, drawing inferences from aggregated macro-level data is subject to ecological biases. Aggregating election results over large geographies also eliminates a substantial fraction of the variation in voting, imposing formidable challenges on empirical designs.

In this paper, we take a new approach to the economic voting literature, exploring the role of the economy on voting decisions at the most disaggregated administrative unit for which official votes are reported: the level of *electoral precincts*. These units cover a contiguous area where all voters go to a single polling station to cast their vote, typically including about 300 to 1,500 people eligible to vote. Exploring economic voting on the precinct-level allows us to unravel the substantial heterogeneity in voting behaviour and in economic circumstances which exist in larger geographies. Our laboratory is Germany, as unlike in many other countries, German precinct boundaries are not politically designed but rather drawn by decentralised authorities without any incentives for strategic manipulation. The disadvantage of this decentralised demarcation is that no central authority (not even the Federal Returning Officer) knows the precise locations of the precincts. In a large-scale data collection project, we collaborated with the local authorities of 354 German cities to establish the most comprehensive and granular cartography of electoral precincts that exists to date. Our German precinct atlas includes the geo-coded boundaries of 23,880 precincts (roughly 40% of all precincts in Germany), covering a rich variation from urban areas to medium-sized and small cities.

We employ our novel data to show that economic circumstances generally have large effects on voting behaviour in electoral precincts. Our identification strategy exploits the momentous shock to incomes brought about by the Covid-19 pandemic. German GDP fell by almost 4% in 2020, initiating the second-largest economic crisis since the Second World War. Importantly, unlike in other crises that are rooted in purely economic factors, a substantial part of the economic crisis following the outbreak of Covid-19 was caused by political attempts to limit the spread of the virus, including production stops, curfews, as well as closings of restaurants and other amenities with human interactions. These policies exerted heterogeneous shocks across industries that were unrelated to the economic situation of the industries before the pandemic. This setting lends itself to a shift-share instrument that relates industry-specific shocks to pre-pandemic industry-shares. For identification, we assume that industry-specific economic shocks are exogenous to each precinct, in line with recent econometric work by Adao et al. (2019) and Borusyak et al. (2022). Intuitively, we think of the industry-specific Covid-19 shock (the shifter) to hit particularly hard in a given precinct when that industry is relatively more important economically for the precinct compared to other industries (the shares). Our empirical setup relates changes in voting between 2017 and 2021 (the elections surrounding the Covid-19 pandemic) to income shocks which materialised over that period and which are instrumented by our precinct-level shift-share instruments. Our design successfully passes a number of checks recently developed to test the exogeneity of shift-share instruments (Adao et al., 2019; Goldsmith-Pinkham et al., 2020; Borusyak et al., 2022). We also account for city-specific resilience against the Covid-19 shock and differentials in local policies by including city fixed effects.

To bring our shift-share design to the data, the first step is to measure industry-shares on the level of precincts. As such data does not exist, we work together with the data science company infas360 to geo-reference all entries in the German Commercial Register (*'Handelsregister'*). Founded in 1820, the register contains details of all tradespeople and legal entities, and also includes the address of each business registered in Germany. Registration is mandatory for all companies as soon as they operate commercially, with heavy fines faced by companies that do not comply with the registration requirement. The geo-referenced version of the trade register allows us to establish a full cartography of companies across precincts that is based on around 1.7 million firms (about 120 firms per precinct). For our baseline specification, we obtain industry-shares by multiplying the number of firms per industry by the industry-specific average firm size in Germany. An important second step of our econometric design is to obtain precinct-specific income levels. We collaborated with the German Federal Employment Agency to obtain a unique dataset of geo-referenced administrative income data on a 1×1 kilometre raster, which we convert into precinct-specific income levels. We find a remarkable degree of variation in income levels and changes during the Covid-19 pandemic across precincts - within and between cities.

Our shift-share instrument is designed to predict 'gross precinct product' (GPP). Differentials between GPP and disposable incomes of individuals living in a certain precinct may arise from commuting flows across precincts. Although for our econometric setting to be biased, it would require that systematically more individuals work outside a specific precinct than within, we also work together with the German Federal Employment Agency to obtain exact information about the location of residence and the workplace of individuals. This allows us to construct a second measure of industry-shares, which is based on the employers of each precinct's inhabitants and which is, hence, robust to commuting.

Our main result is that a negative income shock leads to a redistribution of votes from progressive parties to conservative, market-oriented parties. Our findings imply that in the wake of economic struggles, voters tend to put their trust in parties whose topical priorities and core competencies relate to economic questions. This result is consistent with the idea that economic aspects of policy-making become more important for voters in economically bad times. Our main findings are robust to a series of additional analyses that probe the robustness of our main estimates.

Our results have important policy implications. Recent studies suggest that Western democracies have undergone substantial political changes ending traditional class-based voting (e.g., Gethin et al., 2022). As parties are increasingly competing along socio-cultural lines, it seemed that the relevance of economic matters has continuously decreased for the electorate. The new set of results was, however, obtained in economically calm times. Our estimates suggest that when facing a substantial income loss, economic voting re-emerges as a clear empirical pattern. By exploring the lowest administrative level of voting, we bring the analysis closer to the pocketbook of individuals, while studies using larger geographic regions predominantly reflect sociotropic motives of economic voting. Disentangling individual from societal motives more closely is a promising avenue for future research.

Contribution to the literature. The main contribution of our analysis is to provide the first empirical evidence on economic voting on the level of electoral precincts. By doing so, we connect to several strands of the literature. Our paper connects very broadly to the extensive literature on economic voting. Incumbents could get rewarded for good economic performance during their time in office or they could get punished if the economy did less well than expected (Healy and Lenz, 2014, 2017). This retrospective voting has found mixed evidence in the literature; see Lewis-Beck and Paldam (2000) and Duch and Stevenson (2008) for surveys of previous studies. Others have analysed whether economic developments favour specific parties. Pastor and Veronesi (2020) propose a theoretical model that can explain higher growth rates under Democratic presidencies through voters tending towards the (more risk averse) Democrats during economic crises. What most previous research on the electoral effects of changing economic circumstances has in common is the aggregate level of analysis, for instance, municipalities, counties, or countries (Autor et al., 2020; Dippel et al., 2022). However, a change in economic conditions such as the one resulting from the Covid-19 pandemic does not affect the inhabitants of cities equally but may have very different effects across different parts of the city. Our study, therefore, employs precinct-level data for the largest German cities with an average of 633 voters per precinct and, hence, exploits large within-city heterogeneity.

Secondly, this paper adds to the literature on the electoral effects of economic shocks (see Margalit, 2019, for a survey of the literature). Previous studies examined the extent to which major economic crises caused changes in voting behaviour, such as anti-incumbent voting or populist and nationalist voting (see Guriev and Papaioannou, 2022, for a survey of the broad literature on populism). Evidence for the increased import competition by Chinese firms beginning in the early 2000s shows that this caused increasing political polarisation in the United States (Autor et al., 2020) and also led to a surge in far-right voting in Germany (Dippel et al., 2022). Increasing globalisation in general also has been found to be one driver of support for nationalist and populist parties, one example being the case of Brexit in the United Kingdom (Becker et al., 2017), but also on a cross-country level (Colantone and Stanig, 2018a,b). The experience of more gradual changes in economic circumstances, such as on the housing market or in layoff notices, has also been shown to increase voting for far-right populist parties (Larsen et al., 2019; Ansell et al., 2022; Dehdari, 2022). Our study enhances this literature by examining the electoral effects of the income shock caused by the global Covid-19 pandemic at a fine-grained level, where data was previously unavailable.

Organisation: The remainder of this paper is organised as follows. Section 2.2 presents the data collection and provides first descriptives on the main variables. Section 2.3 explains the empirical strategy and the construction of the instrument. Section 2.4 lays out the estimation results. Section 2.5 concludes.

2.2 Data Sources

This section describes the data sources and provides summary statistics. Our collection of data can be divided into four categories: (1) information on the geographic boundaries of electoral precincts allowing us to geo-locate voting within cities, (2) fine-grained administrative income data that can be mapped to the precincts, (3) a set of precinct-level characteristics which allow to control on observables, and (4) geo-referenced firm-level and employee-firm-level data that we use to construct industry-shares for the precincts. All data is novel and unique in the sense that it has never been employed at such a small geographic level. To achieve this granularity, we closely collaborated with a few hundred local administrations throughout Germany, the data science company infas360, and the German Federal Employment Agency.

2.2.1 Institutional Background

The German federal election takes place every four years. Voters have a first vote to select a candidate representing their constituency and a second vote to determine the party composition of the parliament. There are 299 constituencies, which are approximately equal sized and include on average 202,000 voters. Large cities such as Berlin or Munich are split into more than one constituency, but usually multiple cities are merged into one constituency. While federal and state laws set the regulatory framework, the local administration is responsible for organising and executing federal elections at the city-level. The local administration draws electoral precinct boundaries, sets up polling stations and recruits poll workers. In the 2021 German federal election, there were 66,600 precincts for in-person voting.

Precincts are the most granular level for analysing voting behaviour. The federal election law states that 'no precinct shall contain more than 2,500 inhabitants' and that the number 'must not be so small that it is clear how individuals have voted' (Bundeswahlordnung §12, 2022). Within these boundaries and as long as it serves the purpose of rendering participation as easy as possible, the local administration is free to determine the number and boundaries of precincts (The Federal Returning Officer, 2022). As precincts are set up within the 299 constituencies, they provide no incentives for strategic gerrymandering.[1] Hence, the precincts and their geo-location are only relevant to the respective local administration executing the federal election. While the election results are published at precinct-level by the Federal Returning Officer, the geo-location of precincts is not collected by any governmental institution beyond the individual city.

[1] Voting results from precincts are aggregated to the constituency-level to determine which candidate is elected to parliament. Changing precincts' boundaries, hence, cannot have an effect on relevant voting results.

Cities must alter precinct boundaries when the number of inhabitants grows or decreases beyond the legal boundaries. Changes may also occur voluntarily for administrative or other reasons. For example, due to the Covid-19 pandemic some cities anticipated a shift to postal voting and reduced the number of precincts accordingly. In contrast, other cities increased the number of precincts to split voters over more polling stations and to reduce the likelihood of spreading Covid-19. We employ official documents from the local administration to map the precincts from the 2017 election to the ones from the 2021 election.

2.2.2 Polygons of Electoral Precincts

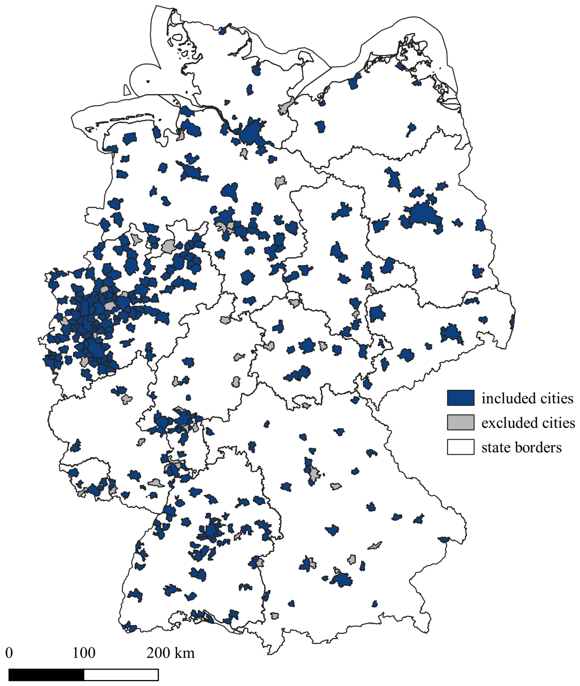
The Federal Returning Officer publishes the election results for each precinct. Due to their purely local relevance, the geo-location of precincts is, however, not centrally collected. The information has to be requested individually from each city. For our data collection project, we approached the 400 largest cities in Germany. In the end, we were able to launch collaborations with 354 cities. Together with local authorities, we compiled and structured three types of information: (i) the geo-location of precincts in 2021, (ii) a mapping to 2017 precincts, and (iii) the location of polling stations in 2021. We obtained largely unstructured data, with the format mostly being Excel spreadsheets containing plain address lists and rarely shapefiles. We next describe how we collaborated with local authorities, cleaned and structured the information, and converted it into digital polygons to establish a comprehensive atlas of German electoral precincts.

2.2.2.1 Collecting precinct information from 354 cities

Over a period of one year, we were in frequent exchanges with local authorities of the 400 largest cities in Germany. We ultimately convinced 354 (almost 90%) to collaborate with us.[2] The 354 cities in our dataset cover all 16 German states. The largest city is Berlin with 3.7 million inhabitants (2,257 precincts) in 2021, the smallest city is Meschede with 29,700 inhabitants (20 precincts). We also include villages with a few hundred inhabitants if they were incorporated into and are now administrated by a larger city. Figure 2.1 illustrates that there is no systematic geographic pattern regarding cities that did and those that did not cooperate with our project. There is also no systematic bias towards smaller or larger cities. Table 2.A.1 in the Appendix

[2] The remaining 46 cities did not provide the requested data. Frequent reasons were: A software update deleting the information, limited personal resources, or the request for a significant payment.

Figure 2.1: THE 400 LARGEST CITIES AND THEIR SPATIAL DISTRIBUTION



Notes: This map presents the location of the 400 largest cities in Germany that we contacted to construct our dataset. The figure differentiates between those cities that we convinced to participate in our data collection (coloured in blue) and those that ultimately dropped out (coloured in grey). The lines in the map refer to the boundaries of the 16 German states, showing that the cities in our dataset are distributed across the entire Germany.

shows how the 354 cities in our dataset are distributed across states and it compares city-level characteristics of our sample to all 400 cities. The average city size in our sample is 109,000 inhabitants, compared to 106,000 inhabitants in the full sample of the largest 400 cities. In total, our dataset covers 23,879 precincts for the federal election 2021. This number corresponds to a share of about 36% of all precincts covering roughly 44% of the German population eligible to vote.

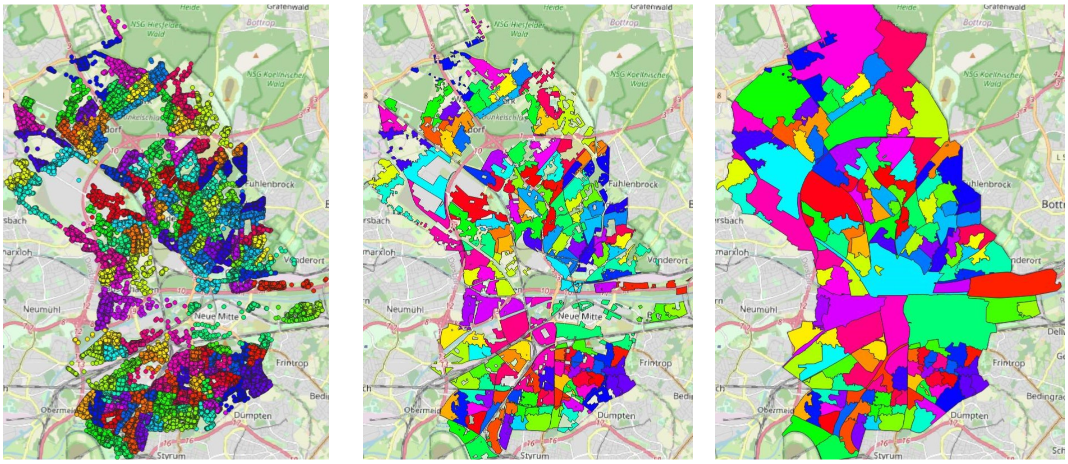
2.2.2.2 Constructing a map

Cooperating cities have provided information in two ways. 87 cities have shared digital maps, shapefiles, generated by their local geo-information office. The remaining 267 cities have sent lists that indicate the name of the precinct for each street (or street and street number combination). To transform these lists into polygons, we have partnered with infas360, a data company specialising in granular geo-statistics. Firstly, the street lists are mapped to the address database of infas360, which is based on administrative data from the Federal Agency for Cartography and Geodesy and which contains all German addresses. These addresses are selected and grouped according to the precincts they belong to (see Figure 2.2a). Secondly, a polygon is formed for each precinct based on the identified addresses (see Figure 2.2b). Thirdly, uninhabited areas without voters, such as forests, exhibition grounds, or football stadiums, are merged to the precinct with which they share the largest border (see Figure 2.2c). The last step improves visualisation but does not impact any household-level variables such as median income because, by definition, these areas do neither contain voters nor households.[3]

Overall, the quality of the process generating the maps is considered to be high. On average, 91% of the addresses with households in a city are identified and grouped into precincts. In addition, for 90% of the cities, more than four-fifths of the addresses are identified. For details, see Table 2.A.2 in the Appendix.

Figure 2.2: CONSTRUCTING A MAP OF PRECINCTS

(a) Identifying addresses (b) Creating polygons (c) Extending polygons



Notes: This figure describes the process followed by infas360 to generate geo-referenced electoral precincts based on lists with street names as provided by 267 cities. The city shown is Oberhausen.

2.2.2.3 Mapping precincts over time (2017 to 2021)

As cities regularly alter their precinct structure, we have to connect the precincts from 2017 to the ones from 2021 to investigate changes in voting behaviour. We have collected further administrative information, which allows us to account for any changes in precincts' boundaries between the two federal elections. This information includes

[3]As many companies are located in uninhabited business districts, the assignment of these areas to specific precincts impacts the industrial share estimated for each precinct. By also constructing the industrial share based on circles and based on the employer of inhabitants, we use two alternative measures which do not suffer from this shortcoming.

the transfer of streets between precincts, the merger of precincts, and the splitting of precincts. Some precincts have also been renamed without experiencing any changes to their boundaries. Overall, only 118 out of the 354 cities in our sample have kept the boundaries for all their precincts constant between 2017 and 2021. For 22 cities with 865 precincts in 2021, it is not possible to map the precincts over time.[4] This is either due to the information not being available or due to major changes which basically link all precincts with each other.

For the remaining 214 cities, we employ an exact matching approach. For example, if streets have been transferred from precinct a to precinct b between 2017 and 2021, we merge these two precincts and calculate the change in voting behaviour for this newly merged precinct. The mapping process reduces the units of observations to 16,946, which is based on 24,165 precincts from 2017 and 23,014 precincts from 2021.[5] It is important to note, however, that we do not lose any information, but only aggregate it. While the average precinct size increases from 446 to 633 voters, applying an exact matching approach allows us to trace out any changes in the voter compositions between 2017 and 2021 resulting from administrative decisions.

2.2.3 Voting Results

We connect the geo-located precincts to the election results from 2017 and 2021 published by the Federal Returning Officer. As is standard, we employ the second vote, which is dedicated to parties rather than to individuals and which determines the number of seats a party is assigned in parliament. To generate a measure for the change in political preferences, we first aggregate the votes over precincts which experienced some form of boundary changes and then estimate the change in vote share between 2017 and 2021.

Connecting to previous work, we first estimate the vote shares (and changes) for the incumbent government of the *grand coalition*, an alliance of the largest and most powerful parties in Germany: the CDU/CSU and the SPD. From 1949 until 2021, these parties held on average a joint share of 80.3% of the parliamentary seats, and every single head of government belonged to either party (see Figure 2.A.1 in the Appendix). Given the unwillingness of other parties to participate in a governing coalition, the grand coalition was pressured to build a government in 2017. With regards to economic policies, however, the differences between the economically left-wing SPD and the right-

[4]Table 2.A.3 in the Appendix provides an overview on the number of observations in our dataset and shows at which part of the data collection process observations were lost.

[5]On average, 1.42 precincts from 2017 are mapped to 1.36 precincts from 2021.

wing CDU/CSU grew over time - as shown by an assessment of the parties' manifestos in 2017 and 2021 (Lehmann et al., 2024). This suggests that within the incumbent government, conflicting political ideologies (and policy platforms) existed on how to overcome the economic challenges posed by Covid-19. Hence, for our main analysis, we will differentiate parties by their political ideologies rather than their incumbency.

To simplify the increasingly fragmented landscape of parties in Germany, we restrict our analysis to parties sitting in the federal parliament and group them according to their political ideologies.[6] We assign the label *Right* to the two market-oriented and economically liberal parties, and the label *Left* to the two state-oriented and redistribution favouring parties. On the edges, we group the two extremist parties under the label *Extreme*. In previous elections, the voters of both extreme parties have primarily desired to express protest rather than support for an economic agenda (King, 2017). This is also evident by the lack of a realistic path into the government, as they have never even been invited to participate in federal coalition talks. The grouping is, in addition, in line with the assessment of the parties' manifestos by Lehmann et al. (2024).[7] When connecting edges, the grouping is similar to the seating order in the German parliament.

While we deliberately target the largest cities, our sample matches overall election outcomes and changes in voting behaviour well. For the six parties in our sample, the average difference between the overall results and our dataset is 2.1 pp. in 2021, 2.0 pp. in 2017, and 1.2 pp. for the change between 2017 and 2021 (see Table 2.A.4 in the Appendix).

Postal voting. Employing a fine-grained measure for changes in voting behaviour comes at the cost of excluding postal voting. As postal precincts have undergone extensive boundary changes in recent years, it is impossible to generate a mapping of postal precincts from 2017 to 2021. Not including postal votes (approx. half the votes in 2021) could bias our estimates if changes in parties' vote shares between 2017 and 2021 were negatively correlated for those votes cast in-person and those cast via post. While there is no intuitive reason for such a pattern, we also address this concern empirically. We first show that across the party spectrum, overall vote shares and

[6] The six parties in our dataset make up a combined share of 94.8% of the votes in 2017 and 91.7% in 2021.

[7] *Right* includes the conservative CDU/CSU and the market-oriented FDP. *Left* includes the social democratic SPD and the environmental Bündnis 90/Die Grüne. *Extreme* includes the right-extreme AfD and the left-extreme Die Linke. The overall scores assigned to the party manifestos in 2021 are: Right (0 and 4), Left (-21 and -24), and Extreme (-36 and 26). With regards to economic policies, the scores are: Right (-3 and -8), Left (-21 and -29), and Extreme (-33 and 0). We connect edges to group extreme parties.

importantly vote changes are well approximated by just employing in-person voting - both at the national-level (see Table 2.B.1 in the Appendix) and at the city-level (see Table 2.B.3). We then construct a mapping of postal and in-person precincts for the election 2021. With this, we can validate the previous findings also for vote shares at the precinct-level (see Table 2.B.5 and Figure 2.B.1). We replicate the analyses for all three levels comparing in-person and postal voting (see Tables 2.B.2, 2.B.4, 2.B.6 and Figure 2.B.2). The high correlation of in-person and postal voting as well as the small differences between in-person and postal vote changes suggest that - if anything - not including postal votes only reduces the significance of our estimates.

Large within-city heterogeneity. Our dataset promises new insights as we observe for the first time the large within-city heterogeneity of voting. On average, the vote share for right parties is 20.1 pp. smaller in the precinct with the lowest compared to the precinct with the highest vote share within the same city. The average within-city difference in the change in the vote share of right parties between 2017 and 2021 is 15.3 pp.. Similar heterogeneity also exists for left and extreme parties (see Table 2.1). The *average* variation in vote shares and changes within cities is larger than the *maximum* variation in voting across states. For example, right parties are strongest in the state of Bavaria and weakest in the city-state Berlin. Comparing the performance of right parties between these two states, the differences are 17.3 pp. in vote shares for the 2021 election and 13.1 pp. in vote changes between 2017 and 2021.

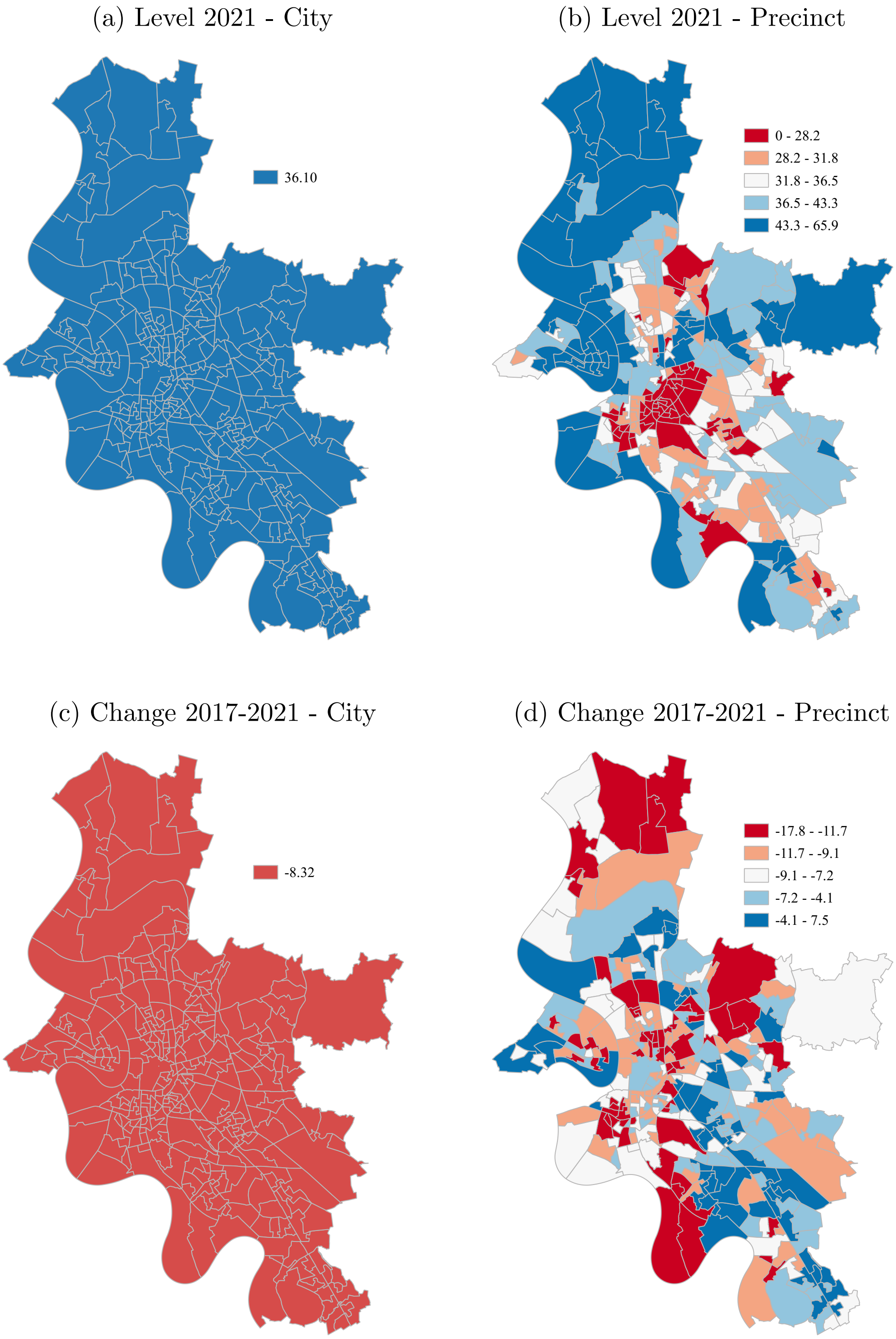
Table 2.1: WITHIN-CITY VARIATION OF VOTING BY PARTY GROUP

	Election 2021			**Changes 2017 to 2021**		
	Largest Δ	Smallest Δ	∅ Δ	Largest Δ	Smallest Δ	∅ Δ
Left	43.1	6.4	17.8	30.1	-11.2	15.5
Right	44.5	6.8	20.1	20.4	-30.6	15.3
Extreme	49.6	0.0	16.7	14.3	-24.4	11.9
Incumbent	63.5	4.8	20.1	22.0	-22.4	15.8

Notes: This table shows the degree of within-city heterogeneity captured in our dataset. For each city, we have estimated the difference between the precinct with the highest and the lowest vote share of each party group and the incumbent government in 2021. Similarly, we have estimated the difference in vote share changes between 2017 and 2021. The table presents the largest, smallest, and average difference for our sample of 332 cities for which a mapping of voting results between 2017 and 2021 is possible. The numbers are based on in-person voting and are for the second vote.

Figure 2.3 illustrates the distribution of precinct-level voting for the city of Düsseldorf, the capital of the most populated German state North Rhine-Westphalia. With roughly 620,000 inhabitants and 309 precincts, it is one of the ten largest German cities. Fig-

Figure 2.3: UNMASKING WITHIN-CITY HETEROGENEITY



Notes: This figure shows the in-person vote share for right parties in the city of Düsseldorf. Panels (a) and (b) show the vote share in the election in 2021 (in %). Panels (c) and (d) show the change in vote share between the elections in 2017 and 2021 (in pp.). As precinct boundaries have not changed between the two elections, for Düsseldorf a one-to-one-mapping is possible. Overall, the vote share of right parties in Düsseldorf is 36.1% in 2021, which is a decrease of 8.3 pp. in comparison to the previous election. More general results on within-city heterogeneity are shown in Table 2.1.

ures 2.3a and 2.3b compare the city-level vote share of the right parties in the 2021 election to granular voting results on the precinct-level. We uncover a substantial degree of heterogeneity across electoral precincts. While in the city centre, the right parties receive only about 15% of the votes, their vote share increases to 66% in the outskirts of Düsseldorf. The city average of 36.1% masks this large heterogeneity in electoral outcomes. Figures 2.3c and 2.3d visualise the change in vote shares between the 2017 and 2021 elections on the city-level and the precinct-level. Again, we find strong heterogeneity across precincts, which would remain hidden when using city-level data. Importantly, at the precinct-level the change in vote shares between 2017 and 2021 in Figure 2.3d is not systematically correlated with the vote shares in 2021 in Figure 2.3b.

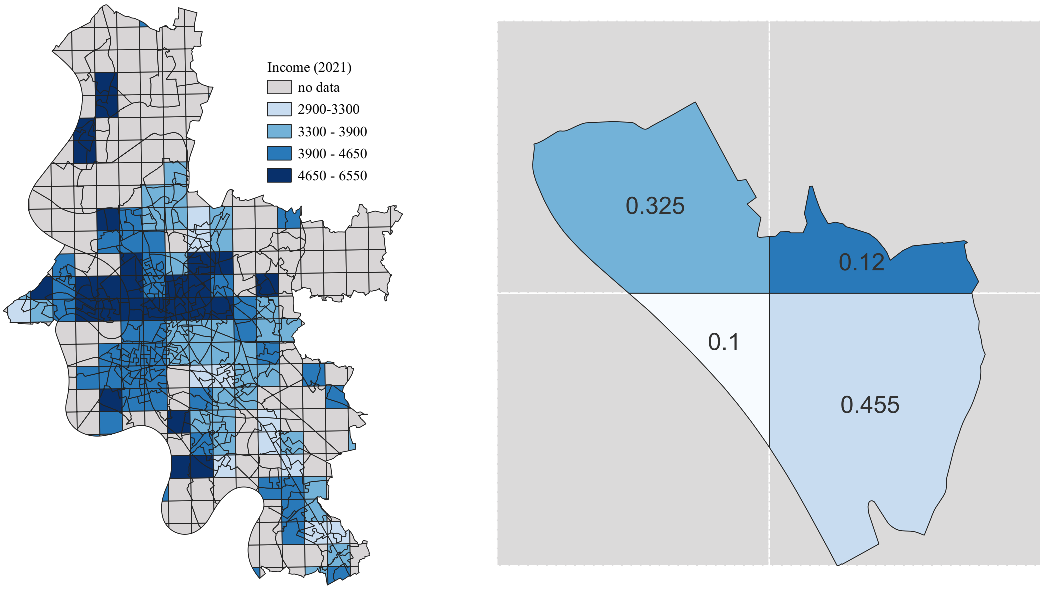
2.2.4 Administrative Income Data

Our variable for income is based on novel grid-level data which we obtained from the German Federal Employment Agency. It measures the gross monthly wages - i.e. before the deduction of taxes and social security contributions - of full-time employees subject to social security contributions. This measure includes all current or one-off income from the main employment up to the contribution assessment ceiling for pension insurance (85,200 Euro in 2021). We observe the *median* gross monthly wage of all working individuals residing in a 1×1 km grid in 2017, 2019, and 2021. Due to strong data protection rules, the German Federal Employment Agency has just started to make such data available and has, in fact, piloted some of their geographic analyses in close collaboration with us.

To transfer grid-level income to the precinct-level, we overlay the grids with our map of precincts to obtain all intersecting geographies. This is shown in Figure 2.4a, again using the city of Düsseldorf as an example. The figure highlights substantial heterogeneity in median income across the city. We calculate the median income for each precinct from the grid-level information by following an area-weighted approach. Figure 2.4b visualises this for an exemplary precinct. The different shades of blue correspond to different grid-level income levels. The precinct is intersected by four different income grids - for each, its share of the precinct's area is calculated. Each grid's income enters the aggregated income at the precinct-level with the respective share of the intersected area. Using a complementary aggregation approach (i.e. just taking the mean of all grid-level intersects), we show that our results are not sensitive to our baseline aggregation rule.

Figure 2.4: CONSTRUCTING PRECINCT-LEVEL INCOME BASED ON GEO-CODED ADMINISTRATIVE DATA

(a) Income at the grid-level (b) Mapping grid-level information



Notes: This figure illustrates our approach to generate precinct-level income based on geo-coded administrative data on a 1×1 kilometre grid-level. Panel (a) shows grid-level income information and electoral precincts for Düsseldorf. Panel (b) visualises how grid-level income is converted into a precinct-level income measure by forming area-weighted averages over all grids that fall within a given precinct. While no income data is available for 141 out of 253 grids in Düsseldorf, these areas are either uninhabited or very sparsely inhabited. Only 2% of the population lives in precincts without income data.

To protect anonymity, income is not available for grids with less than 500 full-time employees subject to social security contributions. Lacking income data, we lose 14.5% of our precincts, which reduces our final dataset to 14,481 merged precincts from 330 cities for which information on both vote and income changes between 2017 and 2021 is available and for which we observe within-city variation. Importantly, the areas for which data protection rules prohibit the use of geo-coded income data are very sparsely populated. For Düsseldof, only 12,800 citizens (about 2% of the total population) live in such precincts.

Variable for income change. We employ the nominal change between 2017 and 2021 to capture median income changes at the precinct-level in the context of the Covid-19 pandemic. This variable covers the income change over the same period as the dependent variable. Table 2.C.1 in the Appendix provides summary statistics of precinct-level income and income changes. For 2021, we find an average precinct-level median income of 3,639 Euro, which varies from 1,109 Euro in the poorest precinct (in Berlin) to 6,700 Euro in the richest precinct (in Frankfurt a.M.). With a standard deviation of 594 Euro, the coefficient of variation is quite large (about 16%). The mean change in precinct-level income between 2017 and 2021 was positive in nominal terms (359 Euro) but negative in real terms (-42 Euro), highlighting that incomes, on average, have decreased between 2017 and 2021 by about 0.1%. We observe rich variation in nominal income changes - ranging from an increase of 184 Euro at the 5th percentile to an increase of 576 Euro at the 95th percentile. Similarly, we observe a rich variation in real income changes, ranging from a decrease of 228 Euro at the 5th percentile Euro to an increase of 171 Euro at the 95th percentile. This does not only suggest that the financial situation of households (and precincts) has developed quite heterogeneously between 2017 and 2021, but it is also in line with households' perception of the effect of Covid-19 on their financial situation, which is discussed in Section 2.3.2.1. To rule out that our results are driven by outliers in the income change, we conduct one robustness check, where we winsorise income levels in 2017 and 2021 at the 5%-level and re-compute income changes.

2.2.5 Additional Precinct-Level Characteristics

Our collaboration with the data science company infas360 provided us with additional precinct-level characteristics to account for the multitude of differences in observable characteristics between electoral precincts. The variables can broadly be grouped into four categories: buildings, amenities, socio-demographics, and polling stations. We observe most variables at two points in time, which allows us to account for their development during the Covid-19 pandemic. The variables are based on seven different geo-located sources and have been calculated for each precinct. An overview of the additional variables is presented in Table 2.2. Below, we provide a short description; a detailed one can be found in the Appendix in Section 2.D.

Buildings. Capturing the building and housing structure within a precinct is informative about the type of neighbourhood its voters are living in. For example, we know which buildings exist within a precinct (e.g. one- to two-party buildings vs. multi-family complexes) and how large the living space of an average household is. These variables are generated from building-level maps provided by the public administrative agencies ZSHH' and 'BKG'. We also measure the wealth composition of a precinct more directly through rent and house purchasing price indices and Gini coefficients. These are based on data from the online real estate broker 'ImmoScout24'.

Table 2.2: OVERVIEW OF PRECINCT-LEVEL VARIABLES

Buildings	**Amenities**	**Socio-demographics**	**Polling stations**
Building type	School	Population density	Distance
Living space	Child care	Household size	Building function
Space inequality	Doctor	Age	
Purchase index	Retirement home	Religion	
House inequality	Pharmacy	Migration	
Rent index	Bank	Education	
Rent inequality	Supermarket	Qualification	
Garden size	Restaurant	Family status	
	Bar	Car segment	
	Bus stop	Car type	
	Train station		
	Recreation area		
	Swimming pool		
	Sport facility		
	Theater		

Notes: For a detailed description of the variables, see in the Appendix Table 2.D.1 for buildings, Table 2.D.2 for amenities, Table 2.D.3 for socio-demographics, and Table 2.D.4 for polling stations.

Amenities. The availability of amenities constitutes a further aspect of neighbourhood quality. Our variables capture the access of inhabitants to various amenities ranging from healthcare over public transportation to entertainment. We calculate the average distance between inhabitants from each precinct to the shortest amenity. To do so, we employ the geo-coded 'points of interest' database which is compiled and maintained by infas360.

Socio-demographics. The socio-demographics of precincts are measured through a rich collection of variables. This includes, for example, population density, age structure, religion, education, and even a classification of cars registered in each precinct. The main sources are the census and micro census from 'Destatis', while the data on cars is from the federal agency responsible for car registrations 'KBA'.

Polling stations. We control for differences in distances to polling stations and the type of building polling stations are set up in. Higher costs of voting associated with a larger distance may lead voters to file their vote via post or to not participate in the election. We have received the exact address of all polling stations in 2021 from the responsible local administrations. This allows to calculate the average distance between the polling station and all addresses within a precinct and to determine whether the building is, for example, a school or a church.

2.2.6 Industry-Shares

Our project is also the first to measure industry-shares on the precinct-level. These shares provide information on the importance of industries for the local economy and, in particular, on how strongly the inhabitants (and voters) of each precinct are impacted by an industry-specific shock. Industry classifications are based on the 21 industries specified in the 'German classification of economic activities' (WZ 2008). The industries are listed in Table 2.E.1 in the Appendix. We follow *two* approaches to calculate fine-grained industry-shares. First, we geo-locate all firms in all cities included in our dataset, match them with our precinct boundaries, and classify them into industries. We then calculate the industry-share for precincts based on the firms located in each precinct. This approach relies on the assumption that a sufficient share of inhabitants works at a firm in close proximity to where they live. Otherwise, a shock to firms in one precinct would have no implications for the inhabitants of that precinct. However, we relax this assumption by calculating industry-shares over all firms within an increasing radius around each precinct. Second, we directly employ information on the employers of each precinct's inhabitants.

Our *first* measure of industry-shares is based on extracting around seven million firm entries from the German Commercial Register (*'Handelsregister'*) as of 2018. The register was founded in 1820 to publicly provide information on tradespeople and their commercial enterprises. Registration at the local court is mandatory for firms as soon as they are operated commercially (*'kaufmännisch'*). The registration includes information on the location and the business segment a firm is active in. We collaborate with infas360 to digitise all entries, match their addresses to our precinct boundaries, and assign entries to industries. This approach provides us with a full mapping of firms operating within Germany to our electoral precincts. Overall, around 1.7 million firms are located in the 14,481 merged precincts which comprise our dataset. The industry-share is calculated for each precinct as the share of its firms belonging to each industry. On average, we observe 120 firms per precinct. To account for commuting and the assignment of uninhabited areas when constructing the maps, we also create alternative industry-shares based on the firms which are located within an up to two-kilometre radius of each precinct. As firm sizes differ between industries, we reweigh industry-shares with the average firm size in each industry.[8] The industry-shares for the firm-based approach are presented in Table 2.E.2 in the Appendix, and their variance across precincts is shown in the following Section 2.3.2 as Figure 2.7b.

[8] The average firm size is the number of active individuals over the number of firms in each industry in 2018. Details are provided in Table 2.E.2 in the Appendix.

Our *second* measure of industry-shares leverages information from around 25 million individual employee-firm matches that existed at the start of 2017. Beyond salaries, the German Federal Employment Agency compiles further detailed administrative information from work contracts between employees and firms. For each full-time employee who pays social security contributions, the agency knows both the home address and the industry that the individual is active in. We work together with the German Federal Employment Agency to obtain exclusive and unique data on geo-coded occupation shares. For each 1×1 km grid, we know how many inhabitants are employed in each of the 21 industries. This is robust to any form of commuting as it even includes the industries of those inhabitants who work in different cities. Hence, this measure directly gauges the exposure of the inhabitants (and voters) of a small area to specific industries. As the data is available for the same grid as income, no observations are lost. The disadvantage of this measure is, however, that originally it is not calculated at the precinct-level and rather has to be re-calculated from the 1×1 km grid level to match our precincts. For this, we follow the approach presented in Figure 2.4b. The industry-shares for the employer-based approach are presented in Table 2.E.3 in the Appendix, and their variance across precincts is shown in Figure 2.E.1.

2.3 Empirical Design

This section describes our empirical setup, which is designed to estimate the causal effect of the economic shock arising from the Covid-19 pandemic on voting in electoral precincts. We employ a shift-share design, which exploits for identification the substantial heterogeneity in industrial composition across precincts and the differentials in industry-level affectedness by the Covid-19 pandemic. We next describe our approach and present evidence of its validity.

2.3.1 Linear Regressions

Our dataset is at the precinct-level and covers data for the German federal election in 2017 and 2021. The main research goal is to test whether an income shock at the precinct-level impacts voting in precincts. More formally, let V_{ic}^p be the vote share for party p in precinct i of city c. Assuming a linear model, we can link this vote share to precinct-level income Y_i via

$$V_{ic}^p = \alpha_c + \gamma Y_i + \mathbf{X}_i \boldsymbol{\beta} + \varepsilon_i, \tag{2.1}$$

where $\mathbf{X}_i$ is a matrix that includes an array of precinct-level characteristics. By including city-level fixed effects α_c, we compare precincts of a particular city with other precincts in that city to eliminate systematic differentials across cities. Such differentials include, for instance, the size, wealth and geographic location of cities.

In the linear specification in levels of Equation (2.1), the estimated parameter $\hat{\gamma}$ returns the average relation between the income level of precincts and the vote share for party p. This specification largely reflects long-term relationships that might be historically grown. For instance, a positive relation between a higher precinct-level income and vote shares for economically liberal parties might suggest that citizens in richer neighbourhoods traditionally vote for more market-oriented policies.

To examine how a short-run shock to incomes relates to voting behaviour, we re-specify Equation (2.1) in *changes*, linking changes in income caused by the pandemic in the years 2020 and 2021 to changes in vote shares between the German federal elections of 2017 and 2021 via

$$\Delta V_{ic}^{p} = \alpha_c + \gamma \Delta Y_i + \mathbf{X}_i \boldsymbol{\beta} + \varepsilon_i. \tag{2.2}$$

In this specification, the city-level fixed effects account for city-specific developments between 2017 and 2021, e.g. city-specific policies and measures taken to tackle the spread of Covid-19. Under strong identification assumptions, estimates for the parameter γ reflect a causal effect of precinct-level changes in income on changes in voting behaviour. The key assumption in this case would be that there are no unobserved factors that correlate simultaneously with changes in incomes and changes in vote shares at the precinct-level. This assumption is largely implausible, given that there might be unobserved shocks that affect both incomes and voting (e.g. migration flows or the establishment of new amenities and public goods).[9] We next describe how our empirical strategy is designed to tackle these confounders.

2.3.2 Shift-Share Instrument for Economic Shock

The OLS specification of Equation (2.2) is likely to produce biased estimates given an array of potential confounders. We address this issue by designing a shift-share instrument that isolates exogenous variation in income changes due to differentials in the affectedness by the Covid-19 shock. Our empirical design rests on two key ingre-

[9] Reverse causation should be less of an issue given that the income changes we examine have materialized *before* the federal election of 2021.

dients: (i) The Covid-19 shock, which struck in early 2020 without warning and which heavily affected production and incomes in large parts of the world, and particularly also in Germany. (ii) The large heterogeneity in how strongly industries have been affected by the Covid-19 shock. We next describe these two ingredients and the source of identifying variation in detail, and then formalise the construction of our shift-share instrument.

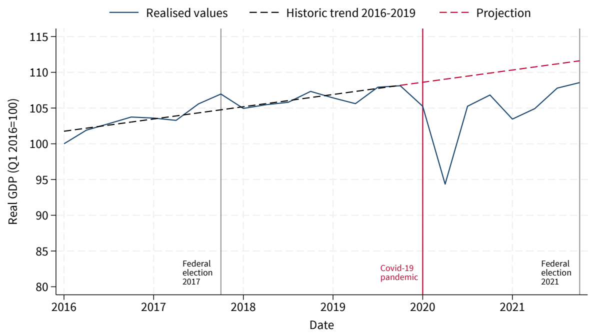
2.3.2.1 The Covid-19 shock in Germany

In early 2020, the Covid-19 pandemic hit the globe. To reduce infections and stabilise the health sector, the German federal government initiated a first lockdown between March and May 2020. In this period, citizens were allowed to meet only one person outside their household and were asked to (and also forced to) work from home. Further, shops, schools, restaurants, and also production plants had to close. According to the Oxford COVID-19 Government Response Tracker (OxCGRT), which records and quantifies policy responses to Covid-19, the German measures to contain the virus were among the most stringent on the planet (Hale et al., 2021). A second lockdown was implemented from late 2020 until May 2021, after infections had started to rise again dramatically. The federal election in 2021 occurred at a time when some restrictions were still in place and the economy had not yet recovered.

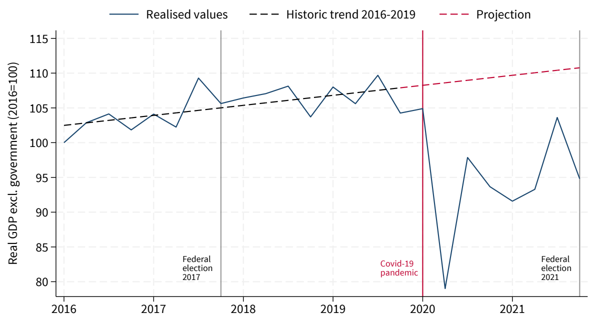
During the pandemic, German companies have suffered substantially from national containment policies. Also, given the German economy's large dependency on exports, the heavy distortions in international trade, as well as global value and supply chains, were particularly harmful for German firms. While macroeconomic recessions usually arise from flaws within the economic system (e.g. the dotcom crisis of 2001 or the financial crisis of 2007-2008), the Covid-19 shock was a truly exogenous shock to the German economy and its industries. It hit at a time when Germany had experienced a decade of strong growth, with an average annual real increase in GDP between the financial crisis and the start of the Covid-19 pandemic of 2.0%. In response to the outbreak of the pandemic in 2020, German real GDP abruptly fell by 3.8% that year (see Figure 2.5a). This strong decline was unexpected and independent of endogenous economic forces. In October 2019, the IMF predicted the German economy to grow by 1.2% in 2020. Hence, the economic recession caused by the Covid-19 pandemic decreased German GDP by about 5% compared to a counterfactual Germany without a pandemic. A back-of-the-envelope calculation based on these numbers suggests that the real GDP loss in 2020 amounted to approximately 175 billion Euro in total, equivalent to 2,100 Euro per capita. Excluding government spending, the economic decline is even more pronounced (see Figure 2.5b). As a result, real incomes in Germany decreased sharply in 2020 - after significant increases in the years before the pandemic (see Figure 2.5c).

Figure 2.5: GERMAN ECONOMIC DEVELOPMENT DURING THE PANDEMIC

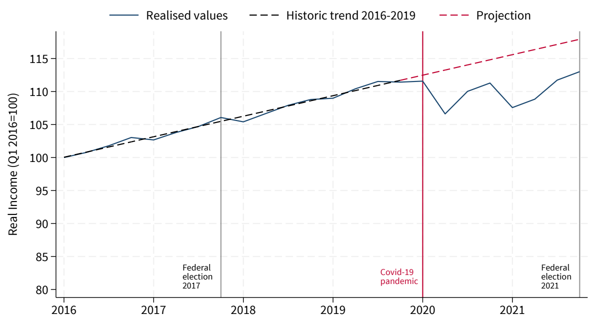
(a) Real GDP



(b) Real GDP excluding government spending



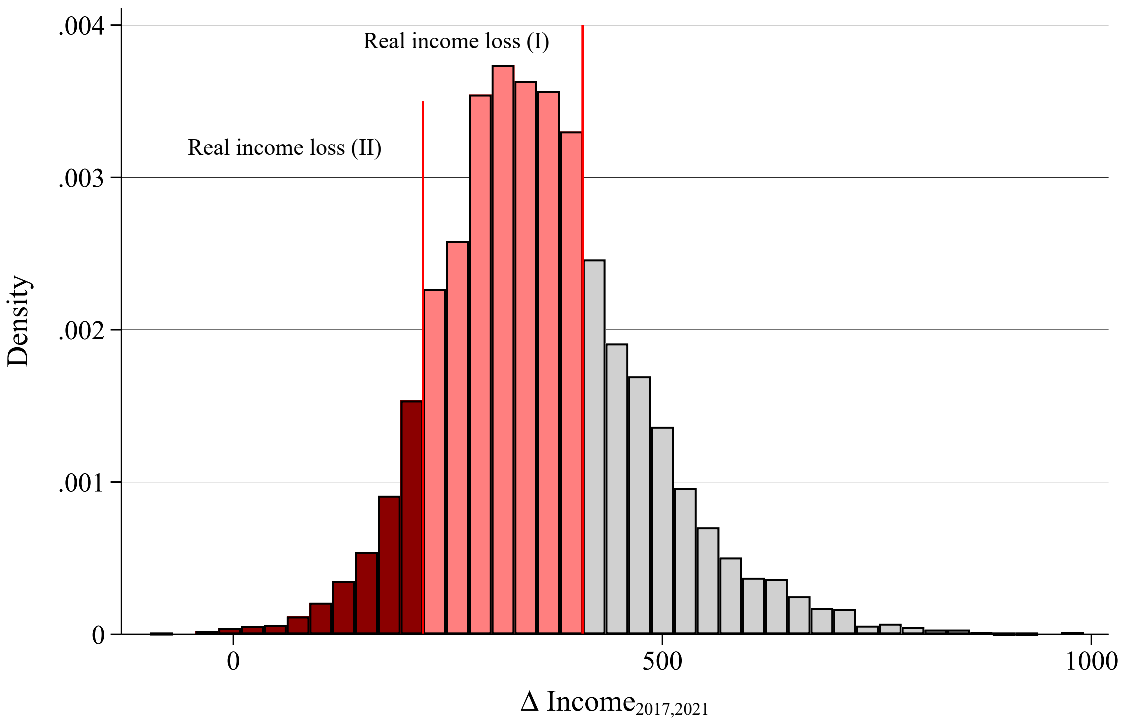
(c) Real labour income



Notes: This figure shows the development of indexed economic indicators from 2016 to 2021: Real GDP in Panel (a), real GDP excl. government spending in Panel (b), and season-adjusted real income in Panel (c). The index is set to 100 for Q1 2016. In Q1 2020, the WHO classified Covid-19 as a pandemic, and the first lockdown was implemented in Germany. For illustration purposes, the historical trend for economic indicators is estimated for the period from 2016 to 2019. The projection is based on this historic trend and starts in 2020. The federal elections happened in Q3 2017 and Q3 2021. Data is based on the national accounts of the federal government ('VGR des Bundes') from the Federal Statistical Office.

Spatial variation in the economic effects of the shock. A remarkable feature of the economic shock initiated by the outbreak of Covid-19 is that it caused substantial heterogeneity in income changes between 2017 and 2021. These differentials are particularly pronounced on the precinct-level. Figure 2.6 shows the distribution of nominal income changes across precincts, with the colours of the bars reflecting whether precincts experienced a decline in real incomes (dark red), a downward adjustment from the previous growth path of average real income (light red), or an upward adjustment from the previous growth path of average real income (grey).

Figure 2.6: DISTRIBUTION OF INCOME CHANGES ACROSS PRECINCTS



Notes: This figure shows the change in median gross wages between 2017 and 2021 for the 14,481 merged precincts from our main analysis. Dark red indicates that the majority of precincts within one bar has experienced a decrease in real median wages. As a comparison, we employ the German consumer price index, which increased by 7.0% during this period. Light red indicates that the majority of precincts within one bar experienced a real median income growth between 2017 and 2021, which was lower than the average growth experienced between 2013 and 2017. As a comparison, we employ the real median wage growth of 4.9% for the previous four-year period, which implies that median wages between 2017 and 2021 would have to grow by 12.2% ($1.07 \times 1.049 - 1$). While nearly all precincts have experienced an increase in nominal median wages, the period between 2017 and 2021 marks for 66.8% a downward adjustment from previous income growth path (light red and dark red) and for 10.9% a loss in real income (dark red).

