# HIGHWAY TO HITLER*

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**Abstract:** When does infrastructure investment win "hearts and minds"? We analyze a famous case – the building of the highway network in Nazi Germany. Highway construction began shortly after Hitler's takeover of the government, and was one of the regime's most important projects. Using newly collected data, we show that highway construction was highly effective, boosting popular support and helping to entrench the Nazi dictatorship. These effects are unlikely to reflect direct economic benefits. Instead, highway construction signaled economic "competence" and an end to austerity, so that many Germans credited the Nazi regime for the economic recovery. In line with this interpretation, we show that support for the Nazis increased particularly strongly where highway construction coincided with greater radio availability – a major source of propaganda. Our results suggest that infrastructure spending can win local "hearts" when "minds" are led to associate it with visible economic progress in the aggregate.

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# 1 Introduction

Major infrastructure projects can have important economic effects. While an early literature had concluded that the invention of the railways did not matter significantly for growth (Fogel 1964), there is now ample evidence that, for example, the building of India's national railway network reduced transport costs, and increased trade (Donaldson 2015). Similarly, better access to transport infrastructure in China and Prussia boosted GDP (Banerjee et al. 2012; Hornung 2015).[1] While the economic effects of large-scale investment in transport infrastructure can be large, it is unclear whether they can affect political outcomes at the national level, effectively buying "hearts and minds".[2] There is at best mixed evidence that politically motivated income transfers and federal spending can affect voting behavior.[3] Also, existing evidence mainly refers to local and regional political outcomes. Remarkably, the literature has so far not found evidence for major political effects of large-scale, nation-wide infrastructure projects.

In this paper, we demonstrate that the building of the first nation-wide highway network in history changed voting behavior in an important way, with major political repercussions. We also demonstrate that electoral gains depended on a synergy with propaganda – they were greatest where highway building coincided with a strong radio signal. Immediately after coming to office in 1933, the Nazi government initiated plans to build thousands of kilometers of high-speed roads, the famous *Autobahn*. The policy was designed to do economic good. Employment creation was a key aim of the new government, and its electoral benefits were an important motivating factor.[4] The Hitler government held an election in late 1933,

[1] There are also well-documented effects on urban layout (Baum et al. 2012), city growth (Duranton and Turner 2012), and skill premia in urban areas (Michaels 2008). In contrast, Faber (2014) finds adverse effects on GDP growth in newly-connected peripheral counties in China.

[2] Dictatorships often have a particular preference for large-scale building projects to signal economic progress – Josef Stalin initiated construction of the White Sea–Baltic Canal shortly after his accession to supreme power, and Ferdinand Marcos committed to a large highway building program immediately after coming to office.

[3] Some studies document that spending programs and income transfers can boost the government's performance at the ballot box (Manacorda 2011; Levitt and Snyder 1997). Politicians may even receive credit for lottery-driven improvements in economic conditions (Bagues and Esteve-Volart 2015) or the success of local sports teams (Healy et al. 2010). On the other hand, many studies only find minimal effects of infrastructure spending on support of the government (Stein and Bickers 1994; Feldman and Jondrow 1984). In line with this, deficit spending before elections is not reliably associated with electoral success (Brender and Drazen 2008; Drazen and Eslava 2010).

[4] In the German edition of the General Theory, John M. Keynes later pointed to the success of demand stimulus in Germany after 1933, arguing that following his precepts was easier in a totalitarian state.

immediately before the start of large-scale construction, and then a plebiscite in August 1934, when road-building was well under way. We show that areas where the new roads were being built saw significant increases in support for the regime.

We first illustrate our main finding by showing the effect of road-building on voting results. Fortunately for our analysis, road-building had started in earnest, in many locations, by August 1934 – but there was almost none before the preceding election, in November 1933.[5] Figure 1 plots the change in support for the Nazi regime by distance bracket.[6] Where the new roads were close, the Nazis gained support. Where they were more than 40 km away, they lost support – and the greater the distance, the greater the losses. The naive analysis in Figure 1 – based on taking averages by distance – implies a difference of 0.47 standard deviations when going from less than 10 to more than 60 km distance. This translates into a vote gain from highway construction of 2.4%, relative to oppositional votes of 10%.[7] Note that none of the new roads were in operation before May 1935, meaning that they cannot have served as a means to transport brownshirts to remote locations, or as a way to lower the cost of local goods. The electoral support generated by road building was one important factor contributing to the consolidation of the Nazi regime. Far from being deeply entrenched, by the summer of 1934, the Hitler government showed signs of fragility. Old conservative elites around the President threatened martial law, and members of the middle class were increasingly worried about the social radicalism of the Nazi Party's left wing. Workers remained apathetic. Under these circumstances, staging a major show of wide-spread support was crucial for the regime, as it permitted the creation of the position of "Führer" – combining the offices of Chancellor and President in the hands of Adolf Hitler. The Nazi government only just succeeded in repeating its electoral successes of the previous winter – but according to our results, opposition would have grown substantially if it had not been for the massive road building project.

Voting records from the Nazi period cannot be taken at face value. Intimidation was massive, and there is some (limited) evidence of fraud. Nonetheless, we argue that information about

[5] Cf. Figure A.1 in the Appendix, which shows that by November 1933, almost no labor was employed in highway construction.
[6] Since the election in 11/1933 and the referendum in 8/1934 are not strictly comparable, we use the difference in standardized vote shares with mean zero and standard deviation one.
[7] This is a lower bound, since there were country-wide effects of the highways, too.

popular support can be extracted from vote shares. First, support for the Nazi government was far from universal. Opposition was not impossible, and it varied importantly over time and space. For example, in Garrel, Lower Saxony, in August 1934, only 60 percent of voters supported Hitler. In Wendlingen, officials recorded support of 99.9 percent.[8] Second, our measure of increases in support comes from comparing voting results in hundreds of German cities before and after the start of *Autobahn* construction – and the Nazis were already in power during the first election in November 1933. This makes it less likely that cross-sectional differences in intimidation or fraud accounted for electoral success; only a *differential* increase in intimidation or fraud in areas with *Autobahn* construction could contaminate our results. Third, we show that areas with *Autobahn* construction, but without good radio coverage, showed *no* differential increase in Nazi support. In other words, without the reinforcing effect of Goebbels' propaganda, explaining the advantages of the Autobahn to the people, highway construction did not buy more votes for the regime – a result that directly contradicts any differential intimidation interpretation. Finally, we perform a number of "election forensics" tests and find no evidence for a relationship between *Autobahn* construction and fraud.

Motorway planning may have followed a political lead after 1933. To deal with potential endogeneity, we construct least-cost paths between terminal cities that were to be connected by highways. Building costs reflect the roughness of the terrain, the number of rivers to be traversed, etc. We then use these least-cost paths as an instrument for actual construction, excluding the terminal cities themselves from the analysis. Our IV results confirm the OLS estimates both in terms of magnitude and statistical significance. We also look at the subset of connections that any road planner would have had to build, connecting Germany's largest 20 cities. Again, we find large positive effects on Nazi support.

What accounts for the *Autobahn*'s success in winning "hearts and minds"? We discuss the benefits. Immediate improvements to transport can be ruled out – very few Germans had cars, and the roads were not ready for use by the time of the plebiscite in 1934. Economic benefits were also probably small, and not decisive for winning support for the government. In the

[8] We do not assume that the aggregate share of "yes"-votes cast is a reliable indicator of actual support for the regime (Evans 2006). Instead, we exploit cross-sectional variation. Even large cities recorded substantial differences: In Aachen, for example, 24% voted "no"; in Nuremberg, on the other hand, only 4.6% voted against Hitler becoming both Chancellor and President.

aggregate, these have been shown to be small (Ritschl 1998). Importantly, the boost in the Nazis' electoral fortunes in response to highway building did not depend on the level of unemployment – areas with high unemployment did not show a greater increase in Nazi support when roads were built.

We argue that highway building "worked" because it successfully signaled government 'competence' – both the ability to get things done, and an effective end of the austerity policies of the pre-1933 era that were implemented by successive Weimar governments (Shand 1984). Goebbels' propaganda, using radio, press, and film, exploited the highways as powerful symbols of an energetic government overcoming 'democratic gridlock' (Evans 2006). We find evidence of a synergy between propaganda and highway construction – where radio signal strength was high and the new roads were under construction, pro-Nazi votes increased particularly strongly. On the other hand, without radio coverage, the roads themselves had a negligible effect on voting behavior. Thus, our results suggest that infrastructure spending can win "hearts and minds" locally – especially when people associate it with nationwide (economic) progress.

In addition to the literature on transport infrastructure and on political effects of government transfers, we also relate more broadly to research on the political economy of regime change (Acemoglu and Robinson 2000), elections and the entrenchment of dictatorships (Egorov and Sonin 2014; Simpser 2013; Jessen and Richter 2011), and on interactions between the military and old elites (Finer 1976; Acemoglu, Ticchi, and Vindigni 2010). Closely linked is work on the origins of totalitarian dictatorships, much of which emphasizes differences between normal autocracies and regimes like the Nazi dictatorship or Communist rule in Russia. Theories of "mass society" focus on industrialization and the associated rise of a large group of economically marginal individuals who have lost their traditional roots (Ortega y Gasset 1993; Arendt 1973). These in turn are said to create a fertile recruiting ground for totalitarian ideology, from both the left and the right.[9] Schmitt (1926), on the other hand, emphasized the need for an – alleged – external or internal threat for totalitarian states to consolidate.

Relative to the existing literature, we make a number of contributions: First, we demonstrate the political benefits of infrastructure spending on electoral outcomes, helping to entrench the

[9] Applications of this approach to the German context include Shirer (1960) and Stern (1972).

Nazi dictatorship. At a crucial moment when the Hitler regime needed to showcase its popularity, *Autobahn* building boosted support. We thus contribute to a rich literature that studies regime change in general and the rise of the Nazis in Germany more specifically (King et al. 2008; Bracher 1978; Spenkuch and Tillmann 2016). Second, we show how even unfree elections under a brutal dictatorship can be used to make inferences about changes in regime popularity and its determinants. Third, we offer suggestive evidence on the channel behind the electoral gains from infrastructure investment. We find that road building was most effective in swaying voters who had previously supported moderate parties, or who were skeptical of the Nazis, such as Catholics. On the other hand, in areas with high support for the communists (such as worker strongholds), highways were less effective in garnering votes. Lizzeri and Persico (2001) suggest that in electoral regimes where the margin of victory matters, public goods are more likely to be provided, and pork barrel spending is less. Our result on the Nazi regime building highways is related, but goes further. It suggests that emphasizing that roads are public goods through propaganda can generate important synergies with actual investment, enabling the regime to show near-universal support. In this sense, the *Autobahn's* success in boosting pro-regime votes relied more on a perceived 'competence' channel (Rogoff 1990) than on any direct economic benefits.

The paper proceeds as follows. We first explain the historical background and context of motorway building in Section 2, and summarize key facts about elections under the Nazi regime. We then describe our data in Section 3 before presenting our main empirical results (Section 4). Next, we discuss possible channels in Section 5, before turning to identification issues (Section 6). The robustness of our findings is discussed in Section 7, and Section 8 concludes.

## 2 Historical Background

In this section, we briefly describe motivations behind the building of the *Autobahn* network and its antecedents. We also discuss the nature of early Nazi elections and the growing strength of the regime.

### *2.a Motorway building under the Nazis*

The Hitler government pursued two aims with the building of the motorway network. First, it aimed for a propaganda success, signaling its competence by "getting things done", as well

as a symbolic break with past economic policies, especially austerity (Ritschl 2003). This aim was pursued vigorously and with success – many elderly Germans still point to the motorway network to argue that the Nazi regime had some positive sides, too. Second, the Nazi government sought to create employment.

Immediately after coming to power, the Nazi government began to plan new roads. At the Berlin Motor Show – only 11 days after becoming Chancellor – Hitler presented far-reaching plans for the 'motorization' of Germany, with provisions for tax subsidies, road-building, and cheaper, compact cars.[10] By the summer of 1933, a new publicly-owned company had been founded to build and operate the new highways Germany-wide. The network was planned using in part earlier plans drawn up by a private think tank, the STUFA (Vahrenkamp 2010). In some cases, the exact trajectory of the actual roads was decided by Hitler himself, who insisted on scenic routes.

To maximize work creation and to demonstrate that the government was serious about road building, construction began at many points simultaneously. Figure 2 shows the 1934 highway network. Thick black segments were under construction; double-ruled segments were approved for construction, but not yet begun; and light grey lines indicate planned segments not yet approved for construction.[11] In 22 locations, construction was under way less than a year after the start of the project. Among the first segments to be built were the link from Frankfurt to Darmstadt and on to Stuttgart, from Berlin to Hannover, the connection Bremen-Hamburg-Lübeck, Leipzig towards Munich, and Munich-Stuttgart. None of them were actually open for traffic by the time of the plebiscite in August 1934.

Highway construction began on a large scale only after the November election in 1933 – a fact that we exploit in our empirical analysis. Figure A.1 in the appendix shows employment

[10] In the Rhineland, another – unrelated – project connected Bonn and Cologne. Konrad Adenauer, later Chancellor of the Federal Republic of Germany, coordinated the building in a bid to reduce unemployment. This first highway opened in 1932. At the time, Italy had already completed the first high-speed roads reserved for car traffic.

[11] We digitized the September 1934 map from Todt (1934), which is the closest available to August 1934. The transition between highway segments "approved for construction" and "under construction" in Figure 2 is fluid, and even the historical maps discussed in Section 2 are not completely clear about the exact timing when construction began. For example, a few smaller segments are listed as "under construction" in the May 1934, but as "approved for construction" in the November 1934 map. We use "under construction" as our main 'treatment' variable, and document the robustness of results to including "approved for construction" in Section 7.b. Whenever we refer to "highways" in the following, we mean segments that were listed as "under construction."

in *Autobahn* construction, by month, for the period 1933-34. Employment in November 1933 was 3,000 men, 5% of the level reached by August 1934, and earlier months had seen even more minute numbers of workers used for highway construction. By April 1934, construction got under way on a significant scale, with the number of men employed 20,000. In August, the number had almost tripled again, to 59,000. While August did not yet constitute the high water mark of *Autobahn* employment, it was higher than in any preceding month, reaching 50% of the all-time peak of employment (June 1936; 121,000 workers).

Together with rearmament, the *Autobahn* is widely seen as a key part of Keynesian demand stimulus by the Hitler government. In line with the regime's propaganda, many observers took it for granted that building the new highway network reduced unemployment substantially. John Maynard Keynes himself, in the introduction to the German edition of his *General Theory,* argued that the Autobahn exemplified the effectiveness of deficit spending.[12] Quantitative research has since established that neither military spending nor highway construction were probably responsible for Germany's recovery after 1933 (Ritschl 1998). Initially planned to employ up to 600,000 workers, motorway building never came close to creating such a number of jobs. At its peak, only 125,000 Germans were working in highway construction.[13] In 1933 itself, relatively little construction took place, with only 3,900 men employed by year-end; by 1934, this rose to 84,000 (Humann 2011). Instead, the rapid rise in output under Hitler is typically explained by the strength of a cyclical upswing, helped by an end to deflation and declining uncertainty over the economy.