The figure shows that there is substantial heterogeneity in the effects of the economic recession following the Covid-19 pandemic, both in nominal and in real terms. While nominal income increased in almost all of the precincts, for 66.8% of the precincts median incomes deviated downwards from the previous growth path. The differentials in income changes are significant, providing rich variation that we can exploit in our empirical setup. There is wide and convincing evidence that the (real) income losses were noticed by households already at that time. In various surveys conducted in 2020 and 2021, between 30% and 40% of the surveyed households indicated that they experienced a worsening of their financial situation or a decrease in their income during the pandemic (IAB, 2020; Forschungsgruppe Wahlen e.V., 2021; Hans-Böckler-Stiftung, 2021; Deutsche Bundesbank, 2023).

2.3.2.2 Industry-specific shocks

A major reason for the differential in income shocks across geographic units is that the economic effects of the Covid-19 shock varied largely between industries. Hence, the shock impacted households' (and, therefore, voters') income differently depending on their industry affiliation. Figure 2.7a displays percentage changes in industry-level GDP between 2019 and 2020, comparing the first year of the Covid-19-pandemic with the last pre-pandemic year. The figure underscores two important empirical regularities. First, there has been a strong decline in output in most industries in response to the pandemic. Second, there is substantial heterogeneity between industries in the degree to which production was cut back by the pandemic. While the manufacturing sector, accommodation and food services, as well as arts and entertainment industries have been particularly affected by Covid-19, sector-specific output rose in financial industries and in agriculture and mining. These differentials are largely caused by differences in the affectedness by Covid-19 measures and the potential to work from home (Alipour et al., 2021, 2023).

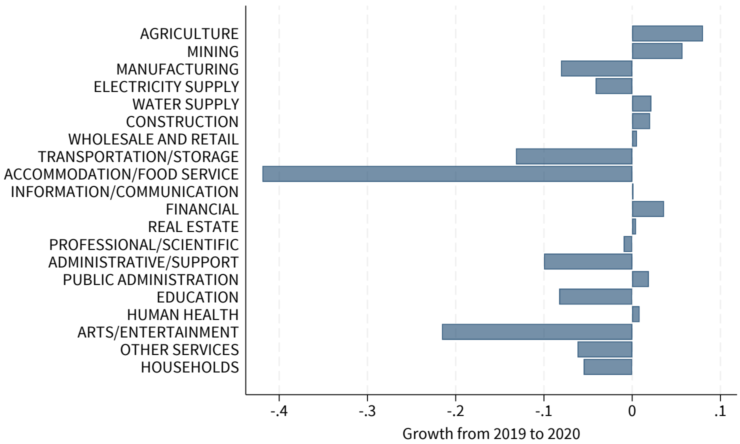
Figure 2.7b shows the distribution of industry-shares across precincts. Importantly, a variety of industries play a key role for the local economies of the urban and mid-sized cities in our sample. This suggests that economic conditions are not driven by one particular industry. In addition, we observe large heterogeneity in the industry-shares between the precincts, which is required for our empirical shift-share instrumental strategy.

2.3.2.3 Construction of the instrument

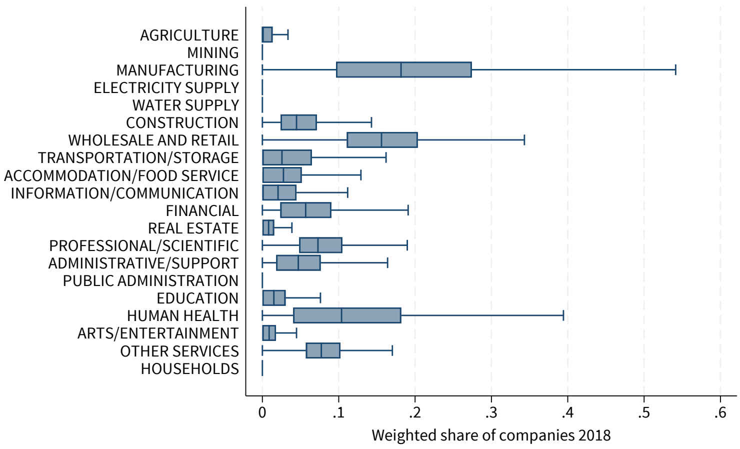
The sharp economic downturn due to the Covid-19 pandemic, the differences in industry-specific GDP growth, and the resulting heterogeneity in income changes at the precinct-level motivate the construction of our instrumental variable design. We adopt a shift-

Figure 2.7: SHIFT-SHARE INSTRUMENT: GROWTH AND SIZE OF INDUSTRIES

(a) Nation-wide shifter: GDP growth by industry from 2019 to 2020



(b) Precinct-level shares: Distribution of industry shares in 2018



Notes: This figure shows the two components of our shift-share instrument. Panel (a) shows nation-wide industry-specific GDP growth from 2019 to 2020. A detailed list of the industries is included in the Appendix in Table 2.E.1. Panel (b) shows a box plot of the variation of industry-shares based on firm locations at the precinct-level in 2018. Industries are re-weighted accounting for average firm size. A similar figure for our second measure of industry shares is shown as Figure 2.E.1 in the Appendix.

share instrumental set-up, which has originally been developed to identify the effect of employment growth on economic growth (Bartik, 1991; Blanchard and Katz, 1992; Bartik, 1994) and which has quickly expanded to a large set of empirical applications (e.g., Card, 2001; Acemoglu and Linn, 2004; Autor et al., 2013, 2020). Given the increasing popularity of shift-share approaches, a growing literature in econometrics has offered guidance on how to specify estimators based on shift-share instruments (e.g., Adao et al., 2019; Goldsmith-Pinkham et al., 2020; Borusyak et al., 2022).

Our setting resembles a classical version of the traditional shift-share design. Let us conceive the Covid-19 shock as a wave that washes over the land. The adverse effects of that wave are greatest where the locks are weaker. In this analogy, the wave is the exogenous industry-specific shock determined by the outbreak of Covid-19 (the 'shift' factor of our instrument). The locks are the pre-pandemic industry-shares (the 'share' factor of our instrument) that determine resilience and susceptibility to the shock.

Formally, our pre-treatment industry-shares (in period 0) consist of two elements: The number of firms per industry k in precinct i, W_{ik}^0, and the total number of firms in that precinct, W_i^0. To account for the relative importance of industries, we weight W_{ik}^0 by average firm size. This design allows us to distinguish smaller bakeries, restaurants, or bars from larger production plants in the manufacturing industries. The precinct-specific shares are then constructed by relating the number of firms in each industry to the total number of firms, W_{ik}^0/W_i^0.

The global shifter in our setting is the national change in gross value added of industry k in response to the Covid-19 shock, denoted by ΔY_k. Borusyak et al. (2022) show that the assumptions for identification can be relaxed when this shock is designed in a leave-one-out specification, i.e. when the industry-specific shock to precinct i is computed based on the change in production computed over all firms in industry k, but leaving out the firms in precinct i. While such a design is not feasible in our setting due to data limitations, the contribution of each precinct to the nationwide industry-specific shock is negligible, given that there are almost 67,000 precincts in Germany.

For our instrument, we combine the share-part and the shift-part. The instrument for income changes in a given precinct is the weighted sum, by industry, of the average change in production multiplied by the precinct's pre-treatment industry-share

$$Z_i = \sum_{k=1}^{K} \left(\frac{W_{ik}^0}{W_i^0} \times \Delta Y_k \right). \tag{2.3}$$

Intuitively, the instrument can be interpreted as the inverted *treatment intensity* of the Covid-19 shock, where lower values (or larger negative values) indicate that a precinct's economy has been hit harder by the Covid-19 pandemic. To facilitate the numerical interpretation of our instrumental variables, we standardise Z_i to mean zero and variance one. The corresponding first-stage equation for the economic shock is

$$\Delta Y_i = \alpha_c + \rho Z_i + \mathbf{X}_i \boldsymbol{\phi} + \zeta_i, \tag{2.4}$$

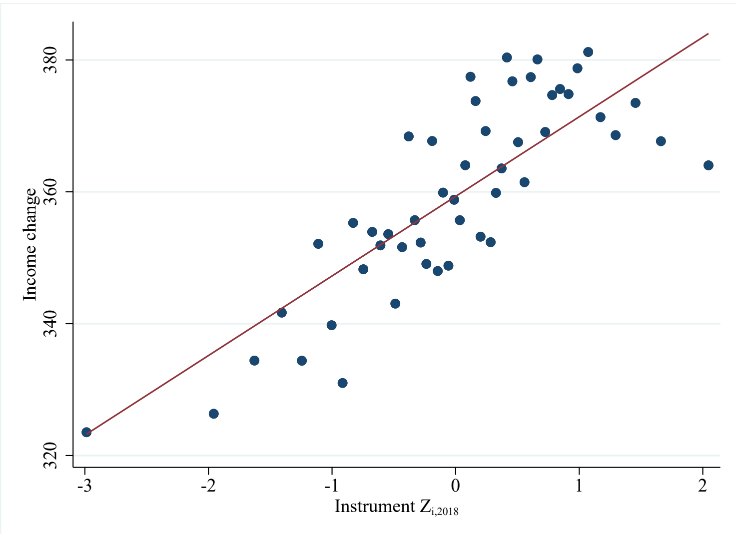
where Z_i is our shift-share instrument constructed according to Equation (2.3).

2.3.2.4 First stage

For our shift-share approach, we expect that the first-stage effect of the instrument on precinct-level income is positive (i.e. $\rho > 0$), as having high previous shares of sectors that developed positively throughout the shock should raise incomes in precincts and vice versa.

Figure 2.8 visualises our first-stage regression results. As expected, the effect of our instrument is positive and statistically significant at the 1% level. For our main specification, we obtain a Kleibergen-Paap F-statistic of 16.5. Taken together, the first stage relationship of our empirical set-up provides a convincing indication that our shift-share design delivers a strong instrument for precinct-level income shocks in response to the Covid-19 pandemic.

Figure 2.8: FIRST-STAGE RESULTS: IMPACT OF SHIFT-SHARE OUTPUT SHOCKS ON PRECINCT-LEVEL INCOME



Notes: This figure visualises the first-stage regression results of Equation (2.4) based on a binned scatter plot between the shift-share instrument (x-axis) and precinct-level nominal income changes (y-axis). City fixed effects are absorbed.

2.3.2.5 Exclusion and exogeneity

The econometric literature on shift-share designs broadly distinguishes between two general approaches for identification. The first approach assumes that the pre-treatment *shares* are as good as randomly distributed, conditional on fixed effects and control variables (e.g., Goldsmith-Pinkham et al., 2020). In our setting, this would require that the industry-composition is uncorrelated with changes in voting behaviour, conditional on city fixed effects, i.e.

$$\mathrm{E}\left\{\frac{W_{ik}^{0}}{W_{i}^{0}} \times u_i | \alpha_c, \mathbf{X}_i\right\} = 0, \forall k, \tag{2.5}$$

where u_i denotes the error term of the reduced-form regression. In order for this assumption to be fulfilled, it is not required that industries are randomly distributed across cities (which is unrealistic given, for example, agglomerations in the automotive industry in Stuttgart, Wolfsburg, or Munich), but the location of industries within cities should be uncorrelated with changes in voting between 2017 and 2021. Still, Equation (2.5) is a relatively strong assumption in our setting.

The second approach in designing shift-share instruments relies on exogenous *shifters* (e.g., Adao et al., 2019; Borusyak et al., 2022). The key identifying assumptions in this type of model are arguably weaker, as the exclusion restriction follows from the shifter rather than from industry compositions, which are often historically grown. For identification, it is required that the global shifter is uncorrelated with changes in vote shares, with no additional requirement imposed on pre-pandemic shares. In our case, the requirement would be that the economic shock in response to the outbreak of Covid-19 is uncorrelated with exposure-weighted average of potential outcomes

$$\mathrm{E}\left\{\sum \frac{\Delta Y_k}{n} \times u_i | \alpha_c, \mathbf{X}_i\right\} = 0, \forall k. \tag{2.6}$$

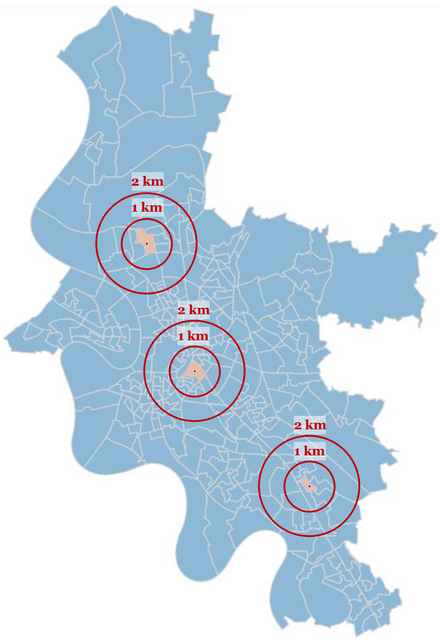
Conditional on city fixed effects, it is very plausible to assume that this requirement is fulfilled, as shocks are allowed to be correlated with exposure-weighted averages of precinct-level unobserved factors (Borusyak et al., 2022).

In line with the guidelines offered by the recent econometric literature, we take several steps to assess the validity of using Z_i as an instrumental variable for Y_i. For brevity, we report those results in Section 2.E. First, to rule out that the shift-share instrument is driven by single industries, we run leave-one-out regressions (see Figure 2.E.2). In each iteration, we omit one industry at a time when calculating our instrument. Our findings are not sensitive to this validity test. Second, we run balance tests on the precinct-level by regressing our instrument on precinct-level characteristics. In Table 2.E.4, we show that the instrumental variable is not significantly correlated with any of these characteristics.

Spillovers across precincts. A key identification issue relates to spillover effects. Industries and firms in neighbouring precincts might impact income changes in a given precinct, particularly through individuals commuting between precincts. In order for our strategy to be valid, individuals in a given precinct should not systematically be more likely to work in a specific other precinct of the city. As long as a randomly drawn individual from a precinct has the highest probability to work in that specific precinct (and not in a certain other precinct), potential spillover effects should be second-order to the main effect of the instrument.

We take two important steps to evaluate the potential impact of spillover effects on our instrument. First, we consider circles of various sizes around the precinct centre and construct our instrumental variable for that precinct based on all firms within this broader geographic unit.[10] This strategy is motivated by the idea that even if individuals do not work in the precinct they live in, many still choose their home close to their workplace to minimise commuting costs and time. Figure 2.9 illustrates our approach exemplary for the city of Düsseldorf. To test robustness to accounting for firms outside the precinct, we employ circles with radii varying from 0.5 kilometres to 2 kilometres.

Figure 2.9: INDUSTRY-SHARES WITHIN COMMUTING CIRCLES



Notes: This figure visualises our approach to account for both commuting and the allocation of uninhabited areas in our geospatial design. We draw circles with a radius of 0.5 km to 2 km around the centroid (geographic centre) of precincts and calculate the industry-share of firms within these circles. The approach is illustrated for three precincts in the city of Düsseldorf. For visual reasons, only radii of 1 km and 2 km are shown.

[10]For each industry, we sum the number of firms in precincts which are intersected by the circle.

Our first approach to account for between-precinct spillovers caused by commuting maintains the geographic structure of our dataset. A remaining empirical challenge is that the instrument potentially also includes an increasing share of firms that are irrelevant for income in one specific precinct - especially when modelling circles with large radii. The first-stage relationship should, hence, weaken with increasing circle size. As a second approach, we construct our shift-share instrument based on the occupation structure of precincts retrieved from social insurance data. We obtain this data in a unique collaboration with the German Federal Employment Agency, as such information is not publicly available in Germany due to data protection. The most fine-grained data we can obtain without violating data protection regulations is on a 1×1 kilometre grid. We convert this data to precinct-level by forming the area-weighted average over all grids that fall into a precinct.

Mapping of industries. Our two strategies to account for spillovers also allow us to tackle a related challenge regarding the precise matching of firms to electoral precincts. When mapping the geo-referenced firm data from the Commercial Register to precincts, uninhabited areas are a special case. Often, such areas are not important for our empirical design, as they mostly cover forests, parks, or fields. To the extent that uninhabited areas also include firms, however, our matching process might distort the precinct-level industry-shares. This is because we matched uninhabited territory to those precincts with which they share the largest border when we constructed our atlas of precincts (see Section 2.2.2.2). By also considering two alternative approaches to estimate precincts' industry-shares that are both unaffected by this issue (i.e. counting firms within larger circles and employing occupation data), we can test the robustness of our matching approach.

2.4 Main Results

This section provides our main empirical results. We start with the traditional economic voting hypothesis. We then present our main results that distinguish between parties' political ideologies. Our baseline specifications are complemented by an array of additional results to inspect the robustness of our empirical design. Importantly and consistent with our argument that only by unmasking the within-heterogeneity of larger geographic units the 'true' underlying economic voting effect can be estimated, we show that results are much more distinct on the precinct-level compared to the municipality-level.

2.4.1 Incumbent Voting

The classical economic voting hypothesis argues that voters reward incumbents for a good economic performance and punish them in times of economic crises. We therefore start our analysis by examining the effect of the economic downturn provoked by the Covid-19 pandemic on incumbent voting.

In Table 2.3, we report our baseline results on the effect of changes in standardised income in response to the Covid-19 pandemic on the vote share received by the incumbent government. We observe a positive coefficient, which is consistent with traditional theories on economic voting, stressing that a favourable development of income in an electoral precinct increases the vote share of the incumbent parties. However, the effect does not turn out to be statistically significant. This does not necessarily mean that economic circumstances are not important for voters on the ballot. Rather, it could also be the case that these average effects mask heterogeneities in voters' reactions to the existing conflicting political ideologies within the incumbent government.

Table 2.3: RESULTS: INCUMBENT VOTING

	(1) $\Delta_{2017,2021}$ **Incumbent Vote Shares**
Panel A: Second stage regression results	
$\Delta_{2017,2021}$ Standardised income	0.0145
	(0.0130)
Observations (# of electoral precincts)	14,481
City FE	Yes
Controls	No
Mean dep. var.	-0.035
Kleibergen-Paap F-Stat. (first stage)	16.49
Panel B: First stage regression results	
Instrument Z_i	0.0379***
	(0.00933)
Observations (# of electoral precincts)	14,481

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote share of incumbent parties between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Our results so far are consistent with our main hypothesis described in Section 2.2.3 that it should be the political ideology of political parties regarding economic policies that matters most in times of crisis. The German government during the Covid-19 pandemic was formed as a *grand coalition*, an alliance between the two largest parties in Germany: The economically left-wing SPD and the economically right-wing CDU/CSU. This implies that within the incumbent government, conflicting political ideologies existed on how to overcome the economic challenges. Hence, to fully understand the economic voting effect and the role of political ideology, we need to disentangle incumbent voting from voting for different political ideologies.

2.4.2 Political Ideology

In this section, we present our main results on the effect of the income shock created by the Covid-19 pandemic on vote shares for parties with different political ideologies.

Table 2.4 presents our main results on the effect of the income shock caused by the pandemic on voting for economically left-wing and right-wing parties.[11] The table shows estimates for changes in vote shares at the election in 2021 compared to 2017 for state-oriented and redistribution-favouring parties (Left), market-oriented and economically liberal parties (Right), and extremist parties (Extreme).[12]

We find that a change in economic circumstances is important for voters at the ballot and that income shocks result in a reallocation of votes between parties with different ideologies. Our main result is that vote shares of left-wing parties increase with higher income gains. At the same time, voters tend to vote less for right-wing parties if the economic development has been favourable.

The robust effects of changes in economic circumstances on voting behaviour are economically meaningful in their size. We estimate that an average increase in our standardised income growth variable by 0.038 (the approximate increase caused by a one-standard-deviation change in the standardised shift-share instrument) increases vote shares for left-wing parties in the 2021 election by about 0.38 percentage points relative to the 2017 election. Again, this means that a respective *decrease* in income during the Covid-19 crisis has the opposite effect, i.e. it decreases votes shares of economically left-wing parties. Our estimates imply that the votes lost by economically left-wing parties go almost equivalently to the more market-oriented parties (an increase

[11]For comparison, benchmark OLS results for party group voting are reported in Table 2.F.1 in the Appendix.

[12]*Right* includes the conservative CDU/CSU and the liberal FDP. *Left* includes the social democratic SPD and the environmental Bündnis 90/Die Grüne. *Extreme* includes the right-extreme AfD and the left-extreme Die Linke. For a detailed discussion see Section 2.2.3.

Table 2.4: MAIN RESULTS: PARTY GROUP VOTING

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0991***	-0.0806***	0.00438
	(0.0245)	(0.0201)	(0.00925)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	16.49	16.49	16.49
Panel B: First stage regression results			
Instrument Z_i	0.0379***		
	(0.00933)		
Observations (# of electoral precincts)	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

by 0.31 percentage points in response to a decline in our standardised income growth variable by 0.038 standard deviations).

Taken together, our results suggest that in economically challenging times, voters tend to be more favourable towards right-wing parties that follow a market-oriented ideology rather than left-wing parties that focus on redistributional policies. Our findings are in contrast to previous work, which suggested that voters shift towards left-wing parties during economic crises (see, e.g., Wright, 2012; Pastor and Veronesi, 2020). There are two explanations for this. First, we do not analyse aggregate shifts in the economy and voting over time, but make use of exogenously caused differences in the local economy at one specific point in time. This brings us as close as possible (with administrative data) to analysing pocketbook voting, while more aggregate settings are likely to be dominated by sociotropic motives. Second, Pastor and Veronesi (2020) argue that recessions increase risk aversion which then drives U.S. voters towards left-wing parties. In contrast, Germany has an extensive welfare state. This may soften the effect of an economic crisis on risk aversion, so that the risk channel is dominated by the desire to see growth-friendly policies implemented. Our key message is, however, similar to previous findings. There is a strong indication that economic factors matter for decisions at the ballot.

2.4.3 Robustness

We conduct a battery of additional analyses to test the robustness of our main results regarding the effect of income shocks on voting for economically left- and right-wing parties. We broadly distinguish these exercises into three groups: (1) accounting for additional precinct-level characteristics, (2) probing the sensitivity of the results to changes in the construction of our instrumental variable, and (3) testing geographic heterogeneity.

2.4.3.1 Accounting for precinct-level characteristics

The electoral precincts in our dataset vary along a number of specific characteristics. Many of these precinct-level characteristics are shaped by Tiebout-sorting, segregation, and gentrification. For instance, we observe large heterogeneity across precincts within cities with respect to the share of migrants, the distribution of religious beliefs, gender composition, education, the distribution of public goods, access to supermarkets and public transport, and many more. In the next step, we gradually augment our baseline model by accounting for a large set of precinct-level characteristics and report these results in the Appendix.[13] Note that, due to issues of multicollinearity, we cannot include all control variables listed in Section 2.D of the Appendix. In Table 2.F.2 in the Appendix, we introduce several socio-demographic characteristics as controls: the population density, the share of migrants per precinct, the share of individuals holding a university degree, the proportion of Catholics, the share of male voters, the old-age ratio, and the share of households with kids. In Table 2.F.3, we add variables measuring local amenities, i.e. the average garden size, the distance to the next public transportation stop, the share of addresses by centrality (4 categories), the distance to the next polling station, the distance to the next doctor, the distance to the next recreation area and the distance to the next theatre. In Table 2.F.4, we address protest voting that may be rooted in scepticism against the political measures taken to contain the Covid-19 pandemic by including the vote share of the party ‘Die Basis’ as an additional control. The party was founded on 4 July 2020, in the context of protests against Covid-19 restrictions, and it is considered the party-political arm of

[13] For descriptives on the set of control variables, see Table 2.C.2 in the Appendix.

the ‘Querdenken’ protest movement. Overall, our results are insensitive to the inclusion of the outlined control variables.

2.4.3.2 Instrument robustness

We also conduct a series of checks to evaluate the robustness of our main shift-share instrument.

Accounting for commuting. The most important potential source of bias comes from commuting, i.e. when individuals receive income from firms that are located in areas outside the precinct they live in. We take two steps to assess the robustness of our main results to commuting. For our first approach, we construct an alternative shift-share instrument that takes the industry-composition in nearby areas into account. To this end, we include all firms that lie within a certain geographic circle around the precinct when computing pre-treatment industry-shares. As it is ex-ante unclear how large these circles should optimally be, we report results for various radii in the Appendix, including geographic circles with 0.5 kilometre (see Table 2.F.5), 1.0 kilometre (see Table 2.F.6), 1.5 kilometres (see Table 2.F.7), and 2.0 kilometres (see Table 2.F.8).

Increasing the number of relevant firms when constructing the instrument decreases the Kleibergen-Paap F statistics. At the same time, first-stage coefficients increase. In our most extensive specification based on 2-kilometre radii, we find that a one-standard-deviation change in the instrumental variable provokes a change in the standardised income variable by 0.121. This leads to a change in left-wing vote shares of almost 1 pp. between 2017 and 2021 and a change in right-wing vote shares of about 0.6 pp. This finding illustrates that our baseline result represents the most conservative estimates of the impact of economic circumstances on voting behaviour at the precinct-level.

For our second approach, we use information on the occupation of full-time employed individuals in each precinct to compute the pre-treatment industry-shares based on their employers. Results are displayed in Table 2.F.9 in the Appendix. Consistent with the results from employing large circles, we find that vote shares of left-wing parties increase with higher income gains, while vote shares for right-wing parties tend to decrease. For this specification, we also find a significant effect for extremist parties. While the size of the effect is small (i.e. a quarter of the effect found for left parties), it suggests that a negative income shock decreases extremist voting.

We want to make sure that our results are not driven by the procedure we adopt to map the income information at the grid-level to the precinct-level. Thus, we adopt a different aggregation method by simply calculating income means over precincts instead of the area-weighting procedure (see Table 2.F.10 in the Appendix).

2.4.3.3 Heterogeneity

The cities in our sample are heterogeneous along a series of dimensions. To rule out that the results are driven by specific cities or regions, we next report the results from additional checks that exclude some outliers or some of the areas in our dataset. In the Appendix, we present results when (i) using an income measure that is winsorised at the 5%-level (see Table 2.F.11), (ii) excluding the German capital city Berlin (see Table 2.F.12), as well as (iii) cities in North Rhine-Westphalia to rule out effects driven by between city-commuting in the densely populated area of the Ruhr Area (see Table 2.F.13). We also present estimates that are based exclusively on high-population cities (see Table 2.F.14) and low-population cities (see Table 2.F.15) to account for potential differentials between urban and rural areas.

For low-population cities, the first-stage relationship does not turn out to be statistically significant. This is expected given that our specification relies on within-city variation, which is limited in smaller cities. On average, low-population cities have 38 precincts compared to 354 for high-population cities. In all other additional analyses, we obtain results that are similar to those found in the baseline regression models, illustrating that the general impact of economic circumstances is not driven by outliers in the income distribution or specific areas in Germany.

2.4.4 Comparison to Municipality-Level Analysis

The fundamental motivation of our study is that previous approaches employing municipalities rather than precincts as their unit of observation eliminate most of the variation in both voting and income. We provide evidence for this important argument in Table 2.5, which presents re-estimates of our main regression results on economic voting on the municipality-level. This is the unit which has been examined by most previous macro-based approaches to economic voting.

Consistent with the ambiguity of findings on economic voting in previous studies, the parameter estimates on the municipality-level are smaller and far from statistical significance at conventional levels. This result provides strong support for our main

Table 2.5: COMPARISON: VOTING ON MUNICIPALITY-LEVEL

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0139*	-0.00100	-0.00637
	(0.00774)	(0.00640)	(0.0107)
Observations (# of municipalities)	4,252	4,252	4,252
State FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.071	-0.078	-0.037
Kleibergen-Paap F-Stat. (first stage)	61.14	61.14	61.14
Panel B: First stage regression results			
Instrument Z_i (weighted)	0.123***		
	(0.0157)		
Observations (# of municipalities)	4,252		

Notes: This table reports 2SLS regression results on the impact of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The analysis is on the municipality group level ('*Gemeindeverband*'). As the number and size of municipalities vary strongly between states, the municipality groups are the appropriate unit for Germany-wide analyses on the local level. This is also illustrated by the fact the median income is only available at the municipality group level. Of the 4,603 municipality groups, 4,270 are sufficiently large to pass the data protection requirements for income. We loose another 18 observations due to municipality mergers between 2017 and 2021. This leaves us with 4,252 observations. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). Standard errors are clustered at the state-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

argument that large within-city variation leads to a regression to the mean - with respect to both income shocks and voting outcomes. Results suffering from this suggest a much weaker relationship between income and voting than the one which can be established through a granular look at the specific neighbourhoods of voters. Our approach, in contrast, allowed us to capture very local trends that are decisive for both voters' pocketbooks and their votes.

The municipality-level results also highlight that our identification strategy requires a fine-grained specification of pre-treatment shares to successfully capture variations in the local affectedness by the treatment and to establish a valid shift-share instrument. This result underlines the advantage of using electoral precincts for the econometric specification of models that aim to uncover the impact of economic circumstances on voting outcomes.

2.5 Conclusion

This paper explores economic voting at the precinct-level, the most granular administrative layer in elections. Our empirical strategy rests on a fine-grained and large-scale cartography of the largest German cities - entering uncharted territory that no one has mapped before. Linking a series of novel geospatial data collections to the boundaries of electoral precincts within cities, we explore how changes in incomes impact voting behaviour. Our empirical design exploits the strong and spatially heterogeneous economic impact of the Covid-19 pandemic in a shift-share setting. This leverages the fact that the local economic affectedness was largely determined by the pre-existing industry compositions. We find no statistically significant effect of the economic shock of the pandemic on incumbent voting, which masks, however, substantial heterogeneity across political ideologies of parties.

As the incumbent at the time was formed by a grand coalition of the largest state-oriented left party and the largest market-oriented right party, it is important to distinguish between political ideologies. Exploring the effect of the income shock on vote shares of parties with different political ideologies, we find that voters in precincts which are hit harder by the pandemic in economic terms tend to vote more for economically right-wing parties and less for left-wing parties. These findings are robust across a series of additional analyses and tests. The main message of our paper is that when experiencing momentous challenges to economic well-being, voters tend to favour parties with core competencies in economic matters and a greater focus on the economy rather than on societal issues.

Our paper is the first to measure the impact of income shocks on voting at the most granular administrative layer. In contrast to a comparable macro-analysis, we leverage rather than ignore the large within-city heterogeneity in voting and income. This allows us to present strong evidence in favour of economic voting. Examining the mechanisms underlying our main findings would be a fruitful avenue for future research.

Appendix to Chapter 2

This Appendix contains the following information:

- Section 2.A provides an overview of the coverage of our dataset.
- Section 2.B provides analyses of differences in postal and in-person voting.
- Section 2.C provides summary statistics.
- Section 2.D provides detailed information on additional variables.
- Section 2.E provides details on the industries and instrument validity tests.
- Section 2.F provides additional results and robustness.

2.A Coverage

Table 2.A.1: INCORPORATED CITIES BY STATES

	Number of cities		Avg. city size		Precincts
	All 400	Our 354	All 400	Our 354	Our 354
BB	11	11	62	62	476
BE	1	1	3,677	3,677	2,257
BW	58	57	79	79	2,449
BY	44	35	123	130	1,728
HB	3	2	338	563	348
HE	39	29	92	109	1,241
HH	1	1	1,854	1,854	1,267
MV	6	6	88	88	332
NI	56	50	68	72	2,597
NW	145	138	100	100	7,769
RP	21	16	78	87	590
SH	12	11	85	72	368
SL	8	7	58	61	224
SN	12	12	152	152	1,201
ST	15	13	70	76	562
TH	14	11	68	75	470
All	**400**	**354**	**106**	**109**	**23,879**

Notes: This table presents our dataset's coverage of the 400 largest cities for each of the 16 German states - in absolute numbers and in terms of city size. The last column presents the number of precincts in 2021 which are captured in our dataset. City size is given in thousand inhabitants in 2021 and is based on administrative information from the Federal Statistical Office ('Destatis').

Table 2.A.2: SHARE OF HOUSEHOLDS IDENTIFIED FOR MAP-GENERATION

Addresses identified	Number of cities	Share of cities
< 70%	6	2 %
70 - 80 %	21	8 %
80 - 90 %	67	25 %
> 90 %	173	65 %

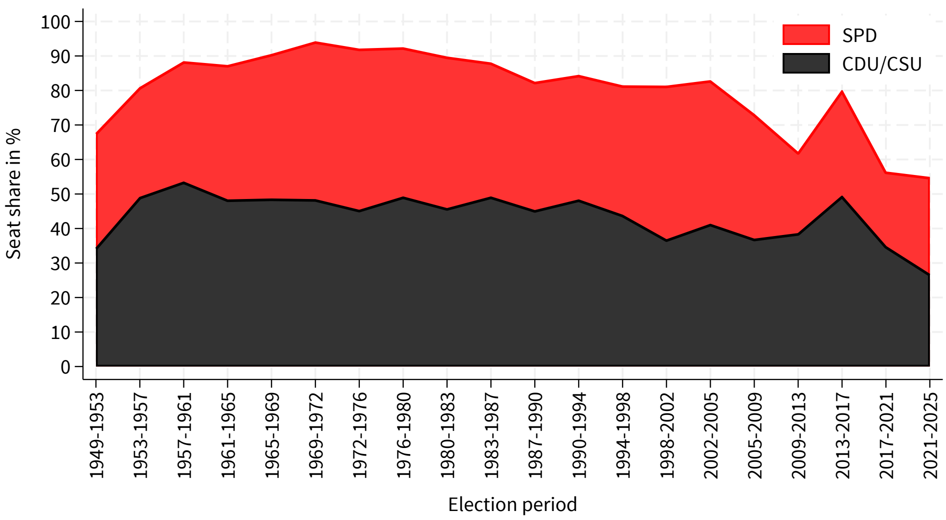
Notes: This table shows the distribution over the share of identified addresses per city when generating maps from street lists. The table covers the 267 cities for which maps were generated from street lists. For the 87 cities which sent shapefiles, the share of households identified is naturally always 100%.

Table 2.A.3: OVERVIEW: NUMBER OF OBSERVATIONS

			Precincts		
		Cities	2021	2017	Merged
I	400 largest cities in Germany	400	-	-	-
II	Generate precinct boundaries for 2021	354	23,879	-	-
III	Map to 2017 precincts	332	23,014	24,165	16,946
IV	Enrich with income data	332	20,266	21,291	14,481

Notes: This table presents the available observations at different stages of our large-scale data collection project. 'Merged' refers to the merging of precincts to account for boundary changes between 2017 and 2021. The drop in merged precincts compared to precincts in 2017 and 2021 is due to the aggregation of information rather than the loss of information. (II) We did not manage to launch a collaboration with 46 cities. (III) For 22 cities it is not possible to map precincts over time. (IV) Income data is not available for 2,462 precincts located in 1×1 grids with less than 500 full-time employed individuals subject to social security contributions. Additionally, due to the use of city-fixed effects, we lose two cities for which we observe only one merged precinct.

Figure 2.A.1: JOINT SEAT SHARE OF CDU/CSU AND SPD FROM 1949 TO 2021



Notes: This figure shows the share of seats in the federal parliament belonging to CDU/CSU and SPD for the 19 legislative periods from 1949 until 2021 (in %). The information is from the Federal Returning Officer.

Table 2.A.4: VOTE SHARE BY PARTY: OVERALL VS. SAMPLE

		2021 Election		2017 Election		2017-21 Change	
		All	Sample	All	Sample	All	Sample
Left	SPD	25.6	26.4	21.0	22.4	4.7	4.0
	Green	13.0	17.3	8.7	10.6	4.3	6.7
Right	CDU/CSU	22.5	19.0	31.5	26.4	-9.0	-7.4
	Liberal	11.4	11.0	10.3	10.6	1.1	0.4
Extreme	AfD	13.6	11.2	13.9	12.8	-0.3	-1.5
	Left	5.3	6.8	9.7	12.1	-4.5	-5.3

Notes: This table presents for each party the vote share in the federal elections 2021 and 2017 as well as the change in vote share between the two elections. These overall results are compared to the vote share and changes of each party in our sample of 14,481 merged precincts employed in the main analysis. The vote share is given in percentage. The change is given in percentage points. The numbers are based on in-person voting only. For a discussion of postal voting see Appendix 2.B. Results are for the second vote.

2.B Detailed Information on Postal Voting

National-level

Table 2.B.1: NATIONAL-LEVEL: IN-PERSON VS. ALL VOTES

		2021 Election		2017 Election		2017-21 Change	
		Person	All	Person	All	Person	All
Left	SPD*	25.6	25.7	21.0	20.5	4.7	5.2
	B90/Grüne	13.0	14.8	8.7	8.9	4.3	5.8
Right	CDU/CSU*	22.5	24.1	31.5	32.9	-9.0	-8.9
	FDP	11.4	11.5	10.3	10.7	1.1	0.7
Extreme	AfD	13.6	10.3	13.9	12.6	-0.3	-2.3
	Die Linke	5.3	4.9	9.7	9.2	-4.5	-4.3

Notes: This table shows the election results for each party for in-person voting vs. the overall voting (in-person and postal). For the elections in 2021 and 2017, the vote share is given in %. The change in vote share between 2017 and 2021 is given in pp. The analysis is based on the universe of voting results for Germany published by the Federal Returning Officer for the respective year. * indicates an incumbent party. Results are for the second vote.

Table 2.B.2: NATIONAL-LEVEL: IN-PERSON VS. POSTAL VOTES

		2021 Election		2017 Election		2017-21 Change	
		Person	Postal	Person	Postal	Person	Postal
Left	SPD*	25.6	25.9	21.0	19.4	4.7	6.5
	B90/Grüne	13.0	16.7	8.7	9.5	4.3	7.2
Right	CDU/CSU*	22.5	25.8	31.5	36.4	-9.0	-10.6
	FDP	11.4	11.5	10.3	12.0	1.1	-0.5
Extreme	AfD	13.6	6.7	13.9	9.6	-0.3	-2.9
	Die Linke	5.3	4.5	9.7	8.0	-4.5	-3.6

Notes: This table shows the election results for each party for in-person and postal voting. For the elections in 2021 and 2017, the vote share is given in %. The change in vote share between 2017 and 2021 is given in pp. The analysis is based on the universe of voting results for Germany published by the Federal Returning Officer for the respective year. * indicates an incumbent party. Results are for the second vote.

City-level

Table 2.B.3: CITY-LEVEL: IN-PERSON VS. ALL VOTES

		2021	2017	2021-2017 Change		
		Corr.	Corr.	Avg.	Med.	SD
Left	SPD*	0.98	0.99	-1.2	-1.1	1.4
	B90/Grüne	0.96	0.99	-0.7	-0.8	1.2
Right	CDU/CSU*	0.96	0.99	0.0	0.1	1.9
	FDP	0.96	0.98	0.5	0.4	1.0
Extreme	AfD	0.97	0.99	2.1	2.0	1.4
	Die Linke	0.97	0.99	-0.1	-0.1	0.6

Notes: This table shows differences in in-person and overall voting (in-person and postal) at the city-level. Column one presents the correlation of in-person and overall voting shares for cities in the 2021 election. Column two is similarly defined for the 2017 election. Column three presents the average difference in the change in in-person voting share and the change in overall voting share between 2017 and 2021 over all cities in pp. ($\Delta InPerson_{21-17} - \Delta Overall_{21-17}$). Column four presents the median and column five the standard deviation of the difference (in pp.). The analysis is based on 4,943 out of 10,641 cities which were assigned a city identifier in the results published by the Federal Returning Officer in 2021. Slightly more than half of the cities could not be included because no results were available for either of the four elements. However, in terms of votes a clear majority is covered by these cities e.g. 85.3% in 2021. * indicates an incumbent party. Results are for the second vote.

Table 2.B.4: CITY-LEVEL: IN-PERSON VS. POSTAL VOTES

		2021	2017	2021-2017 Change		
		Corr.	Corr.	Avg.	Med.	SD
Left	SPD*	0.93	0.93	-2.8	-2.8	3.1
	B90/Grüne	0.89	0.89	-1.4	-1.6	2.4
Right	CDU/CSU*	0.88	0.83	1.1	1.4	4.0
	FDP	0.85	0.85	1.2	1.3	2.3
Extreme	AfD	0.89	0.85	3.1	2.7	2.8
	Die Linke	0.90	0.92	-0.5	-0.6	1.6

Notes: This table shows differences in in-person and postal voting at the city-level. Column one presents the correlation of in-person and postal voting shares for cities in the 2021 election. Column two is similarly defined for the 2017 election. Column three presents the average difference in the change in in-person voting share and the change in postal voting share between 2017 and 2021 over all cities in pp. ($\Delta InPerson_{21-17} - \Delta Postal_{21-17}$). Column four presents the median and column five the standard deviation of the difference (in pp.). The analysis is based on 4,943 out of 10,641 cities which were assigned a city identifier in the results published by the Federal Returning Officer in 2021. Slightly more than half of the cities could not be included because no results were available for either of the four elements. However, in terms of votes a clear majority is covered by these cities e.g. 85.3% in 2021. * indicates an incumbent party. Results are for the second vote.

Precinct-level

Mapping: We mapped postal and in-person precincts for the 2021 election. As described in Section 2.2.3, it is not possible, however, to map changes in postal voting over time. For organising postal balloting no clear rules exist, so local administrations follow different approaches. We have observed three different models: First, for each polling precinct a single postal polling precinct exists, which allows to link postal votes to an exact geo-located area. Second, multiple polling precincts are grouped into one or more postal polling precincts. When a small number of polling precincts is pooled, then the resulting area is still small and allows for an analysis at fine-grained geo-level. However, with more precincts, the size of the area increases and the advantage of having detailed information within cities gradually disappears. Third, cities do not differentiate the geo-origin of a vote when assigning it to a postal polling precinct. This implies that postal polling results for that city cannot be analysed below the city-level. For 268 of 354 cities, we were able to link the precincts for in-person voting to those for postal balloting. This creates 9,198 units, for which both in-person and postal voting at the 2021 election is available and can be compared. These units contain 20,635 in-person precincts which are mapped to 10,673 postal precincts. The average number of voters per unit is 996 for in-person voting and 934 for postal voting.

Table 2.B.5: PRECINCT-LEVEL: IN-PERSON VS. ALL VOTES

		2021 Election				
		Person	All	Corr.	∅ of Δ	SD of Δ
Left	SPD*	25.1	25.6	0.96	-0.5	1.8
	B90/Grüne	17.9	19.4	0.98	-1.5	1.9
Right	CDU/CSU*	19.8	21.0	0.97	-1.2	1.7
	FDP	11.2	11.2	0.95	0.0	1.1
Extreme	AfD	10.7	8.3	0.98	2.4	1.6
	Die Linke	6.8	6.4	0.98	0.4	1.0

Notes: This table shows differences in in-person and postal voting at the precinct-level for 268 cities from our fine-grained dataset. To ensure geographical comparability, we create a mapping between in-person and postal precincts. This reduces the number of observations to 9,198 comparable units. Column one presents the average vote share of each party for in-person voting (in %) and column two is similarly defined for overall voting (in-person and postal). Column three states the correlation between in-person and overall voting at the precinct-level. Column four presents the average difference in in-person and overall voting in pp. ($\Delta = InPerson_{21} - Overall_{21}$). Positive values for Δ indicate that a party has on average a higher vote share in in-person than in overall voting. Column five presents the standard deviation of Δ over all precincts (in pp.). * indicates an incumbent party. Results are for the second vote.

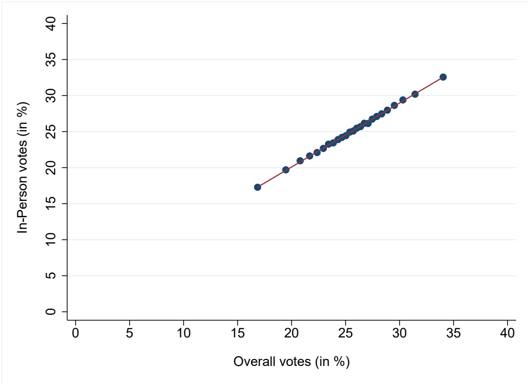
Table 2.B.6: PRECINCT-LEVEL: IN-PERSON VS. POSTAL VOTES

		2021 Election				
		Person	Postal	Corr.	∅ of Δ	SD of Δ
Left	SPD*	25.1	26.3	0.86	-1.2	3.7
	B90/Grüne	17.9	21.0	0.94	-3.1	3.6
Right	CDU/CSU*	19.8	22.1	0.91	-2.3	3.2
	FDP	11.2	11.2	0.81	0.0	2.1
Extreme	AfD	10.7	5.6	0.89	5.1	3.5
	Die Linke	6.8	6.1	0.91	0.6	2.1

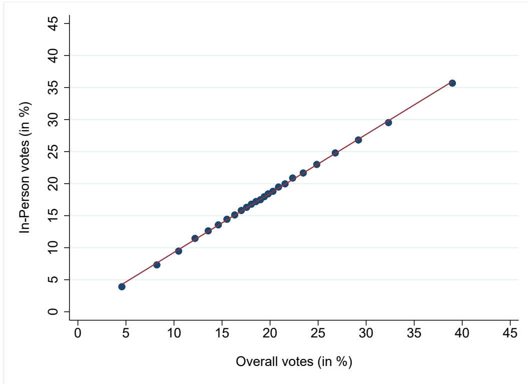
Notes: This table shows differences in in-person and postal voting at the precinct-level for 268 cities from our fine-grained dataset. To ensure geographical comparability, we create a mapping between in-person and postal precincts. This reduces the number of observations to 9,198 comparable units. Column one presents the average vote share of each party for in-person voting (in %) and column two is similarly defined for postal voting. Column three states the correlation between in-person and postal voting at the precinct-level. Column four presents the average difference in in-person and postal voting in pp. ($\Delta = InPerson_{21} - Postal_{21}$). Positive values for Δ indicate that a party has on average a higher vote share in in-person than in postal voting. Column five presents the standard deviation of Δ over all precincts (in pp.). * indicates an incumbent party. Results are for the second vote.

Figure 2.B.1: PRECINCT-LEVEL: IN-PERSON VS. ALL VOTES

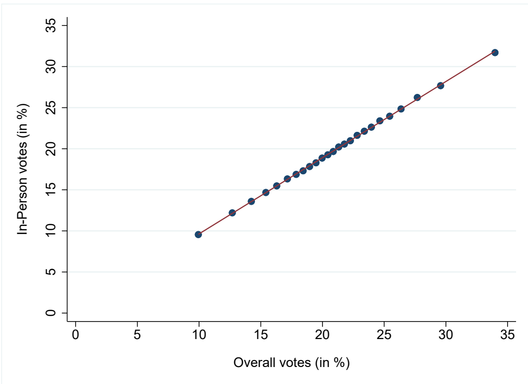
(a) Left - SPD*



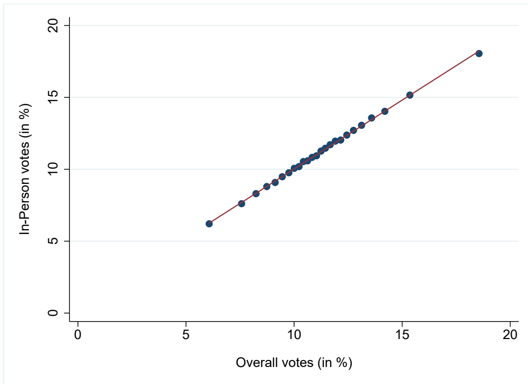
(b) Left - B90/Grüne



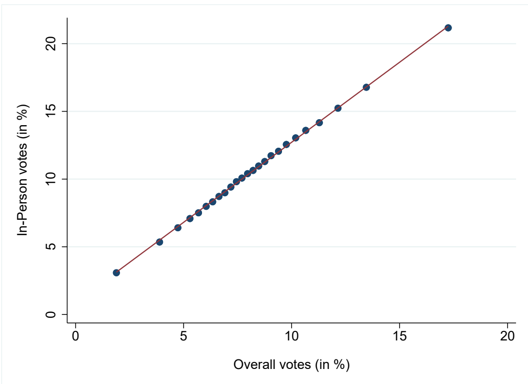
(c) Right - CDU/CSU*



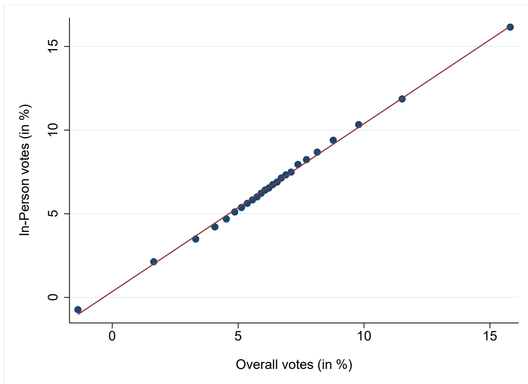
(d) Right - FDP



(e) Extreme - AfD



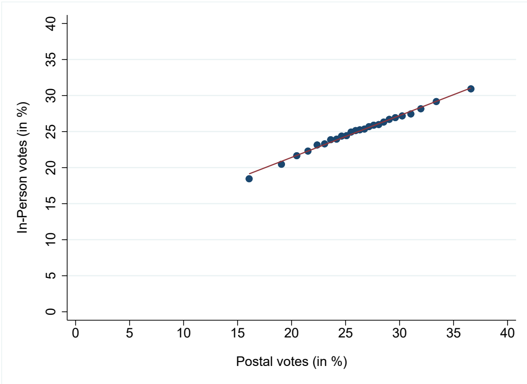
(f) Extreme - Die Linke



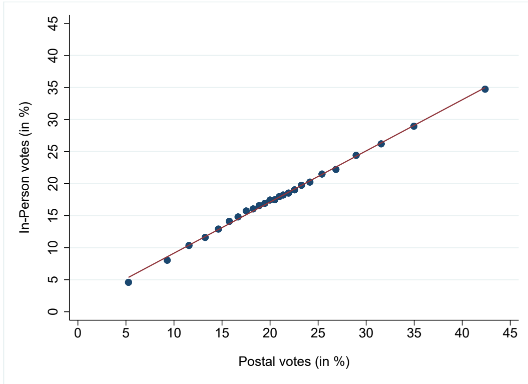
Notes: This figure shows binned scatter plots for the overall vote share i.e. in-person and postal (x-axis) and the in-person vote share (y-axis) at the precinct-level for the 2021 election. City-fixed effects are absorbed. The number of bins is set to 25. The analysis includes 9,198 units from 268 cities. * indicates an incumbent party. Results are for the second vote.

Figure 2.B.2: PRECINCT-LEVEL: IN-PERSON VS. POSTAL VOTES

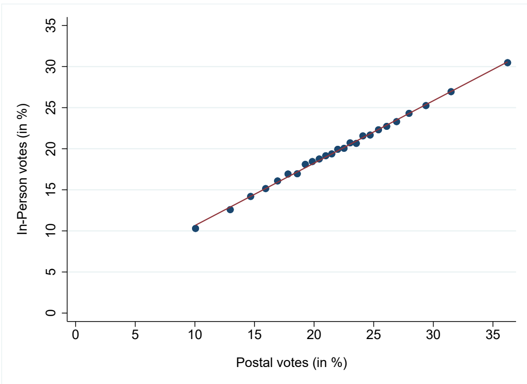
(a) Left - SPD*



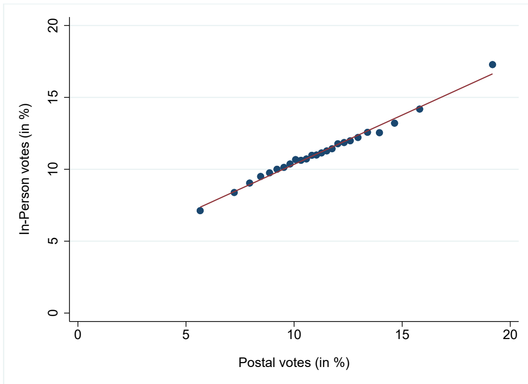
(b) Left - B90/Grüne



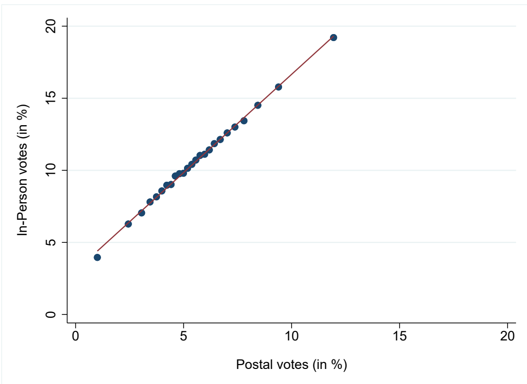
(c) Right - CDU/CSU*



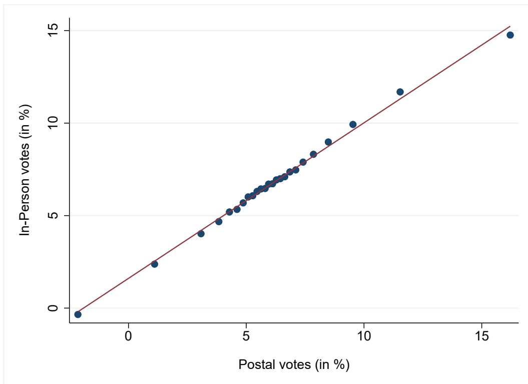
(d) Right - FDP



(e) Extreme - AfD



(f) Extreme - Die Linke



Notes: This figure shows binned scatter plots for the postal vote share (x-axis) and the in-person vote share (y-axis) at the precinct-level for the 2021 election. City-fixed effects are absorbed. The number of bins is set to 25. The analysis includes 9,198 units from 268 cities. * indicates an incumbent party. Results are for the second vote.