From the very beginning, the Nazi regime used the motorway building project for propaganda purposes. The first sod of earth for building the *Autobahn* was turned by Adolf Hitler himself, in September 1933. The weekly news reel shows him addressing a huge crowd of workers. He reminded them that the Nazi regime had asked for four years to show what it could do. Proclaiming the highways a "gigantic undertaking", he argued that the roads would bear witness to "our [the regime's] devotion, our diligence, our ability, and our decisiveness." He then told his audience to "get to work." (Schütz and Gruber 1996). In the first month of the newly-founded Autobahn company's existence, the *Völkischer Beobachter* – the leading party

[12] Keynes (1936). Scholars from Karl Schiller (1936) to Richard Overy (1975) argued along similar lines.
[13] This should be compared with a decline in unemployment from 6 million in January 1933 to 2.5 million in the summer of 1934.

paper – made construction progress front-page news no fewer than four times. Radio similarly played a prominent role – the start of construction was broadcast live to millions of listeners, including speeches by Hitler and Goebbels. At the behest of Propaganda Minister Josef Goebbels, building time tables were coordinated to ensure that work started simultaneously at 22 locations in March 1934. Instead of completing entire stretches of motorway one after the other, thus maximizing use value, construction took place all over the country in a bid to showcase NS economic policy (Shand 1984). The regime emphasized highway construction as an integral part of its war on unemployment (*Arbeitsschlacht*).[14]

As new stretches of motorway opened to the public, the regime celebrated its successes. The first segment was finished in May 1935. Some 90,000 supporters lined the road as Hitler was driven from Frankfurt to Darmstadt. By 1936, some 1,000 km of road (out of 9,000 planned) had been finished; the simultaneous opening of 17 segments of motorway was used for ceremonies all over Germany. Again, these events were used to high effect by the Nazi regime's propaganda machine. Each grand opening of individual segments, as well as benchmarks like the first 1,000 km of *Autobahn*, were extensively covered on the radio, which put on special programs and live coverage of the event, as well as in the press and by the news reels (Schütz 1995). In addition, the *Autobahn* was also celebrated as an aesthetic innovation. The *Autobahn* company commissioned a number of artists to produce paintings of road segments, bridges, ramps, and construction work. A book containing reproductions of these paintings sold over 50,000 copies (Vahrenkamp 2010).

One obvious question is why highway building was prioritized at all, instead of other public works programs or the construction of schools and hospitals – and why it was a popular policy choice. Road building as a make-work measure had been discussed extensively during the Great Depression, but no large-scale construction had taken place. The actual building of the highways signaled a regime change – a willingness to overcome years of austerity (Ritschl 2003). Party propaganda never tired of telling readers that "a decade of Weimar parliaments had produced only talk and sketches, a mere three years of National Socialism had built a thousand kilometres of traversable superhighways… Their very existence seemed to verify the Nazi thesis that the state must be given a free hand, if it were to restore Germany to her

[14] Literally, "battle for labor".

former glory." (Shand 1984, p.194). Especially for the regime's early phase, the *Autobahn* project had paradigmatic character: "Hitler breaking new ground … – the picture became an icon of the year immediately after 1933, a symbol for everything *Autobahn* construction seemed to stand: energy, directness and dynamism of the nationalsocialist movement…" (Schütz and Gruber 1996, p.43).

Interestingly, motorway workers themselves were typically skeptical of the Nazi regime – a fact that works against our finding. Recruited from the unemployed, many were unskilled. A substantial share sympathized with the Social Democratic Party or the Communist movement. While supporters of highway construction had expected workers to be recruited locally, they were instead often drafted from among the unemployed to work far from their homes, often living in barracks, where they were subjected to harsh discipline, and received only a minimal wage. They frequently expressed dissatisfaction with working conditions, pay, and harsh discipline. Disaffected workers painted anti-Nazi slogans on lorries used for motorway construction (Evans 2006). In one incident, workers demanded pay supplements. When their demands were not met, they went on strike, singing "The International" – the anthem of the workers' movement. Work only resumed after the ringleaders were sent to Dachau concentration camp.

Overall, the *Autobahn's* direct benefits were limited. Germany's car ownership rate in 1933 was low – approximately one quarter of England's or France's. Most transport of goods and people took place via rail. The new regime intended to boost the German car industry by all means possible, and not simply via road-building. Hitler had high hopes for the automobile industry as a future source of employment, and because its factories could easily be converted to war production. A tax exemption for the purchase of new automobiles from March 1933 onwards boosted car production, and accelerated the recovery of private car purchases (which had begun to rise in the fall of 1932). Between 1932 and 1938, the total number of cars, motorcycles and trucks on German roads doubled (Evans 2006).

There were also few military advantages to road-building. While the invasion of Austria used the Autobahn to move tanks, almost all troop and supply movements before and during World War II were by rail. Since the Hitler government planned wars of aggression that would take troops far beyond the borders of the Reich, the importance of internal communications was limited. If there was an aspect of road building that mattered militarily, it was motor vehicle

production. Boosting the mobility of army units was a general aim of most armed forces after 1920. Increasing car ownership and the number of trucks in Germany was considered desirable because private vehicles could be confiscated in wartime. Indeed, the invasion of France used some 15,000 trucks requisitioned from private industry (Vahrenkamp 2010).

### *2.b 1933 Elections and the 1934 Plebiscite*

We use two principal measures of Nazi support at the polls – votes for the NSDAP in November 1933, and the share of ”yes”-votes in the plebiscite in 1934. In addition, we use the NSDAP vote share from the March 1933 election in a placebo exercise. Figure 3 illustrates the timeline of elections and highway building.

When Germans went to the polls in March 1933, the Hitler government had already been in power for over a month. Nonetheless, elections were still relatively fair, with intimidation at the polls limited compared to what happened on later occasions. Except for the Communist Party, which had been banned, all parties that had competed during the last free election in November 1932 were still on the ballot paper in March 1933. Despite a massive propaganda campaign, the NSDAP failed to win an absolute majority, receiving 44 percent of the total vote.

In November 1933, the regime held fresh elections. Over the summer, all parties except the NSDAP had been banned. In addition to Nazi MPs, the NSDAP list before the voters also contained 22 “guests” – mostly prominent members of the right-wing elite who were largely aligned with the party’s aims, and were asked to participate to give the new parliament marginally broader representation.[15] On average, the Nazi Party won 92 percent of the popular vote, more than doubling its vote share from March.

Voting in November 1933 was not free and fair; storm troopers collected many voters at home if they had failed to show up, and they stood guard at the voting booths. There, citizens were strongly “encouraged” to vote publicly so that everyone could witness their support of the Nazi regime. Evans (2006), commenting on elections under the Nazis, observes that

> “Intimidation was particularly evident during the national plebiscites and elections that Hitler held from time to time… Under the Third Reich, plebiscites and

[15] In parallel with the parliamentary election, voters were also asked to approve Germany’s leaving the League of Nations. This proposal was wildly popular since the League of Nations was closely associated in the minds of Germans with the (hated) Versailles settlement that saddled Germany with a massive reparations bill (Evans 2006).. The referendum received 95% support.

> elections became propaganda exercises in which the regime mobilized the electorate, by all means at its disposal, to provide the appearance of popular legitimacy for controversial measures."

Despite these intimidation measures, opposition was not zero. On average, eight percent of all Germans voted against the Nazi list (by spoiling their ballot papers – voting "no" was not possible in Nov. 1933). In some areas, there was massive opposition – in the old Hanseatic city of Lübeck, for example, 40,824 voters failed to vote "yes" for the NSDAP list, out of 111,911 votes cast – a proportion of 36.5 percent. Hamburg and Berlin registered similar levels of dissent, with 27 and 26 percent of voters refusing to support the Nazi list. At the opposite end of the spectrum, in Pirmasens, only 218 out of 31,371 votes were spoiled – equivalent to 0.7%.[16]

The plebiscite in August 1934 followed the death of the ailing President Hindenburg in August 1934. It gave the regime the opportunity to demonstrate its popularity. The official merging of the offices of President and Chancellor removed the last de facto checks and balances that the Nazi state had inherited from the Weimar constitution. While overall support was high, and despite massive pressure on the population, the typical German town or city actually saw fewer votes in favor of the proposition to make Hitler both Chancellor and President than there had been "yes" votes for the party list in 1934 – 89.9% voted with yes.[17]

### *2.c Crisis and Entrenchment of the Nazi Dictatorship 1933-34*

> "Don't forget how people laughed at me 15 years ago when I declared that one day I would govern Germany. They laugh now, just as foolishly, when I declare that I shall remain in power!"
> (Adolf Hitler, June 1934, as cited in *Time Magazine*)

After coming to office, the Nazi leadership lost no time asserting administrative and political control. Police forces everywhere were brought under control of Nazi politicians; violence against opponents – suspected or real – was frequent in the first half of 1933 (Evans 2006). Despite its ruthlessness in seizing power, the regime was much less firmly established during its first 18 months than later. By mid-1934, matters were coming to a head. As storm troopers

[16] There are also several smaller towns where support reached 100%.

[17] While the November 1933 election and the 1934 referendum are clearly distinct, there is no obvious downward bias – right down to the end in 1945, Hitler personally was much more popular than the Nazi Party.

(SA) instituted their own kind of justice all over Germany, talk of a "second revolution" grew louder[18] – a transformation even more radical in nature than the initial seizing of power.

In response, opposition to the regime increased. Hitler and his associates had quickly dashed the hopes of conservatives that the Nazis' entry into government would increase their own mass appeal. Middle class voters who had supported the NSDAP before 1933 were appalled at the lawlessness of the SA and feared wider chaos (Behnken and Rinner 1980), and workers – never very supportive of the Nazis – were growing even more skeptical. As one leading historian of the Nazi regime put the situation in the summer of 1934:

> The moment was … critical for the regime. … enthusiasm of the 'national revolution' in 1933 had discernibly fallen off ... The brownshirts were not the only section of the population to feel disappointed .... Social Democratic agents reported to the exiled party leadership in Prague that people were apathetic, constantly complaining, and telling endless political jokes about the Nazi leaders. Nazi meetings were poorly attended … The educated classes feared that the disorder caused by the stormtroopers might spill over into chaos or, worse, Bolshevism. (Evans 2006)

As the year 1934 wore on, the Nazi leadership increasingly feared that the conservatives around von Papen and Hindenburg could join forces with the army, and overthrow the Hitler regime (Evans 2006). The increasingly senile Paul von Hindenburg was still President, and one of his personal favorites, Franz von Papen (a former Chancellor) served as Vice Chancellor. In June 1934, von Papen gave his famous Marburg speech before university students. He warned against a second revolution, decried violence and lawlessness by the SA, and condemned the personality cult of Hitler. Thereafter, his public appearances were often greeted with the shout "Heil Marburg." Time Magazine, reporting on the incident, argued that "if Adolf Hitler came home with a swelled head and hot new ideas for Dictatorship from his visit to Benito Mussolini, certainly last week he was dexterously chilled and shrunk..." and concluded that he was not a "real dictator." Thereafter, the Defence Minister, General Werner von Blomberg, threatened Hitler with the imposition of martial law and a government by the army if the SA was not brought to heel (Wheeler-Bennett 1964). Eventually, Hitler decided

[18] The SA grew out of street-fighting paramilitaries; its leaders envisioned themselves as a Nazi People's Army, and many pursued dreams of a far more left-wing agenda including wholesale nationalization of many industries ("a second revolution"). Threats to Hitler's leadership, however, were largely invented to justify the crackdown on the SA in the summer of 1934.

to murder both the leadership of the SA and influential conservatives close to Hindenburg, blaming the victims for plotting to overthrow the government (the so-called “Röhm Putsch,” after the head of the SA).

The conflicts and threats of the summer of 1934 show that the Nazi regime was still far from its later, omnipotent position, and that popular support could by no means be taken for granted. Indeed, knowledgeable observers concluded that there was "evident shakiness in high Nazi places" and that "Adolf Hitler [got] the scare of his career" (Time July 2, 1934). It is for these reasons that winning the “hearts and minds” of the population mattered, and why the regime cared about being able to showcase overwhelming popular support. It was only after Hitler became both Chancellor and President, and after an overwhelming share of the population publicly supported the Nazi government’s expanded powers, that the regime became fully entrenched.

# 3 Data

We use voting records for more than 3,000 towns and cities in 901 counties, covering the entire area of Weimar Germany (Statistisches Reichsamt 1934). These data are combined with demographic and socio-economic information from the 1925 and 1933 censuses (Falter and Hänisch 1990). To this, we add geographical information from maps of the (planned and built) German motorway network, whose construction began after the summer of 1933, as well as information on vehicle ownership and radio signal strength.

## *3.a Data on Highway Plans and Construction*

As shown in Table 1, of the 3,276 towns and cities in our sample, 2,015 were within 20 km of the planned *Autobahn* according to the general plan (shown in Figure 2). A little more than a third (1,261) were further away. Out of the 2,015 locations close to the planned network, 1,097 saw actual construction by the summer of 1934 – some 54% of the planned total.

Socio-economic characteristics differed between cities close to the highway network and those that were more peripheral. Table 2 gives an overview, showing the sample mean of a variety of socio-economic variables from the 1925 and 1933 German censuses in column 1, the average for cities within 20 km of the highway network (planned or built) in column 2, and the means for cities with and without actual highway construction, among those near the planned network (columns 3 and 4). Cities near the planned highway network were more

populous than the rest; unemployment, the blue-collar share, and industrial employment were also somewhat higher, while there were fewer Catholics than in the sample overall. The share of Jewish population was the same. Next, a comparison of columns 3 and 4 shows that construction began in those parts of the planned network that were closer to larger, more industrial cities, and in more Protestant areas. This gives rise to endogeneity concerns, because support for the Nazis also varied with socio-economic factors. In our empirical analysis we address this issue in a variety of ways, by adding explicit controls and city fixed effects, entropy balancing to create a balanced sample, and the use of least-cost-paths as an instrument for actual highway location. Importantly, pre-existing support for the Nazi regime did *not* affect systematically the location of highway construction, as shown by the balanced NSDAP vote share in March 1933 in Table 2. We explore this in more detail below, showing also that there were no differential pre-trends in Nazi support before highway construction started.

### *3.b Elections and Plebiscites*

Our main analysis focuses on the change in the share of votes supporting the Nazi regime between the November 1933 election and the 1934 plebiscite. As a proxy for initial Nazi support, we also use the NSDAP vote share in the March 1933 election – after Hitler had been appointed as Chancellor, but when other parties were still permitted at the polls. Figure 4 plots the share of "pro-Nazi" votes in the three elections we focus on. Since elections after March 1933 were no longer fair and free, the officially registered support for the regime at the polls surged until November 1933. Between November 1933 and August 1934, the share of pro-Nazi votes declined somewhat – if we want to disregard the fact that the nature of the question changed, too. The dispersion of vote shares also declined after March 1933, as the regime used intimidation and other forms of pressure to reduce measured opposition.

To make the different elections comparable, we rescale vote shares in our empirical analysis, transforming electoral 'pro-Nazi' votes for each election into a standardized variable with zero mean and unit standard deviation. In addition, we compute a broad and a narrow measure of Nazi support. The former ($NS_{broad}$) is defined as the share of yes votes relative to all *eligible* voters. This variable counts nonvoters as opposition to the Nazi regime – which in many cases is justified given the high pressure for turnout (see Section 2). The narrow measure ($NS_{narr}$) is defined as the share of yes votes relative to *actual* voters; it is thus unaffected by voter turnout

(and thus by potential unobserved spatial variation in the pressure to vote).[19] We use $NS_{broad}$ as our main outcome variable, and document the robustness of results using $NS_{narr}$.

### *3.c Radio*

Germany had a highly developed, government-owned system of radio stations, which began to broadcast regularly in the 1920s (Bausch 1956). By the 1930s, governments regularly tried to use radio programs to bolster support (Adena et al. 2015). There is detailed data on the number of radio subscribers in various parts of Germany, and on the strength of radio signals. Since the purchase of a radio subscription may itself be a function of political preferences, we follow Adena et al. (2015) and focus on signal strength – as determined by the power and location of transmitters – as a key measure. [20] We find that listenership increased sharply at a threshold of signal strength, and use this to differentiate between cities with and without good radio coverage (see Appendix A.6 for details.)

## 4 Main Empirical Results

In this section, we show that support for the Nazi regime increased significantly more where the new motorways were being built.