2.C Summary Statistics

Table 2.C.1: SUMMARY STATISTICS: MEDIAN INCOME (IN EURO)

	Mean	SD	5%	95%	Min	Max	N
Income 2021	3639	594	2771	4718	1109	6700	14,481
Income 2017	3280	551	2427	4273	1828	6302	14,481
Δ Nominal income 2017-2021	359	123	183	576	-1751	1284	14,481

Notes: This table shows summary statistics for the median income and changes in median income between 2017 and 2021 at the precinct-level.

Table 2.C.2: SUMMARY STATISTICS: CONTROL VARIABLES

	Mean	SD	Min	Max	N
Population density	5,587.55	5,619.37	0	52389	14,480
Share of foreigners	0.15	0.10	0	2.39	14,480
Share of university graduates	0.01	0.00	0	0.076	14,480
Share of catholics	0.24	0.17	0	1	14,477
Share male	0.48	0.02	0.25	0.75	14,477
Share of households with children	0.20	0.09	0	0.90	14,479
Old age ratio	3.68	11.97	0.13	1418	14,475
Rent index	6.39	1.75	0	14	14,481
Share of diesel cars	0.21	0.03	0	0.43	14,481
Vote share Basis party	0.01	0.01	0	0.078	14,481
Average garden size	290.30	297.00	0	7595	14,480
Distance to the next public transport stop	209.25	151.20	60	3437	14,481
Share addresses central city centre	0.06	0.14	0	0.99	14,482
Share addresses extended city centre	0.18	0.16	0	1	14,482
Share of addresses central location	0.41	0.17	0	1	14,482
Share of addresses decentralised location	0.28	0.21	0	1	14,482
Distance to next polling station	489.75	419.02	92	17027	14,393
Distance to next doctor	251.21	229.72	22	4427	14,477
Distance to next recreation area	458.48	355.42	60	4880	14,477
Distance to next theatre	3,138.17	4,247.01	61	49661	14,477
Distance to next swimming pool	2,141.56	1,437.83	122	11834	14,477

Notes: This table shows summary statistics for the control variables employed in the empirical analysis at the precinct-level.

2.D Detailed Information on Additional Variables

Buildings

The majority of variables on buildings within precincts is constructed from administrative maps on house and property outlines which are provided by the 'Central office for house coordinates and house perimeters' (ZSHH) and the 'Federal Agency for Cartography and Geodesy' (BKG). These maps are employed by infas360 to assign a building type, calculate the living space, and measure the garden size for each address. The variables on house purchasing prices and rents are based on data from the online real estate broker 'ImmoScout24'. Exploiting information on a few million individual deals, infas360 calculates rent and purchasing price indices for precincts. In addition, we use the fact that all variables are available at an address level to estimate Gini coefficients for each precinct.

Table 2.D.1: VARIABLE DESCRIPTION: BUILDINGS

Variable	Definition	2017	2018	2019	2021	Source
Building type	Number of buildings for 31 types: One- to two-party house with residents (big), detached villa, classic semi-detached house (small), classic semi-detached house (medium), classic semi-detached house (big), terraced house (small), terraced house (medium), terraced house (big), detached multi-party house (small), multi-party house with residents (small), multi-party house en bloc (small), detached multi-party house (medium), multi-party house with residents (medium), multi-party house en bloc (medium), detached multi-party house (big), multi-party house with residents (big), multi-party house en bloc (big), multi-party semi-detached house (small), multi-party semi-detached house (medium), multi-party semi-detached house (big), row construction, multi-family complex, high-rise, special type, industry, not classified	x			x	Zentrale Stelle Hauskoordinaten und Hausumringe (ZSHH)
Living space	Average living space per household (in m^2)	x			x	ZSHH
Space inequality	Gini coefficient on living space over all households				x	ZSHH
Purchase index	Average purchasing prices for houses (in Euro per m^2)	x			x	ImmoScout24
House inequality	Gini coefficient on house prices over all addresses				x	ImmoScout24
Rent index	Average rent (in Euro per m^2)	x			x	ImmoScout24
Rent inequality	Gini coefficient on rent over all addresses				x	ImmoScout24
Garden size	Average garden size (in m^2)	x			x	Bundesamt für Kartographie und Geodäsie (BKG)

Notes: This table lists precinct-level variables on buildings. Years indicate the time period covered in our dataset. Source refers to the original source. All variables have been calculated by infas360 on the basis of our geo-located precincts from 2021. To account for the mapping of 2021 to 2017 precincts, we take the sum over mapped precincts (for variables given as a number) or we estimate population-weighted averages (otherwise). When employed for analyses, variables indicated as 'number of' are transformed into shares.

Amenities

The variables on amenities and infrastructure are based on a geo-coded database of 'points of interest' which is compiled and maintained by infas360. For each household address, the shortest point of interest of a specific category is selected and the shortest aerial distance between them is calculated. The variables measure the average distance between all addresses and the closest point of interest for each precinct.

Table 2.D.2: VARIABLE DESCRIPTION: AMENITIES

Variable	Definition	2017	2018	2019	2021	Source
School	Average distance from each address (with at least one household) to the next school (in metres)	x			x	infas360
Child care	Average distance from each address (with at least one household) to the next child care facility (in metres)	x			x	infas360
Doctor	Average distance from each address (with at least one household) to the next doctor (in metres)	x			x	infas360
Ret. home	Average distance from each address (with at least one household) to the next retirement home (in metres)	x			x	infas360
Pharmacy	Average distance from each address (with at least one household) to the next pharmacy (in metres)	x			x	infas360
Bank	Average distance from each address (with at least one household) to the next bank (in metres)	x			x	infas360
Supermarket	Average distance from each address (with at least one household) to the next supermarket (in metres)	x			x	infas360
Restaurant	Average distance from each address (with at least one household) to the next restaurant (in metres)	x			x	infas360
Bar	Average distance from each address (with at least one household) to the next bar (in metres)	x			x	infas360
Bus stop	Average distance from each address (with at least one household) to the next bus stop (in metres)	x			x	infas360
Train station	Average distance from each address (with at least one household) to the next train station (in metres)	x			x	infas360
Recreation area	Average distance from each address (with at least one household) to the next recreation area (in metres)	x			x	infas360
Swimming pool	Average distance from each address (with at least one household) to the next swimming pool (in metres)	x			x	infas360
Sport facility	Average distance from each address (with at least one household) to the next sport facility (in metres)	x			x	infas360
Theatre	Average distance from each address (with at least one household) to the next theatre (in metres)	x			x	infas360

Notes: This table lists precinct-level variables on amenities. Years indicate the time period covered in our dataset. Source refers to the original source. All variables have been calculated by infas360 on the basis of our geo-located precincts from 2021. To account for the mapping of 2021 to 2017 precincts, we take the sum over mapped precincts (for variables given as a number) or we estimate population-weighted averages (otherwise). When employed for analyses, variables indicated as 'number of' are transformed into shares.

Socio-Demographics

The variables on socio-demographics are based on fine-grained raster data from the census which goes down to the level of 100×100 meter grids. Annual information from 'Destatis' such as the micro census is employed by infas360 to keep the variables up to date. The variables on car ownership are from the 'Federal Motor Transport Authority' (KBA) which administers the registration of all German cars. infas360 has access to this administrative data on raster level and for a subset on address-level.

Table 2.D.3: VARIABLE DESCRIPTION: SOCIO-DEMOGRAPHICS

Variable	Definition	2017	2018	2019	2021	Source
Pop. density	Number of inhabitants per km^2	x			x	Destatis
Household size	Number of households in 6 categories: One person, two person, three person, four person, five person and more, not known	x			x	Destatis
Gender	Number of males	x			x	Destatis
Age	Number of inhabitants in 11 age categories: <3, 3-5, 6-9, 10-14, 15-17, 18-29, 30-44, 45-59, 60-64, 65-74, >74	x			x	Destatis
Religion	Share of inhabitants belongig to 3 religous groups: Roman Catholic Church, Protestant Church, other or none	x			x	Destatis
Migration	Number of foreigners in 4 groups: Overall, from EU27 countries, from non-EU27-countries in Europe, from non-European countries		x		x	Destatis
Education	Number of inhabitants aged above 15 in four groups according to their highest school-leaving qualification: Without or not yet any school-leaving qualification, lower secondary school qualification, secondary school certificate and upper classes, advanced technical college entrance qualification and general or subject-linked higher education entrance qualification (Abitur)		x		x	Destatis
Qualification	Number of inhabitants aged above 15 in five groups according to their highest professional qualification: Without or not yet any professional qualification, apprenticeship and vocational training in the dual system, professional school certificate and professional or vocational academy qualification, polytechnic degree and university degree, doctorate		x		x	Destatis
Family status	Number of families in 3 categories: Couples without child, couples with at least one child, single parents		x		x	Destatis
Car segment	Number of private cars in 14 segments: Minis, small cars, compact cars, mid-range cars, mid-size executive cars, large executive cars, SUV, off-road vehicle, sports cars, mini-vans, large-size vans, utilities, camper vans, others			x	x	Kraftfahrt-Bundesamt (KBA)
Car type	Number of private cars of 6 types: Gasoline, diesel, electric, hybrid, gas, other			x	x	KBA

Notes: This table lists precinct-level variables on socio-demographics. Years indicate the time period covered in our dataset. Source refers to the original source. All variables have been calculated by infas360 on the basis of our geo-located precincts from 2021. To account for the mapping of 2021 to 2017 precincts, we take the sum over mapped precincts (for variables given as a number) or we estimate population-weighted averages (otherwise). When employed for analyses, variables indicated as 'number of' are transformed into shares.

Polling Stations

We have received the exact address of all polling stations in 2021 from the responsible local administrations. This allows infas360 to calculate the average distance from each address within the precinct to the polling station. In addition, we classify the type of building which is employed as a polling station. This is based on address-level information from the 'points of interest' database of infas360.

Table 2.D.4: VARIABLE DESCRIPTION: POLLING STATIONS

Variable	Definition	2017	2018	2019	2021	Source
Distance	Average distance from each address (with at least one household) to the polling station (in metres)				x	354 cities
Building function	Classification of building with polling station into one of eight functional categories: Children care, elementary school, secondary school, professional school, other educational building, religious, other public, and not classified				x	infas360

Notes: This table lists precinct-level variables on polling stations. Years indicate the time period covered in our dataset. Source refers to the original source. All variables have been calculated by infas360 on the basis of our geo-located precincts from 2021. To account for the mapping of 2021 to 2017 precincts, we take the sum over mapped precincts (for variables given as a number) or we estimate population-weighted averages (otherwise). When employed for analyses, variables indicated as 'number of' are transformed into shares.

2.E Instrument

Details on Industries

Table 2.E.1: INDUSTRY CLASSIFICATION

WZ-08 Code	Industry Description
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities
T	Activities of households as employers; activities of households for own use
U	Activities of extraterritorial organisations and bodies

Notes: This table presents the industry classification according to the 'German classification of economic activities' (WZ 2008) which separates economic activity into 21 industries.

Table 2.E.2: FIRMS BY INDUSTRY

WZ-08 Code	Number	Share (in %)	Average size
A	7,953	0.47	12.0
B	658	0.04	30.8
C	89,792	5.29	39.4
D	5,231	0.31	5.5
E	3,868	0.23	27.7
F	101,880	6.00	6.9
G	279,086	16.43	11.2
H	27,982	1.65	21.8
I	57,003	3.36	10.8
J	57,261	3.37	11.7
K	83,437	4.91	15.5
L	70,402	4.14	3.3
M	284,846	16.77	5.4
N	58,843	3.46	16.0
O	6,953	0.41	12.0
P	30,448	1.79	8.6
Q	106,214	6.25	21.5
R	28,551	1.68	5.5
S	398,064	23.44	3.4
T	38	0.00	12.0
U	3	0.00	12.0
Total	1,698,513	100	

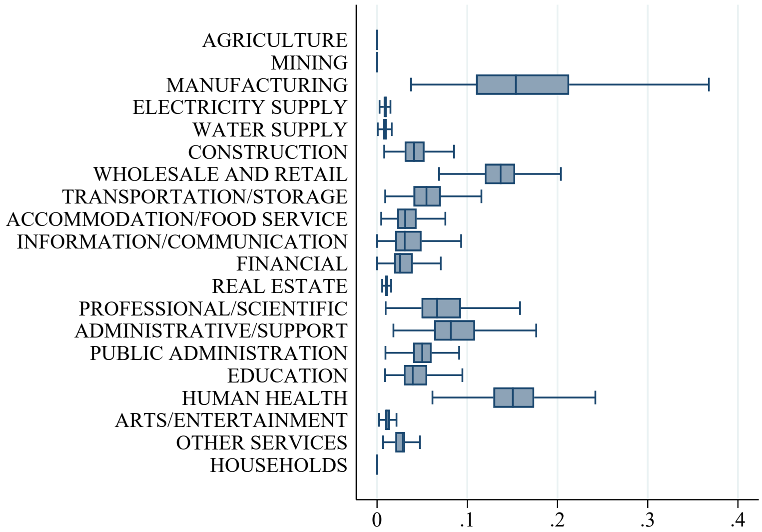
Notes: This table presents the number and share of firms over 21 industries in 2018. In total, 1,698,513 firms are located in the 14,481 precincts from the main analysis. The average firm size is the number of active individuals over the number of firms in each industry in 2018. The average firm size is calculated for the whole of Germany based on industry-specific statistics from the Federal Statistical Office (Destatis). Due to data availability, we have to employ the average firm size for four industries (K, P, Q, R) from 2021. As the overall average firm size has only increased by 0.1 individuals per firm (+1.1%) between 2018 and 2021, this seems reasonable. Also due to data availability, we have to take average values for those four industries (A, O, T, U) where no specific statistics are available. Their weight is the average firm size of 12.0 in 2018, which implies that they are not re-weighted. As these four industries only make up a total share of less than 0.88%, this should not distort results much. The definition for each industry is given in Table 2.E.1.

Table 2.E.3: EMPLOYEES BY INDUSTRY

WZ-08 Code	Number	Share (in %)
A	22,792	0.09
B	17,567	0.07
C	3,590,906	14.39
D	200,499	0.80
E	184,328	0.74
F	975,778	3.91
G	3,262,598	13.07
H	1,443,838	5.78
I	1,029,775	4.13
J	1,166,293	4.67
K	814,339	3.26
L	292,307	1.17
M	2,223,366	8.91
N	2,318,830	9.29
O	1,250,794	5.01
P	1,289,417	5.17
Q	3,773,505	15.12
R	347,228	1.39
S	740,573	2.97
T	9,088	0.04
U	6,349	0.03
Total	24,960,170	100

Notes: This table presents the number and share of inhabitants who are employed in each of the 21 industries in 2017. In total, the industry of an employer is available for 24,960,170 full-time employed inhabitants of the 14,481 precincts from the main analysis. As this is based on information on individual employment contracts, we do not need to re-weight to account for differences in firm sizes across industries. The definition for each industry is given in Table 2.E.1.

Figure 2.E.1: VARIATION OF INDUSTRY-SHARES BASED ON EMPLOYERS

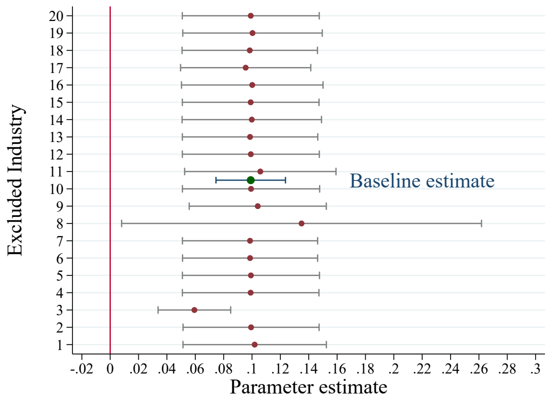


Notes: This figure shows a box plot of the variation of industry-shares between precincts. Industry-shares are based on the classification of the employers of 25 million inhabitants of the 14,481 precincts. The industry-shares are based on information from the start of 2017.

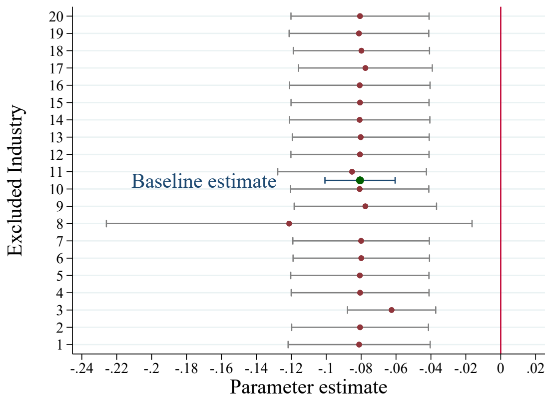
Instrument Validation

Figure 2.E.2: VALIDITY I: NOT DRIVEN BY SPECIFIC INDUSTRY

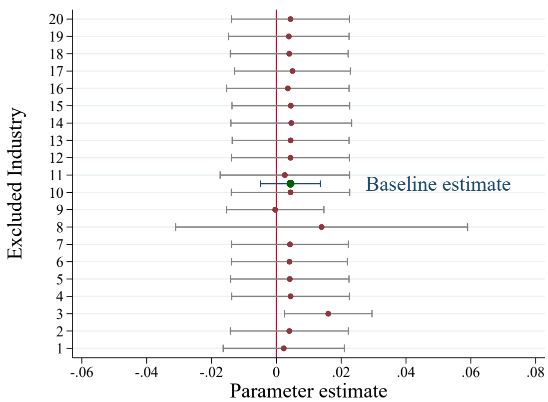
(a) Left



(b) Right



(c) Extreme



Notes: The figures plot the regression coefficients of the income shock in 2SLS regression with the respective change in the party-block vote share as dependent variable. In each separate regression one industry is excluded from the construction of the instrument (leave-one-out). Standard errors are clustered at the city-level. Confidence intervals are at the 90% significance level.

Table 2.E.4: VALIDITY II: BALANCE TESTS

	(1) Instrument Z_i
Δ Pop. density	2982.112*
	(1632.831)
Δ Share male	0.002
	(0.00614)
Δ Share foreign	-0.025
	(0.031)
Δ Univ. graduates	5.531
	(4.525)
Δ Roman catholics	0.219
	(0.407)
Δ Share households with kids	-0.078
	(0.048)
Δ Old age ratio	0.274
	(0.277)
Δ Rent index	-0.007
	(0.007)
Δ Share diesel cars	-0.0002
	(0.0001)
Vote share Basis party	0.00008
	(0.00007)
Δ Share addresses extended city center	0.004
	(0.003)
Δ Dist. to next doctor	1.048
	(0.785)
Δ Dist. to next theater	3.030
	(5.849)
Δ Dist. to next sport facility	-1.645
	(1.140)
Δ Dist. to next swimming pool	-0.331
	(5.571)
Observations (# of electoral precincts)	14,477
City FE	Yes

Notes: This table displays the results of simple balance tests at the precinct-level, where we regress our instrument on precinct-level characteristics. Each line represents one separate regression. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

2.F Additional Results and Robustness

Additional Results

Table 2.F.1: BENCHMARK OLS RESULTS, PARTY GROUP VOTING

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1)	(2)	(3)
	Left	Right	Extreme
$\Delta_{2017,2021}$ Standardised income	0.0119***	-0.00824***	0.000278
	(0.00124)	(0.00143)	(0.000839)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068

Notes: This table reports OLS regression results on the impact of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 2.F.2: RESULTS FOR OUR SHIFT-SHARE DESIGN WITH CONTROLS (I)

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.113***	-0.0793**	-0.000709
	(0.0395)	(0.0336)	(0.0103)
Observations (# of electoral precincts)	14,476	14,476	14,476
City FE	Yes	Yes	Yes
Controls	Controls I	Controls I	Controls I
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	7.58	7.58	7.58
Panel B: First stage regression results			
Instrument Z_i	0.0306***		
	(0.0111)		
Observations (# of electoral precincts)	14,476		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The control variables are population density, share of foreigners, share of university graduates (at the neighbourhood-level), share of catholics, share of males, share of households with kids, and old-age ratio. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.3: RESULTS FOR OUR SHIFT-SHARE DESIGN WITH CONTROLS (II)

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.122**	-0.0973**	0.0173
	(0.0534)	(0.0485)	(0.0185)
Observations (# of electoral precincts)	14,385	14,385	14,385
City FE	Yes	Yes	Yes
Controls	Controls II	Controls II	Controls II
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	5.56	5.56	5.56
Panel B: First stage regression results			
Instrument Z_i	0.0184**		
	(0.00781)		
Observations (# of electoral precincts)	14,385		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The control variables are population density, share of foreigners, share of university graduates (at the neighbourhood-level), share of catholics, share of males, share of households with kids, old-age ratio, average garden size, distance to the next public transportation stop, share of addresses by centrality, distance to the next polling station, distance to the next doctor, distance to the next recreation area, and distance to the next theatre.The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 2.F.4: RESULTS FOR OUR SHIFT-SHARE DESIGN WITH FULL SET OF CONTROLS

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.123**	-0.0966**	0.0179
	(0.0541)	(0.0482)	(0.0188)
Observations (# of electoral precincts)	14,385	14,385	14,385
City FE	Yes	Yes	Yes
Controls	Controls III	Controls III	Controls III
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	5.53	5.53	5.53
Panel B: First stage regression results			
Instrument Z_i	0.0184**		
	(0.00782)		
Observations (# of electoral precincts)	14,385		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The control variables are population density, share of foreigners, share of university graduates (at the neighbourhood-level), share of catholics, share of males, share of households with kids, old-age ratio, average garden size, distance to the next public transportation stop, share of addresses by centrality, distance to the next polling station, distance to the next doctor, distance to the next recreation area, distance to the next theatre, and share of second votes for the Basis party. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Instrument Robustness

Table 2.F.5: ROBUSTNESS: FIRM COMPOSITION IN 0.5 KM RADIUS

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0652***	-0.0594***	0.00715
	(0.0189)	(0.0125)	(0.0120)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	17.74	17.74	17.74
Panel B: First stage regression results			
Instrument Z_i (0.5km radius)	0.0779***		
	(0.0185)		
Observations	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The table shows results for our IV design accounting for spillovers across precincts as described in Section 2.3.2.5. We build our instrument on all companies within a 0.5 km radius around the geographic centre of the precinct. The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.6: ROBUSTNESS: FIRM COMPOSITION IN 1 KM RADIUS

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0664***	-0.0521***	-0.00141
	(0.0228)	(0.0128)	(0.0137)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	11.85	11.85	11.85
Panel B: First stage regression results			
Instrument Z_i (1km radius)	0.103***		
	(0.0301)		
Observations	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The table shows results for our IV design accounting for spillovers across precincts as described in Section 2.3.2.5. We build our instrument on all companies within an 1 km radius around the geographic centre of the precinct. The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.7: ROBUSTNESS: FIRM COMPOSITION IN 1.5 KM RADIUS

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0726**	-0.0520***	-0.00506
	(0.0292)	(0.0154)	(0.0176)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	6.93	6.93	6.93
Panel B: First stage regression results			
Instrument Z_i (1.5km radius)	0.109***		
	(0.0414)		
Observations	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The table shows results for our IV design accounting for spillovers across precincts as described in Section 2.3.2.5. We build our instrument on all companies within an 1.5 km radius around the geographic centre of the precinct.The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.8: ROBUSTNESS: FIRM COMPOSITION IN 2 KM RADIUS

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0724**	-0.0467***	-0.00860
	(0.0314)	(0.0151)	(0.0202)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	5.87	5.87	5.87
Panel B: First stage regression results			
Instrument Z_i (2km radius)	0.121**		
	(0.0498)		
Observations	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The table shows results for our IV design accounting for spillovers across precincts as described in Section 2.3.2.5. We build our instrument on all companies within a 2 km radius around the geographic centre of the precinct. The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.9: ROBUSTNESS: INDUSTRY SHARES BASED ON EMPLOYEES

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0359***	-0.0382***	0.0108***
	(0.00589)	(0.00531)	(0.00266)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	43.32	43.32	43.32
Panel B: First stage regression results			
Instrument Z_i (employees)	0.201***		
	(0.0306)		
Observations (# of electoral precincts)	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The table shows results for our shift-share IV design, where we use the number of full-time employees by industry (instead of the number of firms) to construct our instrument. Given that we observe the actual number of individuals working in a given industry per precinct, we do not have to re-weight the shares. The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.10: ROBUSTNESS: UNWEIGHTED INCOME MEASURE

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.137***	-0.111***	0.00605
	(0.0339)	(0.0278)	(0.0128)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	16.49	16.49	16.49
Panel B: First stage regression results			
Instrument Z_i	0.0274***		
	(0.00676)		
Observations (# of electoral precincts)	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). When aggregating the 1×1 km income grids to the precinct-level, we calculate simple means instead of taking the area-weighted average as described in Section 2.2.4. The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Heterogeneity

Table 2.F.11: RESULTS FOR OUR SHIFT-SHARE DESIGN ACCOUNTING FOR OUTLIERS IN INCOME

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0984***	-0.0800***	0.00435
	(0.0230)	(0.0187)	(0.00919)
Observations (# of electoral precincts)	14,481	14,481	14,481
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.103	-0.067	-0.068
Kleibergen-Paap F-Stat. (first stage)	18.22	18.22	18.22
Panel B: First stage regression results			
Instrument Z_i	0.0382***		
	(0.00894)		
Observations (# of electoral precincts)	14,481		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. To account for outliers, we winsorised the income in 2017 and 2021 at the 5%-level. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.12: HETEROGENEITY SHIFT-SHARE RESULTS: EXCLUDING BERLIN

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.106***	-0.0930***	0.00765
	(0.0286)	(0.0221)	(0.00938)
Observations (# of electoral precincts)	13,741	13,741	13,741
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.102	-0.067	-0.066
Kleibergen-Paap F-Stat. (first stage)	13.22	13.22	13.22
Panel B: First stage regression results			
Instrument Z_i	0.0363***		
	(0.00999)		
Observations (# of electoral precincts)	13,741		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. We exclude the city of Berlin as largest city in the sample. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.13: HETEROGENEITY SHIFT-SHARE RESULTS: EXCLUDING CITIES IN NORTH RHINE-WESTPHALIA

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0769***	-0.0602***	0.00887
	(0.0254)	(0.0216)	(0.0124)
Observations (# of electoral precincts)	9,435	9,435	9,435
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.111	-0.071	-0.072
Kleibergen-Paap F-Stat. (first stage)	11.01	11.01	11.01
Panel B: First stage regression results			
Instrument Z_i	0.0381***		
	(0.0115)		
Observations (# of electoral precincts)	9,435		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. We exclude cities located in the most populous German state North Rhine-Westphalia. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.14: HETEROGENEITY SHIFT-SHARE RESULTS: HIGH-POPULATION CITIES

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.0718***	-0.0586***	0.00743
	(0.0174)	(0.0155)	(0.00822)
Observations (# of electoral precincts)	7,283	7,283	7,283
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.114	-0.067	-0.077
Kleibergen-Paap F-Stat. (first stage)	19.27	19.27	19.27
Panel B: First stage regression results			
Instrument Z_i	0.0695***		
	(0.0158)		
Observations (# of electoral precincts)	7,283		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The results are for high-population cities only. We split at the median city in terms of their 2017 population. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Table 2.F.15: HETEROGENEITY SHIFT-SHARE RESULTS: LOW-POPULATION CITIES

	$\Delta_{2017,2021}$ **Vote Shares**		
	(1) Left	(2) Right	(3) Extreme
Panel A: Second stage regression results			
$\Delta_{2017,2021}$ Standardised income	0.262	-0.212	-0.0138
	(0.193)	(0.144)	(0.0452)
Observations (# of electoral precincts)	7,198	7,198	7,198
City FE	Yes	Yes	Yes
Controls	No	No	No
Mean dep. var.	0.092	-0.067	-0.058
Kleibergen-Paap F-Stat. (first stage)	2.12	2.12	2.12
Panel B: First stage regression results			
Instrument Z_i	0.0102		
	(0.00702)		
Observations (# of electoral precincts)	7,198		

Notes: This table reports 2SLS regression results on the effect of the economic shock created by the Covid-19 pandemic in 2020-21 on changes in the vote shares of parties by ideological group between the federal elections 2017 and 2021. The results are for low-population cities only. We split at the median city in terms of their 2017 population. The empirical specification follows Equation (2.2). A shift-share instrument is employed to capture the exogenous variation in income arising from industry-specific shocks of the Covid-19 pandemic. This is expressed in Equation (2.4). The analysis is on the precinct-level. Standard errors are clustered at the city-level. Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Chapter 3

Conflict's Spatial Echo: Economic Development in the Shadow of War

This chapter presents single-authored work. I would like to thank Luisa Dörr, Klaus Gründler, Sarah Langlotz, Massimo Morelli, Christian Ochsner, Łukasz Olejnik, Niklas Potrafke, Christopher Rauh, Felix Rösel, Timo Wochner, and participants of the 7th International Conference on the Political Economy of Democracy and Dictatorship 2024 in Münster and the Bruto seminar at Università Bocconi for excellent comments. I am also very thankful for excellent research assistance by Ruben Drosten, Maximilian Nübling, and Lissia Weber. I thank Jürgen Dreifke and Ulrich Santana Jäger for sharing data on military installations.

War comes with immense costs: it kills workers, destroys buildings, and diverts attention and resources away from civilian industries. While economic theory suggests that rational agents adjust their behaviour when the probability of war rises, empirical evidence on this is lacking. Recent work has managed to convincingly measure the risk of war (e.g., Mueller and Rauh, 2022; Mueller et al., 2024), showing that the average risk for armed conflict over the next twelve months reached a new peak in 2024. While this underlines the importance of understanding the economic effects of war risk, it remains a challenge to disentangle the effects of war risk from the ones of war itself. This is because an increase in war risk for one country may arise from a war being fought by other countries, e.g. war risk increasing for Poland and Sweden after the Russian invasion of Ukraine.

Our paper overcomes this challenge by investigating the largest geopolitical confrontation in human history that did not escalate into open warfare: the Cold War in Europe. Two hostile military alliances were facing each other at the (inner) German border. As NATO was heavily outnumbered in terms of soldiers and conventional weapons, an invasion by the Warsaw Pact and fighting World War III on West German territory was a realistic scenario during this period.[1] In response, NATO initiated a forward defence strategy in 1963, which implied that invading troops were to be engaged at the (inner) German border. Declassified information on NATO's defence plans shows, however, that the main defence effort against a Soviet attack would happen at the Weser-Lech line *within* West Germany - around a hundred kilometres westward of the (inner) German border.

This paper exploits the geographic discontinuity of war risk at the Weser-Lech line within West Germany after 1963. Territory to the west of the defence line was treated with increased security, while territory to the east faced a higher risk of serving as a battlefield and of being occupied by Soviet troops. We geolocate the Weser-Lech line and investigate two types of military installations to show its military relevance. First, demolition chambers served as barriers to slow or halt a potential Soviet advance - making them of most use in areas where the war risk was high. In fact, only 6% of the demolition chambers were located west of the NATO defence line. In contrast, Nike systems with nuclear ammunition provided strategic air defence. Preventing them from being captured by Soviet troops, areas with low war risk offered the most suitable location. In line with this, 84% of the Nike systems were located west of the defence line. Hence, by guiding the placement of military installations, the NATO defence line provided visible and discontinuous variation in war risk during the Cold War.

[1]For simplicity, we will henceforth refer to an invasion by the Warsaw Pact as 'Soviet invasion'.

Passing all standard validation tests, we employ the NATO defence line as the border in a regression discontinuity design (RDD).[2] In particular, we show that the area around the defence line follows a continuous pattern for a variety of pre-determined variables from 1871 to 1955. This provides evidence against the concern that the NATO defence line was drawn according to pre-existing economic differences or some other factors that also impact economic outcomes. The empirical design estimates the causal local treatment effect of increased security (or of reduced war risk) by comparing municipality groups in the immediate vicinity of the NATO defence line. This is similar to asking what would have happened to regional economic development if historical circumstances had allowed to shift the defence line a bit further east and to provide increased security also to those municipality groups which just fell short of it. The optimal bandwidth is selected to be 33 km following a data-driven process suggested by Cattaneo et al. (2020a).

This paper finds a considerable and lasting effect of reduced war risk provided by NATO defence planning on regional economic development captured through the median income of full-time employees in 2019. For the most demanding specification, we find a treatment effect of 155 Euro in monthly median income, which is equivalent to an increase of 4.2%. We also show that the treatment effect occurs along the entire income distribution, with changes in income around 3.2% to 5.1%. We then conduct a battery of robustness exercises. We show that our results are robust to different types of standard errors. They are also robust to the classical set of plausibility tests applied to RD-settings (e.g., placebo lines, donut-RDD, and sensitivity to bandwidth) and remain significant in further robustness tests such as employing an alternative dependent variable, splitting the sample, conducting jackknife exercises etc.

To confirm that we are measuring the long-term effect of increased security (or of reduced war risk), we next address the concern that the NATO defence line lost its military purpose in 1990. While it is highly unrealistic that another treatment has happened after the Cold War at exactly this border, many military bases were closed after 1990. We first show that the treatment effect also exists for median income in 2002, which is the earliest date captured in our dataset. We then present evidence that the location of military bases during the Cold War and their closure afterwards were well balanced around the NATO defence line. This suggests that a multiplier effect of spending on military bases *cannot* drive our findings. We, hence, conclude that the differences in income across the NATO defence line have been caused by the differences in war risk.

[2] As is standard in the literature on geographic RDD, we also use the term border for the line determining treatment assignment, i.e. the NATO defence line.

While our setting is unique in the sense that there is a discontinuity in war risk, which allows for causal estimation of the treatment effect, the existence of war risk is very common. Around the world, developed countries are facing threats from their neighbours, which may ultimately result in war. Prominent examples include the Baltic states, Israel, South Korea, and Taiwan. In addition, many developing countries are facing a second challenge as they are failing to provide security throughout their territory against threats arising from terrorists, rebel groups, and armed bandits. For the first time, we have shown that the mere risk of war (without any conflict happening) can lead to large distortions in economic outcomes. This offers new insights into the long-term consequences of geopolitical tension.

Contribution to literature. This paper contributes to two main strands of literature. First, it contributes to the literature on the economic effects of insecurity. Research in this area was initially focused on developing countries which suffer from internal conflicts. Fear of exposure to violence can alter the behaviour of economic agents (see Rockmore, 2017; Arias et al., 2019; Tapsoba, 2023). For example, Arias et al. (2019) provide evidence that the pure presence of armed groups in Columbia leads farmers to follow more short-sighted and less profitable farming strategies. More related to our setting, Federle et al. (2022) suggest that in response to the Russian invasion of Ukraine stock markets have assessed country-specific risk of military escalation. For the period preceding the First World War, Verdickt (2020) finds that European companies respond to the risk of war by reducing dividends to build up reserves. Closest to assessing the aggregate economic effects of war risk are Caldara and Iacoviello (2022). They show that higher geopolitical risk foreshadows lower investment and is associated with more pressure on GDP growth in the United States. However, their measure of geopolitical risk includes conflicts and is, hence, no genuine risk measure.[3] Similarly, all previous papers suffer from the issue that violent conflicts occurred in close geographic or temporal proximity. Our setting overcomes these drawbacks. The feared invasion of Soviet troops into West Germany never happened. We, hence, analyse the risk of war in a setting where there is no confounding by a conflict.

We also contribute to the fast-growing literature on the long-run spatial effects of battle and occupation lines. It has been shown that regional exposure to fighting, conquering, or occupying forces has lasting effects on social and political outcomes such as regional identity (Dehdari and Gehring, 2022), social capital (Tur-Prats and Valencia

[3]Their main measure of geopolitical risk includes 'the threat, realization, and escalation of adverse events' (Caldara and Iacoviello, 2022, p.1195). As they are aware that this is not a measure of genuine risk, they also construct a measure which just captures threats. However, only some of their findings are shown to be robust to the genuine risk measure constructed from threats.

Caicedo, 2020), protest (Martinez et al., 2023), and extremism (Ochsner and Roesel, 2020; Fontana et al., 2023). More related to our work, other papers have investigated the effects on regional economic development. In response to the initial occupation of Austrian territory by the Red Army, Ochsner (2023) finds negative economic effects which are driven by a large population decline. Similarly, Dell (2010) shows that the implementation of extractive policies during the occupation of South America, starting in the 15th century, has depressed regional living standards to this day. In contrast, Wahl (2017) provides evidence that the Roman occupation of Germany had positive effects on regional long-run growth, which resulted from the persistence of the Roman road network. Closest to our paper is Oto-Peralías and Romero-Ávila (2017), which analyse the persistent economic effects of insecurity for a military frontier in the late Middle Ages. Employing an RD-setting, they show that military threats lead to the establishment of exploitative institutions, which in turn lead to higher inequality. They compare areas in Granada which were conquered early (the military frontier) to those areas which remained part of a Muslim Kingdom for more than a century longer (being both a threat and the control group). Their paper, hence, captures the effects of institutions. Similarly, in the previous papers treatment and control groups differed in terms of their exposure to hostile troops or to foreign occupation. In contrast, our border divides municipalities within the same country and subject to the same institutions. We are, hence, in a better position to capture the response of economic agents to insecurity itself.

Organisation. The remainder of this paper is organised as follows. Section 3.1 describes the historical background and the treatment assignment. Section 3.2 presents information on the data. Section 3.3 explains the empirical strategy and shows the validity of the identification assumptions. Section 3.4 lays out the empirical results. Section 3.5 provides a discussion of the results and Section 3.6 concludes.

3.1 Historical Background and Treatment Definition

3.1.1 Cold War Security Environment

Living in Germany during the Cold War was risky. With the accession of Germany to NATO and the founding of the Warsaw Pact in 1955, two hostile military alliances were separated at the (inner) German border. In retrospect, we know that war did not happen in Europe. At that time, however, a Soviet invasion and, hence, fighting on West German territory seemed a realistic scenario. Throughout the Cold War, NATO was heavily outnumbered in terms of soldiers and conventional weapons (Palmer, 2019). For example, the ratio of battle tanks in Europe was 2:1 in 1970 and 3:1 in 1985 in favour of the Warsaw Pact (BMVg, 1970, 1985). The Soviet conventional superiority made it likely that NATO itself would have to employ nuclear weapons against Soviet troops on West German territory (Thoß, 2006). With the steady move towards a flexible response strategy after 1961, NATO would have first attempted to stop a Soviet advance with conventional means (Pedlow, 1997). Still, the destruction of infrastructure would have been large. Beyond just the destruction, many contemporaries were frightened of falling into the hands of Soviet troops. Around the end of the Second World War (WWII), large and persistent population movements occurred in Germany (Eder and Halla, 2018) and Austria (Ochsner, 2023) with the sole objective of fleeing the Red Army.

The West German population was well aware of the threats it was facing. During the 1955 NATO field training exercise 'Carte Blanche', it was estimated that the simulated Soviet attack could result in 1.7 million dead and 3.5 million injured civilians in Germany (Davis II, 2018). Two years later, hypothetical Soviet forces were able to occupy large parts of West Germany during the NATO exercise 'Lion Noir' (Thoß, 2006). Newspapers were quick to report on these fatal results (see, e.g., Der Spiegel, 1955). In addition, the population was confronted with U.S. novels and games presenting West Germany as a battlefield (Hammerich, 2017). This facilitated the formation of pacifist groups that kept the public's focus on the precarious security environment. They were particularly popular during the 'fight against atomic death' protests in the 1950s, the Easter peace marches in the 1960s, and the peace movement against the NATO double-track decision in the 1980s.

3.1.2 NATO Defence Planning: The Weser-Lech Line

In line with German demands, the commander of NATO in Europe ordered in 1963 to implement a forward defence strategy (Hammerich, 2014). This implied that the defence against a Soviet invasion would henceforth start at the (inner) German border. The NATO troops were, however, not sufficiently strong to stop an invasion there (Krüger, 2008; Palmer, 2019). The Emergency Defence Plan (EDP 1-63) revealed that while NATO would delay the Soviet advance from the (inner) German border onwards, it was planned to stop Soviet troops only around a hundred kilometres westward at the main defence line called Weser-Lech (Hammerich, 2014).[4] This implies that areas to the west of the Weser-Lech line were treated with increased security after 1963. In contrast, areas to the east were designated as the battlefield. NATO itself was prepared to employ tactical nuclear weapons on these territories in West Germany (Thoß, 2006). While military technology and strategy changed between the 1960s and 1980s, the Weser-Lech line remained relevant.[5]

Even though most documents on NATO defence planning during the Cold War are either still classified or have been destroyed (Bolik and Möllers, 2022), NATO has released a map with the exact location of the Weser-Lech line. The defence line is shown in Figure 3.1. It runs considerably to the west of the two rivers it is named after. Due to this, we interpret the defence line as marking the transition to relatively safe areas, i.e. with a lower risk of being either occupied or a battlefield.[6] The NATO defence line was not a fortified wall. This likely reflected that fortifications such as the Maginot Line and the Atlantic Wall have proven incredibly ineffective during WWII. Also, building a wall protecting only a subgroup of the population would hardly be appealing to a democratic society. Less visible military installations, however, were aligned to the Weser-Lech line (see Section 3.1.3 for a detailed discussion). In contrast to other historic defence lines, the Weser-Lech line is quite unique as it divided one country, was determined by an international military alliance, and the war for which it was built has never happened. This makes an analysis especially appealing.

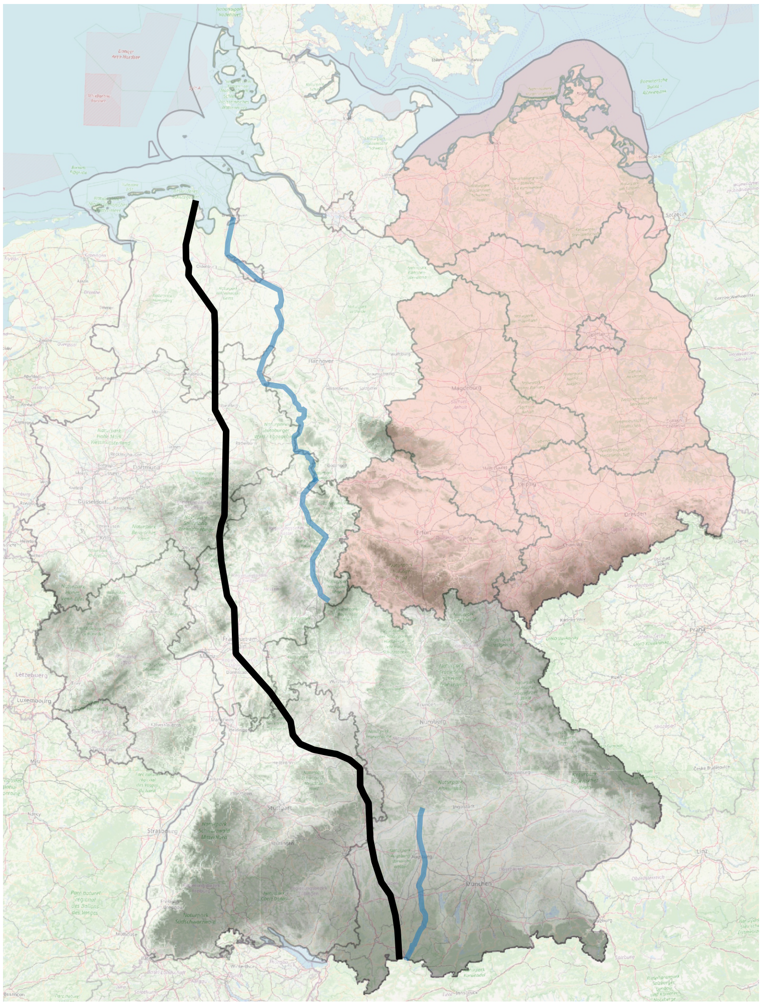
Over time, it became public knowledge that in case of a Soviet attack, NATO was not able to maintain German territorial integrity to the east of the Weser-Lech line. First, NATO training exercises were tailored to actual defence plans (Bolik and Möllers, 2022). This meant that every year, tens of thousands of conscripts were at least getting some realistic impression of the core aspects of NATO defence planning. Second, the existence and the continued importance of the Weser-Lech line were leaked in 1977. The new U.S. administration had initiated a strategic defence review (The White House, 1977). Given insufficient defence capabilities, the memorandum discussed whether it should more openly be communicated that only defence at the Weser-Lech line was reasonable (Schmid, 2007; Frühling, 2015). After Evans and Novak (1977) leaked the

[4] Since 1958, the Weser-Lech line has already been used as a delay zone to slow the Soviet advance. This was the purpose assigned in 1963 to the (inner) German border (Hammerich, 2014).

[5] For example, declassified documents show that the Northern Army Group still planned in 1988 to use the area between the Weser and the inner German border as its battlefield (Hammerich, 2014). Similarly, U.S. war simulations from 1989 and 1990 included the Weser-Lech line as a key barrier (Howe et al., 1989; Schwabe and Wilson, 1990).

[6] An alternative interpretation would be that the defence line marks the front line. Then, areas at least 10-20 km to the west would also suffer from serving as a battlefield. In our empirical specification, we will test robustness to both interpretations.

Figure 3.1: THE WESER-LECH NATO DEFENCE LINE



Notes: This figure shows the Weser-Lech NATO defence line in black. The location of the defence line is extracted from declassified information provided by NATO (2023). In light blue, the two rivers Weser (upper) and Lech (lower) are shown. The red areas are East Germany. Grey lines indicate state borders. Shading represents elevation based on BKG (2023). Dark indicates that something is more elevated. The background is from Open Street Maps. For details on the digitisation of the NATO defence line, see Figures 3.A.1 and 3.A.2 in the Appendix.

information, there was wide international coverage. Third, the term 'Weser-Lech' was first used in English language publications in the early 1960s and experienced a strong increase after 1977 (see Figure 3.A.3 in the Appendix).

3.1.3 Military Installations

To potentially affect economic outcomes, the NATO defence line has to meet two criteria. Firstly, the military has to undertake steps to implement the defence line. These actions must be capable of discontinuously reducing the war risk for areas to the west of the line. Secondly, not only the existence but also the exact location of the defence line has to be known. It could either be public knowledge or at least be known by an important or large subgroup of economic agents who incorporate this information into their decision-making. In the following, we show that the defence line guided location decisions for military installations during the Cold War and that these could be observed by locals. Due to the existence of a conscription system, a large share of the German population was trained to understand the purpose of military infrastructure in their region. From this, they could derive lessons on regional war risk.

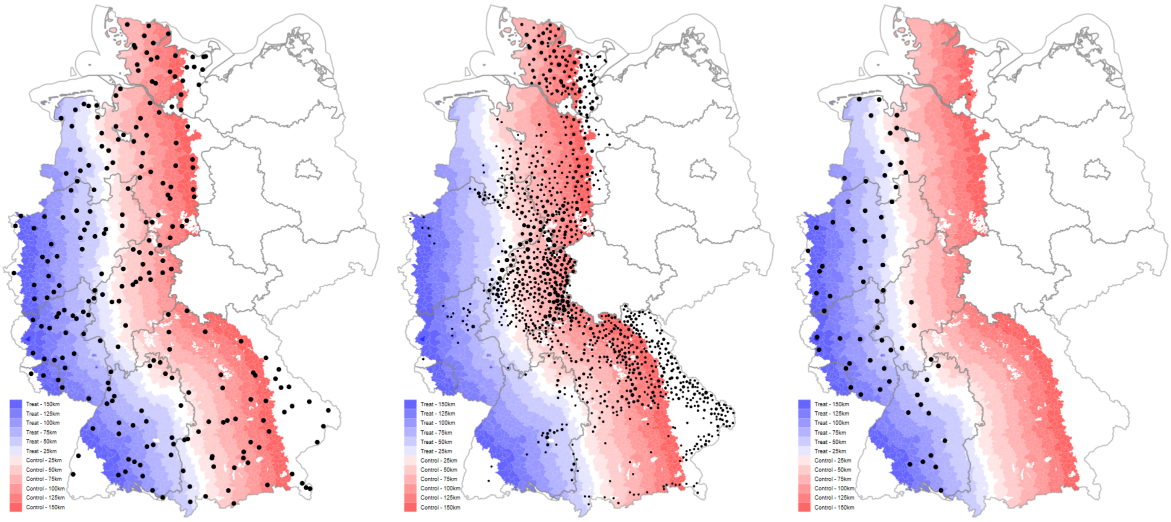
An intuitive approach to place military installations is to disperse them throughout the own territory. This allows to quickly engage an attacking enemy and to simultaneously keep some reserves out of immediate reach of the enemy. In fact, German military bases in 1970 were located in such a dispersed fashion, as shown in Figure 3.2a. Other types of military installations, however, may be optimally placed in a more concentrated manner. For example, to halt a Soviet invasion, demolition chambers were installed on German roads. Seipp (2022, p.215) calls them a 'defining feature' of the military geography of Cold War Germany. After an explosion, the demolition chambers would turn into crater obstacles with a depth of up to six metres (Grube, 2004). In principle, every road in Germany qualified for such an installation. Given limited resources for preparation and maintenance as well as the explosives' storage, demolition chambers should be expected in areas most vulnerable to a Soviet invasion. Figure 3.2b shows the location of 4,600 demolition chambers. They are predominantly placed in the east, close to the (inner) German border, where the territory is presumably more vulnerable.

In contrast, strategic air defence is better not located in areas which may be lost in the initial phase of a war. The so-called Nike belt was established in the 1960s to stop Soviet bombers. It also employed nuclear air-to-air ammunition, which was stored close by (Dreifke, 1998). The purpose of the Nike systems was to protect civilians and important military infrastructure such as air bases, command posts, and logistics units in backward areas - not to engage on a likely battlefield (Spreckelsen and Vesper, 2004). In light of their strategic purpose, their low mobility, and their nuclear ammunition, it is to be expected that the Nike systems are located in relatively safe areas. Figure 3.2c shows the location of 71 nuclear-equipped Nike systems. They are placed predominantly in the west, where the territory is presumably safer.

Strikingly, we observe an accumulation of military installations around the NATO defence line. Excluding municipality groups crossed by the defence line, only 6% of the demolition chambers but 84% of the Nike systems are west of the defence line. This

Figure 3.2: LOCATION OF MILITARY INSTALLATIONS

(a) Military bases (b) Demolition chambers (c) Nike systems



Notes: This figure plots the location of three types of military installations in West Germany during the Cold War. Panel (a) shows military bases, Panel (b) shows demolition chambers, and Panel (c) shows Nike systems. Dots in Panel (a) and (c) indicate the existence of the respective military installation in a municipality group. The dots' size in Panel (b) is proportional to the number of demolition chambers in a municipality group. Municipality groups crossed by the NATO defence line are presented in white. Coloured are West German municipality groups with less than 150 km distance between their centroid and the defence line. Blue implies that a municipality group is to the west of the defence line (i.e. treated with security), and red implies that a municipality group is to the east (i.e. control). Data on military bases is from Dreifke (2008) and ZMSBw (2024). Data on demolition chambers is from cold-war.de (2024). Data on Nike systems is from Trägerkreis Atomwaffen abschaffen (2024) and Dreifke (2024). Details on the data sources are provided in Section 3.B.1 in the Appendix.

suggests that the NATO defence line, indeed, marked a turning point. The placement of military installations suggests that the military was confident that it firstly does not require barriers westward of the NATO defence line and secondly can place its high-value strategic weapon systems there. Within the bandwidth of 33 km applied in our main analysis in Section 3.3.1, the average number of demolition chambers per municipality group is 1.21 to the east of the line and 0.49 to the west. The difference is significant at less than the 1% level.[7] The discontinuous jump suggests that the NATO defence line did, in fact, determine the point where the level of war risk shifted.

The location of military installations provided a signal of which areas were more and which areas were less safe. While the German population was generally aware that a Soviet invasion may occur and would likely not be stopped at the (inner) German border, the military installations served as visible information on the otherwise

[7]As the number of Nike systems within this bandwidth is only 19, a comparison is less fruitful. The probability that a municipality group to the west of the line has a Nike system is 3.2% vs. 2.9% to the east.

secret defence plans. As conscripts, many young men were involved with or at least informed about these installations and their purpose. Both were also observable to locals. The role of the Nike systems was, for example, explained in a letter to municipalities (Spreckelsen and Vesper, 2004) and the systems were so notable that already during the Cold War a book containing their locations was published (Mechtersheimer and Barth, 1986). Similarly, the prepared demolition chambers could easily be distinguished from civilian infrastructure (see Figure 3.B.1 in the Appendix). Throughout the Cold War, local and national newspapers have reported on contracts awarded to civilian firms to build the demolition chambers and also on peace activists who had located and damaged them (e.g., Der Spiegel, 1983; Priotto, 2016). This suggests that other interested parties should have been able to collect information on the positioning of the NATO defence line.