### *4.a Baseline results*

Before presenting econometric estimates, we first present a spatial illustration of our main finding. In the map in Figure 5, we show changes in support for the Nazi regime between November 1933 and August 1934.[21] The darker the red on the map, the greater the (residual) electoral gains of the Nazi Party. Solid black lines are roads under construction; dashed ones, roads approved but not yet being built. The map demonstrates that, on average, areas through which the new highways passed saw much greater gains in support for the Nazis than the rest. This is particularly true in East Prussia, the North of Germany, in the West around the Ruhr, and in the area around Frankfurt. While there are areas with significant increases in support

[19] Note that both measures count invalid votes as opposition to the Nazi regime. In fact, the November 1933 election did not allow for a "no" vote, or for votes for any other parties. Thus, conditional on voting, invalidating the ballot was the only way for voters to express their discontent with the Nazi regime. The 1934 referendum, in contrast, included an option to vote "no." This is another reason why the two elections are not directly comparable, motivating our use of standardized vote shares, rather than comparing levels.

[20] Ruben Enikolopov kindly provided us with signal strength output for all locations in our dataset from the implementation of the radio diffusion model in Adena et al. (2015).

[21] We plot effects after accounting for log city population and unemployment in 1933, as well as regional fixed effects corresponding to 77 administrative districts in Weimar Germany (*Regierungsbezirke*).

without road-building (such as along the shoreline of the North Sea near Holland), they are relatively rare.

Complementing the map shown above, we also find that the shift in Nazi support between November 1933 and August 1934 varied systematically with distance to highway segments under construction. However, this relationship does not hold prior to large-scale highway construction. Figure 6 shows the relationship between the building of the new highways and changes in (standardized) pro-Nazi votes before and after November 1933.[22] The left panel examines the change in Nazi support between March and November 1933. This period serves as a placebo, before highway construction began on a large scale. We find that there is essentially no relationship between distance to highways and change in Nazi support. This pattern changes dramatically after November 1933, when highway building took off: The right panel of Figure 6 shows that by August 1934, it was the areas closest to the highway that saw the biggest relative gains in Nazi support.

We now turn to the econometric analysis. We first examine whether there were pre-existing differences in voting behavior in areas traversed by highways and then compare vote shifts after highway construction began.

We estimate the relationship

$$NS_{it} = \alpha_i + \delta_t + \beta D_i + \gamma X_i + \varepsilon_{it} \quad (1)$$

where $NS_{it}$ are pro-Nazi votes in city $i$ in election $t$, $D_i$ is city $i$'s distance from the nearest highway segment under construction, $X_i$ is a vector of city-level controls, $\alpha_i$ and $\delta_t$ are city and election fixed effects (when we estimate a panel specification), and $\varepsilon_{it}$ is the error term. In panel specifications, we interact all controls with year dummies.

Table 3 presents results for three elections – the last relatively free election of March 1933, the November 1933 election when voters could only support the NSDAP or not, and the 1934 plebiscite. Again, we use standardized pro-Nazi vote shares in order to compare Nazi support across different elections and referenda. Votes for the Nazi Party in March 1933 were not significantly correlated with distance to highways that would be built from late 1933 onwards (col 1). In columns 2 and 3 we examine whether the Nazis gained more support in areas closer

[22] Given that regular scatterplots with every data point would become too crowded for visual interpretation, we use binscatter plots, grouping the x-axis into 25 equal-sized bins. To allow for a more immediate interpretation of the x-axis, we use distance in km, rather than log-km. Results are very similar when we use logs instead.

to the highway in the subsequent two elections (note that the regressions control for initial support, so that we effectively examine changes). Until November 1933, before highway construction had started on a large scale, highways are not associated with gains in support for the Nazis. It is only in the August 1934 referendum that we find a strong and significant (negative) relationship between distance to highway and pro-Nazi voting. Going from a distance of 1 km to 100 km is associated with a reduction in support by 0.27 standard deviations in the dependent variable – equivalent to one-fifth of the overall opposition to the Nazi Party. This implies that with the highway being built nearby, the median city in terms of support change, ranked 1,615 (Bremen) would have moved up more than 500 ranks, to the 1,095$^{th}$ highest increase in our sample of 3,230 cities.[23]

The difference between the coefficients in March/November 1933 and August 1934 is crucial for our argument. It implies that distance from the highway only becomes a predictor of Nazi support after construction began in earnest – after November 1933. Thus, the March and November 1933 elections effectively serve as placebos. The non-results for March and November 1933 also imply that *Autobahn* construction was not used to reward districts with strong previous support for the Nazis; in other words, `favoritism' in the sense of Burgess et al.'s (2015) finding for Kenya is probably not present in our data.

### *4.b Panel results*

The regressions in Table 3 are based on cross-sectional data only and could thus be confounded by city-level unobservables. To address this issue, we perform panel regressions in Table 4, controlling for city-level fixed effects. In columns 1-4, we pool election data on the success of the Nazi Party from the early years of dictatorship (1933-34). We find a negative and significant coefficient on distance to highway construction only for the August 1934 election; for all earlier elections, the interaction with the highway distance variable reveals no statistically significant or economically meaningful relationship. These results are robust and hold when we only include city and election year fixed effects (col 1), when we interact our baseline controls (population and unemployment) with year dummies (col 2),

[23] Our calculation here differs from the one in the introduction, where we used the difference between effects at various distances from non-parametric estimation. In addition, we control for various potential confounders, reducing effect size.

when adding lagged Nazi Party votes (col 3), and when we add interactions of additional socio-economic controls with the year dummies (col 4).

In the last two columns in Table 4, we use data from all elections with city level data during the period 1924-34.[24] We estimate both with fixed effects only (col 5), and with extended controls and lagged Nazi votes (col 6). Again, the 1934 referendum is the only period that shows a statistically significant relationship between Nazi support and distance to highway construction.

Overall, there is no evidence that Nazi support was either high (Table 3, col. 1) or already growing (Table 4) in places where highways were (later) built. Instead, the entire effect of highway construction on electoral outcomes appears quite suddenly, and only for the period November 1933–August 1934. For this reason, we focus on this period in the empirical analysis that follows.

### *4.c Change in Nazi support, November '33 – August '34*

In the following, we estimate regressions of the form:

$$\Delta NS_i = \alpha + \beta D_i + \gamma X_i + \varepsilon_i \qquad (2)$$

where $\Delta NS_i$ is the change in (standardized) pro-Nazi votes between November 1933 and August 1934 in city $i$, $D_i$ is its distance to the nearest highway segment under construction, $X_i$ is a vector of controls, $\alpha$ is a constant, and $\varepsilon_i$ is the error term. If $D_i$ was randomly assigned, $\beta$ would reflect the causal effect of motorway building on support for the Nazi regime. We present OLS results first, and then discuss potential challenges to identification.

In Table 5, we first show the simplest specification, without controls, in column 1. We find a negative and highly significant coefficient on distance to highways. In column 2, we add our baseline controls as well as initial support for the Nazis in November 1933. The coefficient on highways declines but remains highly significant, and it rises again when we add fixed effects for 77 administrative districts in col 3. Adding the latter means that we exploit only the distance to the highway within each district, differencing out any regionally-based shifts in voting patterns. Our results in column 3 thus imply that, relative to all the other towns in

[24] The NSDAP was banned from the 1924 election as a result of the failed Beerhall putsch. Members of the banned NSDAP reconstituted themselves as a party under the label NSFP, which put forward joint lists with the DVFP. The DVFP absorbed much of the Nazi vote in the May 1924 election (Striesow 1981), and we use its standardized vote share in the panel in 1924.

the same district, those closest to the new highways saw particularly large gains in Nazi support.

In terms of control variables, the negative coefficient on initial pro-Nazi votes in November 1933 is significant and negative, which is probably due to the mechanical effect – places with close-to-100% support could hardly gain additional votes. The coefficient on city population size is negative and significant – more populous places saw less of an increase in Nazi support. Finally, the coefficient on unemployment is ambiguous, switching signs and becoming insignificant when we add district fixed effects.

In col 4, we add additional socio-economic controls – the share of blue-collar workers, of Jews, of Catholics, and of industrial workers – the significance of the distance variable is not affected, but it declines in size. Finally, we define a dichotomous variable that takes on value one for towns or cities that were within 20 km of highways under construction, and zero otherwise. In the specification with baseline controls only (col 5), this suggests an increase in support by 0.12 standard deviations if a town was close to the *Autobahn.* In the most restrictive specification – after controlling for fixed effects and all socio-economic variables – we still find an increase in support by 0.05 standard deviations. In Appendix A.2, we show that alternative cut-offs for distance to highways lead to very similar results.

### *4.d Aggregate impact*

How many hearts and minds did the highway win? There were two effects overall – the general increase in support that this popular policy created, and the location-specific effect that we identify through spatial variation. We can only measure the second, by calculating a proxy for the counterfactual vote in the absence of highway construction.

We use our estimates of the (log) distance to nearest highway construction from Table 5, which implies a decline in Nazi support by approximately 0.3-0.5 percentage points (or 0.4-0.1 standard deviations) for each log point increase in distance from highway construction. Then, for each location, we can calculate its predicted change in Nazi support corresponding to its actual log distance to highway construction, and multiply this with the number of eligible voters. This gives, for each location, the shift in votes that is associated with highway construction. This approach implies an increase in Nazi support by 210,000 to 390,000 votes. Thus, our results imply that in the absence of highway construction, instead of the 3.6 million ”no” votes received by the regime in August 1934, opposition would have reached at

least 3.8-4 million. In other words, counterfactual opposition would have been 6-11% higher than it actually was without the highways, and the regime would have had to admit to a much sharper decline in support over the preceding nine months than actually occurred. Note that these figures are a lower bound; aggregate effects of the highway are not captured by this distance-based analysis.

# 5 Channels

Why did the *Autobahn* succeed in winning "hearts and minds"? To gain insight into likely mechanisms, we first show that one alternative interpretation of our results – differential intimidation and manipulation – is unlikely. We then look at evidence for direct economic or other "use" benefits of highway construction. Finally, we analyze if there are alternative channels, such as road building as a signal of government 'competence'.

## *5.a Intimidation and manipulation*

One obvious concern with our data is that (changes in) votes reflect the regime's repressive activities rather than voter preferences. For example, public officials may have been under greater pressure to show that "their" districts supported the regime if the new highways passed through their constituency, leading to more intimidation at the polling station. We point to three empirical regularities that make this unlikely.

First, the modal German municipality saw a *decline* in Nazi support between November 1933 and August 1934. The differential outperformance of municipalities close to highways comes (on average) from smaller declines, and not from larger increases in support. If local party bosses forged results, it made little sense to do so and then still show declining support for the regime. This directly contradicts the alternative interpretation that the party was simply in a better position to manipulate results in places where highways were being built.

Second, as we show below, areas with poor radio coverage showed no effects of highway building. It was only in areas with good radio reception that highway building was associated with greater support. Differential increases in the ability to manipulate and intimidate were not dependent on the radio – local party bosses, if they profited from highway construction in terms of power, would have done so with or without radio signal strength. This makes it highly unlikely that road construction itself led to greater intimidation or more manipulation of voting results.

Third, the Nazi regime brought intense pressure to bear on the population to vote in its favor – supporting the party and saying "yes" in the referenda. Higher turnout can, of course, be a sign of genuine support – or it can reflect intimidation. Voter turnout, in turn, affects our broad measure of Nazi support (pro-Nazi votes relative to *eligible* voters). To tackle this issue, we use an alternative, narrow measure for change in Nazi support (pro-Nazi votes relative to *actual* voters), which is unaffected by voter turnout. Table A.6 in the appendix shows that we confirm our OLS, IV, and restricted sample results when using this alternative measure for Nazi support.[25]

Could our results be driven by manipulation of votes after the election? There is no simple way to detect manipulation in electoral data. Several methods have been proposed, and only confirming evidence across a range of indicators is typically considered clear proof of manipulation (Hicken and Mebane 2015). We implement four tests proposed by Hicken and Mebane (2015):

1. **2BL:** Benford's Law – the empirical regularity that lower digits occur more often than higher digits in most sets of numerical data (such as the set of city population sizes of a country).[26]
2. **LastC:** Beber and Scacco (2012) point out that, without manipulation, values of the final digit of the vote count in an unmanipulated election should be distributed uniformly.
3. **C05s:** A binary variable is constructed that takes value one when the vote count for the winning party is either 0 or 5. In a variant of the Beber and Scacco argument, the expected value of this dummy should be 0.2.
4. **P05s:** This test looks at the final digit of the rounded percentage of votes for the winning party. An overabundance of zeros and fives may signal to authorities that vote counters have complied with their superiors and fulfilled their duty of providing fraudulent results. A mean greater than 0.2 of this variable may indicate fraud.

Figure 7 visualizes the statistics corresponding to the four tests, using deviation from mean tests with bootstrapped confidence intervals (the corresponding numbers are shown in Table A.2 in the appendix). We find no systematic evidence of violations across the four tests: none of the means in the full sample ("all") differs significantly from the expected value in the

[25] Total turnout grew by 0.3% in places without the highway, and by 0.6% in those within 50km of highway construction. Even if everyone pressed to vote was also forced to vote Nazi, this cannot have accounted for more than a 0.3% gain in the yes-share. The actual gain is 1.4% in the 50km band around the highway (and if we examine the co-movement of turnout and yes-votes in general, the implied gain from pushing up turnout by 0.3% is even smaller).

[26] Previous papers using Benford's Law to detect electoral fraud include Pericchi and Torres (2011) and Mebane (2006). The method itself is controversial (Deckert et al. 2011).

absence of fraud (shown by the horizontal line in each panel of Figure 7). We also present results for the subsamples with below- and above-median proximity to highway construction ("close" and "far", respectively). Only in one case – the 2BL test for the 1934 election – is the test statistic significantly different from the expected value under "no fraud." But even in this case, the test value does not differ significantly between the subsamples that are close vs. far from highways under construction. For all remaining election forensics tests, the statistics are tightly distributed around the expected values under "no fraud."

In their survey, Hicken and Mebane (2015, p.39) argue that "an election fraud will not necessarily trigger all of the statistics and tests, but we think a genuine fraud will in general set off many of them." Given that *none* of the test results shows that locations close to the highway had more fraud, we are confident that our results are not driven by manipulation.[27]

### *5.b Direct benefits of highway construction*

If manipulation and intimidation were not responsible for vote gains in areas of road construction, what was? We examine under which conditions highway building was associated with greater swings in favor of the Nazi regime. In Table 6, we split the sample into above- and below-median observations in terms of unemployment and vehicle density.

If the economic benefits of highway construction were key in garnering support, we should expect that it created larger gains in areas where economic distress during the Great Depression was most severe. We do not find evidence for this mechanism – cols 1 and 2 in Table 6 show very similar highway coefficients for cities with low and high unemployment.[28]

Direct effects could also come through vehicle ownership and the greater use-value of automobiles. Germany as a whole had quite low vehicle ownership, with only 674,000 cars on the road (including buses) in 1934, plus another 984,000 motorcycles – equivalent to 10

[27] In Appendix A.3, we present results that go beyond the mean-comparison tests proposed by Hicken and Mebane (2015). For 2BL and LastC, we present chi-square tests that examine whether the whole distribution deviates from Benford's Law and uniform, respectively. The 2BL chi-square test suggests fraud overall, but there is no evidence for *differential* fraud by distance to highways. The reliability of this test, however, is questionable since it may also reflect other factors such as the grouping of voters into aggregation units (see Hicken and Mebane 2015 and the sources cited therein). The LastC chi-square test, in turn, shows no indication whatsoever for election fraud (with p-values close to one in the 1934 referendum).

[28] Nonetheless, it is possible that there were some local demand effects from highway construction. Workers were initially housed in private homes in the villages and towns where the roads were being built; accommodation in barracks came later. In addition, those employed in building the highway also spent money in local inns and shops (Eichner-Ramm 2008). There were also other local benefits: construction crews organized film showings, and construction sites became a popular destination for weekend trips.

cars and 15 motorcycles per 1,000. Any benefits from using these vehicles would have had to be anticipated in August 1934, since new roads only opened from 1935 onwards. In cols 3 and 4 of Table 6, we stratify the sample by the density of motor vehicles (including buses, motorcycles, and cars, available at the province level from Frik 2004). There is no evidence of greater electoral gains in areas with higher vehicle ownership; the coefficients on distance to highway are very similar and (marginally) significant in both subsamples. Our results thus suggest that direct economic benefits are unlikely to account for the effect of highway construction on local Nazi support.