Anecdotal evidence is provided by the board game 'Fulda Gap: The First Battle of the Next War'. The game was released in 1977 and simulated a Soviet invasion of central Germany (Seipp, 2022). The game was perceived to be highly realistic. Not only were military installations such as Nike systems correctly placed on the board, but also the rules were derived from military sources and the game designer was an advisor to the Pentagon (Hammerich, 2017). Crucially, this game's battlefield was nearly exclusively located on West German territory - with the NATO defence line running through the centre of the board (see Figure 3.A.4 in the Appendix). While the player's notes acknowledge that the primary concern for NATO is to defend as far east as possible, it also points out that 'this line will be quickly forced back to Marburg, Giessen, and Frankfurt' (Simulations Publication Inc., 1977, p.17). All three city centres are less than 25 km to the east of the NATO defence line. The game's scenario is, hence, almost identical to the defence line employed in this paper. The game received wide media attention, increased local awareness of war risk, and became a key symbol for the German peace movement (Hammerich, 2017; Seipp, 2022).[8]

3.2 Data

3.2.1 Unit of Observation

Our unit of observation is the municipality group ('Gemeindeverband'). This is the lowest administrative level with data on income being comprehensively available. In

[8]The board game is considered to be so important for the German history after 1945 that it is part of the permanent exhibition at the House of the History of the Federal Republic of Germany in Bonn, the museum dedicated to this period.

total, there are 4,603 municipality groups.[9] Municipality groups in West Germany have on average 19,300 inhabitants in 2019 and stretch an area of 70.6 square kilometers. The advantage of employing municipality groups is that their size in terms of inhabitants is more similar between states than it is the case for municipalities.

We exclude observations from the set of 3,670 municipality groups in West Germany for three reasons. First, uninhabited areas such as forests and lakes sometimes form their own municipality group but naturally do not have any income to report. Second, our empirical approach will incorporate state fixed effects to account for the length of the NATO defence line stretching from North to South Germany. This excludes those five states (incl. two city-states), which are located on one side of the defence line only and, hence, do not experience any variation in treatment. Third, some municipality groups are crossed by the defence line. As their treatment status is unclear, we also exclude them. This leaves us with 2,954 available observations. Of these, 1,031 municipality groups are located west of the NATO defence line (i.e. treated with security), and 1,923 are located east of it.

Operating in an RD-setting, we will focus on a subset of observations within a narrow bandwidth of the border. To determine the treatment and control group, we digitise and geolocate the NATO defence line and estimate the geodetic distance from each municipality group's centroid to the closest point on the defence line (see Figure 3.A.2 in the Appendix). Our main estimation includes 619 municipality groups, which are located within the bandwidth of 33 km (for details, see Section 3.3.1). Our income measure is available for 616 of these - making our treatment group consist of 309 observations and our control group consist of 307 observations.

In the Appendix, we present a map with the location of the municipality groups both for our sample of 616 observations and for the available 2,954 observations (see Figure 3.C.1) as well as a table with their distribution over states (see Table 3.C.1). We also provide summary statistics on the variables covered in Sections 3.2.2 and 3.2.3 for our sample (see Table 3.C.2) and for all available observations (see Table 3.C.3).

3.2.2 Main Variable: Income

To measure long-run regional economic development, we employ administrative data on monthly median income in 2019 (prior to the Covid-19 pandemic). Our income

[9]We employ the municipal structure as of 31 December 2020 as provided by the Federal Agency for Cartography and Geodesy. At that time, there existed 10,796 municipalities. Approx. 70% of the municipality groups are identical to a municipality. The remaining 30% are formed by smaller municipalities agreeing to share administrative tasks.

variable captures *gross* wages, including both regular salaries and all one-off payments from the main employer up to the contribution assessment ceiling for pension insurance (6,700 Euro in 2019). Median income is estimated for the group of full-time employees subject to social security contributions. To protect anonymity, the variable is not available for the 2.4% of West German municipality groups with less than 500 full-time employees. Due to this, we lose three observations in our main regression. The data is based on administrative information from the German Federal Employment Agency and was compiled at the municipality group level for a collaboration with the German newspaper 'Die ZEIT', which has shared the data with us.

Our dataset also includes information on the monthly income of full-time employees at the 20th, 40th, 60th, and 80th percentiles within their municipality group. This allows us to estimate the treatment effect along the entire income distribution. For monthly income at the 80th percentile, 13 municipality groups in our sample actually reach the ceiling of 6,700 Euro, so we only observe censored data for these. We also have information on monthly median income in 2002, which is the earliest date made available. By getting closer to the time of the Cold War, we can provide evidence that the treatment effect occurred during this period and not later. We also employ the natural logarithm of income measures to compare treatment effects both along the income distribution and over time.

For our sample of 616 municipality groups with less than 33 km distance to the border, the average median income is 3,521 Euro in 2019 and 2,606 Euro in 2002. The standard deviation is 326 and 245 Euro, respectively. With an average of 3,522 Euro in 2019 and 2,585 Euro in 2002, median income is very similar for all available observations. There is a large variation in median income between municipality groups. The poorest municipality group in our sample is 'Essen (Oldenburg)' with 2,591 Euro in median income in 2019, and the richest is 'Bad Soden am Taunus' with 5,009 Euro. The average income at the 20th percentile is 2,472 Euro and at the 80th percentile is 5,077 Euro in 2019.

Alternative income measure. For robustness, we also employ the municipal share of income tax as an alternative income measure. The municipal share of income tax is more broadly defined than median income as it also captures labour income from self-employed and part-time work as well as non-labour income from other sources. The annual municipal income tax per inhabitant in 2019 is taken from the 'Federal Institute for Research on Building, Urban Affairs, and Spatial Development' BBSR (2023). Again, municipality groups are the smallest units for which data is available.

Municipalities receive roughly 15% of income tax and 12% of capital gains tax collected from their inhabitants.[10] As the tax rates are the same throughout Germany, the municipal income tax per inhabitant is a good proxy for income. Its correlation with median income is 0.87 for our sample and 0.80 for all available observations. The average value of the municipal income tax in our sample is 571 Euro in 2019, with a standard deviation of 112 Euro.

3.2.3 Control Variables

We collect a series of pre-determined control variables that account for a potential bias arising from a third factor driving both the location of the NATO defence line and regional economic development. To not lose observations, we restrict the set of control variables firstly to geographic variables which can be constructed for all municipality groups from digital maps and secondly to historical population data which has been compiled for the whole of Germany.

Geography. While state and border segment fixed effects account for a large degree of variation in geography within Germany, there may be within-state and within-segment geographic differences which are not adequately captured. We, hence, employ the standard battery of geographic control variables. They cover aspects that are pre-determined but may still impact long-run economic development. All variables are self-computed based on geocoded information contained in Shape-Files employing the tools provided by QGIS. The main file contains polygons of all municipality groups which existed in 2020 (BKG, 2020). This is blended together with information on rivers (EEA, 2023), terrain (BKG, 2023), and suitability of agriculture (Zabel et al., 2014) to generate six geographic control variables: distance to the inner German border, distance to the closest river, elevation, ruggedness, crop suitability, and area. For details on the data generation process, see Section 3.B.2 in the Appendix.

Population. Population dynamics reflect economic performance - at least in the medium- to long-run (Roesel, 2023). We want to make sure that the treatment effect

[10] In practice, the estimation is slightly more complex: 15% of the overall income tax collected by a state is allocated to its municipalities. Each municipality receives a share which is equivalent to the share of what its inhabitants have contributed to the total income tax collected in that state. However, for calculating these shares, only the tax collected from income up to 35k Euro for individuals and 70k Euro for couples is included (for details see, BMF (2023)). This reduces the municipal income tax for municipalities with many high-income earners and increases it for municipalities with many low-income earners. As the applied formula reduces differences between low- and high-income municipality groups, we estimate a lower bound of the treatment effect on realised incomes.

is not driven by dynamics which may have already existed *before* the treatment, such as municipality groups west of the border being consistently larger, faster growing, and more densely populated in the early 20th century. For this, we make use of the German Local Population Database, GPOP, which compiles statistics on local populations between 1871 and 2019 for all German municipalities (Roesel, 2023). A key feature of the database is its consistency with contemporary administrative boundaries. As control variables, we employ the number of inhabitants in 1871, the population density in 1939, and annualised population growth rates between 1871 and 1939.[11]

3.2.4 Additional Variables

The in-depth analyses of this paper require additional variables beyond the ones employed in the main regression. We first collect variables measuring historic economic development between 1930 and 1955 to validate the assumption of pre-treatment balance around the border. Second, we gather information on military bases for the period from 1970 to 2002 to provide evidence that neither their existence during the Cold War nor their closure afterwards drives the results.

Historic economic development. As no historical measure for local per capita income exists, we employ a variety of variables capturing historical economic development to proxy for it. The variables are from both existing and self-compiled datasets. Falter and Hänisch (1990) provide pre-WWII census data such as occupation shares and the industrial structure of municipalities. We also digitise the Statistical Yearbooks of Municipalities from 1950, 1952, and 1955. They contain information on the number of firms, infrastructure, and public finances of municipalities. We geolocate the historical variables and trace mergers. Then, we map the historical to the contemporaneous administrative structure of Germany. Depending on the data source, information was only published for municipalities with more than 2,000 to 10,000 inhabitants at that time, so coverage varies between 236 and 1,159 municipality groups. There is no reason, however, to believe that this biases our results.[12] Finally, to capture the destruction caused by WWII, we deviate from our usual unit of observation and include county-level data on the building and housing census in 1950 from Braun and Franke (2021). For comparison, all variables are normalised to be mean zero and

[11]The rich collection of historical population figures in the GPOP database allows us to calculate even more variables, e.g. population size in a different year. Further variables are listed in Table 3.B.1 in the Appendix and are included in the balance tests in Section 3.3.2.1.

[12]As smaller municipality groups are missing equally on both sides of the border, Figure 3.B.3 in the Appendix shows that data availability is well balanced around the border.

have a standard deviation of one. A detailed description of the data and the applied processes is provided in Section 3.B.2 in the Appendix. Summary statistics are presented for municipality groups within the 33 km bandwidth (see Table 3.C.4) and for all municipality groups in the dataset (see Table 3.C.5).

Military bases. The existence and the closure of military bases can impact local economic development (Zou, 2018). We employ the chronicles of operational Bundeswehr units by Dreifke (2008) to determine for each municipality group whether it hosted a squadron, battalion, or regiment (typically consisting of a few hundred to more than a thousand soldiers) in the years 1970, 1990, and 2002.[13] The chronicles allow us to identify and locate medium-sized and large military bases, while they exclude smaller command posts, independent companies, or depots. The compilation by Dreifke (2008) is based on troop chronicles, site brochures, troop magazines, and documents from the Ministry of Defence. We also employ the database on the location of military bases administrated by the Center for Military History and Social Sciences of the Bundeswehr (ZMSBw, 2024) to validate and specify information. Meeting our criteria, there exist 508 military bases in 243 municipality groups in 1970. The number is broadly constant, with 511 military bases in 1990. It decreases to 247 military bases in 171 municipality groups in 2002. Summary statistics are presented in Table 3.C.7 in the Appendix.[14]

3.3 Identification Strategy

3.3.1 Geographic RDD

The NATO defence line provides idiosyncratic variation in security. As discussed in Section 3.1.2, the defence line marks the point where a Soviet advance was supposed to be stopped by NATO forces with all means. It was determined by military considerations taking the superiority of Soviet armed forces into account. Municipality groups to the east of the defence line were at higher risk both to serve as battlefield and to be occupied by Soviet forces. In the spirit of Dell (2010) and Dell and Querubin

[13]As income data is available from 2002 onwards, we can test for a treatment effect of the NATO defence line on income in that year. Hence, we do not need to be concerned about any changes in military bases happening after 2002.

[14]We also employ the information on military bases together with data on other military installations to show that the NATO defence line guided military installation decisions during the Cold War in Section 3.1.3. For this, we have gathered data on the location of demolition chambers and Nike systems. Both are described in Section 3.B.1 in the Appendix and their summary statistics are presented in Table 3.C.7.

(2018), we employ a geographic RDD. To estimate the causal local treatment effect of increased security on economic development, we compare municipality groups in the immediate vicinity of the NATO defence line. This is similar to asking what would have happened to regional economic development if historical circumstances had allowed to shift the defence line a bit further east and to provide increased security to those municipality groups which just fell short of it. We rationalise this approach by showing in Section 3.3.2.1 that the area around the defence line follows a continuous pattern with regard to a variety of pre-determined variables. The only difference is the NATO defence line, which served as a discontinuous increase in security during the Cold War for municipality groups to its west. We estimate the following regression:

$$Income_c = \alpha + \beta \times Treat_c + p(Distance_c) + \mathbf{z_c'}\gamma + \rho_s + \rho_b + \epsilon_c \tag{3.1}$$

where $Income_c$ is the median income in municipality group c in 2019. $Treat_c$ is a dummy that takes the value 1 if the municipality group is treated with security (i.e. to the west of the defence line) and 0 otherwise. $Distance_c$ is a distance measure from the centroid of a municipality group to the closest point on the defence line. As suggested by Gelman and Imbens (2019), we include a flexible linear distance measure, and we also test robustness for a quadratic polynomial, but we do not include higher-order polynomials. Distance is measured in geodetic fashion, incorporating the curvature of the earth. $\mathbf{z_c}$ includes the control variables for geographic features, which are longitude, latitude, distance to inner German border, distance to rivers, crop suitability, elevation, ruggedness, and area, as well as for population characteristics, namely size in 1871, growth from 1871 to 1939, and density in 1939. $\rho_\mathbf{s}$ and $\rho_\mathbf{b}$ absorb state and 100 km border segment fixed effects, which account for the fact that the defence line crosses very different territory over its length of more than 700 km.

The optimal bandwidth is selected according to Cattaneo et al. (2020a) for the most demanding regression specification, including all control variables. This data-driven process of choosing a bandwidth minimises the mean squared error given our choice of a linear polynomial and a triangular kernel.[15] The optimal bandwidth is set at 33.4 km. This is in line with other studies at the municipality level in Europe choosing a bandwidth of 30 to 35 km (see, e.g., Ochsner and Roesel, 2020; Dehdari and Gehring, 2022; Lang and Schneider, 2023). The employed data-driven process requires the use of standard errors, which are robust to optimal bandwidth selection (Cattaneo et al., 2020a). We also estimate standard errors, which are robust to heteroscedasticity and

[15]Increasing the bandwidth increases the number of observations for estimation and, hence, reduces the variance of the estimated coefficient, but also increases the misspecification error of the local polynomial approximation (i.e. smoothing bias).

robust to spatial spillovers between municipality groups within a 33 km range (Conley, 2008; Colella et al., 2019).

3.3.2 Assumptions

For the RDD to be a valid empirical approach, a few assumptions have to hold. Firstly, there should not be a compound treatment occurring at the same time or subsequently. As is described in Section 3.1.2, the defence line was determined according to military considerations by NATO, an international alliance. For the involved countries, protecting their own soldiers and territory far outweighed any considerations of German domestic policy. The defence line did not follow any administrative or political patterns. While it is named after two rivers, the line is placed on average 25 km behind those rivers, suggesting that the rivers themselves are not the treatment. Secondly, the NATO defence line has to be an actual treatment providing an increased level of security to municipality groups in the west. This is suggested by the location of military installations, in particular demolition chambers and Nike systems, presented in Section 3.1.3. Importantly, Section 3.5.1 shows that the number of military bases, however, does not differ between both sides of the border, suggesting that the opening and closure of military bases is not a compound treatment. Thirdly, municipality groups should not be able to sort into treatment. Neither are municipality groups involved with secret military planning by NATO, nor can municipality groups change their location. Following Cattaneo et al. (2020b), we can also formally test for manipulation into treatment using local polynomial density estimators. Figure 3.D.1 in the Appendix shows that the number of observations on both sides of the border is similar and that confidence intervals of the density estimates overlap. This suggests that no sorting has happened.

3.3.2.1 Balance

The main assumption for our geographic RDD is that in the absence of treatment, all outcomes would vary smoothly at the border. As most (if not all) relevant contemporaneous outcomes in our setting are expected to not be independent of both security and income, there exists no placebo outcome for a placebo test. The assumption has, hence, to be tested for pre-determined variables. It would be a main challenge to identification if the NATO defence line followed pre-determined economic conditions. The main concern is that differences in economic performance existed before the 1960s and that the line was drawn in light of these differences. Another concern is that certain geographic features have shaped economic development before the 1960s and that the same geographic features are also of relevance when defending German territory against Soviet troops. By formally testing for the continuity of pre-determined variables, we make sure that any differences in the contemporaneous economic outcome have occurred after the defence line was established and is, in fact, *caused* by it.

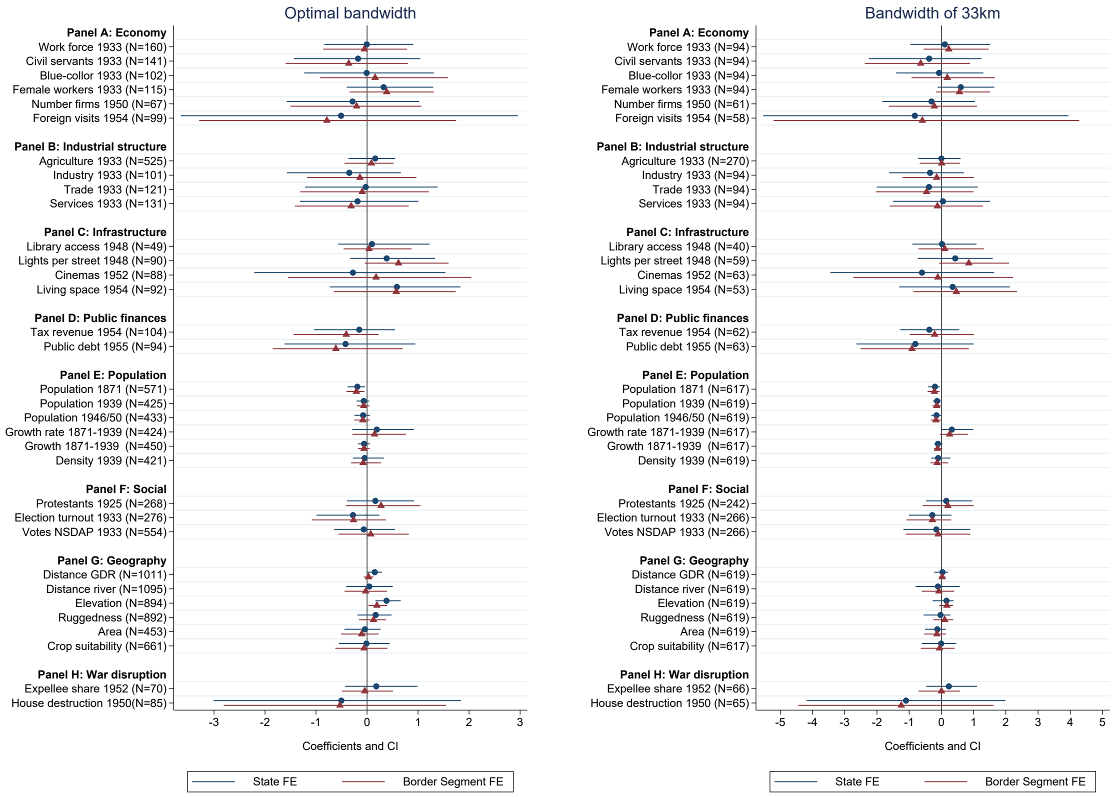
The set of employed pre-determined variables covers both historical economic performance and geographic features. The historical variables extend over the period from 1871 to 1955. This was before Germany joined NATO, so all outcomes had been realised before the defence line came into place. As no historical measure for local per capita income has been published, we employ a variety of variables to proxy for it. For example, a municipality group with higher per capita income can be expected to have healthier public finances and a better public infrastructure. Richer municipality groups are also expected to differ from poorer municipality groups in terms of their industrial composition and social characteristics. In total, 33 variables covering eight topics are tested for balance. A detailed description of the data is provided in Section 3.B.2 in the Appendix.

We formally test the assumption of balance through a geographic discontinuity regression of treatment on the pre-determined variables. We do not employ simple mean comparisons as the setting requires to compare municipality groups close to the defence line.[16] The regression is defined similarly to Equation (3.1). We employ a triangular kernel, a flexible linear polynomial for distance, and either state or segment fixed effects. As is standard, we do not include control variables as they are themselves outcomes in the balancing tests. For illustration, the variables are normalised to be mean zero and have a standard deviation of one. We run the regression twice: first for the optimal bandwidth of the respective variable according to Cattaneo et al. (2020a) and second for a 33 km bandwidth, which is optimal in the main regression. Standard errors are robust to optimal bandwidth selection. We expect to not reject the null hypothesis of no treatment effect because the security treatment through the NATO defence line occurred after the pre-determined variables had been realised.

The results in Figure 3.3 suggest that the identification assumption of continuity at the border is fulfilled. There are no systematic deviations from a smooth variation of the pre-determined variables at the NATO defence line. This is especially striking

[16]For many pre-determined variables, there exist significant differences in a mean comparison. However, this naive approach compares municipality groups a few hundred kilometres to the east and to the west of the defence line. This is conceptually very different from the RD-approach where municipality groups close to the border are compared. Hence, the significant differences in the means of pre-determined variables can be seen as validating the methodological approach taken in this paper.

Figure 3.3: BALANCE OF PRE-DETERMINED VARIABLES



Notes: The figure plots the treatment effect of the NATO defence line on pre-determined variables from 1871 to 1955. For each variable, a separate geographic discontinuity regression has been conducted with a triangular kernel, a flexible linear distance control, and either state fixed effects (blue dots) or border segment fixed effects (red triangles). For the left side, the bandwidth is set to be optimal for each variable. For the right side, the bandwidth of 33 km from the main specification is applied. Standard errors are robustly estimated in line with Cattaneo et al. (2020a). For illustration, the variables have been normalised to a mean of zero and a standard deviation of one. Confidence intervals are shown at the 95% significance level. For each variable, the number of employed observations is given in brackets. For the left side, N is based on the estimation with state fixed effects. For the right side, N is similar with both types of fixed effects. Detailed results are presented in Tables 3.D.1 to 3.D.8 in the Appendix. For results on population growth between 1871 and 1946/50, see also there. All variables are at the municipality group level, with the exception being the variable house destruction which is only available at the county level.

as so many variables are analysed - ranging from the local economic and industrial structure over public infrastructure and finances to social, population, geographic, and war-related factors. The results for elevation suggest that territory to the west of the defence line is more elevated - however, not for the 33 km bandwidth employed in the main analysis. As it is easier to fight from high ground, this emphasises that the defence line follows military considerations. As none of the economic variables from before 1955 has been impacted by this, elevation is unlikely to become a relevant factor for economic development after 1960. With regards to population size, municipality groups treated with security were marginally smaller in 1871 than the control group, and seem to remain smaller. Given the small size of the differences and contrary evidence on both population growth and population density, this does not lead to the conclusion that municipality groups on either side of the border were economically more developed before the Cold War.[17]

Detailed results can be found in the Appendix in Section 3.D.2. This includes more specifications such as a uniform kernel as well as heteroscedasticity-robust and robust to spatial spillovers standard errors (see Tables 3.D.1 to 3.D.8). Figure 3.D.2 shows global RD graphs which also include municipality groups outside of the optimal bandwidth.

3.4 Results

3.4.1 Main Results

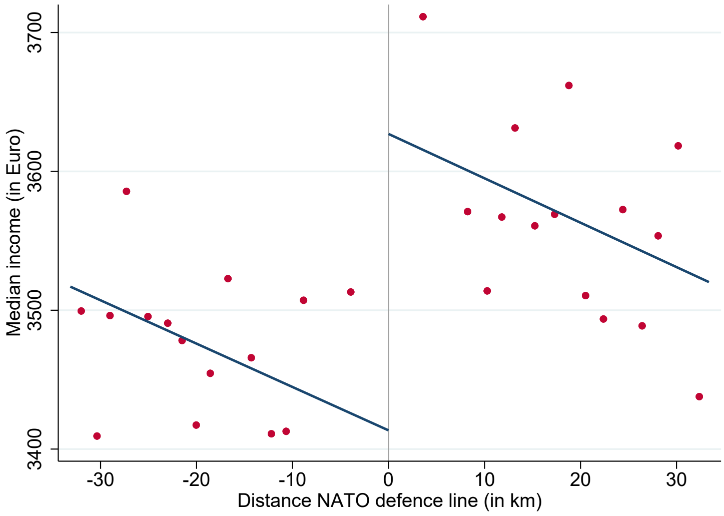
Figure 3.4 displays the treatment effect: Contemporaneous income shows a discontinuity at the former NATO defence line. For the optimal bandwidth of 33 km around the border, the figure firstly plots the binned median income in 2019 and secondly fits a flexible linear polynomial for the most parsimonious specification only absorbing state fixed effects. The discontinuity in the RD plot suggests that the monthly median income for a municipality group just west of the NATO defence line is around 200 Euro higher compared to a municipality group just east of the NATO defence line. This large treatment effect is in stark contrast to our inability to find a discontinuity in pre-determined economic outcomes around the border.[18]

To control for a wide range of variables and to test statistical significance, next we explore the RD setting more formally by implementing Equation (3.1). Depending on the specification, the treatment effect of the NATO defence line on monthly median income varies between 155 and 223 Euro (see Table 3.1). The results for logged values suggest that this is similar to a 4.2% to 6.0% increase in median income for a municipality group located just west rather than east of the border (see Table 3.E.1 in the Appendix). The effect size is large even when including all control variables, it

[17]For treated municipality groups, the relative population growth rates from before the treatment are a bit larger, while their absolute population growth is a bit smaller. Even though these variables are available for all municipality groups and can be precisely estimated, the differences are only significant in very few specifications. Also, for population density (probably the population variable capturing economic development the best), we do not see any discontinuity at the border.

[18]Similar discontinuities are observed at the border when absorbing border segment fixed effects or when plotting third-order polynomials for distance over the entire distribution (see Figure 3.E.1 and Figure 3.E.2 in the Appendix).

Figure 3.4: DISCONTINUITY OF MEDIAN INCOME IN 2019 AT THE BORDER



Notes: This figure plots the treatment effect of the NATO defence line on median income in 2019 at the municipality group level. Positive values for distance indicate that a municipality group is west of the NATO defence line (i.e. treated with security), and negative values indicate being east. The bandwidth is set to be optimal (33 km). A triangular kernel and flexible linear distance controls are included. State fixed effects are absorbed. Bins are quantile-spaced, and their number is chosen according to the mimicking variance criterion. In the Appendix, Figure 3.E.1 shows results with border segment fixed effects. Figure 3.E.2 presents a global RD plot. Figure 3.E.3 shows that findings are robust to excluding municipality groups in immediate proximity to the border.

Table 3.1: MAIN RESULTS: TREATMENT WITH SECURITY

	Plain		+ State FE		+ Coordinates		+ Geo. control		+ Pop. control		+ Border Segments	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)	(VI)	(VI^a)
$Treat_c$	189.0**	195.6**	223.0***	213.7***	206.9***	204.6***	198.6***	189.0***	184.4***	176.3**	168.4***	154.7**
	(0.019)	(0.027)	(0.001)	(0.006)	(0.002)	(0.007)	(0.001)	(0.006)	(0.003)	(0.010)	(0.004)	(0.016)
	[0.133]		[0.026]		[0.044]		[0.025]		[0.036]		[0.059]	
	{0.009}		{0.000}		{0.000}		{0.000}		{0.001}		{0.001}	
State-FE			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates					Y	Y	Y	Y	Y	Y	Y	Y
Geography							Y	Y	Y	Y	Y	Y
Population									Y	Y	Y	Y
Segment-FE											Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km
N	616	616	616	616	616	616	614	614	612	612	612	612

Notes: This table presents the coefficients for the treatment effect of the NATO defence line on median income in 2019 at the municipality group level. Optimal bandwidth has been selected for the most demanding specification (VI^a) following Cattaneo et al. (2020a). *Geographic controls* include distance GDR, distance river, crop suitability, elevation, ruggedness, and area. *Population controls* include population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Table 3.E.1 in the Appendix shows results for the natural logarithm of median income.

is virtually unaffected by employing either a uniform or a triangular kernel, and it is highly significant for three different types of standard errors (robust to optimal bandwidth selection, robust to spatial spillovers, and robust to heteroscedasticity). The findings suggest that there is a considerable long-run effect of reduced war risk provided by the NATO defence line on regional economic development captured through median income.

Median income in 2002. We have previously shown that differences in median income still exist today around the NATO defence line, which has lost its military purpose and, hence, its status as a treatment more than three decades ago. On the one hand, this is strong evidence of the long-lasting effect of security on regional economic activity. On the other hand, it raises concerns about whether the differences have actually been caused by the treatment during the Cold War or may have occurred later. While it is highly unrealistic that another treatment has happened after the Cold War at exactly this border, we want to make sure that it is not the end of the NATO defence line itself causing the economic differences after 1990. For now, the earliest year for which we have access to median income at the municipality group level is 2002. Results in Table 3.E.2 in the Appendix suggest that differences in median income have already existed in 2002 around the border. The size of the treatment effect, ranging from 2.8% to 6.1%, is comparable to the one observed in 2019. While the time gap between 1990 and 2002 is still not optimal, it is reassuring to see that the regional economic differences have already existed in much closer proximity to the end of the Cold War. This implies that military base closures happening after 2002 cannot drive our results. As we trace the first rounds of base closures until 2002, we can show in Section 3.5.1 that they do not provide an explanation for our results. This suggests that the treatment with security during the Cold War actually caused median income to diverge.

Effects along income distribution. To test whether the treatment effect of the NATO defence line is observed along the income distribution, we replace the median income with the 20th, 40th, 60th, and 80th percentile of income for full-time employees in each municipality group. The RD plots suggest a discontinuity of monthly income at the border along the entire income distribution (see Figure 3.E.4 in the Appendix). More formally, we replace the dependent variable in Equation (3.1) with four new measures of monthly income and present results in Table 3.2.[19] We find a large and

[19]Results are for a triangular kernel. See Table 3.E.3 in the Appendix for results for a uniform kernel.

consistent treatment effect of the NATO defence line across the income distribution - with higher absolute increases in income for individuals located further up the income distribution. Relative increases are broadly similar along the income distribution with treatment causing income in 2019 to be between 3.2% and 5.1% higher in municipality groups located west of the NATO defence line (see Table 3.E.4). In the most demanding specification, however, the coefficient for income at the 80th percentile loses its significance. This likely results from the censoring of the income variable at the ceiling for pension contributions at 6,700 Euro per month. For 13 municipality groups, our estimation is employing censored income rather than the actual 80th percentile income. The precision of the estimated treatment effect suffers from this.

Table 3.2: RESULTS ALONG THE INCOME DISTRIBUTION

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
$Treat_c$	100.7**	87.1**	153.3**	112.1**	213.7***	154.7**	305.6***	217.2**	307.1*	179.2
	(0.018)	(0.014)	(0.012)	(0.026)	(0.006)	(0.016)	(0.004)	(0.011)	(0.055)	(0.154)
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates		Y		Y		Y		Y		Y
Geography		Y		Y		Y		Y		Y
Population		Y		Y		Y		Y		Y
Segment-FE		Y		Y		Y		Y		Y
Kernel	T	T	T	T	T	T	T	T	T	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km
N	616	612	616	612	616	612	616	612	616	612

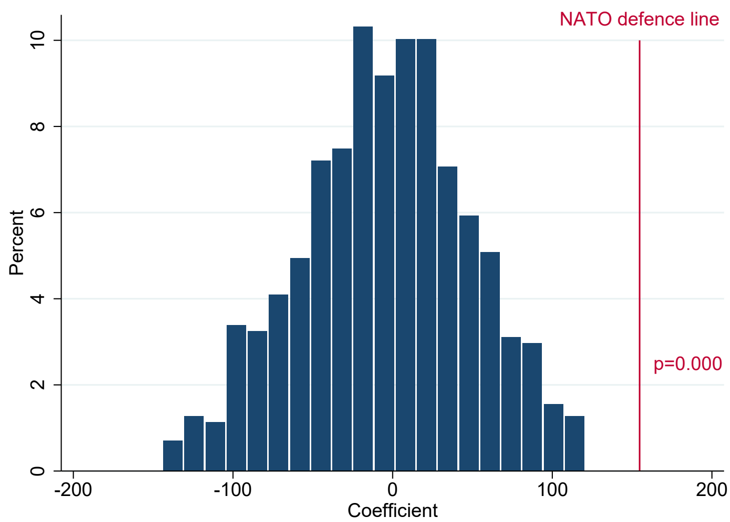
Notes: For five points along the income distribution, this table presents the coefficient for the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a triangular kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01. Table 3.E.3 in the Appendix presents results for a uniform kernel also including spatially-robust and heteroscedasticity-robust p-values. Table 3.E.4 presents results for the natural logarithm of income.

3.4.2 Placebo and Robustness Tests

In the following, we test the plausibility of the RDD assumptions and show robustness of our results. While the underlying assumptions are about unobserved features and, hence, cannot be tested themselves, we follow the practices suggested by Cattaneo et al. (2020a). Through this, we provide empirical evidence supporting the validity of the research design.

Placebo lines. The application of the geographic RDD rests on the continuity assumption. While we have previously shown for a large set of pre-determined variables that there was no discontinuity at the border before treatment, we cannot show that median income itself would be continuous at the border in the absence of treatment. By estimating the treatment effect at placebo lines, we can test, however, whether median income is continuous at other points. To preserve a reasonable military layout of the placebo lines (e.g., not separating North from South), we keep the original NATO defence line and successively shift it to the east and west.[20] For this validation test, large treatment effects occurring at placebo lines would raise doubts about whether the continuity assumption is met. Estimating the treatment effect over a bandwidth of 33 km around more than 700 placebo lines, not a single coefficient is larger than the one estimated for the NATO defence line - suggesting a p-value of 0.000 (see Figure 3.5). Replicating the analysis with an optimal bandwidth selected for each placebo line individually leads to a p-value of 0.005 (see Figure 3.E.5 in the Appendix).

Figure 3.5: HISTOGRAM OF COEFFICIENTS FOR PLACEBO LINES



Notes: This figure plots the distribution of 708 RDD coefficients of the treatment effect on median income in 2019 obtained from placebo lines to the east and west of the NATO defence line. The vertical red line indicates the coefficient of 154.7 from the main specification (VI^a) in Table 3.1. The p-value is calculated as the share of coefficients larger than 154.7. The placebo lines are generated by shifting the defence line repeatedly by 0.5 km - starting from 200 km west and ending 200 km east of the original line. To avoid treatment contamination, we include only the treatment group for placebo lines westward of the original line and only the control group for placebo lines eastward of the original line. For this reason, we do not employ placebo lines within 10 km distance of the original line. Only coefficients from regressions with more than 30 observations on both sides of the border are included. Estimation is based on the most demanding specification, including a triangular kernel as well as all fixed effects and control variables. The bandwidth is set to the optimal value of our main regression (33 km). Figure 3.E.5 in the Appendix plots the histogram when the bandwidth is selected to be optimal for each individual placebo line.

[20]This is similar to what is often called an analysis of placebo cut-offs.

Donut-RDD. This validation test excludes municipality groups which are in close proximity to the border. Classically, this is done because units close to the border are most influential for fitting the polynomial of distance, and they are most likely to have the wrong treatment assignment due to small inaccuracies in historical maps. In the specific setting of our paper, it also tests for the potential destruction caused by artillery fire. Our interpretation of the NATO defence line is that municipality groups to the west are neither battlefield nor occupied - if everything goes according to plan. An alternative interpretation would be that it describes the front-line, implying that some areas to the west of the border were to experience shelling by Soviet artillery. To account for this, we employ a donut-RDD excluding municipality groups up to 20 km distant from the border. The point estimates remain similar. The confidence intervals increase as the number of observations decreases (see Figure 3.E.6 in the Appendix).

Bandwidth. We test the sensitivity of our results to deviations from the optimal bandwidth of 33.4 km. As suggested by Cattaneo et al. (2020a), we vary the applied bandwidth in the range from 22.4 km to 66.8 km, which covers the CER-optimal bandwidth up to double the MSE-optimal bandwidth. The results in Figure 3.E.7 in the Appendix suggest that estimates are consistent for different bandwidths. The fact that confidence intervals are larger for a shorter bandwidth than 33.4 km follows mechanically from the data-driven way the optimal bandwidth is determined.

Alternative income measure. We test robustness of our results to an alternative measure of income in 2019: the municipal income tax per inhabitant. The results in Table 3.E.5 in the Appendix suggest a significant treatment effect for being west of the NATO defence line on long-run income tax (and, hence, on income). Depending on the specification, the income tax per inhabitant in 2019 is between 221 and 389 Euro larger in treated municipality groups.[21] To allow for a comparison to the main results, we run a second regression with logged municipal income tax. Depending on the specification, treatment causes an increase in income tax by four to nine percent (see Table 3.E.6 in the Appendix). This overlaps neatly with the relative increases estimated for median income.

[21] The numbers result from a back-of-the-envelope calculation, which multiplies the coefficients of 33.2 and 58.4 with $6.\overline{6}$ to transfer the municipal income tax per inhabitant into income tax per inhabitant. To convert this into a direct measure of income and to make it comparable to the main results, we would also need to account for income tax rates and the ratio of inhabitants to full-time employed. As this would get increasingly imprecise, we rather compare percentage changes.

Additional robustness tests. As border segments behind the two rivers Weser and Lech may have been more noticeable or stronger protected than border segments in central Germany, which were more distant from rivers, we split the sample and find significant treatment effects for both (see Table 3.E.7 in the Appendix). We also show that results are unaffected when running separate regressions for municipality groups with above median and those with below median population growth from 1871 to 1939 (see Table 3.E.8). Findings remain robust to a jackknife exercise which repeatedly drops one of the border segments of 25 km length excluding up to 10% of the observations (see Figure 3.E.8) and to excluding the least and most populated five percent of municipality groups (see Table 3.E.9). When including municipality groups which are crossed by the NATO defence line, the size of the effect drops due to treatment contamination but it remains statistically significant (see Table 3.E.10). We also show robustness to including flexible second order polynomials for distance (see Table 3.E.11) and to employing an epanechnikov kernel (see Table 3.E.12).

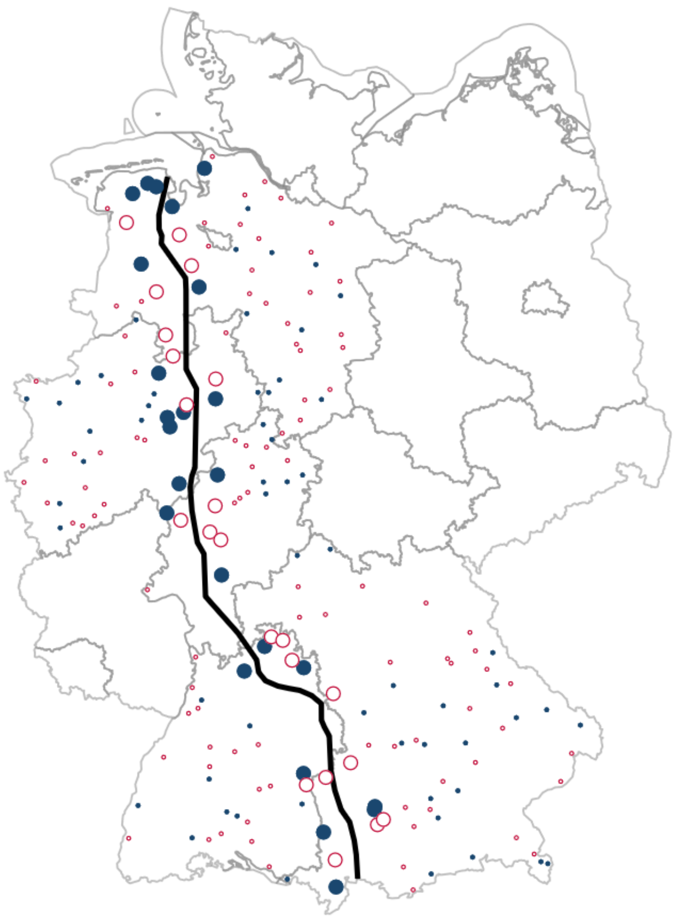
3.5 Discussion

3.5.1 Mechanism

The main idea of this paper is that economic agents react to insecurity affecting economic development. There exist, however, two alternative stories on the economic effects of military bases that could potentially also explain our results. First, it is straightforward that military bases hosting hundreds of soldiers and demanding local goods and services can generate positive spillovers on local economies. If military bases were predominantly located west of the NATO defence line, then we could not distinguish between the effect of the treatment with security and the effect of military bases. Second, both the closure of military bases and their conversion to civilian use impact the local economy. While a base closure is typically found to have negative effects (see, e.g., Zou, 2018; Calia et al., 2021), financial compensations and a transformation into a civilian facility can have positive effects (see, e.g., Poppert and Herzog, 2003; Doerr et al., 2020). If military bases were systematically closed on either side of the border after 1990, then we could not distinguish between the effect of the treatment with security and the effect of the closure of military bases. As we have shown evidence of the existence of a treatment effect in 2002, our concern regarding base closures focuses on the period from 1990 to 2002.

To provide evidence that our results are neither driven by the existence of military bases during the Cold War nor by their closure afterwards, we have collected information on the location of military bases from 1970 to 2002. Figure 3.6 highlights municipality groups that hosted a military base in 1990. Special attention should be paid to large circles as these are assigned to municipality groups located within a 33 km bandwidth of the NATO defence line. Red circles indicate that a municipality group experienced at least one military base closure between 1990 and 2002. In contrast to the two alternative stories, the figure shows that military bases had existed and were closed throughout West Germany without following any geographic pattern nor showing any sign of an accumulation on either side of the NATO defence line.

Figure 3.6: MAP OF MILITARY BASE CLOSURES FROM 1990 TO 2002



Notes: This figure highlights municipality groups that hosted a military base of an operational Bundeswehr unit in 1990. A white-red circle indicates that a municipality group experienced at least one military base closure between 1990 and 2002. A blue circle indicates that a municipality group did not experience any base closure. Large circles indicate that a municipality group is located within the optimal bandwidth of 33 km and is, hence, included in our main analysis. The black line is the NATO defence line. To the west are areas treated with security, and to the east is the control group. The map illustrates that military base closures do not follow a geographic pattern. Formal analyses are conducted in Figures 3.F.1 and 3.F.2 as well as Tables 3.F.1 and 3.F.2 in the Appendix.

Providing more formal evidence, we firstly show that the share of municipality groups hosting a military base is not significantly different between the treatment and control group for 1970, 1990, and 2002 (see Figure 3.F.1 in the Appendix). For three measures of affectedness, we secondly show that there are no significant differences in the share of municipality groups on either side of the border experiencing base closures between 1990 and 2002 (see Figure 3.F.2). As the treatment and the control group have had a similar exposure to both military bases during the Cold War and to base closures after the Cold War, this suggests that military bases cannot explain our findings. For confirmation, we test robustness of our main results to excluding all municipality groups which were hosting a military base in 1990 and separately excluding those which have lost at least one military base between 1990 and 2002. Results are unchanged and the treatment effects remain significant - both for income in 2019 and in 2002 (see Tables 3.F.1 and 3.F.2).

Excluding military bases as a driver of our findings, this suggests that the differences in income across the border have in fact been caused by the treatment with security through the NATO defence line. There are three potential mechanisms explaining how a change in war risk may have impacted the behaviour of economic agents during the Cold War. First, parts of the population may have desired to live in safer areas, and by moving, they have shifted labour supply away from municipality groups with high war risk. Second, the government may have wanted to protect public infrastructure and agencies, locating them with higher probability in areas protected by the NATO defence line. Third, investors may have incorporated war risk into their decision-making, favouring companies west of the NATO defence line for investments as these were less likely to experience war destruction or to fall into Soviet hands. Understanding the exact mechanism is a promising avenue for future research.

3.5.2 External Validity

Defensive fortifications have been a key element of military strategy and, hence, of human history. They have often protected a country's border. Examples are the ancient Roman Limes and Hadrian walls, the pre-WWII Maginot and Siegfried line, and the contemporaneous inner Korean border. Others have been constructed during wars to defend conquered territories, such as the German Hindenburg line in 1917, the German Atlantic wall in 1944, and the Russian Surovikin line in 2022. A third type of defence line is more similar to the one analysed in this paper. Following military and geographic considerations, these lines have been constructed to protect only part of their own territory. Table 3.3 presents a collection of examples ranging from Imperial

China to 20th-century Europe. In all examples, a government or its military has made the decision that some parts of a country's territory are treated with increased security compared to other parts.

Table 3.3: COMPARABLE HISTORICAL DEFENCE LINES

	Name	Through	Against	Period	Details
1	Ming Great Wall	China	Mongolians	C13 - C16	Wall fortification
2	Dutch water lines	Netherlands	Various	C16 - C20	Series of water-based defences
3	Mannerheim line	Finland	Soviet Union	1920 - 1940	Flexible utilising natural terrain
4	Swiss Redoit	Switzerland	Axis Powers	WWII	Fortifcations in Gotthard Massif
5	Lyngen line	Norway	Soviet Union	Cold War	Fortifications in fjord of Lyngen

Notes: This table presents a non-exhaustive list of historical defence lines. Similar to the NATO defence line crossing West Germany, all these lines have left a considerable part of a country's territory undefended. The Ming Great Wall is unique in the sense that it was not built within a country but rather at the border of Imperial China. As it took multiple centuries to be completed, some parts of the territory were more exposed to hostile troops than others during this period.

The distinct feature of our NATO defence line is that the location decision was made by an international alliance, making it most suitable for empirical analysis. As we employ an RDD, the estimated treatment effect is a local estimate for areas around the border in Cold War West Germany. For this specific setting, we have shown that regional differences in security resulting from defence planning have distorted economic activity. History is full of similar settings, and our findings may even be informative for contemporary threats such as the one posed by Russia to NATO. During the Polish national election campaign in 2023, for example, the Polish Defence Minister leaked a defence plan from the previous government showing that territories east of the river Vistula could be captured within seven days of a Russian invasion (Politico, 2023). This did not only reveal that there is a difference in regional war risk in Poland, but it also made the discontinuous jump in insecurity around the Vistula public knowledge. In addition, the relevance of our findings goes beyond inter-state conflicts. Developing countries frequently suffer from weak governments which cannot ensure security in all parts of their country against terrorists, rebel groups, and armed bandits.[22] Our findings suggest that this may distort economic activity beyond those villages which are directly experiencing violence.

[22]Recent examples are the threats posed by FARC in Colombia, Boko Haram in Nigeria, and Taliban in Afghanistan.

3.6 Conclusion

Recent years have seen an increase in geopolitical tension and war risk. While there is a strong prior that economic agents take war risk into account when making decisions, so far there is no empirical evidence of its economic effects. This paper has exploited a unique case to capture the pure effects of war risk. During the Cold War, there existed a realistic scenario of Soviet troops invading West Germany, but this threat has never materialised. Due to the superiority of Soviet troops, NATO defence planning was focused on halting a potential Soviet advance at the Weser-Lech line running through West Germany. We have shown that by guiding the placement of military installations, this defence line provided visible and discontinuous variation in war risk. Territory to the west of the NATO defence line was treated with increased security, while territory to the east faced a higher likelihood of serving as a battlefield and of being occupied by Soviet troops. This allows us to employ the NATO defence line as the border in an RDD.

We have estimated the causal local treatment effect of security (or of reducing war risk) by comparing municipality groups within a bandwidth of 33 km of the NATO defence line. Our main finding is that the border distorted economic outcomes: Monthly median income in 2019 is 155 Euro (4.2%) higher in municipality groups to the west of it. Our results are robust to a variety of tests and extensions as well as alternative specifications of standard errors. We have also shown that the results are not driven by the closure of military bases after 1990.

The key message of this paper is that war risk in itself affects economic outcomes. These effects can be both considerable in size and long-lasting. In light of the recent rise in geopolitical tension, our results provide a dim outlook. Even if no war will happen, just an increase in war risk over a prolonged period of time will be sufficient to distort economic outcomes. This stresses the importance of policies in the realms of diplomacy and defence, which can contribute to a substantial reduction of war risk.

As this is the first paper to find the economic effects of war risk, the literature would benefit from investigating the research question in different settings. A promising avenue for future research is to explore which economic agents (households, firms, or governments) adjust their behaviour most in response to war risk.

Appendix to Chapter 3

This Appendix contains the following information:

- Section 3.A provides additional information on treatment assignment.
- Section 3.B provides a detailed description of the data.
- Section 3.C provides summary statistics.
- Section 3.D provides evidence for the validity of the assumptions.
- Section 3.E provides additional results and robustness.
- Section 3.F provides evidence against military bases as a potential mechanism.

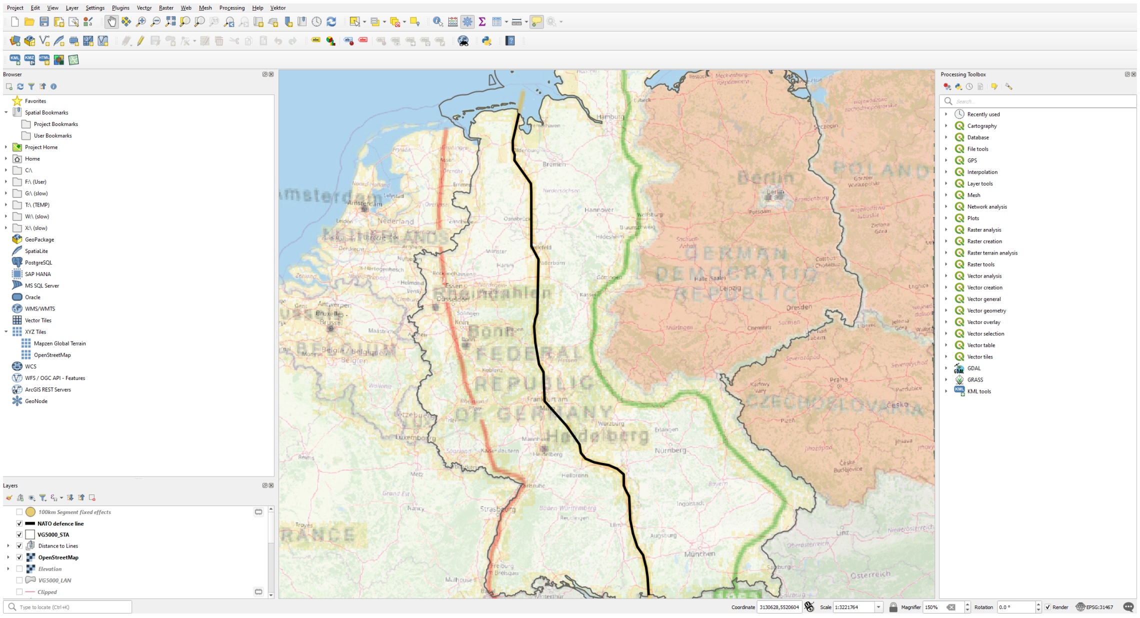
3.A Treatment Assignment

3.A.1 The Weser-Lech NATO Defence Line

Figure 3.A.1: ORIGINAL NATO SOURCE

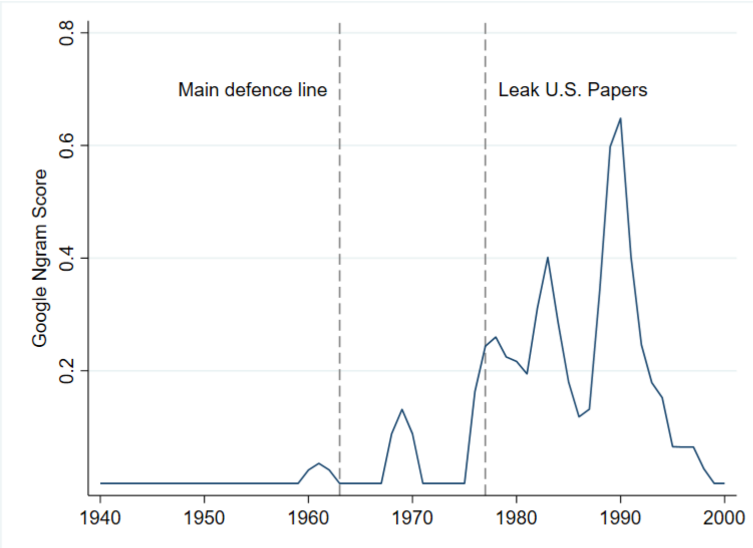
Notes: This figure shows the NATO defence line as presented in NATO (2023). The NATO archives informed us that this map 'is the most authoritative and detailed one that there is'. The dates refer to the year when a defence line was employed as the initial line of resistance (Hammerich, 2014). NATO troops were supposed to delay the Soviet advance from that line towards the west. The main defence line was the subsequent line. For example, in 1963 NATO troops were expected to delay the advance from the inner German border (green) and stop it at the Weser-Lech line (yellow). Due to a lack of conventional NATO forces, the inner German border could never be established as a credible main defence line, so that the Weser-Lech line remained the relevant defence line from 1963 to the end of the Cold War. For a detailed description on the historical background see Section 3.1.2.