### *5.c Propaganda and "competence"*

Next, we examine an alternative hypothesis – that highway building convinced people of the regime's competence. For this to be true, the new roads' construction had to be framed as a major accomplishment of the regime, and one that signaled it having the population's best interests at heart. We therefore expect that, if this supposition is true, there would be a synergy between road building and exposure to government propaganda. A preliminary look at the data suggests that this is in fact the case. To proxy for propaganda, we use the Nazi regime's most powerful tool – the radio. In towns and cities that were close to highway construction (<50 km distance) but did not have radio coverage, Nazi support increased by 2.7 standard deviations. [29] Where highway construction overlapped with radio availability, support increased by 6.3 std. On the other hand, in towns that had neither radio coverage nor highway construction, Nazi support *declined* by 8.1 std.

Table 7 analyzes the relationship between radio coverage, highway construction, and Nazi vote gains more systematically. First, in col 1, we examine gains in Nazi support between March and November 1933, before highway construction began in earnest. While we confirm our previous non-result for distance to highways (see Tables 3 and 4), we find a positive coefficient on radio coverage. In the remaining columns, we return to our main outcome variable, the change in Nazi support between November 1933 and August 1934. In column 2, we show that our main result is robust to controlling for radio coverage. Next, we further refine the analysis: the lower tercile of signal strength was inadequate for radio reception except for enthusiasts (see Appendix A.6). We use this to split the sample into cities where

[29] To proxy for radio coverage, we follow Adena et al. (2015) in using a nonlinear prediction of the radio subscriber share, based on radio signal strength. This procedure is explained in Appendix A.6.

the signal was strong enough for radio reception, and the remainder, where people were unlikely to listen to the radio. For the former, we find strong coefficients on both highway construction and radio coverage (col 3), and for the latter, a very small coefficient on distance to highways under construction, and a negative insignificant effect of radio coverage (col 4). The same pattern holds when we use a dummy for nearby highway construction instead of distance (cols 5 and 6). The p-values reported in Table 7 show that the coefficients on highway construction are significantly larger in cities with radio coverage. This suggests that proximity of the *Autobahn* had a larger effect on electoral support when combined with radio propaganda – which turned every segment opening and every "round" number of kilometers completed into a major media event.[30]

While we cannot pin down exactly the mechanism through which highway building boosted support for the nascent Nazi dictatorship, the evidence presented in this section is suggestive. It indicates that direct economic and utilitarian benefits were probably second-order – neither the severity of unemployment at its peak nor the density of car ownership amplified the popularity-boosting effect of the *Autobahn.* In contrast, where the new roads were being built and coincided with easy access to Goebbels' propaganda spread via radio, the Nazi regime received a particular boost from road-building.

# 6 Identification

We first exploit differences in the timing of construction. We show that even within a narrowly defined sample – areas with planned highways – we find a strong relationship between actual construction and Nazi support. Second, we instrument actual highway construction between given city pairs with terrain characteristics that made road building technically feasible and cheaper; terminal cities themselves are excluded from the regressions. We continue to find large and significant effects.

## *6.a Sample Restriction – Areas with Planned Highways*

So far, we have compared locations close to actual highway construction with all other places in Germany. To provide further evidence that it is *construction* of highways that influenced

[30] Radio signal strength and highway construction are strongly correlated (with a coefficient of 0.378). This renders an analysis with interaction terms infeasible due to multicollinearity.

voting, we examine the impact of distance to *planned* highways, and we restrict the sample to areas designated for highway building.

In Table 8, col 1, we add the minimum distance to any type of highway segment (planned, approved for construction, or under construction) to our specification. The corresponding coefficient is small, positive, and insignificant, while the coefficient on distance to highway under construction remains quantitatively unchanged (compared to our main results in Table 5) and statistically highly significant. If we limit the sample to locations within 20 km of any type of highway segment, we exclude about 1,000 towns and cities in our sample. Nevertheless, the coefficient on distance to highway under construction remains large and significant with and without controls (cols 2 and 3). If we use a simple dichotomous variable for highway construction within 20 km, we find that this is associated with pro-Nazi votes increasing by 0.23 standard deviations in the basic specification (col 4); when adding district fixed effects and all controls, it still adds 0.06 standard deviations to Nazi support (col 5). When we narrow the sample further, to those places within 5 km of the highway, we find an even bigger coefficient – an increase in Nazi support by 0.12 standard deviations, after the use of all controls and district fixed effects (col 6).

### *6.b IV-Results: Least Cost Paths*

The Nazi regime, in planning its network, had to decide which cities to connect – and where the road would run between them. Our results could be affected by endogeneity bias if the Nazis targeted areas that were more likely to increase their support for the regime even in the absence of highway construction. The Nazis could also have planned and built highways to reward (newly) loyal districts, or strong local Nazi officials may have been more successful at both attracting the highway and swaying voters. On the other hand, OLS results could also be downward biased, if Nazi officials built highways where it was particularly difficult to win new supporters. Endogeneity concerns cannot be dismissed out of hand – for example, Hitler himself intervened in the planning of the road from Munich to Salzburg (Vahrenkamp 2010).

To address possible endogeneity bias, we instrument for actual highway building with least-costs paths. Road construction cost is highly sensitive to the slope of the traversed terrain. We use the *Cost Path* tool in ArcGIS to calculate the cheapest way to connect city pairs that appear in official German publications as terminal cities that were to be connected in the first wave

of highway construction.[31] Figure 8 plots least-cost paths (LCPs) and actual highway construction that began before August 1934. They coincide to a large extent. Even where the LCP does not coincide exactly with the actual trajectory of the highway, differences are often small. The only larger deviations are in North Germany, where the terrain is generally flat and small differences in cost can lead to quite different paths.

Least cost paths have substantial explanatory power for actual highway construction: Out of the 3,276 towns and cities in our sample, about one-half (1,602) lie within 20 km of a least cost path. Of these, 1,404 (87.6%) also lie within 20 km of the actually planned highway network, and 914 (57.1%) of them saw actual construction activity by the summer of 1934. In contrast, of the 1,674 towns and cities that were more than 20 km away from least-cost paths, only 183 (10.9%) saw construction.

Our instrumental variable is the distance of each city from the least cost paths (LCPs). Crucially, all regressions exclude the 38 terminal cities, i.e., the end points between which LCPs are computed. Before presenting our IV results, we briefly discuss their interpretation. Importantly, least cost paths affect the *planning* of highways, while the electoral effects we are interested in are due to actual *construction*, or approved segments where construction was imminent and foreseeable to the local voters (see Section 7.b below). Planning of highways translated into highway construction in *some* districts by 1934 – depending on the timing of construction. Our IV strategy estimates the average effect of highway construction on pro-Nazi votes for those cities whose 'treatment status' (proximity to highway construction) was affected by the instrument (proximity to LCPs). Using common IV terminology, we estimate the average treatment effect for "compliers" (cities where proximity to LCPs did results in construction). In contrast, cities close to LCPs where no construction occurred by 1934 ("never-takers") do not affect our estimate; nevertheless, "never-takers" influence the

[31] We compute least-cost paths for all 38 city-pair connections listed in Jahnke (1936). See Appendix A.1 for details. Related work using geographical characteristics or earlier transport infrastructure for identification includes Baum-Snow (2007), Donaldson and Hornbeck (2015), Banerjee et al. (2012), and Faber (2014). We do not use the network analysis as implemented by Faber (2014), for example, who uses Kruskal's minimum spanning tree algorithm to pin down a cost minimizing network structure. As Figure 2 confirms, the Nazi building of the Autobahn did not follow a network logic, with an increasing set of cities connected to existing roads. Instead, the regime initially connected city pairs, and it started to build in multiple disconnected locations all over the country – delaying the opening of the first useable road, but making the project more visible.

reduced-form relationship between LCPs and pro-Nazi votes, as we discuss when interpreting our results.

Table 9 presents our IV results. We first show results for the reduced form, regressing change in support for the Nazi Party on distance to LCPs. We find strong and significant negative coefficients, both without controls (col 1) and with the full set of controls (col 2). Next, we demonstrate the strength of our instrument (cols 3 and 4). The first stage is powerful, with F-statistics above 500. We find highly significant coefficients on instrumented distance to highways in the second stage (cols 5+6). The coefficients are of similar magnitude as our OLS estimates in Table 5. Comparing the magnitude of our second-stage estimates with the reduced form (cols 1 and 2), the latter is about one-third in size. This is consistent with our first-stage estimates: According to the coefficient on LCPs in cols 3 and 4 (which reflect elasticities), doubling the distance to LCPs leads to an increase in average distance to actual construction by one-third. In other words – in terms of distance – the share of "compliers" (cities that saw highway construction because of their proximity to LCPs) among all cities near LCPs is about one-third. Consequently, we should expect the average change in Nazi support due to distance to LCPs to be one-third of its counterpart for "compliers" – i.e., the average treatment effect of highway construction reported in columns 5 and 6. Figure A.4 in the appendix provides further support for the interpretation of our IV results as *local* average treatment effects. It shows that Nazi support increased significantly for compliers, while there is no change in votes for non-compliers.

# 7 Robustness

In this section, we provide additional robustness checks. We examine issues of balancedness and address the potential endogeneity of terminal cities for the highways. We also present results from placebo tests, different measures of distance to highways, and we use matching estimation. The majority of tables reporting robustness checks are shown in the appendix, but their results and interpretation are summarized in the main text.

## *7.a Balancing the Sample*

As we discussed above, covariates are not balanced when comparing cities with and without highway construction (see Table 2). In Table 10, we address this issue by using entropy weighting to effectively create a balanced sample. This method follows Hainmueller (2012);

to implement it, we use the 20 km distance threshold to define the treatment and control group. Entropy balancing reweights the control group data (cities with more than 20 km distance to highway construction) to match the mean of covariates in the 'treatment group' (cities within 20 km of highway construction).[32] We confirm the magnitude and significance of our main result in the full sample (cols 1 and 2). In addition, in column 3 of Table 10, we restrict the sample to cities within 20 km of any highway. There, entropy weighting creates a balanced control group from all cities that saw approved or planned (but no actual) construction within 20 km. We obtain very similar results in this more restrictive specification.

### *7.b Highways approved for construction*

So far, we have focused on the distance to highway segments *under construction*. The map shown in Figure 2 also contains segments that were approved for building, but that were not yet listed as "under construction." As discussed in Section 2.a, the transition between the two is fluid – approved segments likely had engineers staking out the trajectories, and the public knew that the highway was coming. In Table A.7, we use both the distance to highways under construction, and to approved highway segments. The two distances are highly correlated since approved segments typically connect to those under construction. Thus, the results need to be interpreted with caution. Overall, we find that our results on Nazi support do not differ crucially between highway segments under construction and those approved for construction. We ultimately cannot differentiate whether this is due to imprecision in the maps (as discussed in Section 2.a), or because the expectation of the highway's arrival had the same effect as actual construction. If the latter drives the results, this would support our interpretation that highways affected Nazi support mainly via signaling competence in promoting economic progress, as opposed to via immediate local economic effects.

### *7.c "Top 20" highway network*

In Section 6.b (Table 9), we used a set of terminal cities from a Nazi-era publication as nodes for the new highway network. Constructing least cost paths between them, we showed that they have high predictive power for where the actual roads ran. One question that could be asked is whether the nodes themselves might have been chosen so as to expose the cities *between them* to highway construction. To gain a sense of an 'objective' highway network

[32] Table A.5 in the appendix shows that entropy balancing delivers an almost perfectly balanced control group, with the mean of all correlates deviating by less than 0.1% from the corresponding mean in the treated group.

that most sensible road planners would have built, we start with the assumption that connecting the largest 20 cities was a given. Even *if* the Nazi leadership had picked terminal cities to influence population voting in towns in between – an inherently unlikely proposition – it would always have built connections between the country's largest cities. We compute LCPs only for those connections listed in Jahnke (1936) where both terminal cities belong to the top-20 in terms of population in 1933. This reduces the number of city pairs from 38 to 18. In Table A.4 in the appendix, we repeat our IV analysis from Section 6.b, using only "top-20" least-cost path connections.[33] We find strong and highly significant results that closely resemble those from Table 9 above. By limiting us only to the most obvious part of the highway network, we can sidestep concerns about the selection of cities on the list of included nodes.

### *7.d Sample splits*

Table 2 showed that cities with and without highway construction differed along several dimensions: pre-existing voting preferences, population size, unemployment, industrial employment, and the share of Catholics. We partially addressed this issue above in Section 7.a, using entropy balancing. In Table 11, we provide additional results, stratifying the sample by the most important control variables. Throughout, we report p-values for the null that coefficients in the respective subsamples are the same.

Table 11, panel A, stratifies the sample by the political preferences in March 1933. Where the Nazi Party was already polling strongly, the highway made less of a difference – the coefficient on distance to highway construction is significantly smaller in col 2, compared to col 1. The opposite is true for areas with substantial support for parties in the political center (SPD, Zentrum, and BVP). Here, the highway worked particularly well as a tool to change the voting behavior of the population (as shown by the significantly larger coefficient in col 4, as compared to col 3). In areas with massive Communist support, however, highway worked less well – vote gains were less affected by distance to the *Autobahn* (cols 5 and 6).

[33] There is still substantial overlap between the top-20 network and 1934 building: Out of the 1,052 cities that lie within 20 km of the "top 20" LCPs, and 668 (63.50%) saw actual construction activity by the summer of 1934. In contrast, of the 2,224 towns and cities that were more than 20 km away from "top-20" LCPs, only 429 (19.3%) saw construction.

This suggests that the highways were less effective in overcoming opposition at the opposite ideological extreme.[34]

In panel B of Table 11, we stratify by religious composition and city size. Where Catholics were more numerous than average, highway building led to particularly high gains in August 1934 (cols 1 and 2). Catholics had been much more resistant to the Nazi message than Protestants until 1933, in part because they had their own party representing their interests, the Zentrum (Falter 1991), but also because the Catholic Church warned about the dangers of National Socialism (Spenkuch and Tillmann 2016). However, Catholics were not as fervently opposed to the Nazi regime as communists. Catholics constitute an important part of the moderate voters represented in cols 3 and 4 of panel A. Thus, the results here underline that highways seem to have influenced voters closer to the political middle.[35] Jews accounted for only half a percent of the German population; there is no difference in changes in support for the Nazi Party depending on their population share (cols 3 and 4 in Panel B of Table 11). There is also no difference by city size – additional vote gains for the Nazis were as big in small towns as in big cities when they were close to the highway (cols 5 and 6).

### *7.e Placebo tests*

To ensure that our regressions do not pick up the effect of geographical features associated with transport infrastructure (which may have benefited disproportionately from a general revival of economic conditions), we also perform placebo regressions. In Table A.8 in the appendix, we use two other forms of transport in exactly the same way as the *Autobahn* – rivers, and railways.[36] We find no consistent association between distance to these alternative means of transport and support for the Nazi Party. This makes it unlikely that the highway

[34] We find further support for this interpretation when stratifying our sample by socio-economic characteristics that were associated with strong opposition to the Nazi regime: Areas with above-median blue-collar workers or industrial workers (the main recruiting ground for the Communist Party) also show significantly smaller effects of *Autobahn* construction.

[35] Note that in our baseline results, the share of Catholics is strongly *negatively* related to the Nazi vote gain between Nov 1933 and Aug 1934 (see col 4 in Table 5). This makes it unlikely that our results are confounded by convergence of Nazi support in Catholic areas. The data suggest that this convergence had already happened between March and Nov 1933 – over this period, Nazi vote gains are strongly positively related to the share of Catholics.

[36] We take data on historical trajectories of canals and railways from HGIS – the historical information system for Germany. For each town, we code up distance to the nearest railway line or river.

effects simply capture a general swing of voters towards the Nazis in locations with good communications and access to transport infrastructure.