Figure 3.A.2: GEOLOCATING THE MAP WITH QGIS



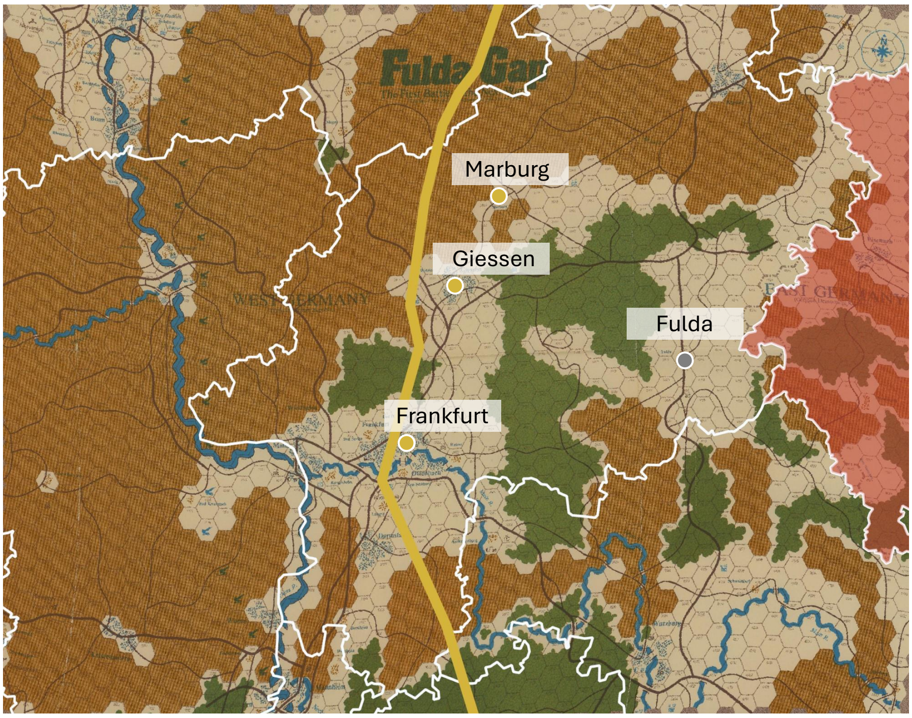
Notes: This figure shows the overlay of the original map of the NATO defence line with a geolocated one generated by employing QGIS. To transfer the original map from Figure 3.A.1 into a geolocated map, we select roughly 20 noticeable points on the original map and feed their coordinates from Google Maps into QGIS. This includes the seven cities (Amsterdam, Berlin, Bonn, Brussels, Heidelberg, Paris, and Rheindahlen) as well as border points and islands. We transfer the geolocated map from the global 'WGS 84' (EPSG: 4326) projection to the Germany-centred 'DHDN / 3-degree Gauss zone 3' (EPSG: 31467) projection, which is the one employed by the Federal Agency for Cartography and Geodesy. After having both the NATO defence line and the map of the municipality groups geolocated in the same projection, we can employ the various geo-tools available in QGIS. To estimate the distance between each municipality group and the NATO defence line, we follow four steps. First, we locate the centroid of each municipality group (a point). Second, we split the NATO defence line into thousands of points with 100m distance between them. Third, we create the shortest line from each centroid to any point on the border. Finally, we estimate the geodetic length of each line. We also employ QGIS to generate the following variables for each municipality group: (1) Distances to the inner German border and the next river, (2) border segments, (3) coordinates, (4) area, and (5) aggregated geodata (elevation, ruggedness, and crop suitability) from a small grid-level.

Figure 3.A.3: GOOGLE BOOKS NGRAMS SCORE FOR WESER-LECH



Notes: This figure shows how often the word 'Weser-Lech' was used in publications over time. The results are based on Google Books Ngrams Viewer for the request '[Weser - Lech]: eng_2019' which was placed on 10 August 2024. The scale is adjusted by multiplying variables with one billion. For illustration purposes, the graph is smoothed. The figure shows that the first ever mention of the word combination 'Weser-Lech' was shortly before it became the main defence line in 1963. The word 'Weser-Lech' gained popularity after the leakage of the defence review initiated by the U.S. administration in 1977 which suggested that territory east of the Weser-Lech line could not be defended. Afterwards, 'Weser-Lech' remained part of the public debate until the end of the Cold War when it slowly phased out.

Figure 3.A.4: BOARD GAME MAP: FULDA GAP



Notes: This figure shows the board of the game 'Fulda Gap: The First Battle of the Next War' from Simulations Publication Inc. (1977). We geolocate the board based on the German cities which are included on the board. The board is then overlaid with the NATO defence line (yellow) and state borders (white). East German territory is marked in red. Strikingly, the board and, hence, the battlefield in this game is nearly exclusively located on West German territory. The NATO defence line broadly runs through the middle of the board. We highlight the three cities Marburg, Giessen, and Frankfurt as the player's notes suggest that this is a realistic location for fighting to take place in case of a Soviet attack. They are all east but still in close proximity to our NATO defence line. The city of Fulda is highlighted as it lends its name to the game.

3.B Data Description

3.B.1 Military Installations

Demolition chambers

During the Cold War, barriers were prepared on the West Germany territory to slow down or even stop a Soviet invasion. In case of an invasion, the prepared barriers could be filled with explosives to destroy roads, bridges, and tunnels. A group of amateur historians has collected, located, and classified 6.700 of these barriers at cold-war.de (2024).[23] This is slightly higher than the 4,800 barriers planned in 1966, shortly after the Weser-Lech line became the main defence line (Grube, 2004). The increase in the number of barriers can likely be explained with the planning and completion of new infrastructure projects during the Cold War.

We focus on demolition chambers for crater obstacles ('Trichtersperren'). With 4,600 observations, they are by far the largest group of barriers in the dataset. Demolition chambers were prepared on roads. They had a width of 60 centimetres and were covered by something which resembled a civilian manhole cover (see Figure 3.B.1). In case of war, the demolition chambers could be filled with explosives and would result in a crater of 12 metres width and 6 metres depth. A unit of Soviet tanks could not cross such a crater. Being stuck in front of the obstacle, the Soviet tanks would provide easy targets. Demolition chambers can potentially be implemented on every road. Their actual location, hence, provides information on where the military expected them to be most useful i.e. what areas they regarded as most vulnerable to a Soviet invasion.

Nike systems

The purpose of the Nike systems was to protect civilians and important military infrastructure such as air bases, command posts, and logistics units in areas far behind the battlefield. The Trägerkreis Atomwaffen abschaffen (2024) has collected and published information on the location of historical nuclear storage sites in West Germany. This also includes Nike systems as their nuclear ammunition was stored close by. For each site, its coordinates are provided which allows to geolocate them. To account for the fact that some Nike systems were first operated at preliminary and then at final locations, we make sure not to double-count them by only including the final location. The

[23] The owner of the website, Ulrich Santana Jäger, provided a KMZ-file containing classification and location of each barrier which was detected before 20 May 2024.

Figure 3.B.1: COVER OF DEMOLITION CHAMBER INSTALLED IN ROAD

Notes: This figure shows a cover of a demolition chamber installed in a German road. It appears like a civilian manhole cover, but it is missing the holes for water drainage. The picture is replicated with the kind permission of Michael Grube from 'geschichtsspuren.de'.

information has been validated with Dreifke (2024) and three Nike systems operated by Belgian troops have been added. In total, our dataset includes 71 Nike systems in 66 municipality groups. As the Nike systems had a strategic role and were not designed to engage on the battlefield, their location provides information on where the military regarded them to be relatively safe from falling into the hands of Soviet troops.

The planning for the 'Nike belt' started in 1958 (Spreckelsen and Vesper, 2004). As the Nike systems were quite demanding, major infrastructural measures had to be carried out at the determined locations - often taking multiple years. While the first Nike system was operated by German troops in 1959, they could only move to the final locations between 1962 and 1973 (Dreifke, 1998). In addition, Belgian, British, Dutch, French, and American troops also operated Nike systems in West Germany - the nuclear ammunition was always in American custody though (Spreckelsen and Vesper, 2004). The last German Nike system operated until 1989 and the last foreign Nike system until 1990 - when it was succeeded by conventional and modern Patriot systems (Dreifke, 1998). However, not all Nike systems remained in operation until then (Dreifke, 1998). When France left the NATO's integrated military command in 1966, it also left the Nike belt. Also, the Dutch reduced their number of Nike systems to half in 1975, Belgium did the same in 1983, and the United States closed their Nike systems by 1984.

3.B.2 Pre-determined Variables

In order to assess whether the key assumption of balance holds for pre-determined variables, a large number of historical variables have been collected. They are informative about the economic development of municipality groups between 1871 and 1955. They cover the pre-war, the war, and the post-war period. The variable definitions and data sources are presented in Table 3.B.1. As data is often only published for municipalities beyond a certain number of inhabitants, the coverage of the variables varies. For an overview of the coverage see Figure 3.B.3.

Geographic Data

Geographic data has been collected from various sources. All variables are self-computed based on geocoded information contained in Shape-Files employing the tools provided by QGIS. As the Shape-Files cover the whole of Germany, geographic variables can be estimated for each municipality group. Hence, they can also be included as control variables in the main specification without loosing observations. The main file employed for all estimations contains the borders and areas of all municipality groups which existed in 2020 in Germany (BKG, 2020).

This file allows to estimate the size of the municipality group as the area of its polygon and the distance from its centroid to the closest point on the inner German border. In a similar fashion, we calculate the distance from each municipality to the closest main river or a tributary based on information from EEA (2023). Detailed terrain information at the 200m-grid-level from BKG (2023) allows to estimate the elevation and ruggedness of a municipality group. Only those 200m-grids are included which are fully contained within the border of a municipality. Elevation is defined as the median elevation and ruggedness is defined as the standard deviation of elevation within a municipality group. A high standard deviation of elevation implies that different levels of elevation exist within a municipality i.e. that its territory is rugged. These variables inform about and control for the fact that the defence line could be drawn according to geographic considerations which may themselves impact economic outcomes.

The suitability of terrain for agriculture should be a good proxy for the historic economic activity in a municipality which may have persistent effects. Our variable is the median agricultural suitability of the terrain. It is based on the 1 km-grids which are fully contained within the borders of the municipality. The data was provided by Zabel et al. (2014). If we were to see a discontinuous jump of agricultural suitability at the border, then we would be concerned whether some geographic conditions may have caused both - the defence line to be drawn at that location and the income to be different on the two sides of the border.

Roesel (2023)

The German Local Population Database, GPOP, compiles statistics on local populations between 1871 and 2019. It was hand-collected and assembled from 52 source. A key feature of the database is that the data has been transformed to be consistent with contemporary boundaries of municipalities. Hence, to employ the data, we just needed to aggregate it to municipality groups. Another important feature is that the database covers all German municipalities. This implies that the variables generated from this dataset can not only be used for the historical analysis, but can also be included as control variables in the main specification without losing observations.

The database includes population statistics for nine points in time. We employ population data for 1871, 1939, and 1946/1950[24] as well as population growth (absolute and relative) between these years, and population density in 1939. Population dynamics are regarded to reflect economic performance - at least in the medium- and long-run (Roesel, 2023). If we were to find that municipality groups in the treatment group are consistently larger, faster growing, and more densely populated than those just on the other side of the border, this would raise doubts whether the defence line was actually drawn without taking economic considerations into account.

Falter and Hänisch (1990)

This dataset compiles census and election data for German municipalities between 1920 and 1933 from various administrative sources. The data is primarily collected from the former 'Statistische Reichsamt' and it is enriched by state and regional administrative sources. We employ information on church membership from 1925 and election results from 5 March 1933. Both are available for municipalities with more than 2,000 inhabitants. The population and occupational census from 1933 is, however, only available for municipalities with more than 5,000 inhabitants - with the exception of statistics on agriculture.

The dataset from Falter and Hänisch (1990) is constructed for the municipality structure from 1925 to 1933, while our dataset (including the geodata) is based on the

[24]Note that data is available for 1946 for three states and for 1950 for two states.

municipality structure of 2020. We had to map historical to current municipalities, for example tracing mergers through 'wiki.genealogy.net'. When multiple municipalities from the past belong to the same municipality group, we sum the data. Data for 470 to 1,159 municipality groups is available in this dataset.

From the dataset, we construct eleven variables which capture three aspects of the pre-war period: Social, economy, and industrial structure. All variables are expressed as shares to capture industrial composition and economic specialisation rather than just the size of a municipality. For example, the number people employed in trade is expressed relative to the total number of people employed. If economic differences had already existed before 1933 and if back then the municipality groups to the west were already richer than those to the east of the defence line, we should observe differences in the industrial structure and the general economy which come with higher development. For example, this could be that a larger share of workers is employed in a specific sector.

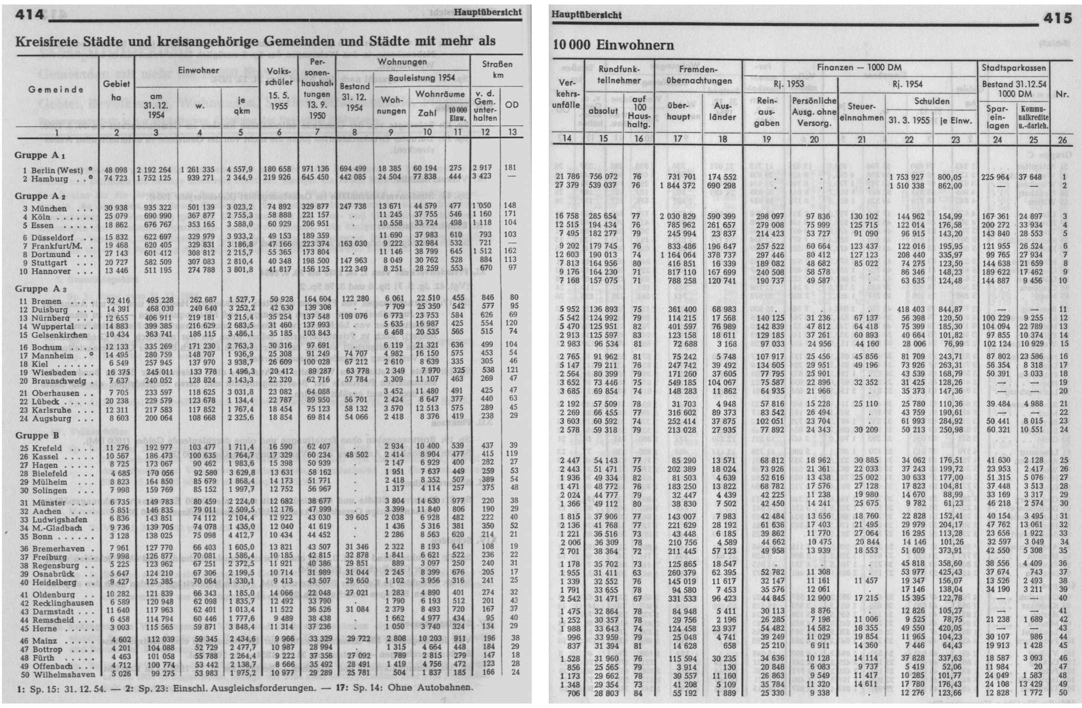
Deutscher Städtetag (1950, 1952, 1955)

The Statistical Yearbooks of Municipalities provide annually changing statistics for municipalities with more than 10,000 inhabitants. While this source comes with a relatively low coverage, it allows to test balance in the 1950s - after the structural changes arising from WWII and the occupation of Germany have occurred. We employ information from the yearbooks 1950, 1952, and 1955 - with the data being collected before Germany joined NATO. It, hence, cannot reflect a response to the NATO defence line.

The yearbooks are available at the website of the TU Braunschweig. Based on scans such as the ones in Figure 3.B.2, we have digitised the books employing the OCR-tool 'Capture2Text'. Again, municipalities had to be mapped to the contemporaneous borders. Firstly, we replicated municipality mergers from 1950 onwards mainly based on 'wiki.genealogy.net'. Second, we had to assign every municipality its current geo-identifier. Third, when municipalities were merged or when more than one municipality from a municipality group was included in the data, we summed over the data. All variables were transformed into relative units to capture wealth - usually dividing by the number of inhabitants. Two variables were already expressed in relative units in the original publication. For them a population-weighted approach was taken when aggregating data. The data is available for 236 to 361 municipality groups.

In total, nine variables from four categories are constructed based on this dataset. The expellee share is providing a direct measure of disruption caused by war and occupation. Information on the public infrastructure and the public finances proxy the wealth of a municipality. If the income gap between inhabitants of municipality groups west and east of the defence line was already existing in the 1950s, then we should observe that the amount of tax collected or the quality of public infrastructure also differed. As no direct measures of economic activity are included in the yearbooks, we take overnight guests and firm numbers as proxies of economic activity.

Figure 3.B.2: EXAMPLE: STATISTICAL YEARBOOK OF MUNICIPALITIES 1955



Notes: The figure shows the main statistical table from the Statistical Yearbook of Municipalities 1955 with the data for the first 50 municipalities (Deutscher Städtetag, 1955). Data was included for all municipalities with more than 10,000 inhabitants. The books have been scanned and published by the TU Braunschweig.

Braun and Franke (2021)

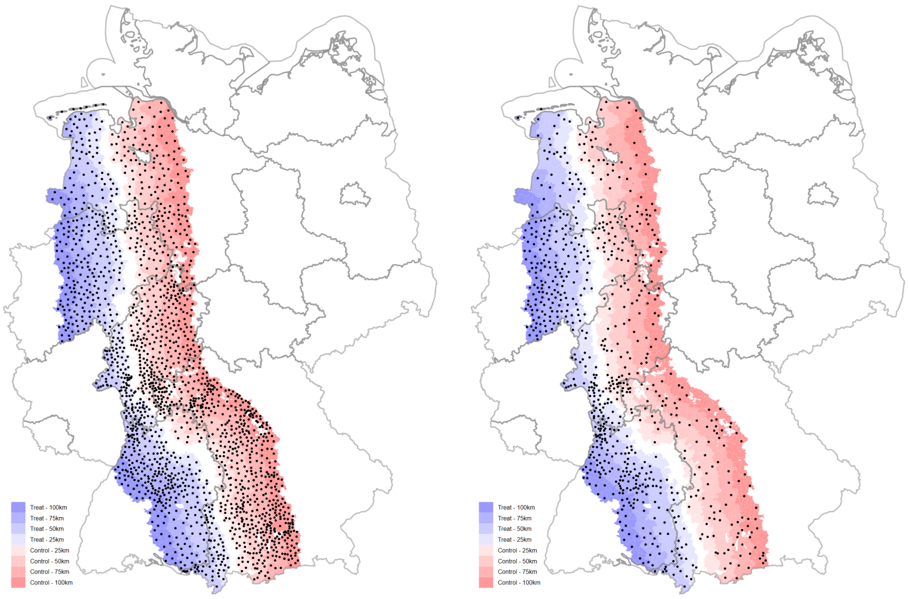
The building and housing census from 13 September 1950 has counted the number of flats and classified them according to the damaged caused by war. The data, however, has only been published for a very low number of municipalities which does not allow to test for balance at a small bandwidth. For this variable, we deviate from the usual analysis at the municipality level and use the county level. The variables have been indexed on a scale of 1 (no war damage) to 4 (very substantial war damage) by the 'Institut für Raumforschung' for each county.

We employ a Shape-File by MPIDR (2021) for the county structure of Germany in 1955 to re-estimate all geodata such as longitude, latitude, and distance to the border. Working with the county level comes with some inaccuracies. For example, some municipality groups which are on either side of the border may belong to a county which is crossed by the border and, hence, not included in the analysis. Similarly, the centroid of a county may be more than 33 km distant from the border while some municipality groups belonging to the county are closer to the border. This suggests that evidence from the county level should be interpreted with caution.

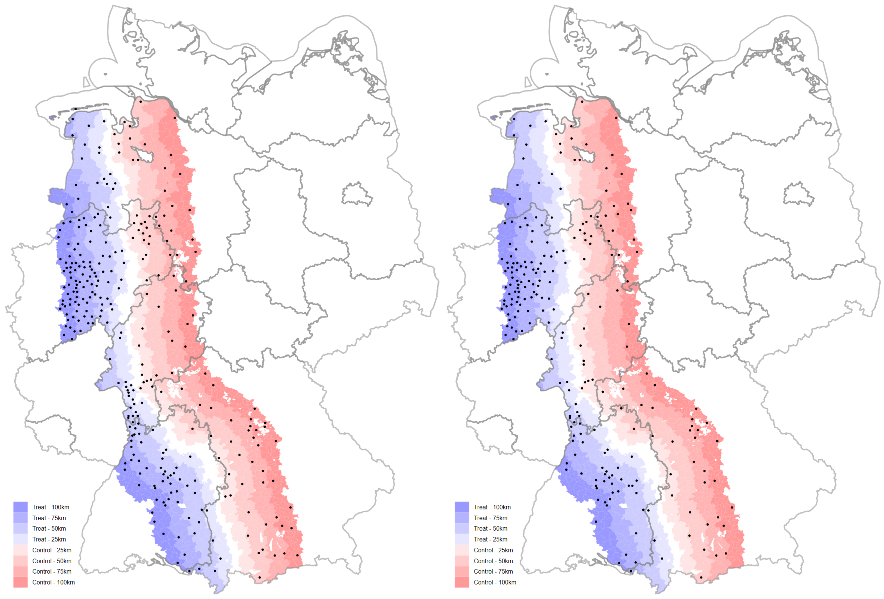
The variable on housing destruction captures the effects of WWII well. We may be concerned that the economy was balanced around the border before the war, but that the war has hit one side of the border harder than the other.

Figure 3.B.3: COVERAGE OF PRE-DETERMINED VARIABLES

(a) Geography & Roesel (2023) (b) Falter and Hänisch (1990) - W



(c) Falter and Hänisch (1990) - N (d) Deutscher Städtetag (1955)



Notes: The figure shows the data availability of pre-determined variables by dataset - marked by dots. Panel (a) shows population size in 1939, Panel (b) shows agriculture in 1933, Panel (c) shows work force in 1933, and Panel (d) shows the expellee share in 1952. As shown in Table 3.B.1, the number of observations also varies within a dataset. However, the within-dataset variation of data availability is usually small. Only for Falter and Hänisch (1990) do some variables include more than double the number of municipality groups than others. For this dataset, hence, we show two maps (wide (W) and narrow (N)). Municipality groups crossed by the defence line are presented in white. Coloured are West German municipality groups with less than 100 km distance between their centroid and the defence line. This includes all the different bandwidths chosen for the analysis of pre-determined variables. Blue implies that a municipality is to the west of the defence line (i.e. treated with security) and red implies that a municipality is to the east (i.e. control). Only states with municipality groups of different treatment status are shown. An overview of all variables is given in Table 3.B.1.

Table 3.B.1: OVERVIEW OF PRE-DETERMINED VARIABLES SORTED BY TIME

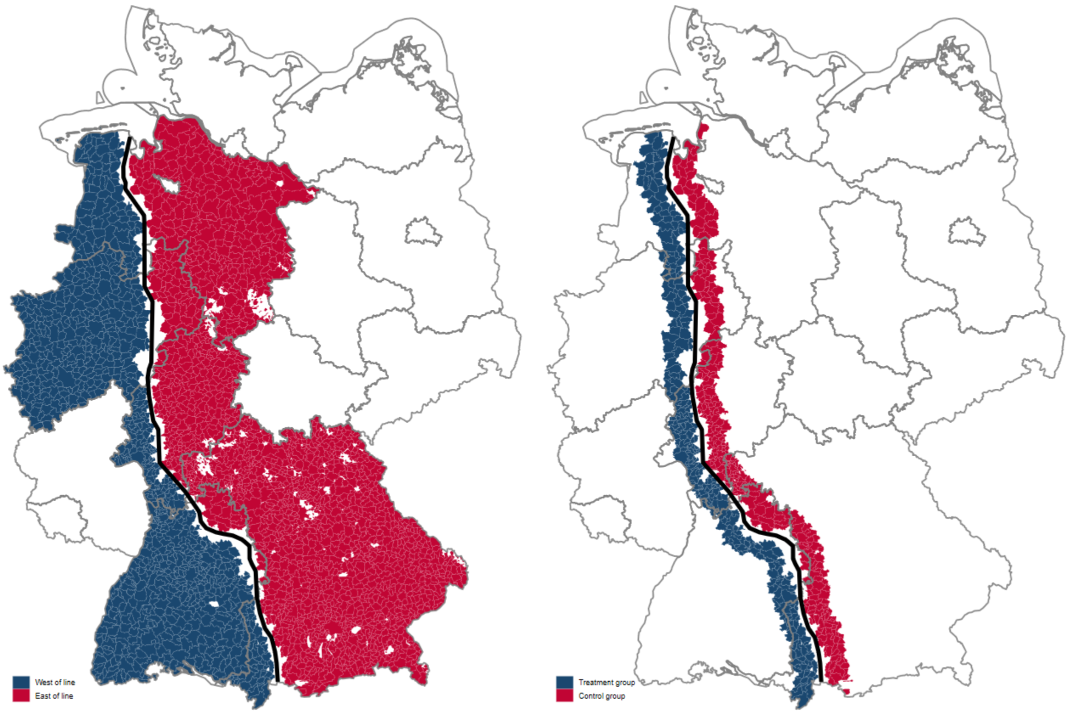
	Time	Category	Name	Definition	N	Source
Pre-War	1871	Population	Population	Number of inhabitants	2,948	Roesel (2023)
	1925	Social	Protestants	Share of protestants (i.e. members of 'Ev. Landeskirchen') relative to population	1,130	Falter and Hänisch (1990)
	1933	Social	Election Turnout	Share of votes casted relative to eligible voters	1,151	Falter and Hänisch (1990)
	1933	Social	Votes NSDAP	Share of votes for the party NSDAP relative to valid votes	1,151	Falter and Hänisch (1990)
	1933	Economy	Work force	Share of work population (employed & unemployed) relative to population	470	Falter and Hänisch (1990)
	1933	Economy	Civil servants	Share of civil servants relative to number of employed	470	Falter and Hänisch (1990)
	1933	Economy	Blue-collor	Share of workers relative to number of employed	470	Falter and Hänisch (1990)
	1933	Economy	Female workers	Share of female work population relative to work population	470	Falter and Hänisch (1990)
	1933	Industrial structure	Agriculture	Share of employed (incl. dependents) in agricult. and forestry relative to population	1,159	Falter and Hänisch (1990)
	1933	Industrial structure	Industry	Share of employed in industry relative to number of employed	470	Falter and Hänisch (1990)
	1933	Industrial structure	Trade	Share of employed in trade relative to number of employed	470	Falter and Hänisch (1990)
	1933	Industrial structure	Service	Share of employed in public and private services relative to number of employed	470	Falter and Hänisch (1990)
	1939	Population	Population	Number of inhabitants	2,954	Roesel (2023)
	1939	Population	Density	Relation of inhabitants to area in square kilometres	2,954	Roesel (2023)
	1939	Population	Growth rate 1871-1939	Average annual growth rate of population from 1871 to 1939	2,948	Roesel (2023)
	1939	Population	Growth 1871-1939	Increase of population from 1871 to 1939	2,948	Roesel (2023)
War	1950	War disruption	House destruction	Index of war damage on scale of 1 (none) to 4 (very substantial)	430	Braun and Franke (2021)
	1952	War disruption	Expellee share	Share of inhabitants who had lived in Berlin, Soviet zone or East Oder-Neiße in 1939	361	Deutscher Städtetag (1952)
Post-War	1948	Infrastructure	Library access	Relation of readers with at least one book loan at public libraries to inhabitants	236	Deutscher Städtetag (1950)
	1948	Infrastructure	Lights per street	Relation of all-night street lights to municipal roads in km	330	Deutscher Städtetag (1950)
	1950	Population	Population 1946/50	Number of inhabitants	2,954	Roesel (2023)
	1950	Population	Growth rate 1871-1946/50	Average annual growth rate of population from 1871 to 1946/50	2,948	Roesel (2023)
	1950	Population	Growth 1871-1946/50	Increase of population from 1871 to 1946/50	2,948	Roesel (2023)
	1950	Economy	Number firms	Relation of non-agricultural firms without public sector to inhabitants	342	Deutscher Städtetag (1952)
	1952	Infrastructure	Cinemas	Relation of active cinemas to inhabitants	350	Deutscher Städtetag (1952)
	1954	Economy	Foreign visits	Relation of annual overnight stays to inhabitants	340	Deutscher Städtetag (1955)
	1954	Infrastructure	Living space	Relation of normal flats to inhabitants	326	Deutscher Städtetag (1955)
	1954	Public finance	Tax revenue	Communal tax revenue per inhabitant (in DM)	337	Deutscher Städtetag (1955)
	1955	Public finance	Public debt	Communal debt per inhabitant (in DM)	360	Deutscher Städtetag (1955)
Permanent	–	Geography	Distance GDR	Geodestic distance from centroid to closest point on inner German border (in km)	2,954	BKG (2020)
	–	Geography	Area	Area of the municipality (in m^2)	2,954	BKG (2020)
	–	Geography	Elevation	Median elevation of all 200m-grids within the municipality area (in m)	2,954	BKG (2023)
	–	Geography	Ruggedness	Standard deviation of elevation of all 200m-grids within municipality area	2,954	BKG (2023)
	–	Geography	Distance River	Geodestic distance from centroid to closest main river or tributary (in km)	2,954	EEA (2023)
	–	Geography	Crop suitability	Median suitability of terrain for agriculture of 1 km-Raster within municipality area	2,949	Zabel et al. (2014)

Notes: This table provides the definitions and sources for all pre-determined variables which are employed for testing balance prior to the treatment. N refers to the number of municipality groups (in West Germany, inhabited, not crossed by border, and in states with variation in treatment) for which a specific variable is observed.

3.C Summary Statistics

Figure 3.C.1: TREATMENT AND CONTROL GROUP

(a) Available observations (b) Sample: Treatment and control group



Notes: This figure visualises the geographic location of the treatment and control group. Panel (a) highlights all available municipality groups. This excludes the six states in East Germany and the five states which do not experience a variation in treatment (i.e. are not crossed by the defence line). For these observations, the optimal bandwidth is determined in a data-driven approach according to Cattaneo et al. (2020a) for the most demanding regression specification. Panel (b) highlights the municipality groups within the optimal bandwidth of 33 km and divides them into treatment and control group. In black, the NATO defence line is drawn. State borders are shown in grey. Municipality groups to the west of the defence line are shown in blue and municipality groups to the east of the defence line are shown in red. Municipality groups crossed by the NATO defence line are excluded. White areas mark uninhabited municipality groups such as lakes and forests.

Table 3.C.1: MUNICIPALITY GROUPS BY STATE AND TREATMENT ASSIGNMENT

	All West Germany					Sample		
State	Total	Uninhab.	West	East	On border	Included	Treatment	Control
Schleswig-Holstein	172	2	1	169	0		0	0
Hamburg	1	0	0	1	0		0	0
Lower Saxony	430	23	98	287	22	Y	53	26
Bremen	2	0	0	2	0		0	0
North Rhine-Westphalia	396	0	320	59	17	Y	39	36
Hesse	426	4	130	259	33	Y	112	89
Rhineland-Palatinate	170	0	170	0	0		0	0
Baden-Württemberg	462	2	417	21	22	Y	57	20
Bavaria	1,559	174	66	1,297	22	Y	51	136
Saarland	52	0	52	0	0		0	0
# municipality groups	3,670	205	1,254	2,095	116	-	312	307

Notes: This table shows the number of of municipality groups over states. Total gives the overall number of municipality groups in each state. This is split by the number of municipality groups which are firstly uninhabited, secondly to the west of the NATO defence line, thirdly to the east of the NATO defence line, and finally crossed by the NATO defence line. For our sample, we only include states which experience a variation in treatment i.e. have municipality groups on both sides of the border. The one municipality group west of the NATO defence line in Schleswig-Holstein is the island of Helgoland. This does not generate sufficient within-state variation and, hence, the state is also not included. The sample comprises municipality groups from included states which are within a 33 km bandwidth of the border. Median income is due to data protection reasons not available for three municipality groups from our sample. Hence, the number of observations in our sample which can be employed for the main analysis drops to 616.

Table 3.C.2: SUMMARY STATISTICS: WITHIN BANDWIDTH

Variable	Observations	Mean	Std. dev.	Min	Max
	Treatment:				
Treatment (1 = West of defence line)	616	0.502	0.500	0	1
Distance to border (in km)	616	-0.293	20.969	-33.148	33.378
	Income:				
Median income 2019 (in Euro)	616	3,521	326	2,591	5,009
Median income 2002 (in Euro)	615	2,606	245	2,045	3,710
Income 20th percentile 2019 (in Euro)	616	2,472	192	1,741	2,908
Income 40th percentile 2019 (in Euro)	616	3,177	267	2,336	4,231
Income 60th percentile 2019 (in Euro)	616	3,909	425	2,874	5,963
Income 80th percentile 2019 (in Euro)	616	5,077	650	3,545	6,700
Municipal income tax 2019 (in Euro)	616	571	112	262	1023
Log median income 2019	616	8.162	0.092	7.860	8.519
Log median income 2002	615	7.861	0.090	7.623	8.219
Log 20% income 2019	616	7.810	0.080	7.462	7.975
Log 40% income 2019	616	8.060	0.085	7.756	8.350
Log 60% income 2019	616	8.266	0.105	7.964	8.693
Log 80% income 2019	616	8.524	0.126	8.173	8.810
Log municipal income tax 2019	616	6.327	0.206	5.567	6.931
	Fixed effects:				
State 1 (Lower Saxony)	616	0.125	0.331	0	1
State 2 (North Rhine-Westphalia)	616	0.122	0.327	0	1
State 3 (Hesse)	616	0.326	0.469	0	1
State 4 (Baden-Württemberg)	616	0.125	0.331	0	1
State 5 (Bavaria)	616	0.302	0.459	0	1
Border segment 1	616	0.036	0.186	0	1
Border segment 2	616	0.070	0.255	0	1
Border segment 3	616	0.107	0.310	0	1
Border segment 4	616	0.102	0.303	0	1
Border segment 5	616	0.256	0.437	0	1
Border segment 6	616	0.148	0.355	0	1
Border segment 7	616	0.099	0.299	0	1
Border segment 8	616	0.167	0.373	0	1
	Coordinates:				
Longitude	616	9.131	0.914	7.437	11.030
Latitude	616	50.119	1.563	47.369	53.721
	Geo. controls:				
Distance GDR (in km)	616	147.821	55.937	66.533	314.123
Crop suitability (index)	614	46.573	20.906	0	81
Elevation (in m)	616	318.578	240.838	-0.147	1,418.85
Ruggedness (in m)	616	42.598	45.943	0.684	472.231
Distance river (in km)	616	25.154	19.018	0.061	80.682
Area (in km^2)	616	64.580	47.903	2.061	258.92
	Population controls:				
Population in 1871	614	4,634	5,207	401	64,702
Population density in 1939 (per km^2)	616	135	14	15	1,939
Annualised pop. growth rate 1871-1939	614	0.005	0.006	-0.006	0.025

Notes: This table shows descriptive statistics of the variables from our main analysis for the 616 employed municipality groups (i.e. within 33 km bandwidth, not crossed by the border, and with income available). Table 3.C.3 presents summary statistics over the entire set of 2,954 available observations. To prevent multicollinearity, we exclude one of the state and segment fixed effects each in the regression.

Table 3.C.3: SUMMARY STATISTICS: ALL AVAILABLE OBSERVATIONS

Variable	Observations	Mean	Std. dev.	Min	Max
	Treatment:				
Treatment (1 = West of defence line)	2,954	0.349	0.477	0	1
Distance to border (in km)	2,954	-37.837	96.028	-254.426	218.368
	Income:				
Median income 2019 (in Euro)	2,882	3,522	353	2,324	5,513
Median income 2002 (in Euro)	2,854	2,585	243	1,830	3,710
Income 20th percentile 2019 (in Euro)	2,882	2,474	191	1,694	3,151
Income 40th percentile 2019 (in Euro)	2,882	3,174	284	2,179	4,641
Income 60th percentile 2019 (in Euro)	2,882	3,923	458	2,543	6,547
Income 80th percentile 2019 (in Euro)	2,882	5,124	690	3,288	6,700
Municipal income tax 2019 (in Euro)	2,954	576	120	68	1,023
Log median income 2019	2,882	8.162	0.098	7.751	8.615
Log median income 2002	2,854	7.853	0.091	7.512	8.219
Log 20% income 2019	2,882	7.811	0.078	7.435	8.055
Log 40% income 2019	2,882	8.059	0.089	7.687	8.443
Log 60% income 2019	2,882	8.268	0.112	7.841	8.787
Log 80% income 2019	2,882	8.533	0.133	8.098	8.810
Log municipal income tax 2019	2,954	6.334	0.213	4.213	6.931
	Fixed effects:				
State 1 (Lower Saxony)	2,954	0.130	0.337	0	1
State 2 (North Rhine-Westphalia)	2,954	0.128	0.334	0	1
State 3 (Hesse)	2,954	0.132	0.338	0	1
State 4 (Baden-Württemberg)	2,954	0.148	0.355	0	1
State 5 (Bavaria)	2,954	0.461	0.499	0	1
Border segment 1	2,954	0.024	0.154	0	1
Border segment 2	2,954	0.061	0.240	0	1
Border segment 3	2,954	0.109	0.311	0	1
Border segment 4	2,954	0.117	0.322	0	1
Border segment 5	2,954	0.088	0.283	0	1
Border segment 6	2,954	0.143	0.350	0	1
Border segment 7	2,954	0.218	0.413	0	1
Border segment 8	2,954	0.231	0.421	0	1
	Coordinates:				
Longitude	2,954	9.929	1.744	5.922	13.777
Latitude	2,954	49.907	1.587	47.369	53.823
	Geo. controls:				
Distance GDR (in km)	2,954	145.431	83.042	0.203	364.061
Crop suitability (index)	2,949	47.156	21.579	0.000	81.000
Elevation (in m)	2,954	353.777	223.740	-0.190	1,418.85
Ruggedness (in m)	2,954	44.412	47.097	0.596	505.619
Distance river (in km)	2,954	18.053	15.182	0.019	80.682
Area (in km^2)	2,954	65.879	50.531	1.929	561.271
	Population controls:				
Population in 1871	2,948	5,231	10,209	54	215,768
Population density in 1939 (per km^2)	2,954	145	242	5	3,526
Annualised pop. growth rate 1871-1939	2,948	0.005	0.006	-0.007	0.051

Notes: This table shows descriptive statistics of the variables from our main analysis for all 2,954 available observations (i.e. West Germany, not crossed by the border, inhabited, and in a state with variation in treatment).

Table 3.C.4: SUMMARY STATISTICS: PRE-DETERMINED VARIABLES (NORMALISED) WITHIN BANDWIDTH

Variable	Observations	Mean	Std. dev.	Min	Max
	Economy:				
Work force 1933	94	0.216	1.030	-2.277	3.378
Civil servants 1933	94	-0.039	0.980	-1.347	4.224
Blue-collor 1933	94	-0.416	0.937	-2.588	1.718
Female workers 1933	94	0.246	0.989	-1.929	2.452
Number of firms 1950	61	0.337	0.751	-1.549	1.907
Foreign visits 1954	58	0.220	1.528	-0.325	8.020
	Industrial structure:				
Agriculture 1933	270	0.295	1.256	-1.045	4.395
Industry 1933	94	-0.379	1.063	-2.708	2.232
Trade 1933	94	0.011	0.992	-2.053	2.058
Services 1933	94	0.020	1.066	-1.523	3.269
	Infrastructure:				
Library access 1948	40	-0.006	0.422	-0.437	1.541
Lights per street 1948	59	0.083	0.789	-0.758	2.466
Cinemas 1952	63	0.344	1.162	-1.395	3.425
Living space 1954	53	0.073	1.055	-1.646	5.328
	Public finances:				
Tax revenue 1954	62	0.004	0.984	-1.460	3.669
Public debt 1955	63	0.105	1.094	-1.459	5.146
	Population:				
Population 1871	614	-0.058	0.510	-0.473	5.826
Population 1939	616	-0.065	0.389	-0.247	4.775
Population 1946/50	616	-0.059	0.467	-0.324	6.124
Growth rate 1871-1939	614	0.002	0.879	-1.869	3.014
Growth 1871-1939	614	-0.064	0.353	-0.276	4.511
Growth rate 1871-1946/50	614	0.045	0.799	-1.978	2.961
Growth 1871-1946/50	614	-0.057	0.449	-0.304	6.283
Density 1939	616	-0.037	0.620	-0.536	7.429
	Social:				
Protestants 1925	242	0.184	1.009	-1.183	1.395
Election turnout 1933	266	0.041	0.939	-4.145	1.780
Votes NSDAP 1933	266	0.105	1.166	-2.669	3.122
	Geography:				
Distance GDR	616	0.029	0.674	-0.950	2.031
Distance river	616	0.468	1.253	-1.185	4.125
Elevation	616	-0.158	1.073	-1.577	4.819
Ruggedness	616	-0.039	0.976	-0.928	9.084
Area	616	-0.026	0.948	-1.263	3.820
Crop suitability	614	-0.027	0.969	-2.185	1.568
	War destruction:				
Expellee share 1952	66	-0.053	0.835	-1.134	1.964

Notes: This table shows descriptive statistics of the pre-determined variables for the sample of 616 municipality groups (i.e. within 33 km bandwidth, not crossed by the border, and with income available). Table 3.C.5 presents summary statistics over the entire set of 2,954 municipality groups. Variables are normalised to mean zero and standard deviation one over the set of observations presented in Table 3.C.5. A detailed description of the data is provided in Section 3.B.2. As historical data has only been published for municipalities beyond a specific size, the number of observations varies largely. Summary statistics for the county-level variable on house destruction in 1950 are presented in Table 3.C.6.

Table 3.C.5: SUMMARY STATISTICS: PRE-DETERMINED VARIABLES (NORMALISED) ALL MUNICIPALITY GROUPS

Variable	Observations	Mean	Std. dev.	Min	Max
	Economy:				
Work force 1933	470	0	1	-4.273	3.378
Civil servants 1933	470	0	1	-1.418	5.674
Blue-collor 1933	470	0	1	-2.893	3.449
Female workers 1933	470	0	1	-3.161	3.126
Number of firms 1950	342	0	1	-2.617	3.560
Foreign visits 1954	340	0	1	-0.335	8.020
	Industrial structure:				
Agriculture 1933	1,159	0	1	-1.087	4.533
Industry 1933	470	0	1	-2.708	2.607
Trade 1933	470	0	1	-2.390	2.919
Services 1933	470	0	1	-1.523	5.744
	Infrastructure:				
Library access 1948	236	0	1	-0.539	14.397
Lights per street 1948	330	0	1	-0.758	12.095
Cinemas 1952	350	0	1	-1.473	4.977
Living space 1954	326	0	1	-1.823	5.328
	Public finances:				
Tax revenue 1954	337	0	1	-1.680	6.623
Public debt 1955	360	0	1	-1.579	5.146
	Population:				
Population 1871	2,948	0	1	-0.507	20.623
Population 1939	2,954	0	1	-0.260	21.029
Population 1946/50	2,954	0	1	-0.345	24.024
Growth rate 1871-1939	2,948	0	1	-1.888	7.213
Growth 1871-1939	2,948	0	1	-0.297	21.205
Growth rate 1871-1946/50	2,948	0	1	-2.335	6.280
Growth 1871-1946/50	2,948	0	1	-0.324	25.278
Density 1939	2,954	0	1	-0.579	13.997
	Social:				
Protestants 1925	1,130	0	1	-1.183	1.402
Election turnout 1933	1,151	0	1	-4.623	1.854
Votes NSDAP 1933	1,151	0	1	-2.669	3.309
	Geography:				
Distance GDR	2,954	0	1	-1.749	2.633
Distance river	2,954	0	1	-1.188	4.125
Elevation	2,954	0	1	-1.577	5.008
Ruggedness	2,954	0	1	-0.930	9.793
Area	2,954	0	1	-1.266	9.804
Crop suitability	2,949	0	1	-2.185	1.568
	War destruction:				
Expellee share 1952	361	0	1	-1.437	5.010

Notes: This table shows descriptive statistics of the pre-determined variables for the sample of 2,954 municipality groups (i.e. West Germany, not crossed by the border, inhabited, and in a state with variation in treatment). Variables are normalised to mean zero and standard deviation one. A detailed description of the data is provided in Section 3.B.2. As historical data has only been published for municipalities beyond a specific size, the number of observations varies largely. Summary statistics for the county-level variable on house destruction in 1950 are presented in Table 3.C.6.

Table 3.C.6: SUMMARY STATISTICS: HOUSE DESTRUCTION

Variable	Observations	Mean	Std. dev.	Min	Max
	A. Sample within 33 km bandwidth:				
House destruction 1950	65	0.133	1.059	-0.518	2.301
	B. All available observations:				
House destruction 1950	430	0	1	-1.927	2.301

Notes: This table presents summary statistics for the pre-determined variable on house destruction at the county level. Variables are normalised to mean zero and standard deviation one. Panel (a) includes counties within 33 km bandwidth of the border which are not crossed by the border. Panel (b) includes all counties in West Germany which are not crossed by the border and which lay in a state with variation in treatment.

Table 3.C.7: SUMMARY STATISTICS: MILITARY INSTALLATIONS

Variable	Observations	Mean	Std. dev.	Min	Max
	A. Sample within 33 km bandwidth:				
Military base 1970 (1 = existence)	616	0.067	0.249	0	1
Military base 1990 (1 = existence)	616	0.063	0.244	0	1
Military base 2002 (1 = existence)	616	0.047	0.212	0	1
Base closure 1990 - 2002 (relative)	39	0.417	0.427	0	1
Base closure 1990 - 2002 (1 = at least one)	39	0.564	0.502	0	1
Base closure 1990 - 2002 (1 = all)	39	0.282	0.456	0	1
Nike sytem (1 = existence)	616	0.031	0.173	0	1
Demolition chambers	616	0.854	2.418	0	22
	B. All available observations:				
Military base 1970 (1 = existence)	2,954	0.061	0.239	0	1
Military base 1990 (1 = existence)	2,954	0.062	0.241	0	1
Military base 2002 (1 = existence)	2,954	0.041	0.199	0	1
Base closure 1990 - 2002 (relative)	183	0.513	0.427	0	1
Base closure 1990 - 2002 (1 = at least one)	183	0.656	0.476	0	1
Base closure 1990 - 2002 (1 = all)	183	0.355	0.480	0	1
Nike sytem (1 = existence)	2,954	0.016	0.125	0	1
Demolition chambers	2,954	1.214	2.810	0	25

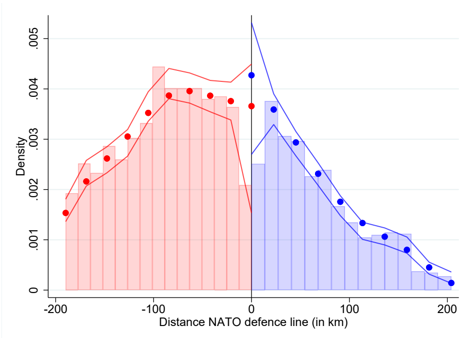
Notes: This table presents summary statistics for variables on military installations. Panel (a) includes the sample of 616 municipality groups within 33 km bandwidth of the border for which income is available and which are not crossed by the border. Panel (b) includes all available 2,954 observations in West Germany which are not crossed by the border and which lay in a state with treatment-variation. The variables on base closure are only generated for municipality groups which have hosted a military base in 1990.

3.D Assumptions

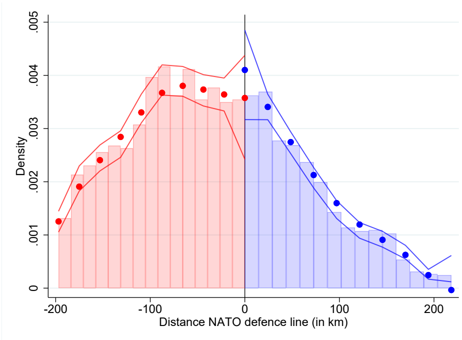
3.D.1 Testing for Sorting Into Treatment

Figure 3.D.1: DENSITY OF THE RUNNING VARIABLE

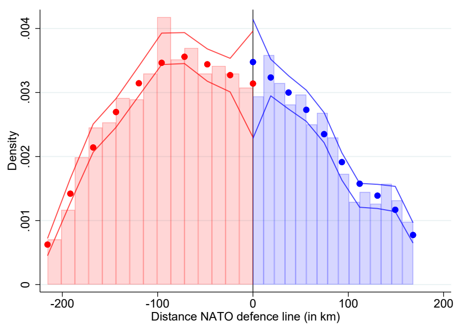
(a) Base Sample



(b) Add crossed municipality groups



(c) Add excluded states



Notes: This figure tests for manipulation using the local polynomial density estimators proposed in Cattaneo et al. (2020b). Panel (a) employs the sample employed for the main analysis. Panel (b) adds those municipality groups crossed by the defence line. Panel (c) adds those West German states which are excluded as they do not experience variation in treatment. The figure shows a histogram of the number of municipality groups according to their distance to the border. It also shows the density estimates with 95% confidence intervals. The density estimates for treatment (blue) and control group (red) at the border are within the confidence interval of the other. This is consistent with failing to reject the null hypothesis of no differences in density of the two groups at the cutoff.

3.D.2 Testing for Balance

Table 3.D.1: BALANCE: PANEL A - ECONOMY

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Work force 1933	-0.01	-0.05	0.02	-0.16	0.11	0.23	0.20	0.05
	(0.938)	(0.927)	(0.894)	(0.631)	(0.658)	(0.372)	(0.473)	(0.536)
			[0.967]	[0.656]			[0.600]	[0.900]
			{0.971}	{0.683}			{0.679}	{0.908}
Bandwidth (in km)	56	48	40	40	33	33	33	33
Eff. observations (N)	160	139	116	117	94	94	94	94
Civil servants 1933	-0.18	-0.36	-0.01	-0.12	-0.38	-0.64	-0.52	-0.82
	(0.758)	(0.515)	(0.918)	(0.876)	(0.573)	(0.373)	(0.542)	(0.277)
			[0.986]	[0.800]			[0.268]	[0.067]
			{0.987}	{0.822}			{0.428}	{0.191}
Bandwidth (in km)	49	49	40	42	33	33	33	33
Eff. observations (N)	141	140	118	121	94	94	94	94
Blue-collor 1933	-0.01	0.16	0.21	0.13	-0.07	0.18	-0.01	0.10
	(0.952)	(0.601)	(0.866)	(0.906)	(0.943)	(0.577)	(0.913)	(0.692)
			[0.590]	[0.651]			[0.954]	[0.748]
			{0.662}	{0.76}			{0.9786}	{0.8526}
Bandwidth (in km)	36	35	39	45	33	33	33	33
Eff. observations (N)	102	98	115	130	94	94	94	94
Female workers 1933	0.33	0.39	-0.03	0.27	0.61*	0.56	0.38	0.27
	(0.298)	(0.252)	(0.954)	(0.543)	(0.09)	(0.118)	(0.341)	(0.441)
			[0.937]	[0.450]			[0.258]	[0.450]
			{0.943}	{0.580}			{0.405}	{0.580}
Bandwidth (in km)	39	37	37	34	33	33	33	33
Eff. observations (N)	115	105	104	94	94	94	94	94
Number firms 1950	-0.28	-0.20	-0.24	-0.18	-0.31	-0.22	-0.34	-0.18
	(0.677)	(0.739)	(0.835)	(0.931)	(0.589)	(0.706)	(0.734)	(0.977)
			[0.619]	[0.757]			[0.507]	[0.757]
			{0.663}	{0.791}			{0.565}	{0.791}
Bandwidth (in km)	37	36	35	34	33	33	33	33
Eff. observations (N)	67	65	64	61	61	61	61	61
Foreign visits 1954	-0.51	-0.79	-0.87	-1.02	-0.82	-0.59	-0.51	-0.46
	(0.837)	(0.548)	(0.447)	(0.188)	(0.743)	(0.848)	(0.895)	(0.946)
			[0.021]	[0.004]			[0.594]	[0.638]
			{0.217}	{0.063}			{0.744}	{0.769}
Bandwidth (in km)	52	68	64	83	33	33	33	33
Eff. observations (N)	99	136	128	180	58	58	58	58
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

Notes: This table shows the coefficients for regressing treatment on pre-determined variables following our RD-specification - including either state or border segment fixed effects. In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one.