### *7.f Matching results and spatial correlation*

To demonstrate that our results are not driven by violations of the linearity assumption, and to further address unobserved heterogeneity, we also perform nearest-neighbor matching. We match with two sets of variables – the baseline controls (log population, unemployment in 1933, and Nazi Party support in 11/1933), and the extended set (which adds socioeconomic factors such as the share of Jews, of Catholics, of industrial employment, and of blue collar workers). We use either 3-neighbor-matching or 1-neighbor, to form comparison groups with a high degree of similarity in control variables. In addition, we restrict the control group to cities from the same district (77 *Regierungsbezirke*) as the treated observation. We also experiment with defining towns and cities within either 20 km or 5 km of the highway as treated, and we restrict the range of locations from which propensity score neighbors can be drawn to cities in the vicinity of the overall planned highway network. In all specifications, we find large, significant effects. The results are reported in Table A.9 and discussed in more detail in the appendix. Matching estimation suggests that places "treated" with the highway show 0.1 to 0.18 standard deviations higher increases in support for the Nazi Party overall, confirming the magnitude of our OLS estimates.

Our estimation results may be affected by spatial correlation – adjacent cities that are "treated" by highway construction may not constitute independent observations. To correct for this possibility, Table A.10 in the appendix repeats our baseline analysis for distance to highways under construction, using a weighting matrix that is based on each city's geographic location. We obtain results that are very similar to our baseline findings, both in terms of magnitude and statistical significance.

## 8 Conclusion

We examine whether a major, nationwide infrastructure project can boost electoral support, turning to one of the most famous examples of road-building in history – the construction of the high-speed road network in Germany after 1933. Construction began shortly after Hitler came to power. We find strong evidence that building the *Autobahn* created an important electoral boost for the regime.

While "only" 44% of Germans voted for the Nazi government in March 1933, it went on to become one of the most popular regimes in history.[37] The transition towards popularity was not smooth. In 1934, the regime was heading towards a crisis as conservatives, middle class citizens, and workers became increasingly restless. The plebiscite of August 1934 – unifying the leadership of Germany in the hands of Hitler – marked a turning point. Thereafter, any hopes of successful internal opposition were remote. The plebiscite was important in showcasing massive support for the regime and for the leadership of Adolf Hitler.

The share of yes-votes in the frequent plebiscites cannot be taken as a direct measure of overall support for the Hitler government. Instead, we argue that cross-sectional differences in changes over time are informative. We examine the size of the electoral swing in favor of the regime during a relatively short period of time – between November 1933 and August 1934, when highway construction began in earnest. We find that support for the nascent dictatorship increased significantly in towns and cities close to the *Autobahn*.

The effects are both large and likely to be causal. We confirm our results when we predict where road-building should occur based on terrain features and the associated cost of construction. We also show that distance to the 1934 *Autobahn* construction is unrelated to Nazi support in prior elections, before highway construction began, and that other transport infrastructure does not have similar predictive power.

Why did motorway building reduce opposition to the regime? Car owners were few and far between, and the roads did not open to traffic before 1935. This rules out direct benefits as a major source of support. The Nazi regime prioritized road-building as an economic stimulus measure. Original plans were for 600,000 workers to be employed; the actual maximum was around 120,000. Economic benefits in the aggregate were probably modest (Ritschl 1998, 2003). Nonetheless, the regime succeeded in convincing the German public (and many foreign observers, including John Maynard Keynes) that the *Autobahn* played an important role in reducing unemployment. The *Autobahn* seemingly demonstrated the new government's determination and abilities in a convincing fashion, along the lines of Rogoff

[37] Electoral results are, of course, not informative. Reports from opposition agents within the Reich, however, as well as the internal assessments by the regime's SD (security service) show massive support for the regime in the late 1930s (Behnken and Rinner 1980; Boberach 1984).

(1990). In other words, the *Autobahn* showcased Nazi Germany's ruthless energy and organizational capabilities, as Hitler promised in his speech inaugurating the project.

After the perceived incompetence and chaos of Weimar politics, many Germans were impressed by the *Autobahn's* rapid progress. The motorways were called "roads of the *Führer*," and the regime lost no time connecting the declining unemployment rate with its public works programs. While perceived competence affected voting in the country as a whole, the regime's accomplishments were visible in districts where the Autobahn was being built. There, the regime scored its greatest successes – and all the more so if radio coverage was good. This implies that local highway construction was particularly persuasive where voters associated it with nationwide progress, as emphasized by radio propaganda. Our results suggest that infrastructure projects can indeed create electoral support for a nascent dictatorship, winning the "hearts and minds" of the populace – and that they are particularly effective when combined with a powerful propaganda message.

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# FIGURES

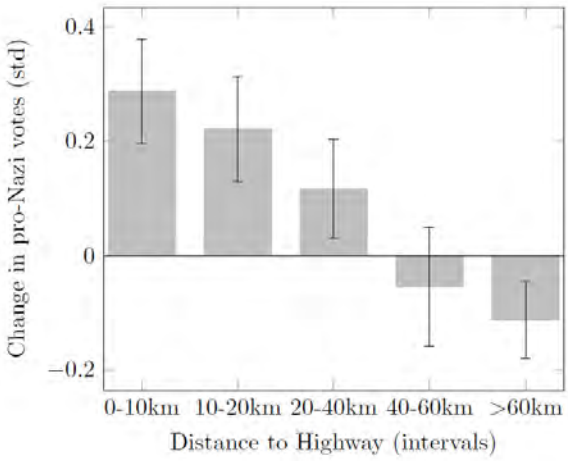


Figure 1: Change in Nazi support, Nov. 33 and Aug. 34, by distance to highway

Note: The figure shows the difference in standardized pro-Nazi votes between the November 1933 election and the August 1934 referendum, for different distance brackets to highway segments under construction (approximately corresponding to distance quintiles). Bars indicate the average change in (standardized) Nazi support; the black lines, the 95% confidence interval.

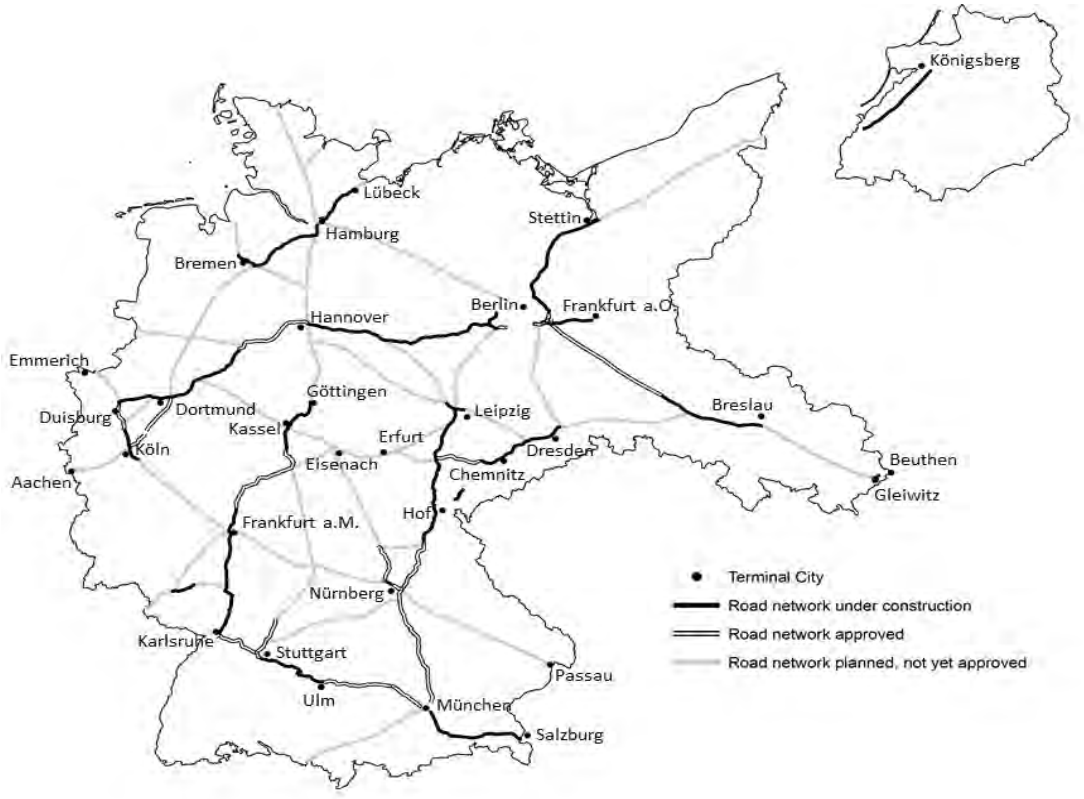


Figure 2: German Highway Network by 1934

*Note*: Location of highway segments from Todt (1934). Map geo-coded by authors.

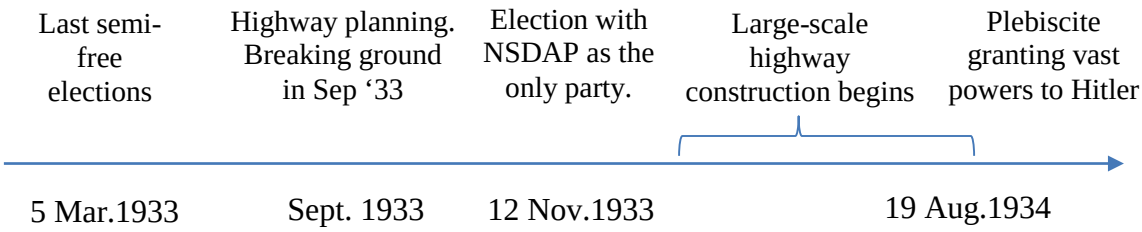


Figure 3: Timeline of events

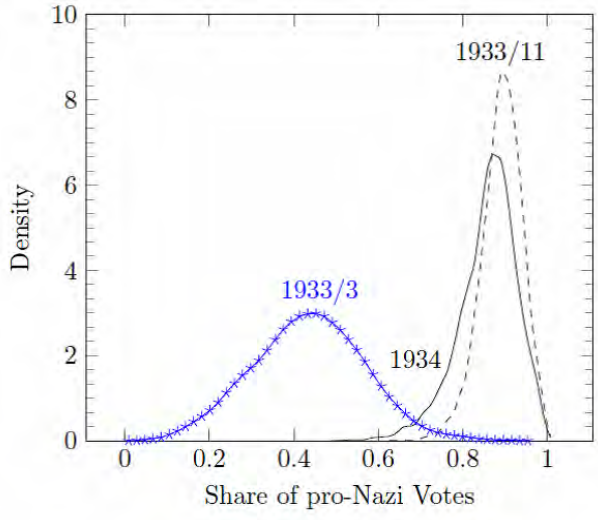


Figure 4: Support for the Nazi Regime, 1933-34

Figure 5: Shift in favor of the Nazi Regime between Nov. 33 and Aug. 34

Note: The figure shows the difference in standardized pro-Nazi votes between the November 1933 election and the August 1934 referendum, after controlling for city population, unemployment, and fixed effects for 77 administrative districts (*Regierungsbezirke*). Small white dots in the figure indicate towns and cities in our dataset.

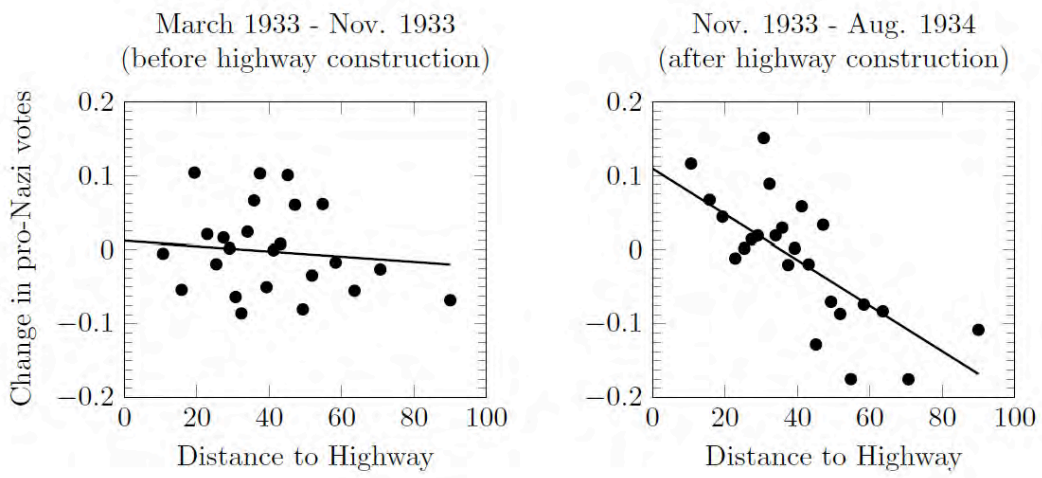


Figure 6**:** Change in pro-Nazi votes, before and after highway construction began

Note: The figure shows the difference in standardized pro-Nazi votes between the March and Nov. 1933 elections (left panel), and between the Nov. 1933 election and the August 1934 referendum (right panel), as a function of distance from highway segments that where under construction by 1934 (construction began in the autumn of 1933). The underlying regressions include the baseline and additional controls listed in Table 2, as well as fixed effects for 77 administrative districts (*Regierungsbezirke)*. For ease of exposition, the binscatter plot groups the x-axis into 25 equal-sized bins.

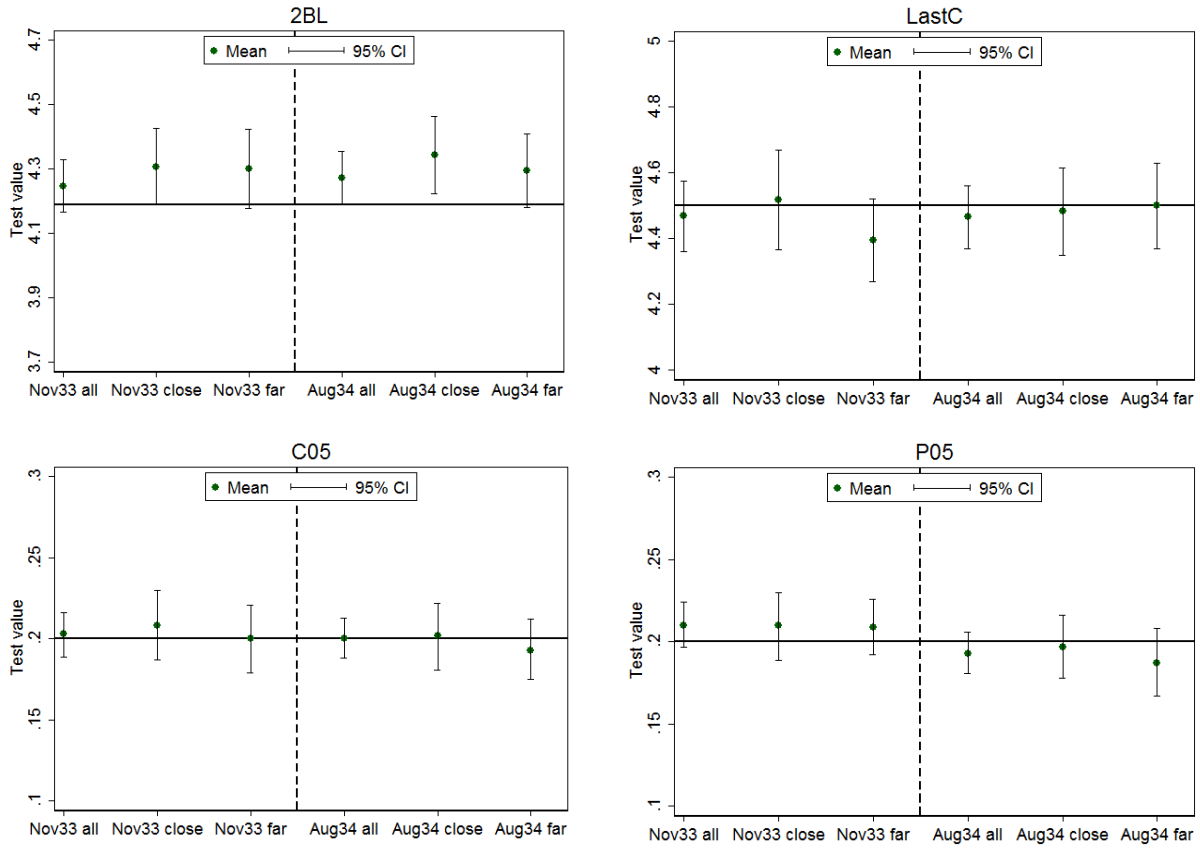


Figure 7: Election Forensics

Note: One the x-axis, for each election (Nov'33 and Aug'34), "all" = all cities in the sample, "close"=close to highways under construction (below median-distance), "far"=above-median distance. The figure implements four tests of election

fraud proposed by Hicken and Mebane (2015). For each test, the horizontal line shows the expected value under no fraud. The tests are the following: 2BL – Benford's Law, based on the second digit of each location's reported pro-Nazi votes (lower digits have a higher frequency according to Benford's Law; the expected average of 2nd digits is 4.19); LastC – analyzes the last digit of the pro-Nazi vote count (this is expected to be normally distributed, with a mean of 4.5); C05 – analyzes the proportion of the pro-Nazi vote count ending in either 0 or 5 (under a uniform distribution, this proportion should be 0.2); P05 – analyzes whether the rounded percentage of pro-Nazi votes has last digit 0 or 5 (these digits are more likely to appear if public officials want to signal that they have committed election fraud. Under a uniform distribution, the corresponding proportion should be 0.2). All statistics are based on reported town/city-level votes in favor of the NSDAP (November 1933) and of "yes" votes in the referendum in August 1934. The 95% confidence intervals are estimated using nonparametric bootstrapping. Table A.2 in the appendix reports the coefficients.

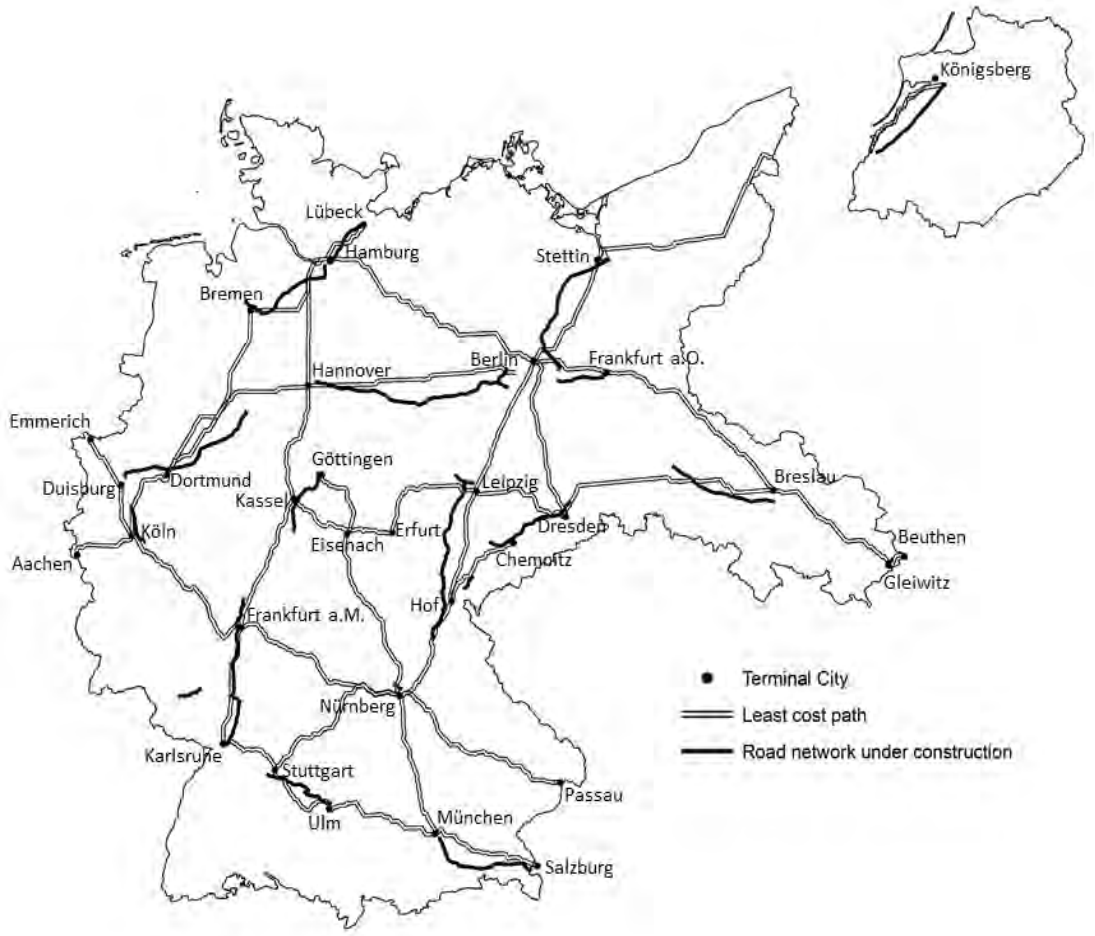


Figure 8: Least Costs Paths and Actual Highway Construction

*Note*: Location of highway segments from Todt (1934). Least-cost paths between terminal cities computed by authors.

# TABLES

Table 1: Number of Towns and Cities in Sample,
Conditional on Highway Construction

| | | Highway under construction in 1934 (< 20 km) | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Part of National Highway plan? (<20 km) | Yes | 1,097 | 918 | 2,015 |
| | No | 0 | 1,261 | 1,261 |
| | Total | 1,097 | 2,179 | 3,276 |

Note: A map with the location of highways is shown in Figure 2.

Table 2: Cities Characteristics, By Highway Plans and Construction

| | Full | Highway planned | | |
|---|---|---|---|---|
| Variable | sample | All | built | not built |
| *Baseline controls* | | | | |
| Population size 1933 | 12,294 | 15,906 | 21,687 | 8,992 |
| Unemployment rate 1933 | 0.152 | 0.164 | 0.182 | 0.142 |
| *Additional controls* | | | | |
| Blue collar share 1933 | 0.336 | 0.347 | 0.364 | 0.328 |
| Share Industrial Employment | 0.297 | 0.315 | 0.340 | 0.285 |
| Share Catholic | 0.364 | 0.339 | 0.283 | 0.404 |
| Share Jewish | 0.005 | 0.005 | 0.004 | 0.005 |
| *Initial Nazi support* | | | | |
| NSDAP vote share in March 1933 | 0.425 | 0.412 | 0.415 | 0.410 |
| Number of cities | 3,276 | 2,015 | 1,097 | 918 |

Under “Highway planned”, “All” comprise all cities within 20 km of planned, approved, or built highways in 1934, according to the highway network in Figure 2; “not built” are those segments that were planned but not yet under construction by 1934.

Table 3: Highways and Percentage Change in Votes for the Nazi Party

| Dep. variable: | (1) NSDAP vote share in March '33 (standardized) | (2) Share of pro-Nazi votes in Nov'33 (standardized) | (3) Share of pro-Nazi votes in Aug'34 (standardized) |
|---|---|---|---|
| log(distance HW) | 0.0209 | 0.0180 | -0.0591*** |
| | (0.0157) | (0.0166) | (0.0121) |
| NSDAP votes March '33 | | 0.251*** | |
| | | (0.0165) | |
| Pro-Nazi votes Nov'33 | | | 0.640*** |
| | | | (0.0157) |
| Baseline controls | ✓ | ✓ | ✓ |
| Observations | 3,230 | 3,218 | 3,234 |
| Adjusted $R^2$ | 0.025 | 0.117 | 0.399 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline controls include the log of city population and the unemployment rate in 1933. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934.

Table 4: Panel Estimation

Dependent variable: Standardized votes for the Nazi Party

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Elections included: | March 1933, Nov 1933, Aug 1934 | | | | 1924-1934 | |
| log(distance HW) × Aug 1934 | -0.0790*** | -0.0647*** | -0.0645*** | -0.0497** | -0.0671*** | -0.0876*** |
| | (0.0204) | (0.0210) | (0.0204) | (0.0225) | (0.0230) | (0.0236) |
| log(distance HW) × Nov 1933 | 0.0174 | 0.00259 | 0.00255 | 0.0159 | 0.0291 | 0.0281 |
| | (0.0238) | (0.0247) | (0.0248) | (0.0240) | (0.0258) | (0.0247) |
| log(distance HW) × March 1933 | | | | | 0.0117 | -0.0221 |
| | | | | | (0.0201) | (0.0209) |
| log(distance HW) × Sep 1930 | | | | | 0.00410 | -0.00194 |
| | | | | | (0.0197) | (0.0186) |
| log(distance HW) × May 1928 | | | | | -0.0190 | |
| | | | | | (0.0176) | |
| Lagged Nazi Party votes | | | 0.0367** | 0.0508*** | | 0.113*** |
| | | | (0.0154) | (0.0156) | | (0.0141) |
| City FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Baseline controls × Year | | ✓ | ✓ | ✓ | | ✓ |
| Additional Controls × Year | | | | ✓ | | ✓ |
| District FE × Year | | | | ✓ | | ✓ |
| Observations | 9,775 | 9,712 | 9,681 | 9,654 | 19,457 | 16,095 |
| Adjusted $R^2$ | 0.459 | 0.462 | 0.464 | 0.672 | 0.351 | 0.564 |

Standard errors in parentheses, clustered at the city level * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934. Baseline controls include log population and unemployment rate in 1933. Additional controls include the share of blue

collar workers and the share of industrial employment in 1933, as well as the share of Catholics and of Jews in 1925. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany. The election in May 1924 uses the (standardized) vote share for the DVFP, which presented a joint list with Nazi candidates while the NSDAP was banned (see footnote 24).

Table 5: Distance to Highways and Change in Nazi Support

Dependent variable: change in standardized pro-Nazi votes, Nov 1933- Aug 1934

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| log(distance HW) | -0.0970*** | -0.0591*** | -0.0775*** | -0.0380*** | | |
| | (0.0132) | (0.0121) | (0.0135) | (0.0125) | | |
| HW within 20km | | | | | 0.127*** | 0.0522** |
| | | | | | (0.0274) | (0.0245) |
| Pro-NSDAP votes in Nov 1933 | | -0.360*** | -0.427*** | -0.442*** | -0.359*** | -0.443*** |
| | | (0.0157) | (0.0167) | (0.0158) | (0.0158) | (0.0159) |
| ln(population) in 1933 | | -0.0518*** | -0.0357*** | -0.0449*** | -0.0533*** | -0.0443*** |
| | | (0.0145) | (0.0131) | (0.0135) | (0.0144) | (0.0135) |
| unemployment rate in 1933 | | 0.547** | -0.0599 | -0.136 | 0.614*** | -0.0764 |
| | | (0.225) | (0.213) | (0.221) | (0.221) | (0.220) |
| Share of Jews in 1925 | | | | -1.443 | | -1.514 |
| | | | | (1.609) | | (1.612) |
| Share of Catholics in 1925 | | | | -1.049*** | | -1.054*** |
| | | | | (0.0570) | | (0.0567) |
| Blue-collar share in 1933 | | | | 0.730*** | | 0.769*** |
| | | | | (0.202) | | (0.202) |
| Share industrial workers in 1933 | | | | -0.0671 | | -0.0863 |
| | | | | (0.163) | | (0.162) |
| District FE | | | ✓ | ✓ | | ✓ |
| Observations | 3,256 | 3,234 | 3,234 | 3,216 | 3,234 | 3,216 |
| Adjusted $R^2$ | 0.014 | 0.185 | 0.469 | 0.554 | 0.185 | 0.554 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934; "HW within 20km" is a dummy that takes on value one if "Distance HW" is below 20 km, and zero otherwise. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany.

Table 6: Possible Mechanisms: Unemployment and car ownership
Dependent variable: Change in votes for the Nazi Party, Nov'33-Aug'34

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Unemployment rate relative to median | | Vehicle ownership relative to median | |
| | below | above | below | above |
| log(distance HW) | -0.0549** | -0.0696*** | -0.0412* | -0.0449*** |
| | (0.0223) | (0.0173) | (0.0217) | (0.0158) |
| Test that coeff are equal: | col (1) = col (2) p-value: 0.602 | | col (3) = col (4) p-value: 0.891 | |
| Controls | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,626 | 1,608 | 1,618 | 1,472 |
| Adjusted $R^2$ | 0.033 | 0.009 | 0.015 | 0.038 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Controls include the log of city population and the unemployment rate in 1933.

Table 7: Radio Coverage
Dep. var.: Change in (standardized) votes for the Nazi Party over indicated period

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Period: | March'33-Nov'33 | November 1933 – August 1934 | | | | |
| Cities in sample: | all | all | Radio reception‡ yes | Radio reception‡ no | Radio reception‡ yes | Radio reception‡ no |
| log(distance HW) | 0.00143 | -0.0560*** | -0.0912*** | -0.0205 | | |
| | (0.00089) | (0.0128) | (0.0159) | (0.0250) | | |
| HW under construct. within 20km | | | | | 0.191*** | 0.00937 |
| | | | | | (0.0342) | (0.0575) |
| Test that coeff are equal: | | | col (3) = col (4) p-value: 0.017 | | col (5) = col (6) p-value: 0.007 | |
| Radio Listeners (predicted)# | 0.0544* | 0.311 | 1.264*** | -1.610 | 1.285*** | -0.879 |
| | (0.0283) | (0.375) | (0.431) | (4.351) | (0.433) | (4.284) |
| Baseline controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 3,214 | 3,230 | 1,946 | 1,284 | 1,946 | 1,284 |
| Adjusted $R^2$ | 0.877 | 0.185 | 0.173 | 0.217 | 0.173 | 0.216 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934. "Baseline controls" include log population, unemployment rate in 1933, as well as the (standardized) share of pro-Nazi votes in the November 1933 election.

# Nonlinear prediction of radio listeners, as described in Appendix A.6.

‡ Corresponds to radio signal strength above 20. Below this point, radio signal quality was insufficient to listen to the radio (see Appendix A.6 for detail).

Table 8: Planned vs. Built Highways
Dependent variable: Change in standardized pro-Nazi votes, Nov'33-March'34

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Sample | All cities | Only cities with distance<$x$ km from any HW[#] | | | | |
| | | $x$<20km | $x$<20km | $x$<20km | $x$<20km | $x$<5km |
| log(distance HW under construction) | -0.0974*** | -0.109*** | -0.0503*** | | | |
| | (0.0187) | (0.0201) | (0.0163) | | | |
| log(distance to any HW)[#] | 0.0103 | 0.00232 | 0.0110 | | | |
| | (0.0165) | (0.0201) | (0.0127) | | | |
| HW under construct. within 20km | | | | 0.226*** | 0.0578* | |
| | | | | (0.0381) | (0.0306) | |
| HW under construct. within 5km | | | | | | 0.120** |
| | | | | | | (0.0533) |
| All controls | | | ✓ | | ✓ | ✓ |
| District FE | | | ✓ | | ✓ | ✓ |
| Observations | 2,797 | 1,799 | 1,788 | 2,002 | 1,979 | 711 |
| Adjusted $R^2$ | 0.012 | 0.018 | 0.567 | 0.018 | 0.564 | 0.568 |

Note: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All controls include log population, unemployment rate in 1933, the (standardized) share of pro-Nazi votes in the November 1933 election, the share of blue collar workers and the share of industrial employment in 1933, as well as the share of Catholics and of Jews in 1925. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany.
[#] Distance to any highway is the distance to the nearest planned, approved, or built highway segment.