Table 3.D.2: BALANCE: PANEL B - INDUSTRIAL STRUCTURE

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Agriculture 1933	0.16	0.08	0.04	0.04	0.00	0.01	0.15	0.15
	(0.690)	(0.870)	(0.827)	(0.898)	(0.850)	(0.892)	(0.721)	(0.719)
			[0.886]	[0.890]			[0.624]	[0.638]
			{0.873}	{0.878}			{0.598}	{0.609}
Bandwidth (in km)	62	55	37	37	33	33	33	33
Eff. observations (N)	525	458	303	299	270	270	270	270
Industry 1933	-0.35	-0.14	0.02	0.01	-0.35	-0.14	-0.44	-0.29
	(0.425)	(0.849)	(0.827)	(0.759)	(0.440)	(0.866)	(0.286)	(0.495)
			[0.956]	[0.972]			[0.124]	[0.398]
			{0.965}	{0.974}			{0.347}	{0.550}
Bandwidth (in km)	36	37	36	40	33	33	33	33
Eff. observations (N)	101	105	102	116	94	94	94	94
Trade 1933	-0.02	-0.09	0.41	0.18	-0.38	-0.46	-0.15	-0.18
	(0.898)	(0.939)	(0.385)	(0.705)	(0.587)	(0.507)	(0.937)	(0.993)
			[0.388]	[0.697]			[0.788]	[0.751]
			{0.395}	{0.746}			{0.798}	{0.768}
Bandwidth (in km)	41	41	41	38	33	33	33	33
Eff. observations (N)	121	121	118	109	94	94	94	94
Services 1933	-0.19	-0.31	0.01	-0.26	0.05	-0.12	-0.19	-0.32
	(0.795)	(0.598)	(0.673)	(0.885)	(0.989)	(0.831)	(0.870)	(0.698)
			[0.983]	[0.564]			[0.452]	[0.438]
			{0.984}	{0.584}			{0.749}	{0.595}
Bandwidth (in km)	46	47	49	45	33	33	33	33
Eff. observations (N)	131	134	141	130	94	94	94	94
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

Notes: This table shows the coefficients for regressing treatment on pre-determined variables following our RD-specification - including either state or border segment fixed effects. In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one.

Table 3.D.3: BALANCE: PANEL C - INFRASTRUCTURE

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Library access 1948	0.10	0.04	-1.74	-2.14	0.02	0.11	0.08	0.22
	(0.472)	(0.542)	(0.196)	(0.269)	(0.852)	(0.558)	(0.767)	(0.389)
			[0.000]	[0.038]			[0.793]	[0.502]
			{0.090}	{0.534}			{0.847}	{0.624}
Bandwidth (in km)	40	64	16	17	33	33	33	33
Eff. observations (N)	49	85	11	12	40	40	40	40
Lights per street 1948	0.39	0.62*	0.63	0.96**	0.43	0.85*	0.42	0.66
	(0.237)	(0.063)	(0.299)	(0.042)	(0.467)	(0.067)	(0.447)	(0.143)
			[0.054]	[0.058]			[0.223]	[0.050]
			{0.298}	{0.174}			{0.440}	{0.259}
Bandwidth (in km)	48	46	26	30	33	33	33	33
Eff. observations (N)	90	89	43	49	59	59	59	59
Cinemas 1952	-0.28	0.18	0.17	0.33	-0.6	-0.11	0.20	0.68
	(0.724)	(0.787)	(0.626)	(0.480)	(0.486)	(0.840)	(0.982)	(0.522)
			[0.585]	[0.322]			[0.666]	[0.323]
			{0.730}	{0.616}			{0.856}	{0.557}
Bandwidth (in km)	45	48	65	55	33	33	33	33
Eff. observations (N)	88	93	138	108	63	63	63	63
Living space 1954	0.59	0.57	0.39	0.30	0.35	0.47	0.53	0.45
	(0.400)	(0.372)	(0.429)	(0.562)	(0.642)	(0.368)	(0.492)	(0.435)
			[0.360]	[0.406]			[0.417]	[0.470]
			{0.479}	{0.569}			{0.497}	{0.567}
Bandwidth (in km)	50	51	52	57	33	33	33	33
Eff. observations (N)	92	94	95	101	53	53	53	53
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

Notes: This table shows the coefficients for regressing treatment on pre-determined variables following our RD-specification - including either state or border segment fixed effects. In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one.

Table 3.D.4: BALANCE: PANEL D - PUBLIC FINANCES

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Tax revenue 1954	-0.15	-0.41	0.23	-0.69**	-0.37	-0.21	-0.15	-0.18
	(0.543)	(0.154)	(0.858)	(0.047)	(0.440)	(0.975)	(0.787)	(0.892)
			[0.509]	[0.043]			[0.708]	[0.794]
			{0.574}	{0.094}			{0.756}	{0.799}
Bandwidth (in km)	53	58	42	53	33	33	33	33
Eff. observations (N)	104	117	77	104	62	62	62	62
Public debt 1955	-0.42	-0.61	-0.51	-0.73	-0.81	-0.91	-0.47	-0.76
	(0.609)	(0.377)	(0.435)	(0.189)	(0.379)	(0.334)	(0.608)	(0.373)
			[0.128]	[0.007]			[0.283]	[0.010]
			{0.238}	{0.131}			{0.466}	{0.270}
Bandwidth (in km)	47	44	56	47	33	33	33	33
Eff. observations (N)	94	89	112	95	63	63	63	63
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

Notes: This table shows the coefficients for regressing treatment on pre-determined variables following our RD-specification - including either state or border segment fixed effects. In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one.

Table 3.D.5: BALANCE: PANEL E - POPULATION

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Population 1871	-0.19**	-0.21**	-0.19*	-0.19*	-0.20**	-0.22***	-0.22**	-0.24**
	(0.017)	(0.011)	(0.052)	(0.051)	(0.013)	(0.009)	(0.042)	(0.030)
			[0.042]	[0.048]			[0.008]	[0.006]
			{0.071}	{0.057}			{0.005}	{0.005}
Bandwidth (in km)	31	31	21	21	33	33	33	33
Eff. observations (N)	571	574	340	352	617	617	617	617
Population 1939	-0.06	-0.06	0.02	0.08	-0.13*	-0.14**	-0.15	-0.17*
	(0.211)	(0.232)	(0.694)	(0.356)	(0.067)	(0.045)	(0.138)	(0.093)
			[0.862]	[0.604]			[0.000]	[0.002]
			{0.807}	{0.474}			{0.015}	{0.013}
Bandwidth (in km)	24	24	16	17	33	33	33	33
Eff. observations (N)	425	421	238	247	619	619	619	619
Population 1946/50	-0.08	-0.08	0.05	0.27	-0.15*	-0.17**	-0.18	-0.20*
	(0.220)	(0.203)	(0.568)	(0.277)	(0.078)	(0.049)	(0.149)	(0.099)
			[0.751]	[0.396]			[0.001]	[0.002]
			{0.642}	{0.397}			{0.018}	{0.015}
Bandwidth (in km)	25	25	16	14	33	33	33	33
Eff. observations (N)	433	429	236	199	619	619	619	619
Growth Rate 1871-1939	0.19	0.15	0.46**	0.27	0.32**	0.26*	0.32*	0.25*
	(0.305)	(0.376)	(0.032)	(0.124)	(0.047)	(0.082)	(0.056)	(0.096)
			[0.001]	[0.129]			[0.108]	[0.163]
			{0.029}	{0.193}			{0.062}	{0.119}
Bandwidth (in km)	24	25	27	24	33	33	33	33
Eff. observations (N)	424	438	476	416	617	617	617	617
Growth 1871-1939	-0.06	-0.06	0.12	0.05	-0.10	-0.11	-0.12	-0.14
	(0.313)	(0.277)	(0.355)	(0.406)	(0.155)	(0.111)	(0.237)	(0.165)
			[0.441]	[0.708]			[0.000]	[0.001]
			{0.350}	{0.604}			{0.033}	{0.026}
Bandwidth (in km)	26	26	15	16	33	33	33	33
Eff. observations (N)	450	445	215	234	617	617	617	617
Growth Rate 1871-1946/1950	0.24	0.23	0.28	0.10	0.35**	0.29**	0.35**	0.29**
	(0.240)	(0.239)	(0.121)	(0.382)	(0.029)	(0.046)	(0.027)	(0.046)
			[0.063]	[0.661]			[0.067]	[0.111]
			{0.194}	{0.615}			{0.023}	{0.043}
Bandwidth (in km)	25	27	23	22	33	33	33	33
Eff. observations (N)	432	471	398	367	617	617	617	617
Growth 1871-1946/1950	-0.07	-0.07	0.07	0.03	-0.13	-0.14	-0.16	-0.18
	(0.333)	(0.273)	(0.515)	(0.972)	(0.173)	(0.114)	(0.249)	(0.169)
			[0.580]	[0.788]			[0.001]	[0.003]
			{0.481}	{0.750}			{0.038}	{0.029}
Bandwidth (in km)	26	26	18	18	33	33	33	33
Eff. observations (N)	465	452	269	274	617	617	617	617
Density 1939	-0.05	-0.08	-0.02	-0.18	-0.10	-0.13	-0.13	-0.17
	(0.858)	(0.902)	(0.875)	(0.326)	(0.909)	(0.654)	(0.540)	(0.370)
			[0.880]	[0.102]			[0.000]	[0.000]
			{0.928}	{0.346}			{0.293}	{0.168}
Bandwidth (in km)	24	25	19	20	33	33	33	33
Eff. observations (N)	421	439	296	332	619	619	619	619
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

Notes: This table shows the coefficients for regressing treatment on pre-determined variables following our RD-specification - including either state or border segment fixed effects. In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one.

Table 3.D.6: BALANCE: PANEL F - SOCIAL

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Protestants 1925	0.16	0.28	0.18	0.35	0.15	0.20	0.10	0.27
	(0.429)	(0.402)	(0.364)	(0.242)	(0.511)	(0.595)	(0.488)	(0.333)
			[0.610]	[0.306]			[0.767]	[0.410]
			{0.519}	{0.261}			{0.715}	{0.395}
Bandwidth (in km)	37	38	35	35	33	33	33	33
Eff. observations (N)	268	277	250	249	242	242	242	242
Election turnout 1933	-0.28	-0.26	-0.38*	-0.26	-0.28	-0.28	-0.24	-0.23
	(0.234)	(0.337)	(0.066)	(0.183)	(0.306)	(0.273)	(0.156)	(0.166)
			[0.071]	[0.251]			[0.383]	[0.437]
			{0.054}	{0.186}			{0.334}	{0.354}
Bandwidth (in km)	35	31	47	46	33	33	33	33
Eff. observations (N)	276	245	382	381	266	266	266	266
Vote NSDAP 1933	-0.06	0.07	0.11	0.19	-0.16	-0.10	-0.16	-0.06
	(0.871)	(0.712)	(0.702)	(0.523)	(0.795)	(0.837)	(0.846)	(0.984)
			[0.841]	[0.696]			[0.724]	[0.900]
			{0.713}	{0.476}			{0.669}	{0.876}
Bandwidth (in km)	68	53	45	51	33	33	33	33
Eff. observations (N)	554	436	369	415	266	266	266	266
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

Notes: This table shows the coefficients for regressing treatment on pre-determined variables following our RD-specification - including either state or border segment fixed effects. In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one.

Table 3.D.7: BALANCE: PANEL G - GEOGRAPHY

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Distance GDR	0.15*	0.03	0.17	0.00	0.03	0.03	0.10	0.03
	(0.060)	(0.539)	(0.038)	(0.991)	(0.961)	(0.680)	(0.388)	(0.604)
			[0.297]	.			[0.373]	.
			{0.019}	{0.986}			{0.254}	{0.527}
Bandwidth (in km)	53	38	42	28	33	33	33	33
Eff. observations (N)	1011	720	791	512	619	619	619	619
Distance river	0.04	-0.03	0.07	-0.04	-0.10	-0.07	-0.08	-0.08
	(0.836)	(0.904)	(0.674)	(0.865)	(0.744)	(0.687)	(0.947)	(0.718)
			[0.855]	[0.705]			[0.760]	[0.676]
			{0.765}	{0.873}			{0.763}	{0.686}
Bandwidth (in km)	58	43	38	29	33	33	33	33
Eff. observations (N)	1095	817	710	520	619	619	619	619
Elevation	0.38***	0.19**	0.30**	0.19	0.16	0.17	0.30*	0.20**
	(0.001)	(0.024)	(0.013)	(0.280)	(0.749)	(0.178)	(0.069)	(0.029)
			[0.083]	[0.074]			[0.074]	[0.002]
			{0.026}	{0.105}			{0.037}	{0.015}
Bandwidth (in km)	48	42	35	23	33	33	33	33
Eff. observations (N)	894	784	645	397	619	619	619	619
Ruggedness	0.17	0.13	0.22	0.10	-0.02	0.10	0.09	0.12
	(0.390)	(0.429)	(0.265)	(0.559)	(0.514)	(0.686)	(0.958)	(0.568)
			[0.130]	[0.183]			.	[0.054]
			{0.156}	{0.384}			{0.633}	{0.334}
Bandwidth (in km)	47	40	41	29	33	33	33	33
Eff. observations (N)	892	740	763	533	619	619	619	619
Area	-0.04	-0.10	-0.17	-0.13	-0.12	-0.14	-0.17	-0.16
	(0.624)	(0.457)	(0.344)	(0.446)	(0.276)	(0.257)	(0.281)	(0.261)
			[0.293]	[0.296]			[0.273]	[0.169]
			{0.288}	{0.387}			{0.240}	{0.291}
Bandwidth (in km)	26	27	30	31	33	33	33	33
Eff. observations (N)	453	490	535	572	619	619	619	619
Crop suitability	-0.01	-0.06	-0.06	-0.06	0.00	-0.06	-0.04	-0.10
	(0.83)	(0.67)	(0.982)	(0.833)	(0.785)	(0.669)	(0.790)	(0.527)
			[0.751]	[0.754]			[0.778]	[0.551]
			{0.757}	{0.748}			{0.829}	{0.598}
Bandwidth (in km)	36	34	35	34	33	33	33	33
Eff. observations (N)	661	633	653	630	617	617	617	617
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

Notes: This table shows the coefficients for regressing treatment on pre-determined variables following our RD-specification - including either state or border segment fixed effects. In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one.

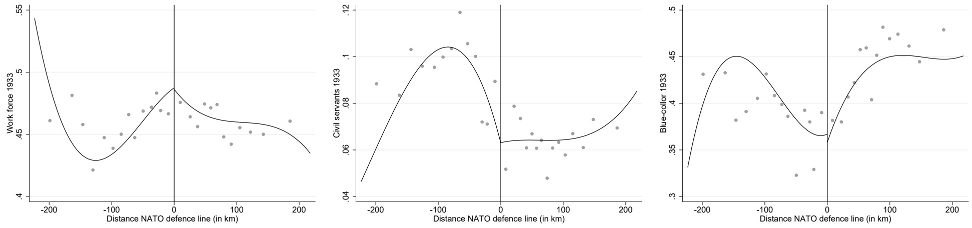
Table 3.D.8: BALANCE: PANEL H - WAR DISRUPTION

	Optimal bandwidth				Bandwidth of 33 km			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Expellee share 1952	0.18	-0.04	0.14	-0.13	0.23	0.00	0.10	-0.10
	(0.44)	(0.976)	(0.507)	(0.799)	(0.425)	(0.844)	(0.588)	(0.643)
			[0.593]	[0.614]			[0.711]	[0.746]
			{0.62}	{0.563}			{0.703}	{0.732}
Bandwidth (in km)	35	53	30	46	33	33	33	33
Eff. observations (N)	70	112	53	96	66	66	66	66
House destruction 1950	-0.51	-0.54	-0.05	0.04	-1.10	-1.24	-0.54	-1.08
	(0.634)	(0.567)	(0.969)	(0.948)	(0.486)	(0.362)	(0.680)	(0.382)
			[0.946]	[0.958]			[0.627]	[0.359]
			{0.951}	{0.963}			{0.650}	{0.412}
Bandwidth (in km)	42	45	42	44	33	33	33	33
Eff. observations (N)	85	92	85	90	65	65	65	65
Fixed effects	State	Segment	State	Segment	State	Segment	State	Segment
Kernel	T	T	U	U	T	T	U	U

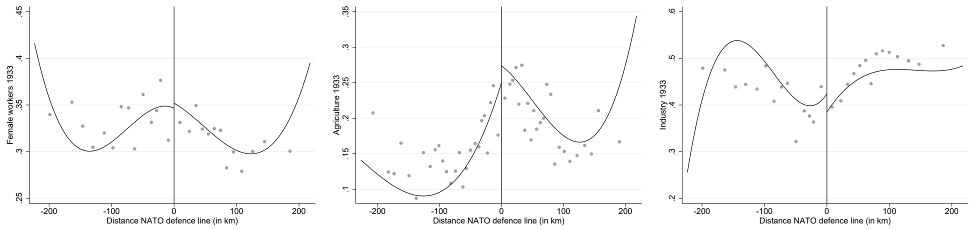
Notes: In specifications (I) - (IV) the optimal bandwidth is selected for each variable individually based on Cattaneo et al. (2020a). In specifications (V) - (VIII) the same bandwidth of 33 km as in the main specification is employed. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel. Figure 3.3 provides a intuitive presentation of the results in the specifications in (I), (II), (V), and (VI). For comparability, variables have been normalised to a mean of zero and a standard deviation of one. The variable house destruction is on the county level.

Figure 3.D.2: GLOBAL RD PLOT: PRE-DETERMINED VARIABLES

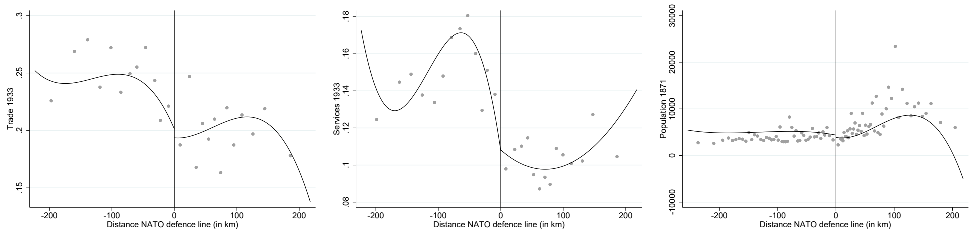
(a) A: Work force 1933 (b) A: Civil servants 1933 (c) A: Blue-collor 1933



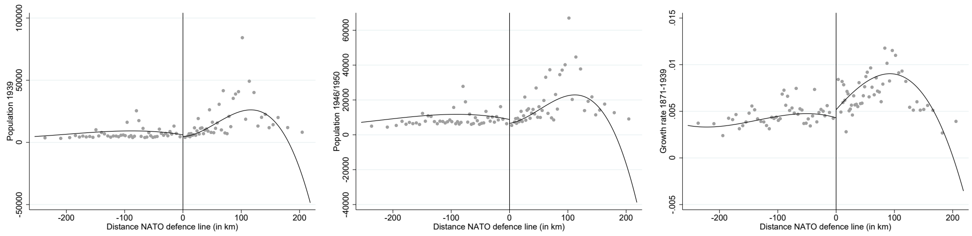
(d) A: Fem. workers 1933 (e) B: Agriculture 1933 (f) B: Industry 1933



(g) B: Trade 1933 (h) B: Services 1933 (i) E: Population 1871



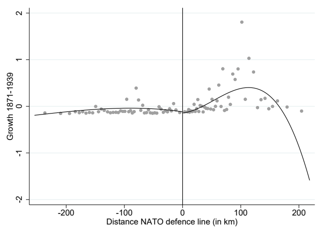
(j) E: Population 1939 (k) E: Population 1946/50 (l) E: G. rate 1871-1939



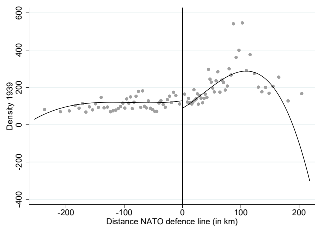
Notes: Continued on next page.

Figure 3.D.2: GLOBAL RD PLOT: PRE-DETERMINED VARIABLES (*continued*)

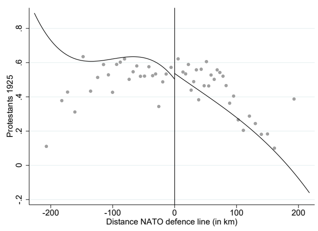
(m) E: Growth 1871-1939



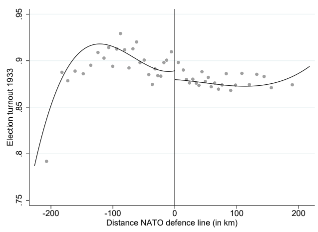
(n) E: Density 1939



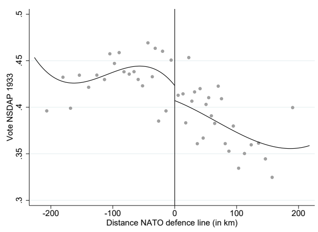
(o) F: Protestants 1925



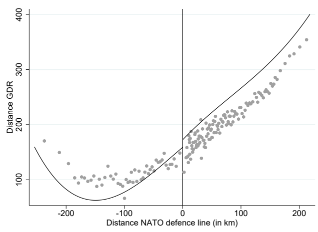
(p) F: Elec. turnout 1933



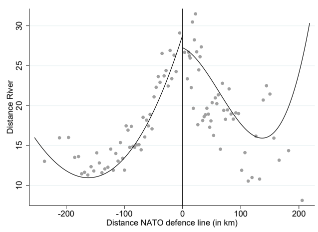
(q) F: Vote NSDAP 1933



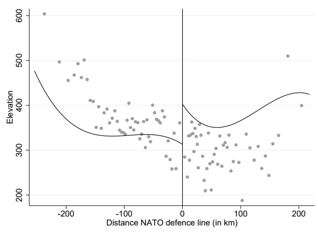
(r) G: Distance GDR



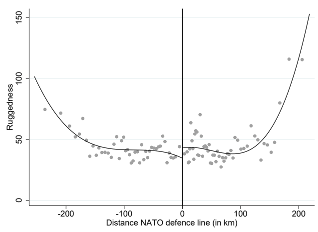
(s) G: Distance river



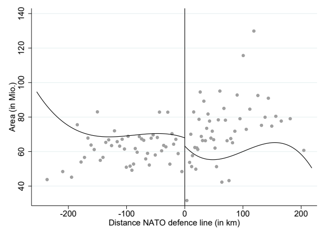
(t) G: Elevation



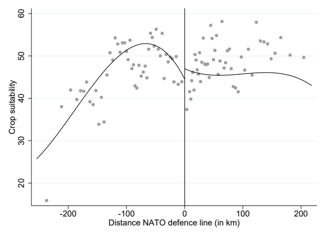
(u) G: Ruggedness



(v) G: Area



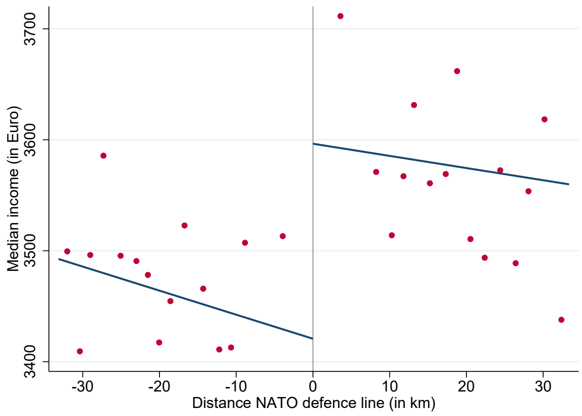
(w) G: Crop suitability



Notes: The figure illustrates the global behaviour of the pre-determined variables. Only variables with at least 400 observations are shown. Even then, the number of observations for some variables is quite low which leads to over-fitting and odd behaviour at the boundary when employing a global polynomial of order four as is standard. Hence, a global polynomial of order three is employed for fitting the data on each side of the boundary. State fixed effects are included. A triangular kernel is employed. Bins are quantile-spaced and their number is chosen according to the mimicking variance criterion. Positive values for distance indicate that a municipality is west of the NATO defence line (i.e. treated with security) and negative values indicate being east. Letters indicate the group a variable belongs to: Economy (A), industrial structure (B), population (E), social (F), geography (G).

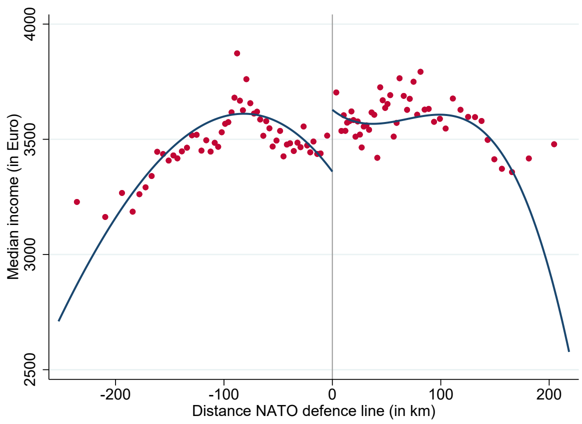
3.E Additional Results and Robustness

Figure 3.E.1: RD PLOT: SEGMENT FIXED EFFECTS



Notes: This figure plots the treatment effect of the NATO defence line on median income in 2019 at the municipality group level. Positive values for distance indicate that a municipality group is west of the NATO defence line (i.e. treated with security) and negative values indicate being east. The bandwidth is set to be optimal (33 km). A triangular kernel and flexible linear distance controls are included. 100 km segment fixed effects are absorbed. Bins are quantile-spaced and their number is chosen according to the mimicking variance criterion.

Figure 3.E.2: RD PLOT: GLOBAL

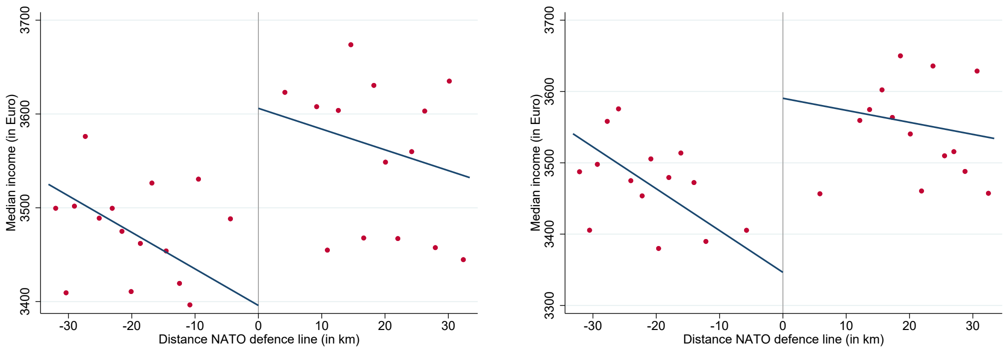


Notes: This figure plots the treatment effect of the NATO defence line on median income in 2019 at the municipality group level. Positive values for distance indicate that a municipality group is west of the NATO defence line (i.e. treated with security) and negative values indicate being east. A triangular kernel and flexible polynomials of order three are included. State fixed effects are absorbed. Bins are quantile-spaced and their number is chosen according to the mimicking variance criterion.

Figure 3.E.3: RD PLOT: DONUT

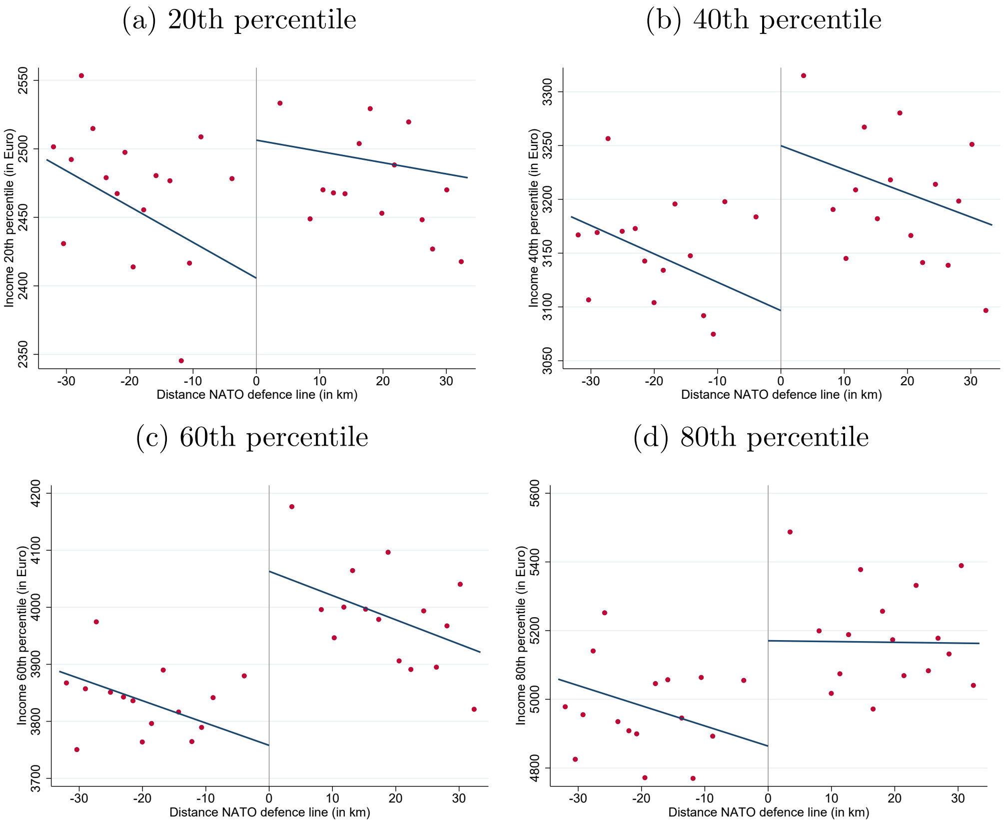
(a) Donut of 5 km

(b) Donut of 10 km



Notes: This figure plots the treatment effect of the NATO defence line on median income in 2019 at the municipality group level excluding areas in close proximity to the border. Panel (a) excludes municipality groups with a centroid less than 5 km away from the border and Panel (b) does the same for a distance of 10 km. Positive values for distance indicate that a municipality group is west of the NATO defence line (i.e. treated with security) and negative values indicate being east. The bandwidth is set to be optimal (33 km). A triangular kernel and flexible linear distance controls are included. State fixed effects are absorbed. Bins are quantile-spaced and their number is chosen according to the mimicking variance criterion.

Figure 3.E.4: RD PLOT: ACROSS INCOME DISTRIBUTION



Notes: For four points along the income distribution, this figure plots the treatment effect of the NATO defence line on income in 2019 at the municipality group level. Positive values for distance indicate that a municipality group is west of the NATO defence line (i.e. treated with security) and negative values indicate being east. The bandwidth is set to be optimal (33 km). A triangular kernel and flexible linear distance controls are included. State fixed effects are absorbed. Bins are quantile-spaced and their number is chosen according to the mimicking variance criterion.

Table 3.E.1: MAIN RESULTS: LOGGED MEDIAN INCOME 2019

	Plain		+ State FE		+ Coordinates		+ Geo. control		+ Pop. control		+ Border Segments	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)	(VI)	(VI^a)
$Treat_c$	0.047**	0.049**	0.058***	0.056***	0.054***	0.053***	0.052***	0.049***	0.048***	0.047**	0.043***	0.041**
	(0.031)	(0.038)	(0.002)	(0.008)	(0.003)	(0.008)	(0.002)	(0.008)	(0.004)	(0.012)	(0.005)	(0.019)
	[0.151]		[0.025]		[0.043]		[0.026]		[0.038]		[0.067]	
	{0.019}		{0.000}		{0.001}		{0.001}		{0.001}		{0.002}	
State-FE			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates					Y	Y	Y	Y	Y	Y	Y	Y
Geography							Y	Y	Y	Y	Y	Y
Population									Y	Y	Y	Y
Segment-FE											Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km
N	616	616	616	616	616	616	614	614	612	612	612	612

Notes: This table presents the coefficient for the treatment effect of the NATO defence line on logged median income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). *Geographic controls* include distance GDR, distance river, crop suitability, elevation, ruggedness, and area. *Population controls* include population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Table 3.E.2: MAIN RESULTS: LOGGED MEDIAN INCOME 2002

	Plain		+ State FE		+ Coordinates		+ Geo. control		+ Pop. control		+ Border Segments	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)	(VI)	(VI^a)
$Treat_c$	0.054**	0.059**	0.055***	0.049**	0.049***	0.047**	0.046***	0.041**	0.038**	0.033*	0.034**	0.028*
	(0.021)	(0.021)	(0.004)	(0.017)	(0.007)	(0.015)	(0.003)	(0.013)	(0.012)	(0.050)	(0.014)	(0.064)
	[0.112]		[0.035]		[0.041]		[0.018]		[0.028]		[0.060]	
	{0.007}		{0.001}		{0.001}		{0.000}		{0.002}		{0.003}	
State-FE			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates					Y	Y	Y	Y	Y	Y	Y	Y
Geography							Y	Y	Y	Y	Y	Y
Population									Y	Y	Y	Y
Segment-FE											Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km
N	615	615	615	615	615	615	613	613	611	611	611	611

Notes: This table presents the coefficient for the treatment effect of the NATO defence line on logged median income in 2002 at the municipality group level. The bandwidth is set to be optimal (33 km). *Geographic controls* include distance GDR, distance river, crop suitability, elevation, ruggedness, and area. *Population controls* include population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Table 3.E.3: MAIN RESULTS: INCOME DISTRIBUTION UNIFORM KERNEL

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
$Treat_c$	113.4***	99.7***	160.9***	121.7***	223.0***	168.4***	322.1***	242.2***	309.9**	186.8
	(0.002)	(0.002)	(0.003)	(0.008)	(0.001)	(0.004)	(0.001)	(0.002)	(0.037)	(0.130)
	[0.005]	[0.024]	[0.022]	[0.074]	[0.026]	[0.059]	[0.017]	[0.039]	[0.050]	[0.239]
	{0.002}	{0.002}	{0.001}	{0.004}	{0.000}	{0.001}	{0.000}	{0.000}	{0.008}	{0.036}
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates		Y		Y		Y		Y		Y
Geography		Y		Y		Y		Y		Y
Population		Y		Y		Y		Y		Y
Segment-FE		Y		Y		Y		Y		Y
Kernel	U	U	U	U	U	U	U	U	U	U
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km
N	616	612	616	612	616	612	616	612	616	612

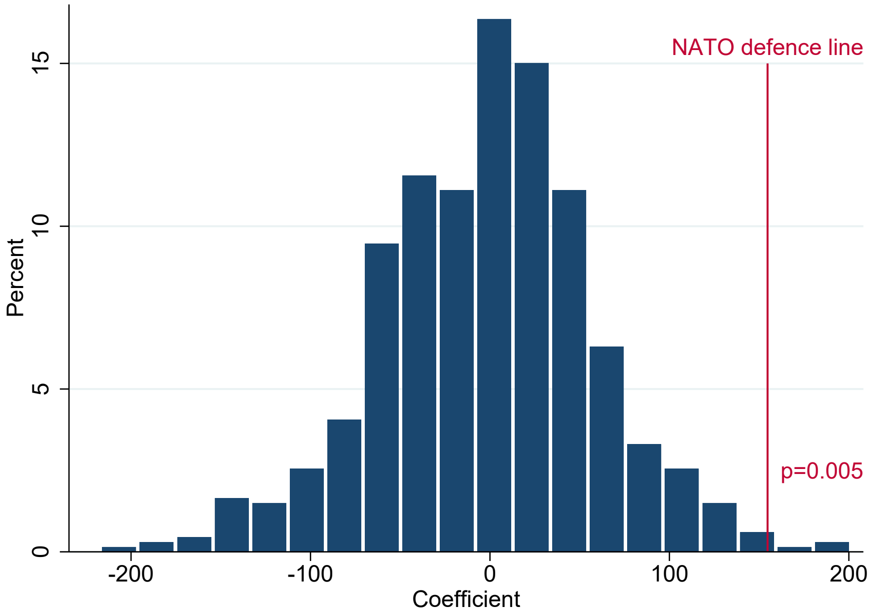
Notes: For five points along the income distribution, this table presents the coefficient for the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented.

Table 3.E.4: MAIN RESULTS: INCOME DISTRIBUTION LOGGED

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
$Treat_c$	0.039**	0.034**	0.045**	0.033**	0.056***	0.041**	0.070***	0.050**	0.055*	0.031
	(0.026)	(0.019)	(0.015)	(0.030)	(0.008)	(0.019)	(0.005)	(0.012)	(0.067)	(0.181)
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates		Y		Y		Y		Y		Y
Geography		Y		Y		Y		Y		Y
Population		Y		Y		Y		Y		Y
Segment-FE		Y		Y		Y		Y		Y
Kernel	T	T	T	T	T	T	T	T	T	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km
N	616	612	616	612	616	612	616	612	616	612

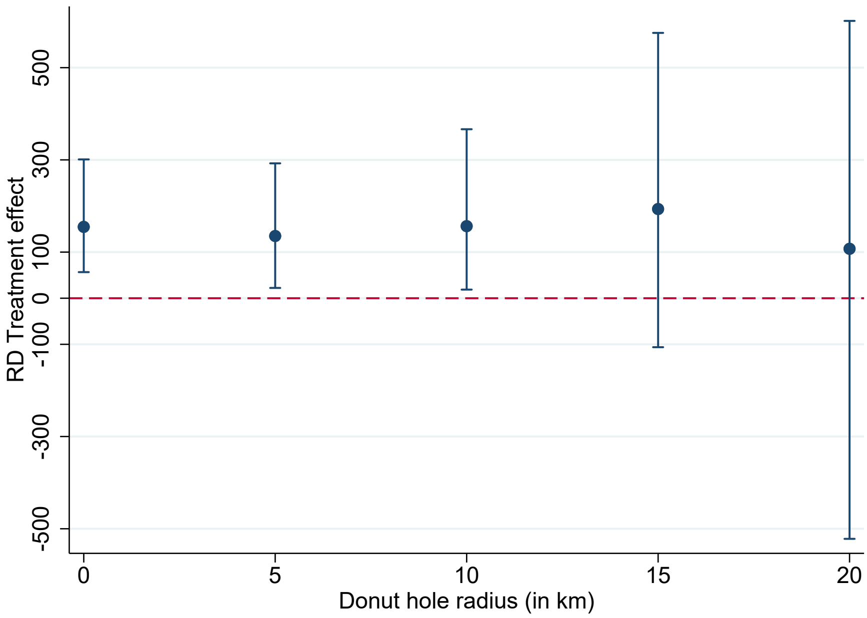
Notes: For five points along the income distribution, this table presents the coefficient for the treatment effect of the NATO defence line on logged income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a triangular kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

Figure 3.E.5: VALIDATION: COEFFICIENTS FOR PLACEBO LINES WITH OPTIMAL BANDWIDTH BEING SET FOR EACH PLACEBO LINE



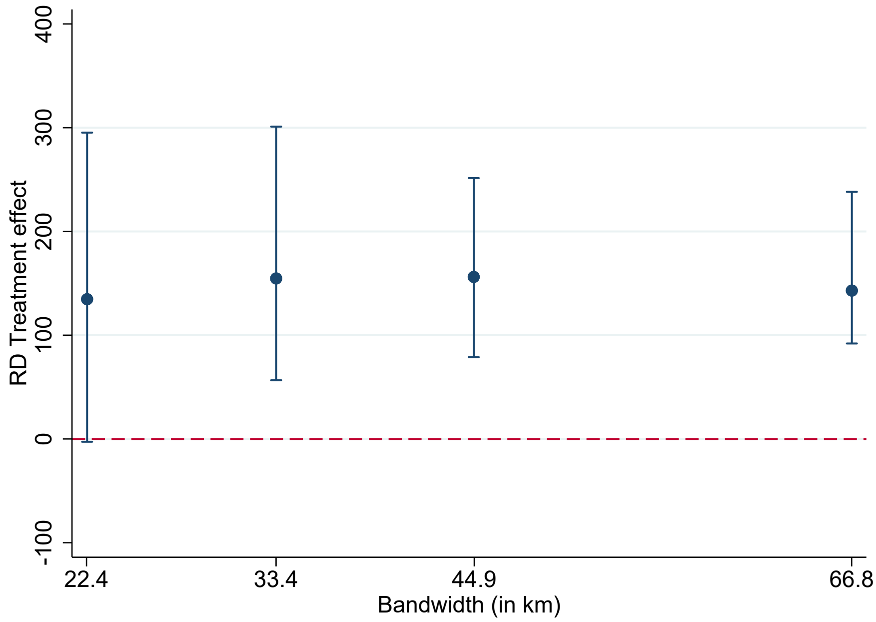
Notes: This figure plots the distribution of 666 RDD coefficients of the treatment effect on median income in 2019 obtained from placebo lines to the east and west of the NATO defence line. The vertical red line indicates the coefficient of 154.7 from from the main specification (VI^a) in Table 3.1. The p-value is calculated as the share of coefficients larger than 154.7. The placebo lines are generated by shifting the defence line repeatedly by 0.5 km - starting from 200 km west and ending 200 km east of the original line. To avoid treatment contamination, we include only the treatment group for placebo lines westward of the original line and only the control group for placebo lines eastward of the original line. For this reason, we do not employ placebo lines within 10 km distance to the original line. Only coefficients from regressions with more than 30 observations on both sides of the border are included. Estimation is based on the most demanding specification including a triangular kernel as well as all fixed effects and control variables. The bandwidth is selected to be optimal for each individual placebo line according to Cattaneo et al. (2020a).

Figure 3.E.6: VALIDATION: DONUT



Notes: This figure shows the donut validation test as suggested by Cattaneo et al. (2020a). We exclude an increasing share of municipality groups which are closest to the border - starting with 5 km and going to 20 km. The coefficient for median income in 2019 is shown. Estimation is based on the most demanding specification including a triangular kernel as well as all fixed effects and control variables. The bandwidth is selected to be optimal for each donut regression. Confidence intervals are at the 90% significance level and are robust to optimal bandwidth selection. The increasing length of confidence intervals results from excluding a growing share of observations.

Figure 3.E.7: VALIDATION: BANDWIDTH SENSITIVITY



Notes: This figure shows the validation test concerning bandwidth sensitivity as suggested by Cattaneo et al. (2020a). From left to right, we extend the bandwidth starting with municipality groups with their centroid within 22.4 km distance to the border (CER-optimal bandwidth) and extend this to 66.8 km (double MSE-optimal bandwidth). The coefficient for median income in 2019 is shown. Estimation is based on the most demanding specification including a triangular kernel as well as all fixed effects and control variables. Confidence intervals are at the 90% significance level and are robust to optimal bandwidth selection. The fact that confidence intervals are longer for a shorter bandwidth follows mechanically from the data-driven way the bandwidth of 33 km is determined. Naturally, reducing the bandwidth below 33 km increases the variance and reduces the bias. Similarly, increasing the bandwidth above 33 km reduces the variance and increases the bias.

Table 3.E.5: ROBUSTNESS: INCOME TAX AS DEPENDENT VARIABLE

	Plain		+ State FE		+ Coordinates		+ Geo. control		+ Pop. control		+ Border Segments	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)	(VI)	(VI^a)
$Treat_c$	37.6	40.1	58.4***	53.3**	52.0**	49.3**	48.5**	44.3**	42.5**	38.2*	40.1**	33.2*
	(0.143)	(0.139)	(0.006)	(0.026)	(0.012)	(0.029)	(0.011)	(0.035)	(0.025)	(0.068)	(0.031)	(0.094)
	[0.195]		[0.011]		[0.031]		[0.038]		[0.057]		[0.084]	
	{0.101}		{0.001}		{0.003}		{0.003}		{0.008}		{0.009}	
State-FE			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates					Y	Y	Y	Y	Y	Y	Y	Y
Geography							Y	Y	Y	Y	Y	Y
Population									Y	Y	Y	Y
Segment-FE											Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T	U	T
Bandwidth	35km	35km	35km	35km	35km	35km	35km	35km	35km	35km	35km	35km
N	647	647	647	647	647	647	645	645	643	643	643	643

Notes: This table presents the coefficient for the treatment effect of the NATO defence line on the per-capita municipal share of income tax in 2019 at the municipality group level. Optimal bandwidth has been selected for most demanding specification (VI^a) employing Cattaneo et al. (2020a). *Geographic controls* include distance GDR, distance to river, crop suitability, elevation, ruggedness, and area. *Population controls* include population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 35 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Table 3.E.6: ROBUSTNESS: LOGGED INCOME TAX AS DEPENDENT VARIABLE

	Plain		+ State FE		+ Coordinates		+ Geo. control		+ Pop. control		+ Border Segments	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)	(VI)	(VI^a)
$Treat_c$	0.042	0.048	0.088**	0.080**	0.075**	0.073**	0.069**	0.065*	0.059**	0.056*	0.055*	0.048
	(0.306)	(0.263)	(0.011)	(0.039)	(0.023)	(0.044)	(0.024)	(0.055)	(0.049)	(0.094)	(0.062)	(0.127)
	[0.366]		[0.021]		[0.065]		[0.089]		[0.123]		[0.167]	
	{0.302}		{0.003}		{0.010}		{0.012}		{0.030}		{0.036}	
State-FE			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates					Y	Y	Y	Y	Y	Y	Y	Y
Geography							Y	Y	Y	Y	Y	Y
Population									Y	Y	Y	Y
Segment-FE											Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T	U	T
Bandwidth	35km	35km	35km	35km	35km	35km	35km	35km	35km	35km	35km	35km
N	647	647	647	647	647	647	645	645	643	643	643	643

Notes: This table presents the coefficient for the treatment effect of the NATO defence line on logged per-capita municipal share of income tax in 2019 at the municipality group level. The bandwidth is set to be optimal for the income tax variable (35 km). *Geographic controls* include distance GDR, distance to river, crop suitability, elevation, ruggedness, and area. *Population controls* include population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In square brackets, p-values robust to spatial spillovers within a 35 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Table 3.E.7: ROBUSTNESS: SAMPLE SPLIT FOR RIVERS

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
A. No rivers										
$Treat_c$	128.9***	110.2**	164.0**	137.6*	241.8***	198.2**	358.5***	280.4**	289.5	216.7
	(0.002)	(0.012)	(0.013)	(0.052)	(0.005)	(0.036)	(0.003)	(0.034)	(0.177)	(0.273)
	[0.000]		[0.000]		[0.000]		[0.000]		.	
	{0.009}		{0.021}		{0.006}		{0.002}		{0.062}	
N	279	279	279	279	279	279	279	279	279	279
B. Weser-Lech										
$Treat_c$	91.1**	83.6*	91.5*	88.2	109.4*	107.7	147.4*	139.3*	123.3	113.0
	(0.030)	(0.072)	(0.067)	(0.106)	(0.070)	(0.101)	(0.060)	(0.098)	(0.379)	(0.491)
	[0.105]		[0.241]		[0.264]		[0.249]		[0.587]	
	{0.035}		{0.069}		{0.050}		{0.026}		{0.255}	
N	377	377	377	377	377	377	377	377	377	377
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Segment-FE										
Kernel	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km

Notes: This table shows robustness to splitting the sample according to the location of border segments with regards to the rivers Weser and Lech. Panel (a) includes those border segments from central Germany which are not placed behind either of the rivers and Panel (b) includes the border segments behind both Weser and Lech. For an illustration see Figure 3.1. Coefficients present the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. We do not include 100 km segment fixed effects - as the sample is split along segments. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

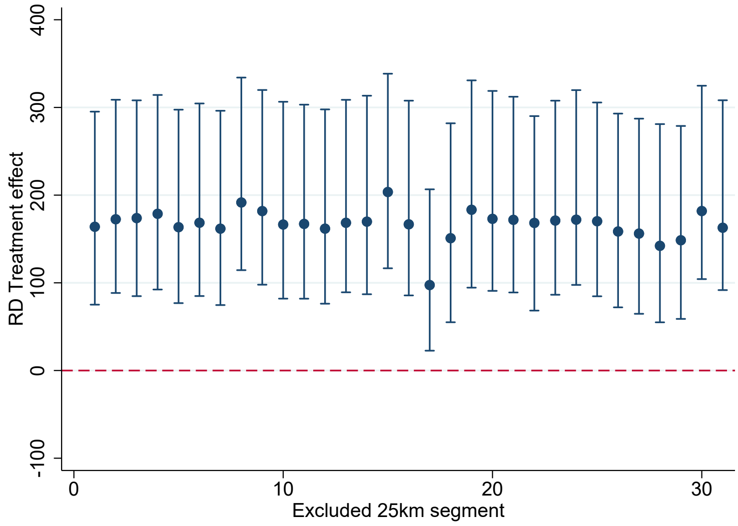
Table 3.E.8: ROBUSTNESS: SAMPLE SPLIT FOR POPULATION GROWTH 1871-1939

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
A. Low growth										
$Treat_c$	106.9***	114.2***	96.4*	101.7**	129.3**	134.8**	209.0***	209.4***	298.1**	318.8**
	(0.005)	(0.004)	(0.054)	(0.049)	(0.035)	(0.026)	(0.008)	(0.008)	(0.021)	(0.016)
	[0.026]		[0.116]		[0.080]		[0.016]		[0.010]	
	{0.007}		{0.049}		{0.023}		{0.004}		{0.007}	
N	307	307	307	307	307	307	307	307	307	307
B. High growth										
$Treat_c$	112.2**	74.1	175.7***	126.8*	239.7***	171.8*	321.3***	222.8*	217.9	104.2
	(0.021)	(0.169)	(0.008)	(0.090)	(0.005)	(0.070)	(0.004)	(0.071)	(0.207)	(0.605)
	[0.067]		[0.047]		[0.036]		[0.031]		[0.265]	
	{0.030}		{0.010}		{0.004}		{0.002}		{0.122}	
N	305	305	305	305	305	305	305	305	305	305
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Segment-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km

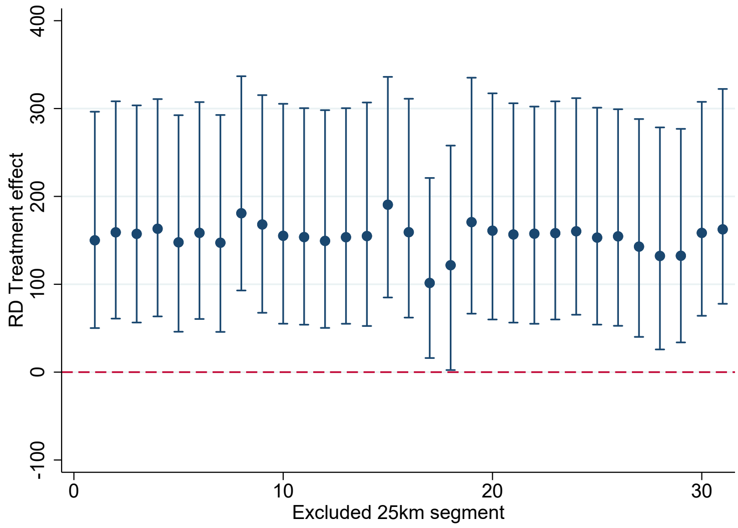
Notes: This table shows robustness to splitting the sample according to annualised population growth rates between 1871 and 1939. Panel (a) includes those municipality groups with below median annualised growth rates of 0.38% and Panel (b) includes the ones with above median growth rates. Coefficients present the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Figure 3.E.8: ROBUSTNESS: EXCLUSION OF 25 km BORDER SEGMENTS

(a) Uniform kernel



(b) Triangular kernel



Notes: This figure plots the treatment effect for median income in 2019 when excluding from North to South repeatedly one of 31 border segments with a length of 25 km each. Panel (a) shows the coefficients for a uniform kernel and Panel (b) shows the coefficients for a triangular kernel. The border segment with most observations includes 56 municipality groups which is excluding around 10% of the observations. The bandwidth is set to be optimal (33 km). Estimation is based on the most demanding specification including a triangular kernel as well as all fixed effects and control variables. The bandwidth is selected to be optimal for each donut regression. Confidence intervals are at the 90% significance level and are robust to optimal bandwidth selection.

Table 3.E.9: ROBUSTNESS: EXCLUSION OF SMALL & LARGE MUNICIPALITY GROUPS

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
A. Exclude small										
$Treat_c$	97.9***	84.8**	117.3**	106.4**	163.3***	148.5**	236.3***	210.2**	175.0	169.2
	(0.003)	(0.020)	(0.011)	(0.040)	(0.005)	(0.025)	(0.002)	(0.017)	(0.166)	(0.210)
	[0.026]		[0.083]		[0.066]		[0.042]		[0.273]	
	{0.003}		{0.006}		{0.002}		{0.000}		{0.053}	
N	604	604	604	604	604	604	604	604	604	604
B. Exclude large										
$Treat_c$	101.9***	83.5**	123.8***	105.4*	170.8***	146.1**	244.9***	205.6**	185.7	160.3
	(0.002)	(0.027)	(0.008)	(0.052)	(0.004)	(0.033)	(0.002)	(0.023)	(0.143)	(0.265)
	[0.015]		[0.052]		[0.043]		[0.027]		[0.218]	
	{0.002}		{0.004}		{0.001}		{0.000}		{0.037}	
N	589	589	589	589	589	589	589	589	589	589
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Segment-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km

Notes: This table shows robustness to excluding the 5% smallest (<2,331 inhabitants) and 5% largest municipality groups (>52,388 inhabitants) in terms of population size in 2019. Coefficients present the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Table 3.E.10: ROBUSTNESS: INCLUSION OF OBSERVATIONS CROSSED BY BORDER

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
$Treat_c$	79.8***	66.3***	89.7***	70.9**	118.0***	90.8**	162.5***	121.1**	132.6	102.6
	(0.000)	(0.005)	(0.004)	(0.029)	(0.003)	(0.026)	(0.002)	(0.023)	(0.113)	(0.201)
	[0.034]		[0.103]		[0.088]		[0.069]		[0.242]	
	{0.000}		{0.002}		{0.001}		{0.000}		{0.030}	
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Segment-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km
N	726	726	726	726	726	726	726	726	726	726

Notes: This table shows robustness to including municipality groups which have originally been excluded as their territory is crossed by the NATO defence line. While conceptually it is not clear whether they belong to the treatment or control group, technically it is only possible to assign them based on the location of their centroid. If the centroid is west of the NATO defence line, a municipality group crossed by the border is assigned to the treatment group and otherwise to the control group. Coefficients present the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Table 3.E.11: ROBUSTNESS: SECOND ORDER POLYNOMIAL OF DISTANCE

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
$Treat_c$	111.5***	115.7**	150.0**	151.7**	208.7***	205.2***	307.4***	291.2***	267.9*	235.1
	(0.009)	(0.011)	(0.016)	(0.016)	(0.007)	(0.009)	(0.002)	(0.005)	(0.056)	(0.114)
	[0.016]		[0.029]		[0.017]		[0.013]		[0.182]	
	{0.006}		{0.005}		{0.001}		{0.000}		{0.020}	
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Segment-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T
Bandwidth	61km	61km	61km	61km	61km	61km	61km	61km	61km	61km
N	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144

Notes: This table shows robustness to including a second order polynomial of distance. Coefficients present the treatment effect of the NATO defence line on income in 2019 at the municipality group level. Optimal bandwidth has been selected for most demanding specification for median income (III^a) employing Cattaneo et al. (2020a). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 60.6 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

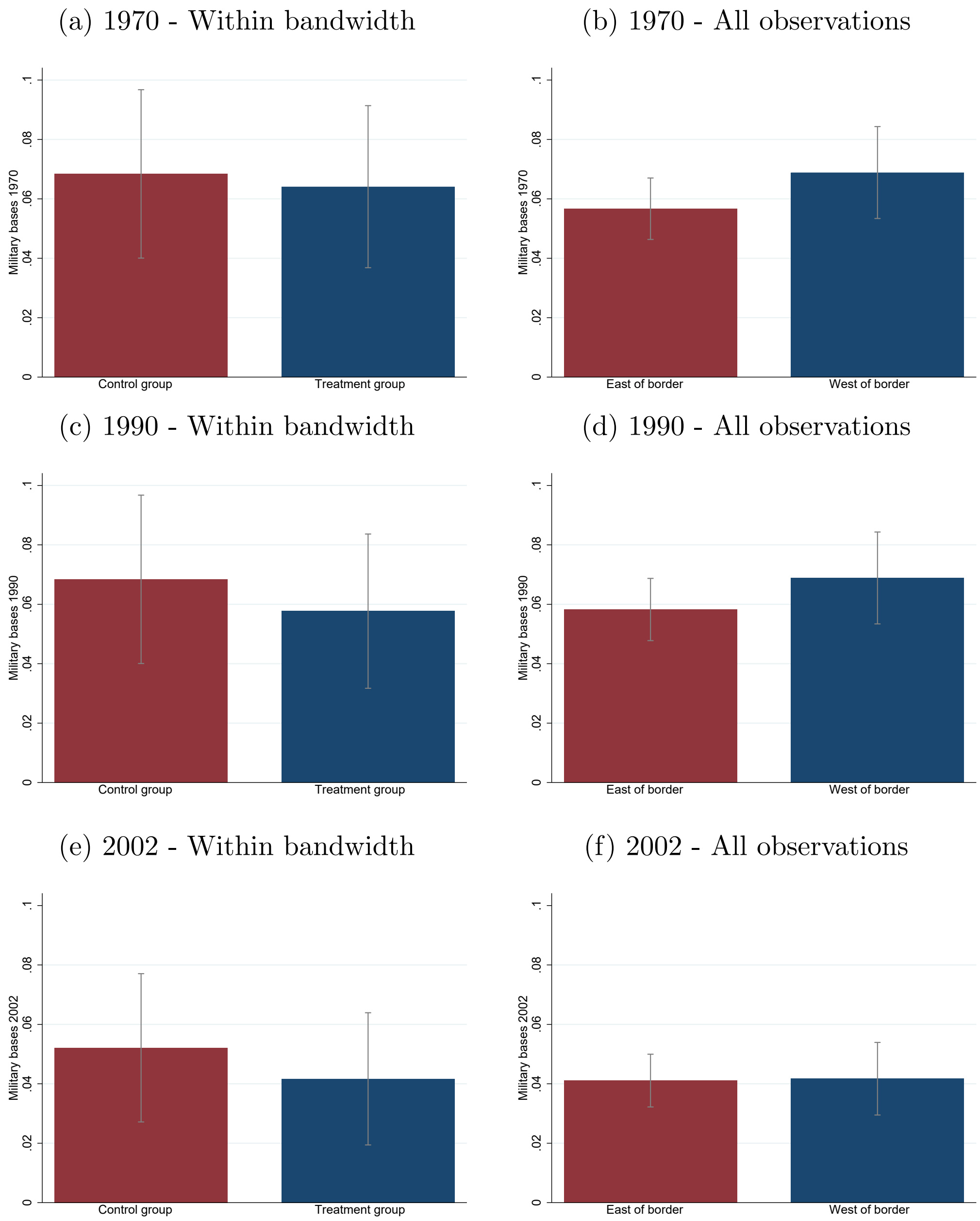
Table 3.E.12: ROBUSTNESS: EPANECHNIKOV KERNEL

	20th percentile	40th percentile	Median	60th percentile	80th percentile
	(I)	(II)	(III)	(IV)	(V)
$Treat_c$	90.7***	115.0**	158.3**	223.6***	181.0
	(0.008)	(0.018)	(0.011)	(0.007)	(0.145)
State-FE	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y
Segment-FE	Y	Y	Y	Y	Y
Kernel	E	E	E	E	E
Bandwidth	33km	33km	33km	33km	33km
N	612	612	612	6124	612

Notes: This table shows robustness to employing an epanechnikov (E) kernel. Coefficients present the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows: * p<0.10, ** p<0.05, *** p<0.01.

3.F Excluding Military Bases as Mechanism

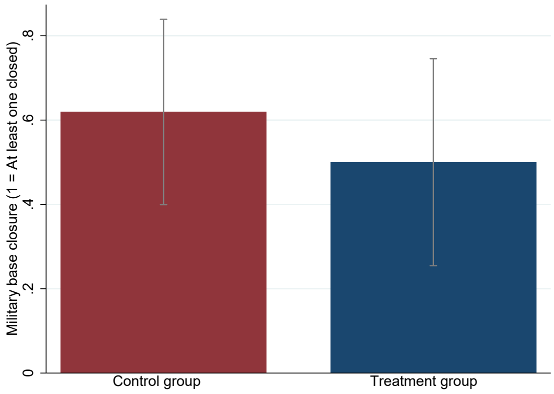
Figure 3.F.1: MEAN COMPARISON: EXISTENCE OF MILITARY BASE



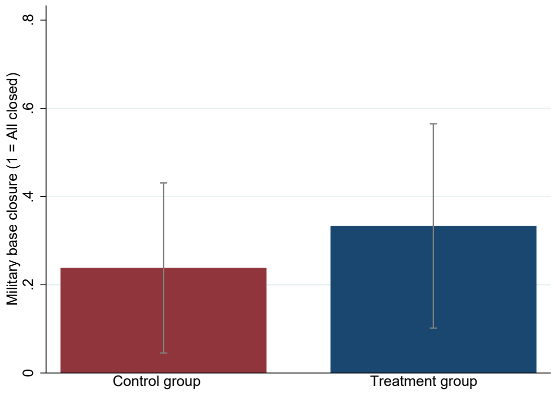
Notes: This figure plots the mean probability of municipality groups hosting a military base. Panels (a), (c), and (e) include the sample of 616 municipality groups within the bandwidth. Panels (b), (d), and (f) include all 2,954 available observations. The confidence intervals are set at 95% level.

Figure 3.F.2: MEAN COMPARISON: CLOSURE OF MILITARY BASES 1990-2002

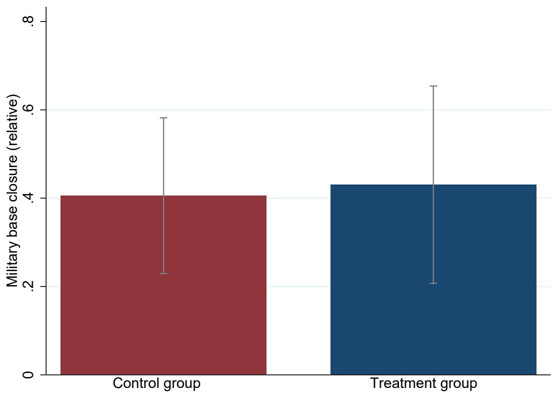
(a) At least one military base closed



(b) All military bases closed



(c) Relative military base closures



Notes: This figure plots the mean military bases closures between 1990 and 2002 for those municipality groups in our sample which were home to a military base in 1990. The variable in Panel (a) takes the value one if at least one military base in a municipality group has been closed - and zero otherwise. The variable in Panel (b) takes the value one if all military bases in a municipality group have been closed - and zero otherwise. The variable in Panel (c) is the share of military bases which have been closed. The confidence intervals are set at 95% level.

Table 3.F.1: ROBUSTNESS: EXCLUSION OF MUNICIPALITY GROUPS WITH MILITARY BASES (2019 INCOME)

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
A. Base in 1990										
$Treat_c$	103.1***	96.1***	124.2***	121.0**	173.5***	167.6**	251.3***	236.4***	196.3	208.0*
	(0.001)	(0.008)	(0.007)	(0.020)	(0.003)	(0.012)	(0.001)	(0.007)	(0.101)	(0.098)
	[0.029]		[0.087]		[0.065]		[0.042]		[0.252]	
	{0.002}		{0.004}		{0.001}		{0.000}		{0.031}	
N	573	573	573	573	573	573	573	573	573	573
B. Closed base										
$Treat_c$	103.9***	95.7***	125.6***	120.3**	173.6***	165.3**	250.3***	233.0***	198.8*	201.1
	(0.001)	(0.007)	(0.006)	(0.019)	(0.003)	(0.012)	(0.001)	(0.007)	(0.092)	(0.107)
	[0.026]		[0.077]		[0.060]		[0.038]		[0.236]	
	{0.001}		{0.003}		{0.001}		{0.000}		{0.027}	
N	590	590	590	590	590	590	590	590	590	590
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Segment-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km

Notes: This table shows robustness of our main results to the exclusion of municipality groups with specific characteristics regarding military bases. Panel (a) excludes municipality groups which hosted a military base in 1990 and Panel (b) excludes municipality groups which have lost at least one military base between 1990 and 2002. Coefficients present the treatment effect of the NATO defence line on income in 2019 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Table 3.F.2: ROBUSTNESS: EXCLUSION OF MUNICIPALITY GROUPS WITH MILITARY BASES (2002 INCOME)

	20th percentile		40th percentile		Median		60th percentile		80th percentile	
	(I)	(I^a)	(II)	(II^a)	(III)	(III^a)	(IV)	(IV^a)	(V)	(V^a)
A. Base in 1990										
$Treat_c$	47.4**	42.6	75.6**	66.1*	102.0**	89.2*	126.1**	107.8*	40.5	33.1
	(0.038)	(0.112)	(0.015)	(0.062)	(0.011)	(0.050)	(0.019)	(0.077)	(0.748)	(0.811)
	[0.106]		[0.099]		[0.064]		[0.055]		[0.650]	
	{0.034}		{0.005}		{0.002}		{0.003}		{0.446}	
N	572	572	572	572	572	572	572	572	572	572
B. Closed base										
$Treat_c$	47.1**	42.0	75.1**	64.7*	101.6***	87.4**	125.9**	106.2*	43.6	31.8
	(0.033)	(0.107)	(0.013)	(0.059)	(0.009)	(0.048)	(0.016)	(0.073)	(0.680)	(0.812)
	[0.109]		[0.098]		[0.061]		[0.052]		[0.619]	
	{0.031}		{0.004}		{0.002}		{0.002}		{0.402}	
N	589	589	589	589	589	589	589	589	589	589
State-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coordinates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Segment-FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kernel	U	T	U	T	U	T	U	T	U	T
Bandwidth	33km	33km	33km	33km	33km	33km	33km	33km	33km	33km

Notes: This table shows robustness of our main results to the exclusion of municipality groups with specific characteristics regarding military bases. Panel (a) excludes municipality groups which hosted a military base in 1990 and Panel (b) excludes municipality groups which have lost at least one military base between 1990 and 2002. Coefficients present the treatment effect of the NATO defence line on income in 2002 at the municipality group level. The bandwidth is set to be optimal (33 km). The full set of controls includes distance GDR, distance river, crop suitability, elevation, ruggedness, area, population in 1871, population growth between 1871 and 1939, and population density in 1939. Coefficients are presented for a uniform (U) and triangular (T) kernel. In parentheses, p-values robust to optimal bandwidth selection are presented (Cattaneo et al., 2020a). Asterisks are defined as follows and refer to p-values in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In square brackets, p-values robust to spatial spillovers within a 33 km distance are presented (Conley, 2008; Colella et al., 2019). In braces, p-values for heteroscedasticity-robust standard errors are presented. Due to limitations in the employed statistical packages, spatially-robust and heteroscedasticity-robust p-values cannot be presented for a triangular kernel.

Chapter 4

Intellectual Reparations: Mapping a Large-Scale Program of Knowledge Transfers

This chapter presents co-authored work with Sebastian Hager and Timo Wochner. We want to thank the Deutsches Museum in Munich, the Imperial War Museum and The National Archives in London, and the Rare Books collection of the Cambridge University Library for access to archival sources, as well as the Library of Congress and the National Archives in Washington for information on their collection. We want to thank Mathias Bühler, Davide Cantoni, Fabian Gässler, Michela Giorcelli, Albrecht Glitz, Claudia Steinwender, and Fabian Waldinger for insightful conversations and valuable suggestions. Ruben Drosten, David Geiger, Lea Geißendörfer, Aaron Günther, Maximilian Nübling, Nils Süßenbach, Lissia Weber, and Ecem Yargizi provided excellent research assistance. We are also grateful to the Connex program of the Dr. Hans Riegel-Stiftung for financial support.

4.1 Introduction

The Second World War (WWII) was a time of rapid technological innovation (e.g., Gross and Sampat, 2023). The advancement in technology did not stop with the war's end. Beginning in the immediate post-war period, the United States and the Soviet Union competed for global leadership in military and industrial technology. Allied post-war reparation programs explicitly targeting German science and technological know-how became a key tool in this race. Most famously, as part of the U.S. 'Operation Paperclip' and the Soviet 'Operation Osoaviakhim' thousands of German scientists were taken to work abroad on long-range missiles, aeronautics, and space programs (e.g., Uhl, 2001; Jacobsen, 2014). But these were not the only programs of 'intellectual reparations' that focused on German science and technology in the immediate post-war era.

A lesser-known program under the labels of BIOS, CIOS, and FIAT directly targeted Germany's industry - collecting detailed information on the know-how of individual firms and inventors. With the landing of the Western Allies in France in 1944, British and U.S. military forces immediately started to gather intelligence on German technology that could be useful for winning WWII. Soon, the Western Allies expanded their investigations to non-military technology. Between 1945 and 1947, U.S. and British investigators visited firms and production sites across Germany to gather any information that could be useful for private industries. One Washington official has called it 'the first orderly exploitation of an entire country's brainpower' (Walker, 1946, p.329).

In this paper, we provide the first systematic and quantitative analysis of this unprecedented program of intellectual reparations. Based on a hand-collected dataset on nearly all investigations of German firms, we present a series of findings on the extent of this program. We present facts on which German firms, industries, and technologies were investigated. Moreover, by linking the investigated German firms to the investigating U.S. firms, we can directly trace and analyse the resulting knowledge transfers.

We assemble a novel database on nearly all British and U.S. investigations of firms in Germany between 1945 and 1947. Based on archival sources, we hand-collect and digitise around 90% of the reports written by British and U.S. investigating teams. These reports contain the findings of the investigations and explicitly list the set of investigated German firms. In total, the database contains 3,873 investigation reports and more than 20,000 firm investigations.

We present findings on three main aspects of the investigations. First, we study which firms in Germany were investigated. The reports detail the names of the investigated German firms, their locations, and which individuals were interviewed during the investigations. This allows us to map out the extent of the investigations. We show that firms were visited across Germany, with industrial centres being targeted the most. The British and U.S. investigators focused in particular on investigations in their own occupation zones.

Second, we analyse which technologies and industries were targeted by the investigations. We link the reports database to archival documents containing an industry categorisation. This allows us to consistently group reports into major industries. We find that the mechanical engineering and chemical industries were investigated most often. We also document that military-related industries were more strongly investigated in the early phase of the program. After WWII, the focus shifted to industries with civilian applications whose know-how would be of more use for private industries in the United Kingdom and the United States.

Third, we observe which U.S. firms were involved in the investigations. Based on a list of U.S. personnel who were sent to Germany, we observe the employers of U.S. investigators. We link this information to our main database and thus observe which U.S. firms sent investigators to which German firms. Hence, we can directly measure knowledge transfers between German and U.S. firms. In further work, this can be used to examine the effects of access to German technological know-how on U.S. innovation and industrial performance.

These findings contribute to two strands of literature. First, we contribute to a broad literature on industrial policy in post-war settings. A large literature has studied the macroeconomic effects of post-war policies such as the Marshall Plan (see, for example, De Long and Eichengreen, 1991; Eichengreen and Uzan, 1992). Recent literature has focused on the microeconomic effects of industrial policy in post-war Europe (e.g., Poege, 2022) and the effects of war-time or post-war R&D spending on U.S. innovation (e.g., Gross and Sampat, 2023; Kantor and Whalley, 2024). While a few papers have explicitly studied the effects of war reparations on development (e.g., Mitrunen, 2024), this is the first paper to explicitly study intellectual reparations in the form of firm-to-firm knowledge transfers. We contribute to the literature on post-war industrial policy by assembling and analysing a novel database on one of the largest programs of intellectual reparations.

Second, we contribute to the literature on international technology diffusion.[1] Since knowledge transfers are difficult to measure directly, one strand in the literature focuses on the effects of migration on international knowledge diffusion (e.g., Hornung, 2014; Moser et al., 2014; Kerr et al., 2016). Recent papers in the literature have focused on knowledge transfers at the firm level (Giorcelli, 2019) or on the effects of industrial espionage (Glitz and Meyersson, 2020). In this paper, we study a government-backed program of firm-to-firm knowledge transfers. We contribute by building a dataset that allows us to link the investigating U.S. firms and the investigated German firms, thus observing knowledge transfers directly.

4.2 Historical Background

4.2.1 World War II and Reparations

The unconditional surrender of the German armed forces on 8 May 1945 marked the end of WWII in the European theatre. In June 1945, Germany was divided into four occupation zones governed under military law by France, the Soviet Union, the United Kingdom, and the United States. Four years later, they were succeeded by the founding of an East and a West German state.

After the war, Germany had to pay reparations to the Allied powers. For example, territory was ceded to Poland and the labour of German prisoners of war held in Allied nations was exploited. The Allies also agreed on a reduction of the German economic potential, which allowed for the dismantling of German plants. While dismantling was most pronounced in the French and Soviet zones, it also happened in the British and U.S. zones. Especially for the United States, however, it soon became evident that heavy physical reparations would not offer many benefits due to the vast geographic distance. Instead, they focused on intellectual reparations such as research results, intellectual property, and technical innovation (Gimbel, 1990; O'Reagan, 2021). In line with international law, they initially aimed for innovation, which had been applied to the military. However, even while the war was still ongoing, they had already extended the program to also include German civilian industry.

[1] For a comprehensive review of the literature, see for example Comin and Mestieri (2014).

4.2.2 German Know-How as Intellectual Reparations

As part of the Allied war effort, the United Kingdom and the United States decided in the summer of 1944 to form a combined scientific and technical intelligence unit, the so-called Combined Intelligence Objectives Subcommittee (CIOS). Although CIOS was designed as a joint civilian-military effort, its initial focus was to gather intelligence on Germany's military innovations in areas such as weapons, radar technology, and jet engines (Gimbel, 1990). It was also responsible for locating, detaining, and interrogating German scientists and technicians who could possess such information. Its mission was to gather intelligence that could benefit the war against Japan. After the Allied landing in Normandy in the summer of 1944, CIOS sent its first specialist teams of investigators to Paris and soon afterwards to other liberated cities, such as Nancy, Luxembourg, and Brussels (Glatt, 1994). Already in September 1944, the first calls emerged to also investigate 'economic and industrial intelligence targets of vital postwar interest, but not of immediate military value' (Gimbel, 1990, p. 6).

To deal with the expansion of the program, the United Kingdom and the United States each created further agencies staffed with intelligence officers, military personnel, and civilians.[2] Their tasks included the compilation of a target list, the selection of individuals for the missions to Germany, and the training of investigators. They were also responsible for seizing and securing important targets, organising travel logistics and hospitality, and facilitating the distribution of findings through reports. After the war had ended, in July 1945 the combined headquarters of Allied forces and other combined organisations such as CIOS were terminated. To continue the intellectual reparation program, both the United Kingdom and the United States shifted the responsibility to national agencies. The two most notable ones were the U.S. FIAT (Field Intelligence Agency, Technical) and the British BIOS (British Intelligence Objectives Subcommittee), which lent their names to the reports published on the investigations.

In late 1946, the military government in charge of Germany started to lobby for the program's termination (Gimbel, 1990). Over time, strategic reservations against the political and economic costs of the intellectual reparation program had increased. Firstly, in the emerging new geopolitical environment West Germany was no longer regarded as a defeated enemy but as a potential ally against the Soviet Union. Secondly, the reduction of occupation costs required a recovery of the German economy. The extraction of reparations was counter-productive in this regard. In February 1947, FIAT published a 'last call for Germany' (Gimbel, 1990, p.111) to invite U.S. companies

[2] Details on all involved agencies and their particular responsibilities can be found in Gimbel (1990), Glatt (1994), and O'Reagan (2021).

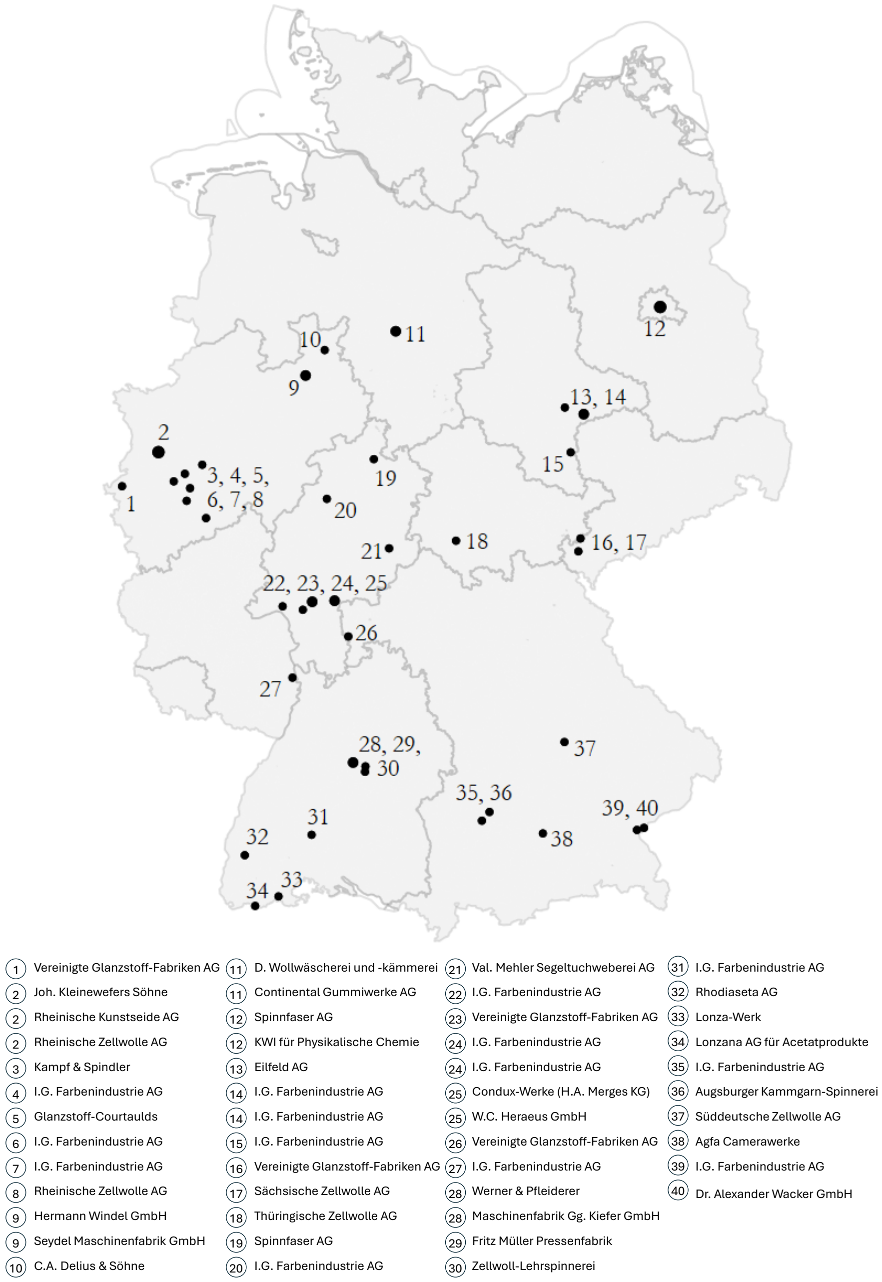
to participate in a field trip. The United Kingdom and the United States agreed in February 1947 that no new investigations were permitted after 15 May of that year. All investigations were terminated by 30 June 1947 - less than a month after the Marshall Plan had been announced.

Figure 4.1: CIOS INVESTIGATION TEAM, SUMMER 1945

Notes: This figure shows members of the team reporting on their investigations on synthetic fibre developments in CIOS report XXXIII-50. The investigations took place from 28 June to 14 September 1945. The team included five U.S. and four British investigators. The picture shows the investigators in military uniforms: Leroy H. Smith, Dr. G. Preston Hoff, Dr. Joseph B. Quig, Dr. Jan J. Schilthuis, Dr. Dan B. Wicker (all U.S.) and Dr. Rowland Hill, Dr. F. Stanley Brown, Geoffrey Loasby, and Dr. David Traill (all British). The picture has been provided by the Deutsche Museum in Munich - for details see Section 4.A in the Appendix.

By that time, teams of British and U.S. private industry employees had investigated German firms for over two years. For instance, four British and five U.S. investigators, as shown in Figure 4.1, travelled through Germany from 28 June to 14 September 1945. They gathered information on synthetic fibre developments presented in CIOS report XXXIII-50. In total, they investigated 56 firms located throughout Germany - from the Ruhr area to Munich (see Figure 4.2). They even investigated a few firms located in what was to become the Soviet zone - before the area was handed over by U.S. troops. While the investigators were employees of private companies, they were given military authority and uniforms for their investigations in Germany. In line with military law, German firms had to share all requested information. However, information was overwhelmingly shared voluntarily, for example, to gain preferential treatment by the occupiers. CIOS report XXXIII-50 states, ‘when the individual found the investigators [...] could use military force if necessary, we had no further trouble and received accurate information. In most cases, the Germans involved were quite proud of their research work and development and were happy to talk about them' (p.6).

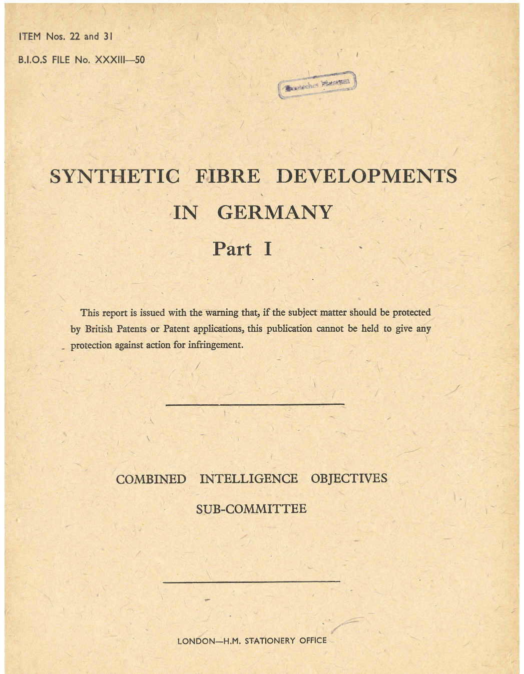
Figure 4.2: EXEMPLARY TRAVEL ROUTE: CIOS REPORT XXXIII-50



Notes: This figure shows all firm investigations in Germany covered in CIOS report XXXIII-50. Larger dots indicate that multiple firms were located in one municipality. The map is based on the municipality and state structure from 2023. Table 4.B.1 in the Appendix lists the respective dates of each investigation (from 28 June to 14 September 1945).

Figure 4.3: EXAMPLE: CIOS REPORT XXXIII-50 ON SYNTHETIC FIBRE DEVELOPMENT

(a) Cover page


ITEM Nos. 22 and 31

B.I.O.S FILE No. XXXIII—50

SYNTHETIC FIBRE DEVELOPMENTS

IN GERMANY

Part I

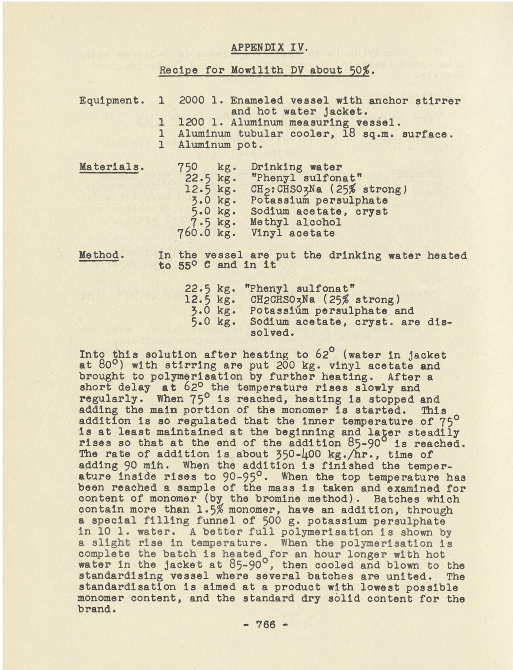
This report is issued with the warning that, if the subject matter should be protected by British Patents or Patent applications, this publication cannot be held to give any protection against action for infringement.

COMBINED INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

(b) Product recipe


APPENDIX IV.

Recipe for Mowilith DV about 50%.

Equipment. 1 2000 l. Enameled vessel with anchor stirrer and hot water jacket.
1 1200 l. Aluminum measuring vessel.
1 Aluminum tubular cooler, 18 sq.m. surface.
1 Aluminum pot.

Materials.
750 kg. Drinking water
22.5 kg. "Phenyl sulfonat"
12.5 kg. CH_2:$CHSO_3Na$ (25% strong)
3.0 kg. Potassium persulphate
5.0 kg. Sodium acetate, cryst
7.5 kg. Methyl alcohol
760.0 kg. Vinyl acetate

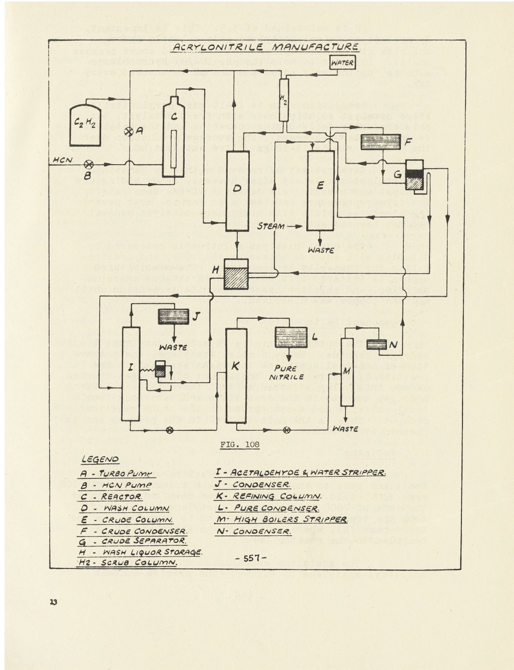
Method. In the vessel are put the drinking water heated to 55° C and in it

22.5 kg. "Phenyl sulfonat"
12.5 kg. CH_2CHSO_3Na (25% strong)
3.0 kg. Potassium persulphate and
5.0 kg. Sodium acetate, cryst. are dissolved.

Into this solution after heating to 62° (water in jacket at 80°) with stirring are put 200 kg. vinyl acetate and brought to polymerisation by further heating. After a short delay at 62° the temperature rises slowly and regularly. When 75° is reached, heating is stopped and adding the main portion of the monomer is started. This addition is so regulated that the inner temperature of 75° is at least maintained at the beginning and later steadily rises so that at the end of the addition 85-90° is reached. The rate of addition is about 350-400 kg./hr., time of adding 90 min. When the addition is finished the temperature inside rises to 90-95°. When the top temperature has been reached a sample of the mass is taken and examined for content of monomer (by the bromine method). Batches which contain more than 1.5% monomer, have an addition, through a special filling funnel of 500 g. potassium persulphate in 10 l. water. A better full polymerisation is shown by a slight rise in temperature. When the polymerisation is complete the batch is heated for an hour longer with hot water in the jacket at 85-90°, then cooled and blown to the standardising vessel where several batches are united. The standardisation is aimed at a product with lowest possible monomer content, and the standard dry solid content for the brand.

- 766 -

(c) Plant structure



Notes: This figure presents pages from CIOS report XXXIII-50, which covers three months of investigations on more than 1,000 pages. Panel (a) shows the cover page, including the title 'Synthetic Fibre Developments in Germany'. Panel (b) presents the recipe for the glue Mowilith DV, which is, according to the report (p.750), an innovation on 'the most important single product manufactured' by I.G. Farbenindustrie AG in Höchst. Panel (c) sketches the plant for the production of the chemical intermediate acrylonitrile at I.G. Farbenindustrie AG in Leverkusen. The report includes dozens of such recipes and plant sketches, as well as pictures and drawings of machinery. The pictures have been provided by the Deutsche Museum in Munich - for details see Section 4.A in the Appendix.

4.2.3 Reports on Investigations

The United States attempted to distribute the knowledge gained through intellectual reparations. With Executive Order 9604 from the summer of 1945, U.S. President Truman ordered the release of all scientific and industrial information obtained from the enemy to the public (Gimbel, 1990). This included the so-called 'final reports' that British and U.S. investigators were supposed to write on the German firms they had investigated (Gimbel, 1990). Written under the joint CIOS label in early 1945, the first of the reports were meant for circulation within the government only (Glatt, 1994). Following Truman's Executive Order, both governments decided to publish the reports. The reports provided the means to share the knowledge gathered in Germany with the wider British and U.S. industry - beyond those firms sending their own investigators. After the CIOS program had ended, both the investigations and the reports were administrated separately by BIOS and FIAT. The governments continued, however, to exchange reports that could then be read and bought in public libraries across the United Kingdom and the United States.

Many reports contained commercially exploitable business secrets. For example, the CIOS report XXXIII-50 includes product recipes and plant sketches from I.G. Farbenindustrie AG, which was among the globally leading chemical companies at the time (see Figure 4.3). After reading this report, one American manufacturer remarked: 'This report would be worth twenty million dollars to my company if it could have it exclusively' (Walker, 1946, p.336). Also, the Soviet Union purchased every single report (Walker, 1946). Experts reviewing some of the findings at the I.G Farbenindustrie plants judged that 'this windfall information will advance the American dye industry by at least 5 years, and will save millions of dollars in terms of new products and man-hours of research' (U.S. Department of Commerce, 1947, p.9). Information in the reports was considered 'so valuable that to get it a single day ahead of a competitor may be worth thousands of dollars' (Walker, 1946, p.335). A U.S. aircraft company responded to the question of whether the information in the reports had made the company any money with: 'Yea - at least a hundred thousand dollars' (Walker, 1946, p.335). Others were less optimistic about the overall value of reports. O'Reagan (2021) suggests that the most important findings were not written in reports and were rather kept secret by the investigators. He also argues that no matter how well a report was written, firms could not reproduce the described technology. Irrespective of the reports' value to firms not involved in the investigations, reports such as CIOS XXXIII-50 illustrate well that many investigators collected important technical know-how in Germany.

4.3 Data

4.3.1 Data Sources

Investigation Reports

The final reports are key to understanding the extent of the investigation program. They contain all relevant information on the names and locations of the German firms that were investigated. While investigators could purposely not report on specific discoveries made at individual firms, they had to fully document their itinerary. As transportation was provided by government agencies, these were well-informed about the German firms each investigator had investigated. The investigation reports, hence, provide the full picture of which German firms were investigated by which investigators.

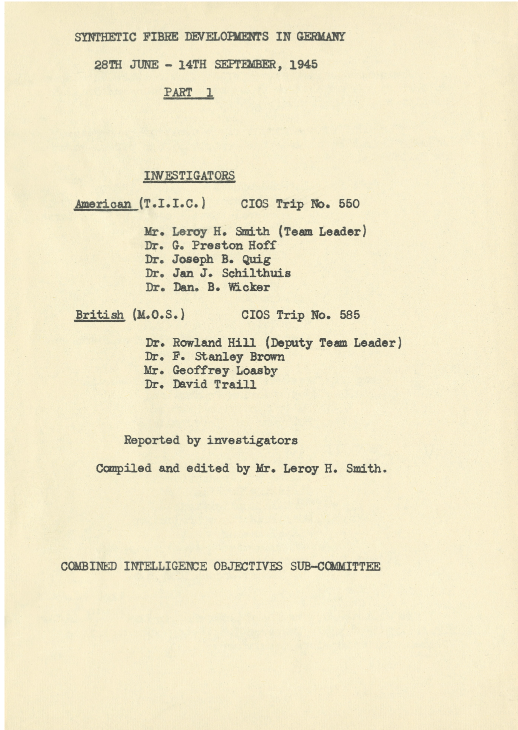
We digitise information from the full stock of BIOS, CIOS, and FIAT reports archived at the Deutsches Museum in Munich and the Imperial War Museum in London.[3] We processed more than 150,000 pages of paper. Our database is the first systematic and comprehensive collection of information on the investigations. For each final report, we collect information on the investigators (names, military ranks, private-sector employers), the investigations (date and location), investigated German firms (names and interviewed employees), and the publication itself (report number, title, date, classification, and pages). Generally, the reports were supposed to include all this information to be informative for intelligence agencies and private businesses alike. Figure 4.4 shows how this information is presented in the reports.

Going beyond the illustrative example provided by CIOS report XXXIII-50, the reports are in general relating well to a program aimed at collecting insights into the German industry. This can be shown by analysing the words employed most often in the reports' titles (see Figure 4.B.2 in the Appendix). The most used words are either economic or corporate terms (e.g., manufacture, industry, production, research, and development), describe the approach to collect information (e.g., investigation, interrogation, and report) or refer to a German firm's name (e.g., *Farbenindustrie*).

[3] The reports have never been digitised, forcing us to manually extract information from the physical copies of the reports. In fact, the archives in the United States have not cataloged the reports yet, with the exception of CIOS at NARA and FIAT at the Library of Congress.

Figure 4.4: EXAMPLE: EXTRACTING INFORMATION FROM REPORTS

(a) Investigators



SYNTHETIC FIBRE DEVELOPMENTS IN GERMANY

28TH JUNE - 14TH SEPTEMBER, 1945

PART 1

INVESTIGATORS

American (T.I.I.C.) CIOS Trip No. 550

Mr. Leroy H. Smith (Team Leader)
Dr. G. Preston Hoff
Dr. Joseph B. Quig
Dr. Jan J. Schilthuis
Dr. Dan. B. Wicker

British (M.O.S.) CIOS Trip No. 585

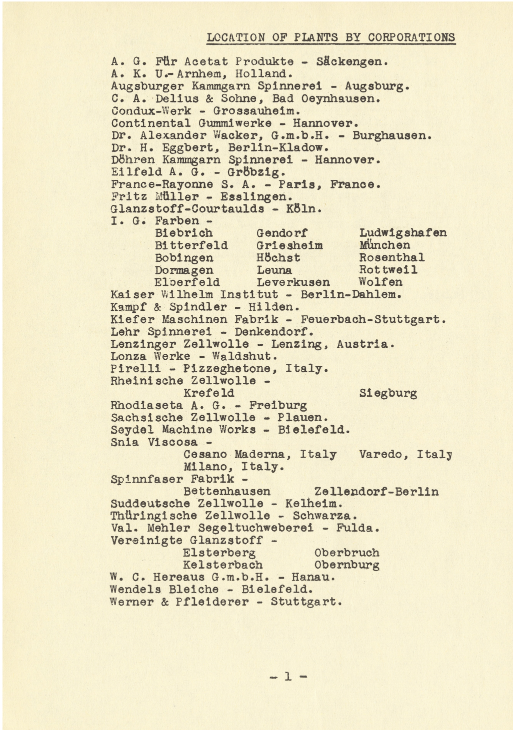
Dr. Rowland Hill (Deputy Team Leader)
Dr. F. Stanley Brown
Mr. Geoffrey Loasby
Dr. David Traill

Reported by investigators

Compiled and edited by Mr. Leroy H. Smith.

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE

(b) German firms

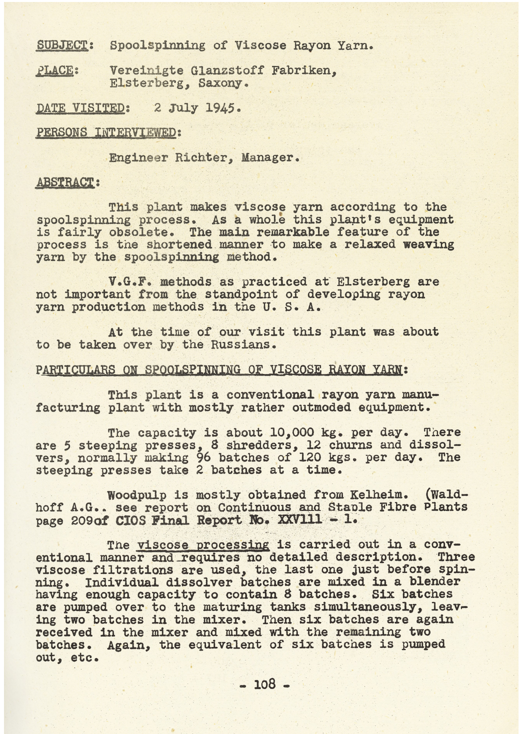


LOCATION OF PLANTS BY CORPORATIONS

A. G. Für Acetat Produkte - Säckengen.
A. K. U.-Arnhem, Holland.
Augsburger Kammgarn Spinnerei - Augsburg.
C. A. Delius & Sohne, Bad Oeynhausen.
Condux-Werk - Grossauheim.
Continental Gummiwerke - Hannover.
Dr. Alexander Wacker, G.m.b.H. - Burghausen.
Dr. H. Eggbert, Berlin-Kladow.
Döhren Kammgarn Spinnerei - Hannover.
Eilfeld A. G. - Gröbzig.
France-Rayonne S. A. - Paris, France.
Fritz Müller - Esslingen.
Glanzstoff-Courtaulds - Köln.
I. G. Farben -
Biebrich Gendorf Ludwigshafen
Bitterfeld Griesheim München
Bobingen Höchst Rosenthal
Dormagen Leuna Rottweil
Elberfeld Leverkusen Wolfen
Kaiser Wilhelm Institut - Berlin-Dahlem.
Kampf & Spindler - Hilden.
Kiefer Maschinen Fabrik - Feuerbach-Stuttgart.
Lehr Spinnerei - Denkendorf.
Lenzinger Zellwolle - Lenzing, Austria.
Lonza Werke - Waldshut.
Pirelli - Pizzeghetone, Italy.
Rheinische Zellwolle -
Krefeld Siegburg
Rhodiaseta A. G. - Freiburg
Sachsische Zellwolle - Plauen.
Seydel Machine Works - Bielefeld.
Snia Viscosa -
Cesano Maderna, Italy Varedo, Italy
Milano, Italy.
Spinnfaser Fabrik -
Bettenhausen Zellendorf-Berlin
Suddeutsche Zellwolle - Kelheim.
Thüringische Zellwolle - Schwarza.
Val. Mehler Segeltuchweberei - Fulda.
Vereinigte Glanzstoff -
Elsterberg Oberbruch
Kelsterbach Obernburg
W. C. Hereaus G.m.b.H. - Hanau.
Wendels Bleiche - Bielefeld.
Werner & Pfleiderer - Stuttgart.

- 1 -

(c) Details of investigation



SUBJECT: Spoolspinning of Viscose Rayon Yarn.

PLACE: Vereinigte Glanzstoff Fabriken, Elsterberg, Saxony.

DATE VISITED: 2 July 1945.

PERSONS INTERVIEWED:

Engineer Richter, Manager.

ABSTRACT:

This plant makes viscose yarn according to the spoolspinning process. As a whole this plant's equipment is fairly obsolete. The main remarkable feature of the process is the shortened manner to make a relaxed weaving yarn by the spoolspinning method.

V.G.F. methods as practiced at Elsterberg are not important from the standpoint of developing rayon yarn production methods in the U. S. A.

At the time of our visit this plant was about to be taken over by the Russians.

PARTICULARS ON SPOOLSPINNING OF VISCOSE RAYON YARN:

This plant is a conventional rayon yarn manufacturing plant with mostly rather outmoded equipment.

The capacity is about 10,000 kg. per day. There are 5 steeping presses, 8 shredders, 12 churns and dissolvers, normally making 96 batches of 120 kgs. per day. The steeping presses take 2 batches at a time.

Woodpulp is mostly obtained from Kelheim. (Waldhoff A.G.. see report on Continuous and Staple Fibre Plants page 209of CIOS Final Report No. XXV111 - 1.

The viscose processing is carried out in a conventional manner and requires no detailed description. Three viscose filtrations are used, the last one just before spinning. Individual dissolver batches are mixed in a blender having enough capacity to contain 8 batches. Six batches are pumped over to the maturing tanks simultaneously, leaving two batches in the mixer. Then six batches are again received in the mixer and mixed with the remaining two batches. Again, the equivalent of six batches is pumped out, etc.

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Notes: This figure shows how the relevant information is presented based on the CIOS report XXXIII-50. Panel (a) presents the names of the British and U.S. investigators who were part of the investigations. For the U.S. investigators George P. Hoff, Leroy H. Smith, Dr. Joseph B. Quig, Dr. Jan J. Schilthuis, and Dr. Dan B. Wicker, we know their private-sector U.S. employers from the investigator list. Panel (b) lists the German firms and their locations which have been investigated by this group. Panel (c) presents details on the investigation at 'Vereinigte Glanzstoff Fabriken' in Elsterberg on 2 July 1945, including names and positions of the German personnel interviewed. The pictures have been provided by the Deutsche Museum in Munich - for details see Section 4.A in the Appendix.

Data coverage. To assess the completeness of our dataset, we distinguish between published and non-published reports. Out of 2,726 published reports, more than 99% are included in our dataset (see Table 4.B.2 in the Appendix). However, not every report has been published and made available to the industry. Some reports were classified due to the sensitivity of the content or were not considered to contain sufficiently valuable technical information. These reports were only circulated within the administration. Our dataset includes another 1,150 of these non-published reports. A few reports, however, were of such low quality that they were not even circulated within the administration. With only limited copies of these reports being produced, some were not archived and, hence, can not be included in our dataset.[4] Naturally, our dataset does not cover investigations for which no report has been written. While every investigator was expected to submit a report, not everyone followed the rules. Yet, our dataset still covers 89% of all potential reports.[5] In terms of firm investigations, the covered share should be even higher as the number of German firms in published reports is twice the number in non-published reports. Also, we do not expect strategic reasons for not submitting a report or writing it of poor quality, because investigators who wanted to hide their findings could have also written a proper report without sharing any valuable information.

Summary statistics. The initial dataset includes 3,873 reports. Not all of these reports allow us to extract information on investigated German firms. Some reports describe investigations at administrative and military offices, others translate scientific papers, or just do not mention individual firms. 352 reports do not cover investigations of firms (see Figure 4.5a). With 13% each, the share of such reports is the largest for CIOS and FIAT. For CIOS, this is mainly driven by reports on the government and military, while for FIAT, those are primarily translations of scientific papers. In addition, 160 reports are exclusively on investigations of firms which are located outside of Germany (see Figure 4.5b). This is mainly relevant for CIOS reports, as these were written before Germany was liberated.

Our final dataset consists of 3,361 reports, which all contain information on investigations of firms located in Germany. Figure 4.5c shows the share of published reports. Overall, 70% of the reports have been made available in public libraries and

[4] The archive of the Imperial War Museum in London, which is one of our data sources, is generally considered to be the archive with the most complete collection of final reports.

[5] We arrive at this number by taking the highest report number for each label (BIOS, CIOS, and FIAT) to calculate the amount of potentially missing reports. This is the most conservative estimate for completeness as it assumes that missing report numbers do actually exist. Missing report numbers could, in contrast, also be explained by reports being merged or teams not travelling to Germany. Hence, 89% should be seen as the lower bound for how complete our data collection is.

Figure 4.5: INFORMATION ON REPORTS

Notes: This figure shows in Panels (a) and (b) how we reduce the initial dataset to the final dataset. Panels (c) and (d) present summary statistics for the final dataset. Our initial dataset includes 3,873 reports: 1,756 BIOS, 974 CIOS, and 1,143 FIAT. Not all these reports contain valuable information on investigations of German firms. Panel (a) shows the number of reports which are not on a firm investigation. Panel (b) shows the number of reports that focus on firms located outside of Germany. Panels (c) and (d) do not include these 'not relevant' reports. For the final dataset, Panel (c) shows the share of reports published in libraries and offered for sale to companies. Panel (d) shows the share of reports initially classified as Secret, Confidential, or Restricted.

offered for sale. The largest share of reports was published for BIOS. Reasons for a report not being published were low quality, little insights, or a classification due to sensitive content. 529 reports were classified, which implies that sensitive content was the main reason for reports not being published (see Figure 4.5d). Non-published and classified reports remain in our dataset as they provide valuable information on who was potentially able to extract knowledge from firms in Germany.

Investigator List

While reports mention the investigators who were collecting information on German firms, most reports do not state their employers. We collect data on U.S. investigators from an index of U.S. personnel published in May 1947.[6] This document by the Department of Commerce lists the technical and administrative personnel associated with the investigations. Figure 4.6 is an excerpt from this list showing the name and location of a U.S. firm employing one of the investigators. It shows the entry for a U.S. investigator named LeRoy Smith, who worked at American Viscose Corporation in Roanoke, Virginia. The figure also lists three of the reports on investigations in which LeRoy Smith was involved.

As no investigators were permitted to enter Germany after May 1947, the list is a near-to-complete collection of civilian investigators. It allows us to understand which U.S. firms were involved in the investigation. Out of 1,143 FIAT reports and 974 CIOS reports, we are able to link 900 (79%) and 354 (36%) reports to someone on the investigator list, respectively.[7] This is a relatively high share, as many investigations were also conducted by technically educated soldiers (for FIAT and CIOS) and by British investigators (for CIOS).

Figure 4.6: INVESTIGATOR LIST

SMITH, LeRoy H. General Manager American Viscose Corp. Roanoke, Virginia	14473	FIAT 147	Behnsen Continuous Shredder, Wolf- gang Bei Hanau (Microfilm .50 Photostat $1.00)
	14517	FIAT 35	Bobbin Finning Process of Viscose Rayon Textile Yarn and of Yarn for Tire Cord at Snia Viscosa Cesano Maderno (Microfilm .50 Photostat $1.00)
	1113	FIAT 10	Continuous Process for Spinning Vis- cose Yarn at Zellwolle Lenzing Akti- engellschaft Lencing Oberdonau Aus- tria (Microfilm .50 Photostat $1.00)

Notes: This figure shows an excerpt from the investigator list. From this, we learn that Leroy H. Smith, an investigator from CIOS report XXXIII-50, was a general manager at American Viscose Corp. in Roanoke, Virginia. The company was a large rayon producer, which relates well to the subject Mr. Smith was investigating in Germany. The company is also among the top three U.S. firms conducting investigations in Germany, as shown in Table 4.2.