Table 9: Instrumental Variable Regressions with Least Cost Paths

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Reduced Form | | First Stage | | Second Stage | |
| Dependent Var: | Change in votes for the Nazi Party, Nov'33-March'34 | | log(distance to highway) | | Change in votes for the Nazi Party, Nov'33-March'34 | |
| log(distance to Least Cost Path) | -0.0370*** | -0.0318*** | 0.375*** | 0.305*** | | |
| | (0.0112) | (0.0105) | (0.0158) | (0.0160) | | |
| log(distance HW) | | | | | -0.0988*** | -0.104*** |
| | | | | | (0.0296) | (0.0344) |
| Weak-IV robust p-value | | | | | [0.0009] | [0.0025] |
| Baseline controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Additional controls | | ✓ | | ✓ | | ✓ |
| District FE | | ✓ | | ✓ | | ✓ |
| First Stage F-Statistic | | | 565.0 | 364.8 | | |
| Instrument partial $R^2$ | | | 0.222 | 0.168 | | |
| Observations | 3,204 | 3,186 | 3,204 | 3,186 | 3,204 | 3,184 |
| Adjusted $R^2$ | 0.019 | 0.374 | 0.304 | 0.510 | | |

Note: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934. Baseline controls include log population and unemployment rate in 1933. Additional controls include the share of blue collar workers and the share of industrial employment in 1933, as well as the share of Catholics and of Jews in 1925. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany.

Table 10: Entropy Balancing
Dependent variable: Change in standardized pro-Nazi votes, Nov'33-March'34

| | (1) | (2) | (3) |
|---|---|---|---|
| Sample includes: | All cities | | Cities located <20km from any HW[#] |
| HW within 20km | 0.116*** | 0.0837*** | 0.0875** |
| | (0.0316) | (0.0316) | (0.0393) |
| Baseline controls | ✓ | ✓ | ✓ |
| Additional controls | | ✓ | ✓ |
| District FE | | ✓ | ✓ |
| Observations | 3,234 | 3,216 | 1,979 |
| Adjusted $R^2$ | 0.005 | 0.242 | 0.257 |

Note: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Regressions are estimated using entropy weighting, which creates balanced samples by reweighting the control group data (farther than 20 km from highway construction) to match the mean of covariates in the treatment group (less than 20 km from highway construction). See Hainmueller and Xu (2013) for details; Table A.5 shows the means for covariates before and after rebalancing. "Baseline controls" include log population, unemployment rate in 1933, as well as the (standardized) share of pro-Nazi votes in the November 1933 election. "Additional controls include all other variables listed in Table 2. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany.

[#] Distance to any highway is the distance to the nearest planned, approved, or built highway segment.

Table 11: Sample Splits
Dependent variable: Change in votes for the Nazi Party, Nov'33-March'34

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **PANEL A: Sample split by vote shares in March 1933 election** | | | | | | |
| | NSDAP relative to median | | Moderate parties relative to median | | Communist Party relative to median | |
| | below | above | below | above | below | above |
| log(distance HW) | -0.141*** | -0.0696*** | -0.0599*** | -0.155*** | -0.144*** | -0.0516*** |
| | (0.0238) | (0.0220) | (0.0206) | (0.0264) | (0.0292) | (0.0182) |
| Test that coeff are equal: | col (1) = col (2) | | col (3) = col (4) | | col (5) = col (6) | |
| | p-value: 0.024 | | p-value: 0.004 | | p-value: 0.006 | |
| Baseline controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| District FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,609 | 1,609 | 1,599 | 1,619 | 1,619 | 1,599 |
| Adjusted $R^2$ | 0.393 | 0.133 | 0.153 | 0.370 | 0.343 | 0.197 |
| **PANEL B: Sample split by religion and population size** | | | | | | |
| | Share of Catholics relative to 50% | | Share of Jews relative to median | | City population relative to median | |
| | below | above | below | above | below | above |
| log(distance HW) | -0.0521*** | -0.194*** | -0.104*** | -0.115*** | -0.108*** | -0.107*** |
| | (0.0168) | (0.0338) | (0.0211) | (0.0240) | (0.0248) | (0.0210) |
| Test that coeff are equal: | col (1) = col (2) | | col (3) = col (4) | | col (5) = col (6) | |
| | p-value: 0.0001 | | p-value: 0.725 | | p-value: 0.970 | |
| Baseline controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| District FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 2,103 | 1,131 | 1,598 | 1,618 | 1,592 | 1,642 |
| Adjusted $R^2$ | 0.136 | 0.340 | 0.351 | 0.262 | 0.313 | 0.287 |

Note: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934. Baseline controls include log population and unemployment rate in 1933. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany.

# ONLINE APPENDIX

- Not for publication -

# Highway to Hitler

## A.1: Highway Planning and Construction

Figure A.1 shows the number of workers employed in highway construction between 1933 and 1938.

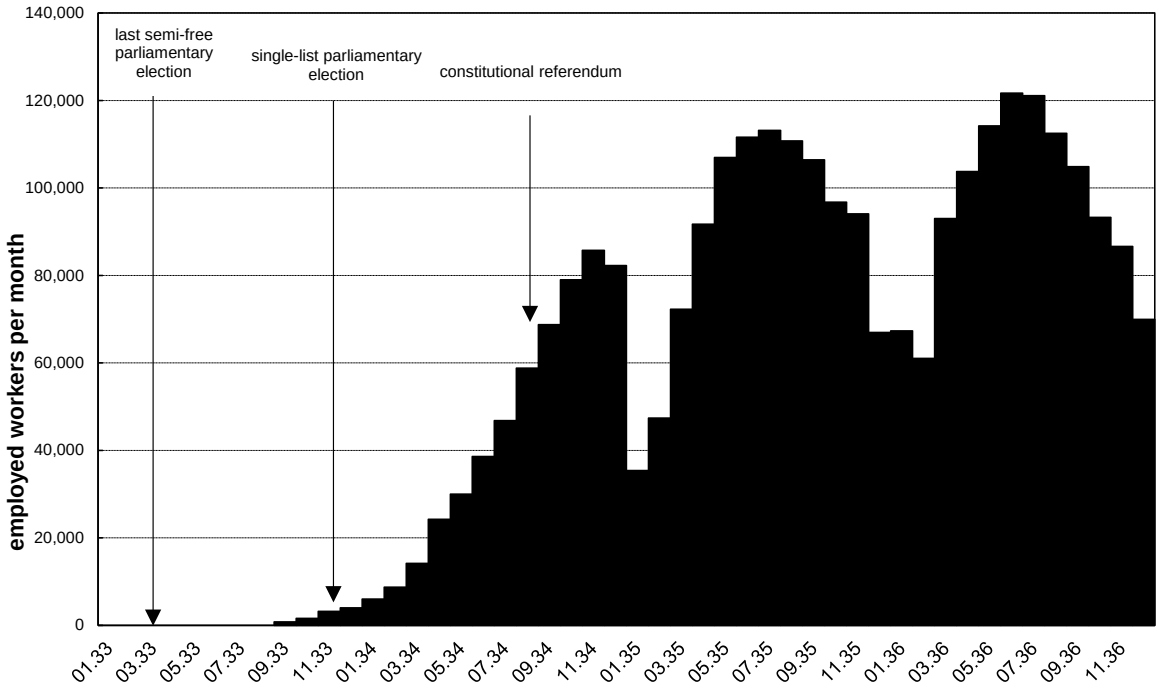


Figure A.1: Manpower used for highway construction

Source: Humann (2011)

Table A.1 lists the 38 city pairs that were to be connected in the first wave of highway construction, according to the plans listed in Jahnke (1936). There are altogether 32 cities that were to be connected.

Table A.1: Terminal city connection pairs used to construct Least Cost Paths

| | City A | City B | | City A | City B |
|---|---|---|---|---|---|
| 1. | Lübeck | Hamburg | 20. | Berlin | Frankfurt an der Oder |
| 2. | Hamburg | Hannover | 21. | Emmerich | Duisburg |
| 3. | Hannover | Kassel | 22. | Köln | Duisburg |
| 4. | Kassel | Frankfurt am Main | 23. | Köln | Frankfurt am Main |
| 5. | Frankfurt am Main | Karlsruhe | 24. | Nürnberg | Frankfurt am Main |
| 6. | Königsberg | Stettin | 25. | Nürnberg | Passau |
| 7. | Stettin | Berlin | 26. | Hamburg | Berlin |
| 8. | Berlin | Leipzig | 27. | Berlin | Breslau |
| 9. | Leipzig | Nürnberg | 28. | Breslau | Gleiwitz |
| 10. | Nürnberg | München | 29. | Gleiwitz | Beuthen |
| 11. | Karlsruhe | Stuttgart | 30. | Aachen | Köln |
| 12. | Stuttgart | Ulm | 31. | Köln | Dortmund |
| 13. | Ulm | München | 32. | Dortmund | Bremen |
| 14. | München | Salzburg | 33. | Hamburg | Bremen |
| 15. | Kassel | Erfurt | 34. | Dresden | Berlin |
| 16. | Dresden | Erfurt | 35. | Chemnitz | Hof |
| 17. | Dresden | Breslau | 36. | Göttingen | Eisenach |
| 18. | Dortmund | Hannover | 37. | Eisenach | Nürnberg |
| 19. | Berlin | Hannover | 38. | Stuttgart | Nürnberg |

Source: Terminal City Connections as listed in Jahnke (1936) "1000 km Reichsautobahnen" pp. 973-974.

## A.2: Alternative Cut-off Distance for Dichotomous Treatment Variable

In the text, we use a cut-off of 20 km distance to the highway to define a dichotomous treatment variable. This is clearly arbitrary. Here we shows that alternative cut-off values yield very similar results. Figure A.2 plots the coefficient on the dummy variable for highway proximity for a number of distances – 5, 10, 20, and 40 km – with and without (baseline) controls. While the results are not identical, they are always significant. The 20 km cut-off used in the main part of the paper does not yield the biggest coefficients, demonstrating the robustness of our findings and the magnitudes involved.

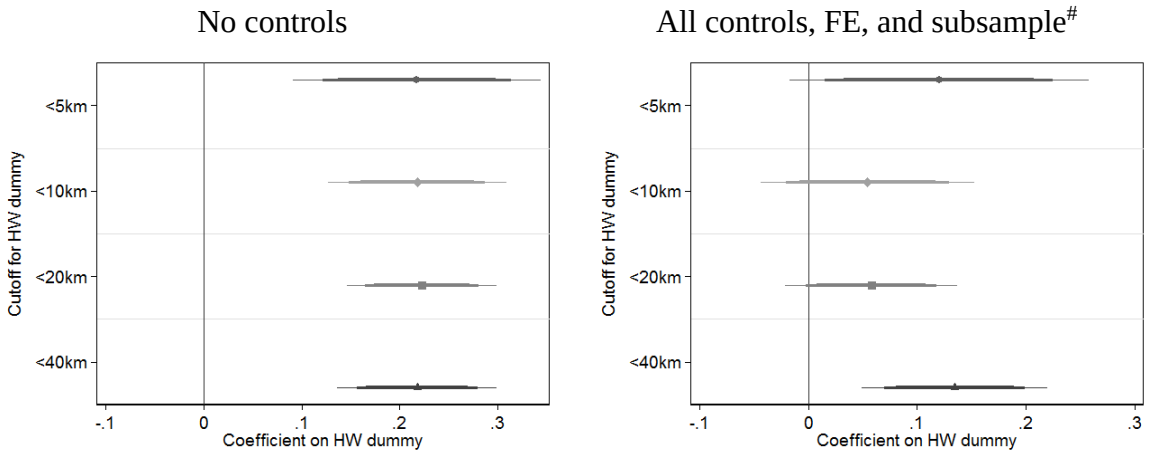


Figure A.2: Vote gain for the Nazi regime, by proximity of cities to highway (defined as less than 5, 10, 20, or 40 km distance). The figure plots the coefficient on a dummy for highway proximity, for a regression where the dependent variable is the change in (standardized) pro-Nazi votes between 11/1933 and 8/1934. The thick (medium, thin) lines correspond to the 90% (95%, 99%) confidence intervals. The left panel includes no control variables. The right panel shows our most restrictive specification, controlling for log population, unemployment rate in 1933, the (standardized) share of pro-Nazi votes in the November 1933 election, the share of blue collar workers in 1933, the share of industrial employment in 1933, the share of Catholics and of Jews in 1925, as well as district fixed effects for 77 *Regierungsbezirke* in Weimar Germany.
# Subsample includes only cities within 5, 10, 20, or 40 km (depending on the specification) of any planned, approved, or constructed highway.

## A.3: Additional Results on Election Forensics

This section presents additional results on (potential) election fraud in November 1933 and August 1934). We begin by showing – in Table A.2 the detailed statistics for the four tests illustrated in Section 5.a in the paper.

Table A.2: Election Forensics – Evidence of Manipulation

| Test | Election/ Referendum | Value if no fraud | Full Sample | | | Distance to HW under construction: Below median | | | Distance to HW under construction: Above median | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | 95% CI | | Mean | 95% CI | | Mean | 95% CI | |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| **2BL** | Nov 33 | 4.19 | 4.25 | 4.15 | 4.34 | 4.31 | 4.19 | 4.43 | 4.30 | 4.16 | 4.45 |
| | Aug 34 | 4.19 | 4.27 | 4.17 | 4.37 | 4.34 | 4.19 | 4.49 | 4.29 | 4.15 | 4.44 |
| **LastC** | Nov 33 | 4.5 | 4.47 | 4.39 | 4.55 | 4.52 | 4.37 | 4.66 | 4.40 | 4.27 | 4.52 |
| | Aug 34 | 4.5 | 4.47 | 4.38 | 4.55 | 4.48 | 4.33 | 4.63 | 4.50 | 4.36 | 4.64 |
| **C05** | Nov 33 | 0.2 | 0.20 | 0.19 | 0.22 | 0.21 | 0.19 | 0.23 | 0.20 | 0.18 | 0.22 |
| | Aug 34 | 0.2 | 0.20 | 0.19 | 0.21 | 0.20 | 0.18 | 0.22 | 0.19 | 0.17 | 0.22 |
| **P05** | Nov 33 | 0.2 | 0.21 | 0.20 | 0.23 | 0.21 | 0.19 | 0.23 | 0.21 | 0.19 | 0.23 |
| | Aug 34 | 0.2 | 0.19 | 0.18 | 0.20 | 0.20 | 0.18 | 0.22 | 0.19 | 0.17 | 0.21 |

Note: The table implements the following tests of election fraud proposed by Hicken and Mebane (2015): 2BL – Benford's Law, based on second digit of each location's reported pro-Nazi votes (lower digits have a higher frequency according to Benford's Law; the expected average of 2nd digits is 4.19); LastC – analyzes the last digit of the pro-Nazi vote count (this is expected to be normally distributed, with a mean of 4.5); C05 – analyzes the proportion of the pro-Nazi vote count ending in either 0 or 5 (under a uniform distribution, this proportion should be 0.2); P05 – analyzes whether the rounded percentage of pro-Nazi votes has last digit 0 or 5 (these digits are more likely to appear if public officials want to signal that they have committed election fraud. Under a uniform distribution, the corresponding proportion should be 0.2). "Value if no fraud" is the mean of the respective variable in the absence of election fraud. See Section 5.a in the paper for detail. All statistics are based on reported town/city-level votes in favor of the NSDAP (November 1933) and of "yes" votes in the referendum in August 1934. The 95% confidence intervals are estimated using nonparametric bootstrapping.

Next, we present $\chi^2$ statistics to test Benford's Law and the "Last C" criterion described in Section 5.a. in the paper. Instead of comparing the mean in the data to the expected value under "no fraud", the $\chi^2$ statistics examine whether the whole distribution deviates from Benford's Law and a uniform distribution, respectively. Figure A.3 illustrates Benford's Law for the two elections. The bars show the actual share of digits; the dotted line reflects the theoretical distribution. We focus on the second digit of pro-Nazi votes because vote manipulation of the first digit would be too egregious – leading to unrealistic shares of pro-Nazi votes in most cases.[1] In November 1933 and August 1934, there appear to be considerable violations of Benford's Law: the second digits 2, 3, and 4 are overrepresented. This is borne out by the $\chi^2$ statistics and the p-values for the null of "no manipulation" shown in Table A.3 (Panel A, col 1). If we are to believe the Benford indicator, this suggests

[1] For example, changing pro-Nazi votes in a city with 1,400 voters from 1,095 to 1,295 may not raise suspicion, while changing it to 2,095 certainly would.

manipulation of votes – although manipulation by systematically rounding second digits to 2,3, or 4 appears somewhat unlikely.