Topic List

The confidential topic list by H.M. Stationary provides an overview of the BIOS, CIOS, and FIAT reports that have been published in the United Kingdom until October 1949. It groups the reports into 21 categories, such as Agriculture, Metal Industries, and Optical and Mechanical Precision Instruments. It also provides an even more

[6] For details on the employed archival sources see Section 4.A in the Appendix.

[7] No list of British investigators and their employers is archived at The National Archives in London.

detailed grouping into 221 subcategories. Figure 4.7 shows an excerpt for the category Chemicals, which lists the numbers and names of reports belonging to this category. Most reports are assigned to one category (47%) or two categories (39%), with 15% of the reports being assigned to more than two categories.

Figure 4.7: TOPIC LIST

(1) Chemicals generally—*contd.*

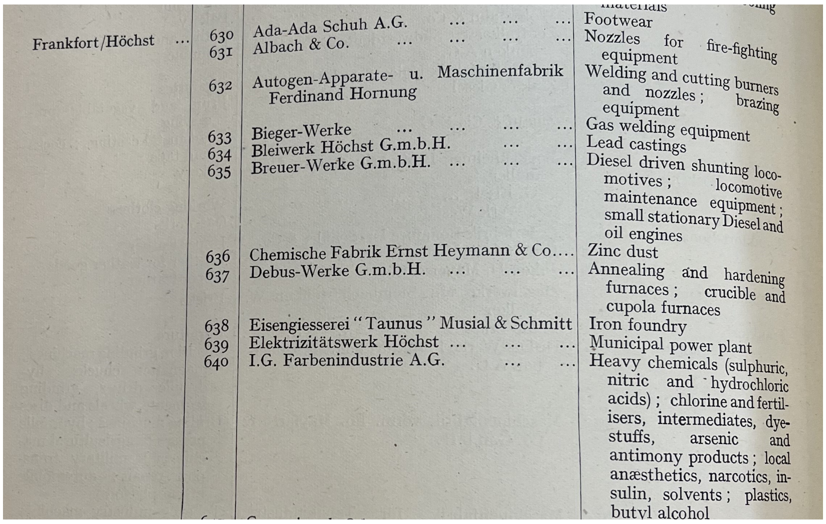
FIAT 715	*Ion Exchange, Coating and Plywood Resins at I.G. Ferbenindustrie, Th. Goldschmidt A.G., Permutit A.G., and Chemische Werke, Albert.*	5s. 0d. (5s. 2d.)
FIAT 723	*German Carbon Bisulfide Manufacture*	4s. 6d. (4s. 8d.)
FIAT 762	*New Plastics for German Aircraft. (Structural Materials, Glazings and Paints.)*	1s. 6d. (1s. 7d.)
FIAT 788	*Aluminium Hydroxy Chloride Production at Ludwigshafen by Electro-Chemical and Chemical Methods.*	1s. 0d. (1s. 1d.)
FIAT 790	*Production of Sodium Sulfide from Sodium Amalgam*	1s. 0d. (1s. 1d.)
FIAT 819	*Metallic Sodium from Sodium Amalgam at Gersthofen*	2s. 0d. (2s. 1d.)
FIAT 820	*Degussa Sodium Production using Downs Cells*	2s. 0d. (2s. 2d.)
FIAT 830	*English translation of "Sodium in Germany and the Relations between I.G. and Degussa in this field."*	2s. 0d. (2s. 1d.)
FIAT 852	*English translation of "N-Chloro-Amides of Higher Molecular Fatty Acids and their Conversion Products."*	1s. 0d. (1s. 1d.)
FIAT 862	*Poly-Vinyl Chloride Production at Burghausen and Ludwigshafen*	2s. 6d. (2s. 8d.)
FIAT 863	*Activated-Carbon Production at I.G. Farbenindustrie, Leverkusen*	1s. 0d. (1s. 1d.)
FIAT 867	*The Production of Mono-Vinyl Chloride*	2s. 0d. (2s. 1d.)
BIOS E/R 236	*I.G. Farbenindustrie.* Production of Barium Sulphide and Barium Sulphate.	2d. (3d.)
BIOS E/R 281	*I.G. Farbenindustrie.* Synthetic materials	2d. (3d.)
CIOS XXXIII—50	*Synthetic Fibre Developments in Germany (in four volumes)*	55s. 0d. (55s. 8d.)
BIOS 576	*German Limeburning Industry*	14s. 0d. (14s. 4d.)
BIOS 756	*Polymeric Processes at I.G. Ludwigshafen*	2s. 0d. (2s. 1d.)

Notes: This figure shows an excerpt from the topic list. We learn that the CIOS report XXXIII-50 is categorised as dealing with Chemicals - more specifically its subcategory Generally. The report is also grouped to one further category and three further subcategories, which are all not shown in this figure.

Target List

The German Industry Survey provides an index of more than 6,000 relevant German firms, which has been compiled by the Foreign Office and the Ministry of Economic Warfare. It is structured by geographic area in five books and excludes the Soviet zone. Gimbel (1990) refers to this as blue books providing guidance for the investigations. The target list was prepared in late 1944 and early 1945 (Gimbel, 1990). Initially, it was supposed to include only targets of military value that could benefit the war against Japan. But before the war ended, it was already extended to include the most relevant private-sector German firms that were known to Allied intelligence. The target list allows to differentiate between investigated German firms that were designated as a target before the war was over and those for which the decision to investigate came later. Figure 4.8 shows an excerpt from the target list for the Hesse area providing names and location of firms as well their products.

Figure 4.8: TARGET LIST



			materials
Frankfort/Höchst ...	630	Ada-Ada Schuh A.G.	Footwear
	631	Albach & Co.	Nozzles for fire-fighting equipment
	632	Autogen-Apparate- u. Maschinenfabrik Ferdinand Hornung	Welding and cutting burners and nozzles; brazing equipment
	633	Bieger-Werke	Gas welding equipment
	634	Bleiwerk Höchst G.m.b.H.	Lead castings
	635	Breuer-Werke G.m.b.H.	Diesel driven shunting locomotives; locomotive maintenance equipment; small stationary Diesel and oil engines
	636	Chemische Fabrik Ernst Heymann & Co....	Zinc dust
	637	Debus-Werke G.m.b.H.	Annealing and hardening furnaces; crucible and cupola furnaces
	638	Eisengiesserei "Taunus" Musial & Schmitt	Iron foundry
	639	Elektrizitätswerk Höchst	Municipal power plant
	640	I.G. Farbenindustrie A.G.	Heavy chemicals (sulphuric, nitric and hydrochloric acids); chlorine and fertilisers, intermediates, dyestuffs, arsenic and antimony products; local anæsthetics, narcotics, insulin, solvents; plastics, butyl alcohol

Notes: This figure shows an excerpt from the target list. We learn that I.G. Farbenindustrie AG was a suggested target for the city of Frankfurt. It was also visited by the investigators reporting on their findings in CIOS report XXXIII-50.

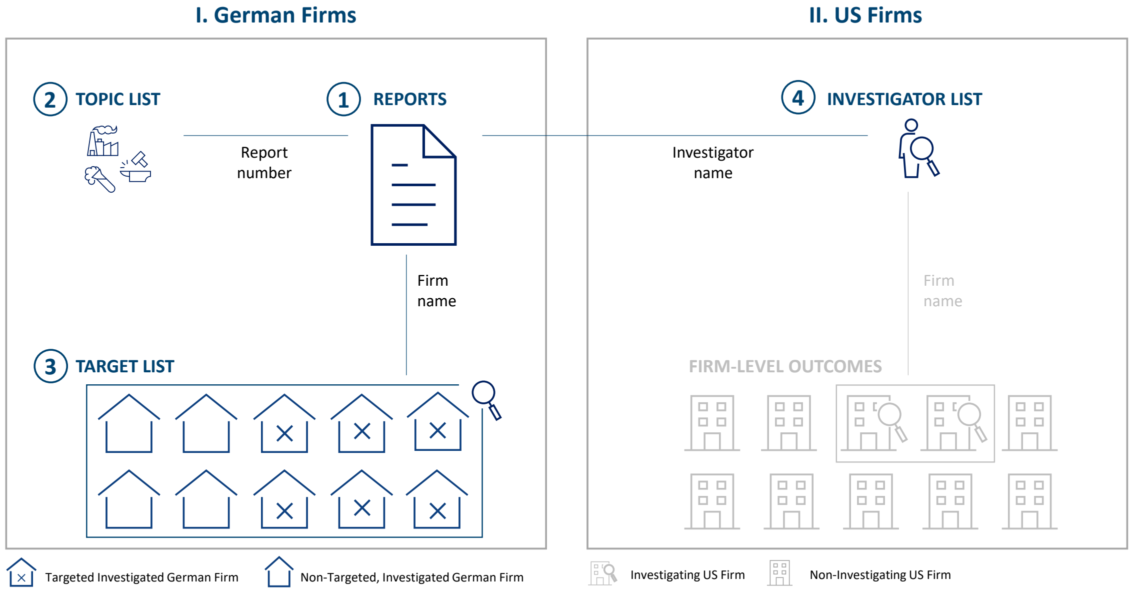
4.3.2 Final Dataset on Knowledge Transfers

Our dataset is centred around the investigations at German firms between 1945 and 1947. This dataset can be linked to other data on firm outcomes for U.S. firms that have sent their employees as investigators to Germany. To construct our dataset in such a way, we combine four distinct archival sources collected from four archives in Germany, the United Kingdom, and the United States. To the best of our knowledge, none of these data sources has been employed for research before.

Figure 4.9 illustrates how the four data sources form the final dataset on the investigations. The main dataset is extracted from investigation reports that were written by British and U.S. investigators on German firms (see (1) in Figure 4.9). The reports provide names and locations of the investigated firms. Each report is assigned a unique number, which allows us to match them to the topic list prepared by the British government (2). The topics are informative about the industry a German firm was active in. Based on whether a firm's name is included on a target list prepared before the end of the war, we also know whether a firm was deliberately targeted by British and U.S. investigators or merely visited by chance (3). Crucially, the investigator list allows us to link U.S. investigators to the U.S. firms they were employed at (4). In the future, we can add any firm-level data to the U.S. side of our dataset.

Overall, the key contribution of our dataset is to connect investigated German firms with investigating firms from the United States. Our dataset is informative about

Figure 4.9: LINKING DATA SOURCES



Notes: This figure shows how our dataset is constructed by linking four archival data sources. While the dataset is centred on German firms, the investigator list builds a bridge to U.S. firms. This allows us to link investigated German firms to U.S. firms that sent their employees as investigators to Germany.

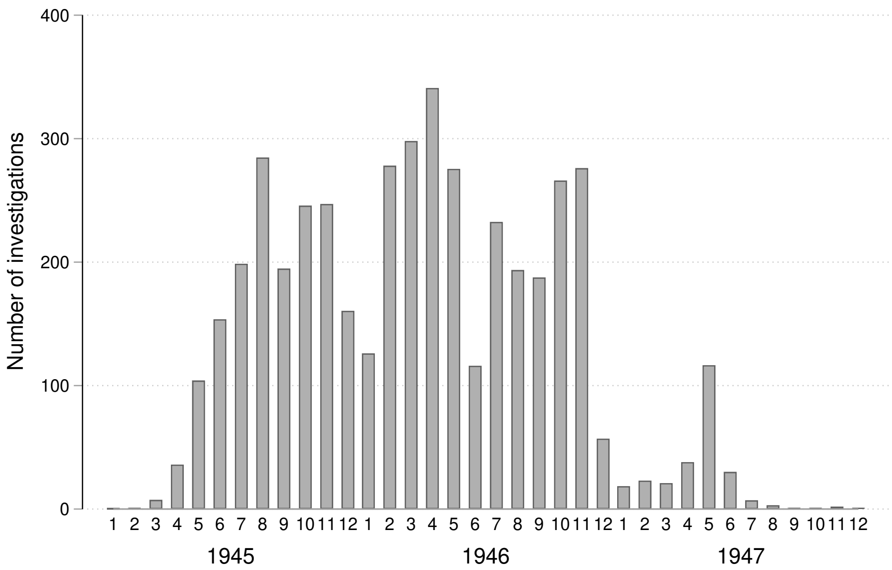
which U.S. firms received deep knowledge about specific German firms by sending their employees to conduct detailed investigations. For example, using balance sheet data we can investigate the effects of the investigations on the overall performance of participating firms. Alternatively, patent data can be used to study follow-on effects on U.S. innovation.

4.4 Mapping the Intellectual Reparations Program

In total, more than 20,000 investigations of German firms were conducted by British and U.S. investigators. The cumulative time spent on the investigations was 25,000 days (based on the subset of 50% of investigations which can be dated). Accordingly, the effort arising from this program was immense - both for the investigators and their administrations, but also for the German firms that had to receive and answer to the investigators. The busiest period lasted for 18 months, from May 1945 to November 1946, when every month at least 100 dated investigations were conducted (see Figure 4.10).

While some investigations took place before the German surrender, the program increased in scale just when hostilities had ended in the European war theatre, which shows its predominantly civilian character. The last investigators were permitted to enter Germany in May 1947, and the program was terminated in July 1947. However, throughout 1947 the number of investigations was already low - with a small peak before the program's end. Figure 4.10 illustrates these temporal patterns.

Figure 4.10: NUMBER OF INVESTIGATED GERMAN FIRMS OVER TIME



Notes: This figure shows the number of firm investigations by British and U.S. investigators in Germany for each month between 1945 and 1947. The date is available for close to half of the investigations, implying that only a subset of investigations is shown here.

On average, an investigator team included three members, but numbers varied between one and eleven investigators. Since travel could be organised more easily from the United Kingdom, British investigator teams were usually larger than those from the United States. In total, the investigators spoke to more than 29,000 employees of German firms. As most reports did not just include the names but also the occupations of these German employees, we can classify them into two groups: those with a managerial and those with a technical background. Based on this grouping, we observe that investigators interviewed German employees with managerial and technical backgrounds to a similar degree. The share of employees with a doctoral degree among the interviewed was 40%. This shows that investigators did not just desire a superficial understanding of the business a firm was conducting but rather to spot technical and scientific innovation that may prove valuable for British and U.S. industries.

Our data suggests that investigating teams were operating under a busy schedule. Given the limited capacity to host and transport investigators, the trips were rather short. On the report level, the average days spent on investigations was 14, and the median was five. During this time, investigators attempted to see many German firms rather than just a few. The average number of firms investigated per report is six, and the median is two. The travel itinerary in Section 4.2.2 illustrates how an investigating team traveled through the whole of Germany. The most common scenario was that investigators spent just one day at a German firm, and very rarely did it last more than five days (see Figure 4.B.3 in the Appendix). The short time period spent at each German firm suggests that a high level of cooperation from the investigated German firms was necessary for the investigators to gain deeper insights.

4.4.1 Which German Firms Were Investigated?

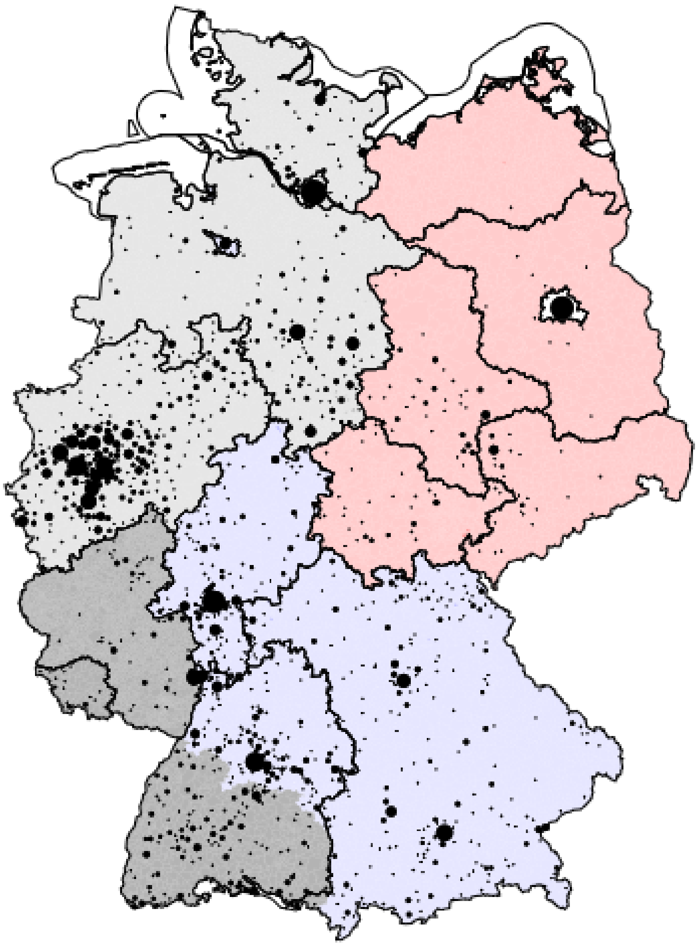
We geolocate all investigated German firms.[8] Our findings show that investigations took place all over Germany (see Figure 4.11). In fact, investigated firms were located in more than 1,200 different municipalities. There is, however, a concentration of investigations in large municipalities. With 1,100 investigations, Hamburg is the most visited municipality, followed by Berlin (880), Frankfurt (860), and Düsseldorf (590). But also smaller municipalities with important firms were subject to frequent investigations. For example, the relatively unknown Krefeld and Ludwigshafen on the Rhine are among the top ten investigated municipalities, with more than 350 investigations each. Both host a site of I.G. Farbenindustrie, which was the most investigated German firm.

We show that also firms in some parts of the Soviet zone were investigated by British and U.S. investigators. Plotting the location of investigations over time shows, however, that these investigations in the Soviet zone occurred nearly exclusively in 1945 (see Figure 4.B.4 in the Appendix). The reason is that the respective territory was initially held by U.S. troops and, hence, could be investigated until July 1945, when it was handed over to the Soviets in exchange for access to Berlin. Apart from this, the pattern of municipalities visited by investigating firms remained broadly similar between 1945 and 1946. For 1947, the sharp decline in the number of investigations is also visible on the maps.

The majority of investigations by British and U.S. investigators were conducted in their own respective zones (see Figure 4.B.5 in the Appendix). For example, 58% of

[8] We employ and, hence, refer to the current municipality structure from 2023.

Figure 4.11: LOCATION OF INVESTIGATIONS IN GERMANY



Notes: This figure shows the location of investigations. The size of the dots is proportional to the number of investigations in each municipality. Germany was divided into four occupation zones: Blue is the U.S. zone, light grey is the British zone, dark grey is the French zone, and red is the Soviet zone. The zone borders are based on a map by Kunz (2004). Investigations are extracted from the reports of BIOS, CIOS, and FIAT which include British and U.S. investigators, but not French or Soviet ones. The map is based on German borders as well as the municipality and state structure from 2023. Figure 4.B.4 in the Appendix shows the location of investigations for the years 1945, 1946, and 1947 separately. Figure 4.B.5 in the Appendix shows aggregate statistics for investigations by occupational zone.

the firms investigated by British teams (BIOS) were located in the British zone. Due to agreements between the United States and the United Kingdom, their investigators could also investigate pre-approved firms in the other's zone. In fact, 28% of the firms investigated by British investigators were located in the U.S. zone. For firms visited by U.S. investigators, the shares of 44% being in the U.S. and 37% being in the British zone are even closer. The low number of investigations in the French zone shows that investigation trips were, to a certain degree, limited by access to the desired German firms. This is well illustrated with the Soviet zone. While 20% of the CIOS investigations were of firms located in the Soviet zone, the number dropped to almost none after U.S. troops had retreated from that area. At the same time, Berlin became available for investigations by BIOS and FIAT teams, which chose around 7% of their investigations to cover firms in Berlin.

Table 4.1: TOP 10 INVESTIGATED GERMAN FIRMS

	Name	Location	Number	First	Last	Target	Industry
1	I.G. Farbenindustrie AG	Frankfurt	1,312	09.03.45	20.06.47	Y	Chemical
2	Friedrich Krupp AG	Essen	195	14.04.45	03.06.47	Y	Metal
3	Dynamit Nobel AG	Troisdorf	140	28.04.45	27.05.47	Y	Chemical
4	Siemens Halske AG	Berlin	119	09.03.45	13.05.47	Y	E. Engineering
5	Siemens-Schuckertwerke AG	Berlin	114	15.04.45	22.04.47	Y	E. Engineering
6	Degussa GmbH	Frankfurt	112	09.03.45	13.12.46	Y	Chemical
7	Vereinigte D. Metallwerke GmbH	Frankfurt	99	28.05.45	04.11.46	Y	M. Engineering
8	Robert Bosch GmbH	Stuttgart	99	22.05.45	02.12.46	Y	E. Engineering
9	AEG AG	Berlin	93	08.05.45	13.05.47	Y	E. Engineering
10	Rheinmetall-Borsig AG	Düsseldorf	84	23.04.45	09.10.46	Y	Armaments

Notes: This table shows the ten German firms which have been investigated most often. As ten to 61 locations of each firm have been investigated, the table presents only the most investigated location. 'Number' gives the total number of investigations. The start date of the first investigation is given in 'First', and the finishing date of the last investigation is given in 'Last'. The information on whether a firm was a target is based on the target list. The industry is given as the category from the topic list, which is most often assigned to a report on the firm. 'E. Engineering' is Electrical Engineering, and 'M. Engineering' is Mechanical Engineering.

Table 4.1 presents the ten German firms that have been investigated most often. The single most investigated German firm is I.G. Farbenindustrie AG. With around 1,300 investigations, it comprises more than 5% of the overall program. For the remaining nine firms, the number of investigations is in the range of 80 to 200. As the program lasted for around two years, that is for each of the firms on average one to two investigations per week. All investigations at these ten German firms started either before the German surrender in May 1945 or immediately afterwards. For four of the ten firms, the investigations had ended already in 1946, while they lasted for the remaining six until the end of the program in mid-1947. All firms were included on the target list, which was compiled by U.S. intelligence in 1944. The ten most investigated firms were primarily associated with the electrical engineering and chemicals industries. Rheinmetall-Borsig AG was the only firm in the category of armaments and ammunition.

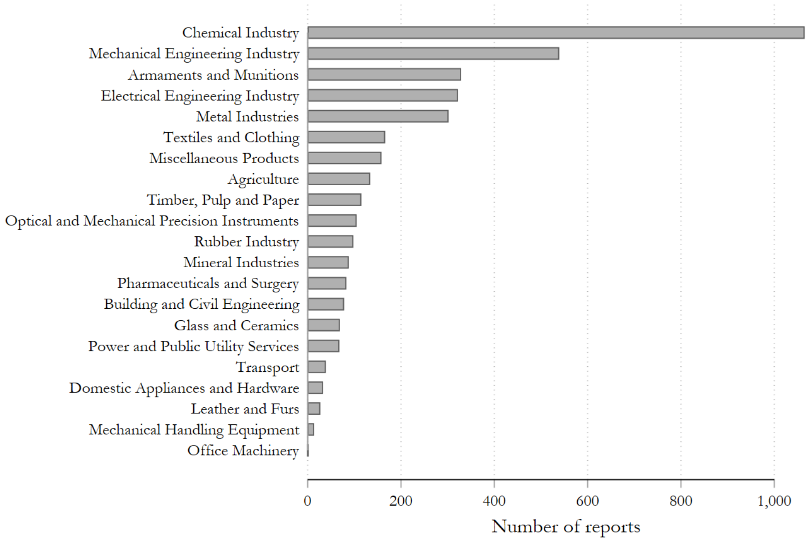
4.4.2 Which Industries Were Targeted?

Based on the topics assigned to reports, we can examine which industries were predominantly investigated. With more than 1,000 reports being devoted to it, the chemical industry received the most attention from British and U.S. investigators (see Figure 4.12a). Also, the mechanical engineering, the electrical engineering, and the metal industries are with 300 to 550 reports among the five most investigated industries. The target list shows that chemicals, engineering, and metals at that time were the most important industries of the German economy. In total, 2,900 of the 6,100 firms mentioned in the target list belong to either of these industries. The investigators, however, had a disproportionately large interest in the chemical industry. According to the target list, the chemical industry represented 11% of the firms considered to be most relevant, but 21% of the reports are about the chemical industry. Relative to the share of engineering and metal firms on the target list (26% and 10%), the share of reports on these industries is disproportionately small (17% and 6%).

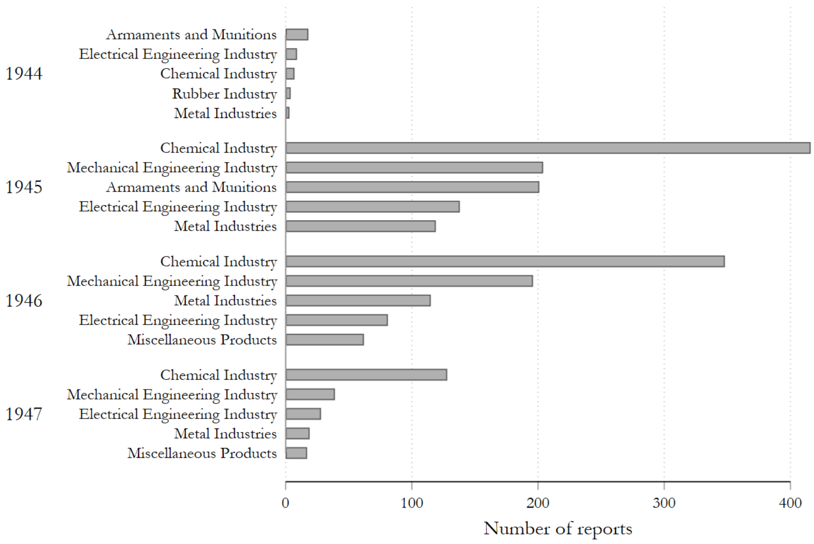
With its non-civilian products, the armaments and munition industry is an exception among the five most investigated industries. Figure 4.12b presents the development of reports dedicated to the top five industries over time. It shows that the defence industry was only of interest in the initial phase of the program in 1944 and 1945. Neither in 1946 nor in 1947 were armaments and munitions part of the top five investigated industries. This suggests that the program's concentration on civilian industries increased over time - especially after both Germany and Japan had surrendered in 1945.

Figure 4.12: INDUSTRY FOCUS OF INVESTIGATIONS

(a) Investigated industries



(b) Top five investigated industries over time



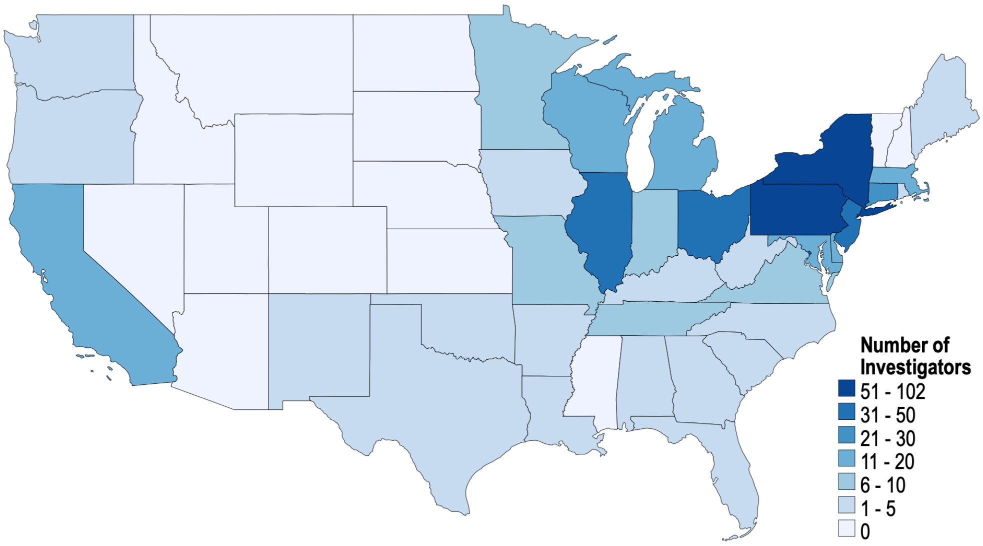
Notes: This figure shows the distribution of investigations over industries. Panel (a) plots the number of reports belonging to each of the 21 topic categories from the topic list. This information is only available for published reports. Panel (b) plots the number of reports for the top five categories from 1944 to 1947. The report date is available for close to half of the reports, implying that Panel (b) shows a subset of reports from Panel (a). To illustrate the shift in the program's topical focus, we also include those reports from 1944, which are on firms and military infrastructure outside of Germany. Most reports are assigned to one category (47%) or two categories (39%), with 15% of reports assigned to more than two categories.

4.4.3 Which U.S. Firms Sent Investigators?

In the last part of this paper, we connect investigating U.S. firms to investigated German firms. This allows us to observe specific knowledge transfers. Based on the investigator list, we observe the employers for 491 U.S. investigators. Most of these investigators were sent by employers located in New York (102 investigators), Pennsylvania (61), and Washington, D.C. (42). Table 4.B.3 in the Appendix lists the top ten states in terms of employed investigators. Figure 4.13 indicates that most investigators came from the East Coast and the Midwest. Fifteen states did not host a single firm sending an investigator to Germany. This geographic pattern even persists when accounting for population size (see Figure 4.B.6 in the Appendix).

Table 4.2 lists the ten U.S. firms that have conducted most investigations in Germany as part of the intellectual reparation program. The number of total investigations by their employees varies between 62 and 201. Nine of the ten most active U.S. firms were located either on the East Coast or in the East of the Midwest. In line with the generally strong focus on the chemical industry, a majority of the ten firms was mainly involved with investigations of German firms operating in this industry. In addition, two firms focused on the mechanical engineering industry, one on the timber, pulp, and paper industry, and one on the armaments industry. All ten firms started their investigations early in mid-1945 and mostly finished in the same year. Only one of the ten firms was still conducting investigations in 1947. In contrast, three firms finished their investigations within just three months.

Figure 4.13: NUMBER OF U.S. INVESTIGATORS BY STATE



Notes: This figure shows the number of investigators from each U.S. state. The information on the location of investigators is drawn from the investigator list.

Table 4.2: TOP 10 INVESTIGATING U.S. FIRMS

	Name	Location	Number	First	Last	Topic
1	E. I. duPont de Nemours & Comp.	DE, NJ	201	27.06.45	30.07.47	Chemicals
2	American Viscose Corp.	DE, VA, WV	152	27.06.45	06.09.45	Chemicals
3	Westinghouse Electric Corp.	NJ, NY, PA	102	01.06.45	14.11.45	M. Engineering
4	The American Enka Corp.	NC	93	27.06.45	06.09.45	Chemicals
5	American Lumber & Treating Comp.	IL	90	04.06.45	05.10.45	Timber
6	The Dow Chemical Comp.	MI	77	09.05.45	12.01.46	Chemicals
7	Newport News Shipbuilding	VA	74	24.06.45	02.08.45	Armaments
8	American Cyanamid Comp.	CT, NJ, NY	71	09.05.45	31.08.46	Chemicals
9	Allis-Chalmers Comp.	IL, WI	64	01.06.45	21.11.45	M. Engineering
10	Standard Oil Comp.	LA, NJ	62	25.03.45	30.09.46	Chemicals

Notes: This table shows the ten U.S. firms which have conducted the most investigations in Germany. U.S. firms have been merged to investigation reports based on the investigator list. 'Location' gives the states where the firms' investigators are based. 'Number' gives the total number of investigations. The start date of the first investigation is given in 'First', and the finishing date of the last investigation is given in 'Last'. The industry is given as the category from the topic list, which is most often assigned to a report written by an employee of each firm. The full name of the U.S. firm at position seven is Newport News Shipbuilding & Dry Dock Company. 'M. Engineering' is Mechanical Engineering, and 'Timber' is Timber, Pulp and Paper.

4.5 Discussion and Conclusion

In this paper, we present the first systematic and quantitative analysis of the intellectual reparations program faced by the German industry in the aftermath of WWII. We assemble a novel database covering more than 90% of the reports on British and U.S. investigations of German firms. We then present a series of facts on the regional, industrial, and technological breadth of this unprecedented program. Our findings contribute to a broader literature on both the German economic miracle and the emergence of the United States as the world's leading economic power after WWII.

A further contribution of our newly assembled database lies in observing which U.S. firms were involved in the investigations. By linking the investigated German firms to the investigating U.S. firms, we can observe and analyse the resulting knowledge transfers. In further work, we can examine the effects of access to German technological know-how on industrial performance and innovation in the United States. For example, using balance sheet data on U.S. firms, we can study the effects of the investigations on the performance of participating firms. Alternatively, using patent data we can investigate the effects of the knowledge transfers on follow-on innovation in the United States and thereby examine the long-run effect of the intellectual reparations on U.S. innovation.

Appendix to Chapter 4

This Appendix contains the following information:

- Section 4.A provides details on the archival sources.
- Section 4.B provides additional figures and tables.

4.A Sources of Historical Data

Reports: We digitise the whole stock of FIAT, BIOS, and CIOS final reports from the archives of the Deutsche Museum in Munich and the Imperial War Museum in London.

Investigator List: We source and digitise the information on the names of the investigators and their employers from a report by the Department of Commerce from 1947 ('Reports resulting from the investigation of German technology, 1945-1946, and index of personnel'). The document is available at the library of UC Berkeley (call number: T26.G3.U5.).

Topic List: We source and digitise the information on the topics of each of the FIAT, BIOS, and CIOS published final reports from the 'Reports on German and Japanese Industry - Classified Lists No. 18-20' by the H.M. Stationary Office from 1948 to 1951. The documents are available in the Rare Books section of the University of Cambridge library (catalogue number: OPR.2.67).

Target List: We source and digitise the information on the target list from the 'Economic Survey' and 'Zone handbooks' of Germany by the Foreign Office and the Ministry of Economic Warfare from 1945. The documents are available at the Imperial War Museum in London and offer a subject index and complete index of firms (catalogue number: LBY 28768-13).

Sources for Figures:

- Figure 4.1: Deutsches Museum, München, Archiv, CD 91638
- Figure 4.3a: Deutsches Museum, München, Archiv, CD 91634
- Figure 4.3b: Deutsches Museum, München, Archiv, CD 91640
- Figure 4.3c: Deutsches Museum, München, Archiv, CD 91639
- Figure 4.4a: Deutsches Museum, München, Archiv, CD 91635
- Figure 4.4b: Deutsches Museum, München, Archiv, CD 91636
- Figure 4.4c: Deutsches Museum, München, Archiv, CD 91637
- Figure 4.B.1: Deutsches Museum, München, Archiv, CD 91633

4.B Additional Figures and Tables

Figure 4.B.1: BIOS INVESTIGATION TEAM, SUMMER 1945

Notes: This figure shows members of the investigation team from BIOS report 300 on the German automotive industry. Investigations took place from 24 June to 1 October 1945. The report with 130 pages includes 78 investigations at firms such as BMW, Daimler Benz, M.A.N., Maybach, Opel, Porsche, Volkswagen, and Zahnradfabrik. 24 investigators and 7 liaison officers split into seven teams. The 24 investigators all came from private British industry such as Rolls Royce and Vauxhall. The names and private-sector employers of the members from the depicted 'Team C' are V.W. Pilkington (Leyland Motors Ltd.), F. Grimshaw (Leyland Motors Ltd.), G.J. Rackham (Associated Equipment Co. Ltd.), and Captain T.H.P. Cain. All wore military uniforms. The picture has been provided by the Deutsche Museum in Munich - for details see Section 4.A.

Table 4.B.1: DETAILS ON EXEMPLARY TRAVEL ROUTE - CIOS REPORT XXXIII-50

Number	Location	Firm	Date
1	Heinsberg	Vereinigte Glanzstoff-Fabriken AG	16.8.1945
2	Krefeld	Joh. Kleinewefers Söhne	16.8.1945
2	Krefeld	Rheinische Kunstseide AG	15.8.1945
2	Krefeld	Rheinische Zellwolle AG	15.8.1945
3	Hilden	Kampf & Spindler	14.8.1945
4	Dormagen	I.G. Farbenindustrie AG	10.8.1945-16.8.1945
5	Köln	Glanzstoff-Courtaulds	15.8.1945
6	Leverkusen	I.G. Farbenindustrie AG	10.8.1945-11.8.1945
7	Wuppertal	I.G. Farbenindustrie AG	13.8.1945
8	Siegburg	Rheinische Zellwolle AG	17.8.1945; 21.8.1945
9	Bielefeld	Hermann Windel GmbH	9.8.1945
9	Bielefeld	Seydel Maschinenfabrik GmbH	9.8.1945
10	Bad Oeynhausen	C.A. Delius & Söhne	7.8.1945
11	Hannover	Döhren Wollwäscherei und -kämmerei	8.8.1945
11	Hannover	Continental Gummiwerke	10.8.1945-11.8.1945
12	Berlin	Spinnfaser AG	30.8.1945
12	Berlin	KWI für Physikalische Chemie	29.8.1945
13	Südliches Anhalt	Eilfeld AG	2.7.1945
14	Bitterfeld-Wolfen	I.G. Farbenindustrie AG	27.6.1945; 28.8.1945-1.7.1945
15	Leuna	I.G. Farbenindustrie AG	2.7.1945; 25.8.1945
16	Elsterberg	Vereinigte Glanzstoff-Fabriken AG	2.7.1945
17	Plauen	Sächsische Zellwolle AG	2.7.1945
18	Schwarza	Thüringische Zellwolle AG	2.7.1945-3.7.1945
19	Kassel	Spinnfaser AG	3.7.1945
20	Rosenthal	I.G. Farbenindustrie AG	15.8.1945
21	Fulda	Val. Mehler Segeltuchweberei AG	22.8.1945
22	Wiesbaden	I.G. Farbenindustrie AG (Kalle & Co.)	4.8.1945
23	Kelsterbach	Vereinigte Glanzstoff-Fabriken AG	5.9.1945
24	Frankfurt am Main	IG Farben	3.8.1945-4.8.1945; 17.8.1945
25	Hanau	Condux-Werk (Herbert A. Merges KG)	25.9.1945
25	Hanau	W.C. Heraeus GmbH	6.9.1945
26	Obernburg a.Main	Vereinigte Glanzstoff-Fabriken AG	1.9.1945-2.9.1945
27	Ludwigshafen	I.G. Farbenindustrie AG	4.8.1945; 21.8.1945-25.8.1945
28	Stuttgart	Werner & Pfleiderer	30.8.1945
28	Stuttgart	Maschinenfabrik Gg. Kiefer GmbH	30.8.1945
29	Esslingen am Neckar	Fritz Müller Pressenfabrik	29.8.1945
30	Denkendorf	Zellwoll-Lehrspinnerei	31.8.1945
31	Rottweil	I.G. Farbenindustrie AG	28.8.1945
32	Freiburg	Rhodiaseta AG	20.9.1945
33	Waldshut-Tiengen	Lonza-Werk	19.8.1945
34	Bad Säckingen	Lonzana AG für Acetatprodukte	19.8.1945
35	Bobingen	I.G. Farbenindustrie AG	26.7.1945-30.7.1945
36	Augsburg	Augsburger Kammgarn-Spinnerei	27.7.1945
37	Kelheim	Süddeutsche Zellwolle AG	28.7.1945
38	München	Agfa Camerawerke (I.G. Farben)	8.7.1945-9.7.1945; 28.7.1945
39	Burgkirchen a.d.Alz	I.G. Farbenindustrie AG	10.7.1945-11.7.1945; 13.7.1945
40	Burghausen	Dr. Alexander Wacker GmbH	2.7.1945; 12.7.1945; 17.7.1945; 1.8.1945-3.8.1945

Notes: This table lists all locations, firms, and dates of the investigations shown in Figure 4.2.

Figure 4.B.2: WORD CLOUD: TITLES OF REPORTS

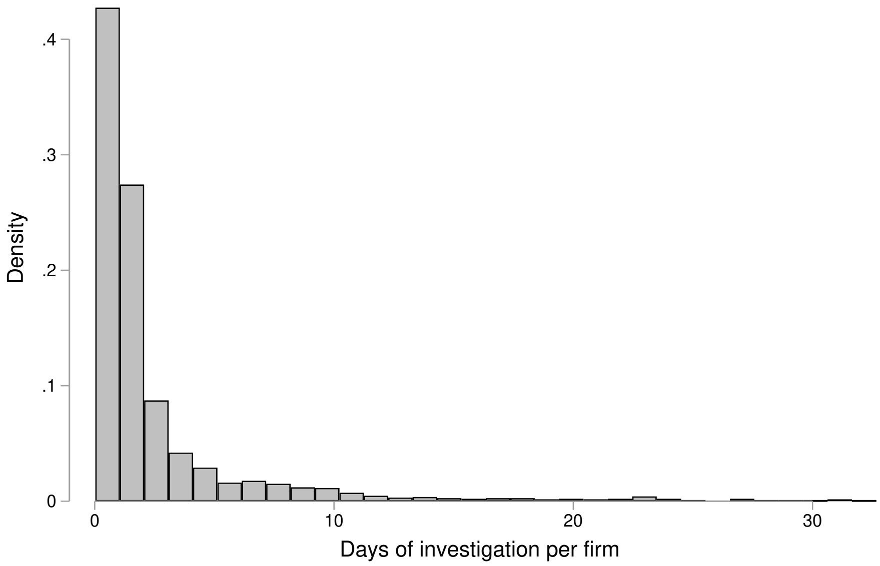
Notes: This figure shows a word cloud of the words which have most often been used in the title of BIOS, CIOS, and FIAT reports. Larger font size implies that a word has been used more often.

Table 4.B.2: COMPARISON: OUR DATASET VS. UNIVERSE OF REPORTS

		CIOS	BIOS	FIAT	Total
Published	In Dataset	573	1,463	687	2,723
	Maximum	574	1,465	687	2,726
	Share (in %)	100	100	100	100
Not Published	In Dataset	401	293	456	1,150
	Maximum	532	436	653	1,621
	Share (in %)	75	67	70	71
Total	In Dataset	974	1,756	1,143	3,873
	Maximum	1,106	1,901	1,340	4,347
	Share (in %)	88	92	85	89

Notes: This table compares the number of reports in our dataset with the maximum number of potentially written reports. The maximum number is taken from the report with the highest numerical value. The calculated share is a lower bound. For example, a report may be missing if two reports were merged and published under one number only. The information whether a report has been published was taken from the topic list.

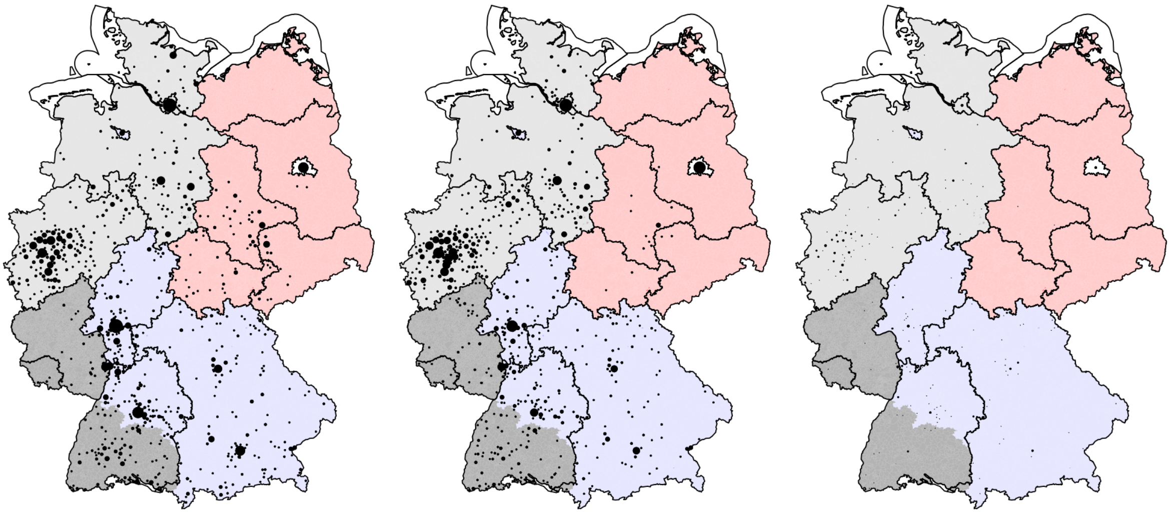
Figure 4.B.3: TIME SPENT ON INVESTIGATIONS



Notes: This figure shows the distribution of days that were spent investigating an individual firm. The date of investigation is available for close to 50% of investigations, implying that only a subset of all investigations can be employed for this analysis.

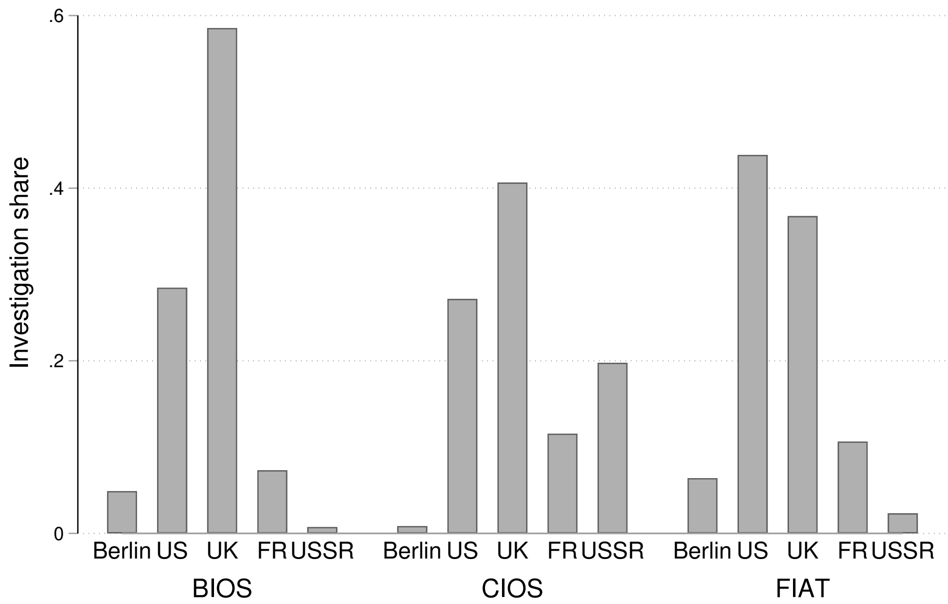
Figure 4.B.4: LOCATION OF INVESTIGATIONS BY YEAR

(a) 1945 (b) 1946 (c) 1947



Notes: This figure shows the location of investigations for each year of the program. The size of the black dots is proportional to the number of investigations in each municipality. The scale is similar for all three sub-figures. The date of investigation is available for close to 50% of investigations, implying that only a subset of the investigations from Figure 4.11 is shown here. Germany was divided into four occupation zones: Blue is the U.S. zone, light grey is the British zone, dark grey is the French zone, and red is the Soviet zone. The zone borders are based on a map by Kunz (2004). Investigations are extracted from the reports of BIOS, CIOS, and FIAT which include British and U.S. investigators, but not French or Soviet ones. The maps are based on German borders as well as the municipality and state structure from 2023.

Figure 4.B.5: LOCATION OF INVESTIGATIONS BY ZONE



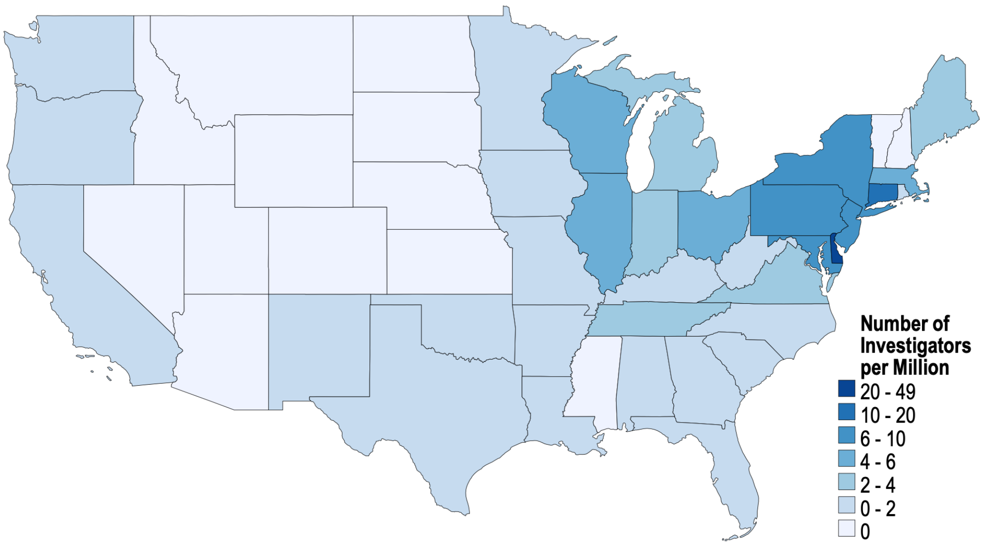
Notes: This figure shows the share of investigations occurring in each zone and Berlin separately for BIOS, CIOS, and FIAT. The assigning of municipalities to occupational zones is based on a map by Kunz (2004).

Table 4.B.3: TOP 10 STATES BY NUMBER OF INVESTIGATORS

	State	Investigators	Inhabitants
1	New York	102	13,479,142
2	Pennsylvania	61	9,900,180
3	Washington D.C.	42	663,091
4	Ohio	37	6,907,612
5	Illinois	33	7,897,241
6	New Jersey	30	4,160,165
7	Connecticut	23	1,709,242
8	Massachusetts	19	4,316,721
8	Michigan	19	5,256,106
10	Wisconsin	18	3,137,587

Notes: This table shows the top ten U.S. states by the number of investigators sent to Germany. The information on the location of investigators is drawn from the investigator list. The number of inhabitants is for the year 1940 and it is taken from U.S. Bureau of the Census (1950).

Figure 4.B.6: NUMBER OF INVESTIGATORS PER INHABITANTS BY STATE



Notes: This figure shows the number of investigators from each U.S. state per one million inhabitants. The information on the location of investigators is drawn from the investigator list. The number of inhabitants is for the year 1940 and it is taken from U.S. Bureau of the Census (1950).

Conclusion

As is typical for the economics profession, my thesis has approached important questions by investigating very specific settings which allow for (causal) empirical analysis. Every chapter presents a novel idea: transferring gambling-style behaviour to politics, analysing economic voting at the precinct-level, measuring the economic effects of war risk, and capturing the largest intellectual exploitation of human history in a database. The respective findings are like pieces of a puzzle. While I am confident that they contribute to our understanding, more evidence is needed to see the full picture. Hence, I encourage other fields, such as political science and war studies, to employ their techniques to approach the same questions. To facilitate this, I will not conclude but rather put forward four claims which invite discussion and contradiction. Each claim incorporates the findings of one chapter, but the claims are on purpose formulated in a broad, exaggerated, and thought-provoking fashion.

I. When you lose, do not gamble to win. Politicians behave just like managers of a firm called 're-election'. With the erosion of the traditional party system well underway, populists and extremists exploit every opportunity to claim that centre parties serve their own interests rather than those of voters. We have provided novel empirical evidence that gambling-style behaviour is present when choosing political leaders. This suggests that re-election motivated politicians may on purpose choose a worse leader by trading off expected quality against riskiness. When politicians' incentives are such that they care more about themselves than the destiny of both their party and their country, then something is very flawed. Traditional parties need to find ways to again make politics strictly in the interest of the country and not just for party members and party elites. Otherwise, election results will keep reminding them of this lesson.

II. It will always be the economy, stupid. The focus of the political debate on socio-cultural topics in recent years was a luxury, which could only be afforded as the economy performed well. Since the financial crisis in 2007 and 2008, the German economy had constantly delivered strong growth outperforming its European peers. As the electorate seemed to place low relevance on economic matters, parties shied away from ambitious economic policies. We have shown that the disruptions caused by the Covid-19 pandemic put the economy back on the political agenda of voters. We find that a negative income shock leads to a shift of votes from progressive parties to market-oriented parties, which have their topical priorities and core competences related to the economy. As Germany is facing a variety of economic challenges right now, parties need to strengthen and prioritise their economic agenda. Their voters care about it.

III. Being weak makes you weaker. The Free World needs to level up its resilience against hybrid warfare. Its adversaries, such as China, Iran, North Korea, and Russia, threaten, provoke, and escalate to worsen the security environment for liberal democracies. We have shown that in a capitalist economy an increase in war risk creates real economic costs. Even if no war will happen, our findings suggest that a prolonged period of insecurity will be sufficient to distort economic outcomes. This implies that liberal democracies not only need to prepare for war (to deter it), but must simultaneously learn how to respond to the hybrid warfare leveraged against them. On a positive note, the message that a lack of security has economic costs may serve as a motivation to the European nations struggling to bear the financial costs of adequately equipping their armed forces.

IV. Take, so that you can give. The history of the European economic recovery after WWII was written by the victors. The Marshall Plan has found a place in the collective memory of Europe and the United States. Whenever there is a crisis to be overcome, it is not long until calls for extensive government aid under the label of a 'New Marshall Plan' are raised. We have told and quantified the largely forgotten story of an extensive British and U.S. intellectual reparation program. Just before the United States generously gave aid, they collected the intellectual property of thousands of German firms to benefit U.S. industries. Going forward with this project, we will estimate the value of the program for the U.S. industry and quantify it in relation to the Marshall Plan aid. We will also test whether the investigations harmed German economic recovery or had a positive effect due to the formation of international business connections.

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