Next, we examine if there is *differential* evidence for cheating for locations close to the highway. Table A.3, Panel A gives the statistical results for Benford's Law.[2] In the November 1933 election and the August 1934 referendum, we observe strong deviations from Benford's law, and thus suggestive evidence for electoral fraud. However, the $\chi^2$ statistics are very similar for cities with above- and below-median distance to highways, suggesting that manipulation did not differ systematically with highway building. Finally, in Panel B of Table A.3. we also report $\chi^2$ statistics for the LastC test of election fraud. Here, we find no indication whatsoever for election fraud.

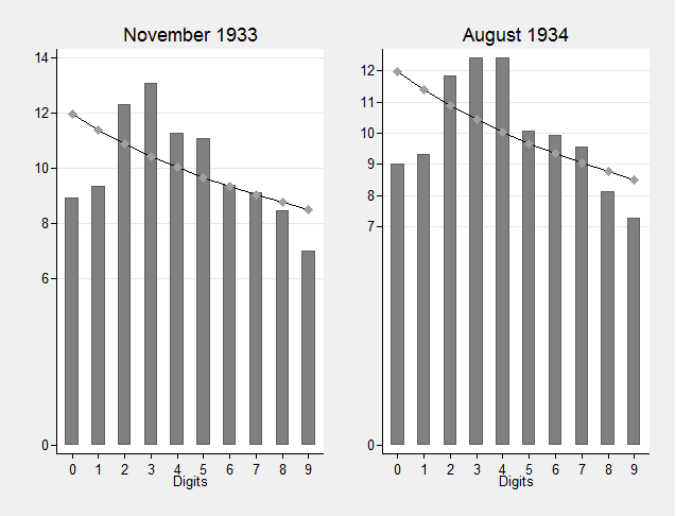


Figure A.3: Benford's Law, based on 2nd digit distributions, Nov 1933 and Aug 1934

[2] We split the sample into cities with below- and above-median distance to highway segments under construction (32 km). This ensures that the two subsamples have the same size, so that we can compare the $\chi^2$ statistics in cols 2 and 3.

Table A.3: Benford's Law and Last C – $\chi^2$ Tests

| | (1) | (2) | (3) |
|---|---|---|---|
| | Full sample | Distance to highway (under construction): | |
| | | below median | above median |
| **Panel A: Benford's Law** | | | |
| November 33 | 91.3 | 50.5 | 47.6 |
| *p-value* | *(0.000)* | *(0.000)* | *(0.000)* |
| August 34 | 86.0 | 49.5 | 47.9 |
| *p-value* | *(0.000)* | *(0.000)* | *(0.000)* |
| **Panel B: Last C** | | | |
| November 33 | 6.4 | 5.6 | 6.9 |
| *p-value* | *(0.61)* | *(0.69)* | *(0.55)* |
| August 34 | 0.9 | 1.9 | 1.3 |
| *p-value* | *(0.99)* | *(0.98)* | *(0.99)* |

Note: The table reports Pearson's $\chi^2$ statistic (probability of rejection the null of no manipulation). In Panel A, this statistic is based on the second digit of the number of reported votes in favor of the NSDAP (November '33) and of yes-votes (August'34), using the *digdis* routine in STATA to examine deviations from Benford's Law. In Panel B, deviations from a uniform distribution are examined for the same elections.

## A.4: Additional Figures and Tables for Main Empirical Results

Figure A.4 shows the change in standardized pro-Nazi votes between November 1933 and August 1934 for the subsample of cities within 20 km of least-cost paths (LCPs). "Compliers" are cities for which the location close to LCPs coincided with actual highway construction by the summer of 1934; "non-compliers" are cities close to LCPs where highway construction did not take place. The figure shows that Nazi support increased significantly for compliers, while there is no change in votes for non-compliers.

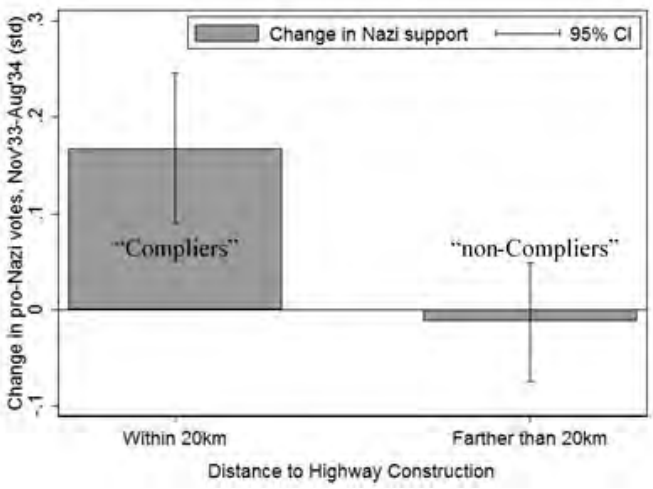


Figure A.4: Compliers and non-compliers in the IV regressions

Table A.4 shows our results when using only the top-20 cities in terms of population size to compute least-cost path connections.

Table A.4: Instrumental Variable Regressions with Least Cost Paths – top 20 cities only

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Reduced Form | | First Stage | | Second Stage | |
| Dependent Var: | Change in votes for the Nazi Party, Nov'33-March'34 | | log(distance to highway) | | Change in votes for the Nazi Party, Nov'33-March'34 | |
| log(distance to Least Cost Path) | -0.0243** | -0.0367*** | 0.365*** | 0.335*** | | |
| | (0.0107) | (0.0126) | (0.0151) | (0.0193) | | |
| log(distance HW) | | | | | -0.0668** | -0.109*** |
| | | | | | (0.0293) | (0.0368) |
| Weak-IV robust p-value | | | | | [0.02] | [0.004] |
| Baseline controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Additional controls | | ✓ | | ✓ | | ✓ |
| District FE | | ✓ | | ✓ | | ✓ |
| First Stage F-Statistic | | | 590.6 | 306.9 | | |
| Instrument partial $R^2$ | | | 0.212 | 0.155 | | |
| Observations | 3,215 | 3,197 | 3,215 | 3,197 | 3,215 | 3,195 |
| Adjusted $R^2$ | 0.018 | 0.374 | 0.295 | 0.501 | | |

Note: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934. Baseline controls include log population and unemployment rate in 1933. Additional controls include the share of blue collar workers and the share of industrial employment in 1933, as well as the share of Catholics and of Jews in 1925. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany.

Table A.5 complements our entropy balancing exercise in Table 10 in the paper; it shows that entropy balancing delivers an almost perfectly balanced control group, with the (weighted) mean of all correlates deviating by less than 0.1% from the corresponding mean in the treated group.

Table A.5: Covariates before and after Entropy balancing

| | Treatment group (<20km from HW) | Control group (>20km from HW) | |
|---|---|---|---|
| Variable | Mean | Mean before re-balancing | Mean after re-balancing |
| Population size 1933 | 8.685347 | 8.439072 | 8.685298 |
| Unemployment rate 1933 | 0.182052 | 0.137428 | 0.182045 |
| Blue collar share 1933 | 0.363053 | 0.322727 | 0.363044 |
| Share Industrial Empl. 1933 | 0.338796 | 0.276304 | 0.338785 |
| Share Catholic 1925 | 0.284215 | 0.404694 | 0.284251 |
| Share Jewish 1925 | 0.00407 | 0.005451 | 0.00407 |

Note: The table shows the means for covariates in cities in the treated and control group in specification 2 in Table 10 in the paper, before and after rebalancing.

## A.5: Additional Figures and Tables for Robustness Checks

Table A.6 uses our narrow measure for change in Nazi support: pro-Nazi votes relative to *actual* voters. As discussed in the main text, this measure is not affected by voter turnout.

Table A.6: Narrow definition of pro-Nazi votes

Dep. Var.: Narrow Definition of Change in standardized pro-Nazi votes, Nov'33-March'34

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | OLS | | IV | | Planning vs. Building | |
| Sample includes: | All cities | | All cities | | Cities located <20km from any HW[#] | |
| log(distance HW | -0.0899*** | -0.0300** | -0.141*** | -0.0576* | -0.0881*** | -0.0435** |
| under construction) | (0.0146) | (0.0136) | (0.0279) | (0.0334) | (0.0219) | (0.0181) |
| log(distance to | | | | | -0.000415 | 0.0102 |
| any HW)[#] | | | | | (0.0226) | (0.0144) |
| All controls | | ✓ | | ✓ | | ✓ |
| District FE | | ✓ | | ✓ | | ✓ |
| First Stage F-Statistic | | | 664.6 | 616.9 | | |
| Instrument partial $R^2$ | | | 0.261 | 0.167 | | |
| Weak-IV robust p-value | | | [0.000] | [0.085] | | |
| Observations | 3,228 | 3,188 | 3,191 | 3,157 | 1,788 | 1,777 |
| Adjusted $R^2$ | 0.010 | 0.564 | | | 0.009 | 0.570 |

Note: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The narrow definition of pro-Nazi votes is unaffected by voter turnout; it is defined as the "yes" votes relative to valid votes. All controls include log population, unemployment rate in 1933, the (standardized) share of pro-Nazi votes in the November 1933 election, the share of blue collar workers and the share of industrial employment in 1933, as well as the share of Catholics and of Jews in 1925. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany. Cols 1 and 2 replicate our main OLS specifications (corresponding to cols 1 and 4 in Table 5); cols 3 and 4 show the IV results, and cols 5 and 6 control for distance to any planned, approved, or built highway (corresponding to cols 2 and 3 in Table 8).

[#] Distance to any highway is the distance to the nearest planned, approved, or built highway segment.

Table A.7 uses the distance to both highway segments under construction, and to segments whose construction had been approved, but not yet begun by the summer of 1934. In column 1, without any controls, distance to approved highways is positively correlated with Nazi support, while distance to segments under construction shows the same pattern as documented above. When using the minimum of the two distances, we also find a strong negative coefficient. In column 3, we add our full set of controls and district fixed effects. The coefficient on distance to approved roads is now negative and significant, and of similar magnitude as the coefficient on distance to constructed segments. Again, using the minimum of both distances yields a negative and significant coefficient. The pattern of the last two specifications is confirmed in columns 5 and 6, where we control for distance to any (planned/approved/constructed) highway, and restrict the sample to cities located within 20 km from any highway segment. Overall, the evidence thus suggests that there are no crucial differences between highway segments under construction and those approved for construction.

Table A.7: Using highway under construction and those approved for construction
Dependent variable: Change in standardized pro-Nazi votes, Nov'33-March'34

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Sample includes: | All cities | | All cities | | Cities located <20km from any HW[#] | |
| log(distance HW under construction) | -0.113*** | | -0.0260* | | -0.0448*** | |
| | (0.0150) | | (0.0134) | | (0.0167) | |
| log(distance approved HW) | 0.0328** | | -0.0389** | | -0.0391** | |
| | (0.0129) | | (0.0151) | | (0.0173) | |
| log(distance HW approved or under construction) | | -0.1000*** | | -0.044*** | | -0.0617*** |
| | | (0.0119) | | (0.0114) | | (0.0162) |
| log(distance to any HW)[#] | | | | | 0.0171 | 0.0202 |
| | | | | | (0.0132) | (0.0137) |
| All controls | | | ✓ | ✓ | ✓ | ✓ |
| District FE | | | ✓ | ✓ | ✓ | ✓ |
| Observations | 3,256 | 3,216 | 3,220 | 3,186 | 1,799 | 1,788 |
| Adjusted $R^2$ | 0.018 | 0.555 | 0.016 | 0.368 | 0.023 | 0.568 |

Note: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All controls include log population, unemployment rate in 1933, the (standardized) share of pro-Nazi votes in the November 1933 election, the share of blue collar workers and the share of industrial employment in 1933, as well as the share of Catholics and of Jews in 1925. District FE correspond to 77 *Regierungsbezirke* in Weimar Germany.
[#] Distance to any highway is the distance to the nearest planned, approved, or built highway segment.

Table A.8 uses the distance to railroads and canals as a placebo. In col 1, we regress standardized Nazi Party votes in November 1933 on distance to the railroad and find a small, insignificant coefficient; when we look at changes in votes between November 33 and August 1934, we again find a small negative and insignificant coefficient (col 2). When we restrict this to locations close to the highway network – to see if access to alternative transport mattered differentially where the highway was being built – we again find no effect (col 3). For distance to river (cols 4-6), we find negative, insignificant coefficients except when we look at places close to highways, when the sign changes. Overall, there is no evidence in our placebo exercise to suggest that the highway effects simply capture a general swing of voters towards the Nazis in locations with good communications and access to transport infrastructure.

Table A.8: Placebo Regressions

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Std Nazi votes, Nov'33 | Change in Nazi votes, Nov'33-March'34 | | Std Nazi votes, Nov'33 | Change in Nazi votes, Nov'33-March'34 | |
| Cities in sample | all | all | Distance any HW<20km[#] | all | all | Distance any HW<20km[#] |
| log(distance to Railroad) | 0.00840 | -0.0113 | -0.00437 | | | |
| | (0.0106) | (0.00923) | (0.0123) | | | |
| log(distance to River) | | | | -0.00718 | -0.00593 | 0.00610 |
| | | | | (0.0115) | (0.00981) | (0.0119) |
| Controls: | | | | | | |
| Baseline | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| District FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 3,306 | 3,306 | 1,985 | 3,306 | 3,306 | 1,985 |
| Adjusted $R^2$ | 0.294 | 0.286 | 0.307 | 0.294 | 0.285 | 0.307 |

Note: Standard errors in parentheses $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$
[#] Distance to any highway is the distance to the nearest planned, approved, or built highway segment.

Table A.9 presents our matching results. As discussed in the text, we use either 3-neighbor-matching (cols 1-4) or the nearest neighbor only (cols 5 and 6). We also add restrictions on the range of locations from which propensity score neighbors can be drawn (col 2-6). When we restrict matches to come from the same district, we find bigger effects; and even under very strict conditions, matching on both the same district and being close to a *planned, approved or built* highway (cols 4-6), we find effects of up to 0.15 standard deviations increase in Nazi support. Under these specifications, the range of possible matches is

restricted even further, to places that are both in the same district and also close to the highway network in general (including planned or approved segments). In other words, when we compare changes in votes for the Nazis in locations that are in the same *Regierungsbezirk* and also close to a planned highway, we find effects that are, if anything, even larger than in our OLS regressions (compared, in particular, to cols 4-6 in Table 8 in the paper).

Table A.9: Matching estimation
Dependent variable: Change in votes for the Nazi Party, Nov'33-March'34

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Matching with 3 nearest neighbors | | | | 1 nearest neighbor | |
| HW under construct. | 0.101*** | 0.181*** | 0.159*** | 0.149*** | 0.108** | |
| within 20km | (0.0310) | (0.0335) | (0.0377) | (0.0373) | (0.0461) | |
| HW under construct. | | | | | | 0.130** |
| within 5km | | | | | | (0.0530) |
| Matching variables: | | | | | | |
| Baseline controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Additional controls | | | | ✓ | ✓ | ✓ |
| Matching restrictions: | | | | | | |
| within districts | | ✓ | ✓ | ✓ | ✓ | ✓ |
| within 20km of any HW# | | | | ✓ | ✓ | |
| within 5km of any HW# | | | | | | ✓ |
| Observations | 3,234 | 3,234 | 3,234 | 3,216 | 3,216 | 3,216 |

Note: The reported coefficients are average treatment effects on the treated (ATT), based on propensity score matching. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline controls are ln(city pop in 1933), unemployment rate in 1933, and the standardized vote share for the Nazi Party in the November 1933 election. Additional controls include the share of Jews in 1925, the share of Catholics in 1925, the share of blue-collar workers in 1933, and the share of industrial employment in 1933. "Districts" are the 77 *Regierungsbezirke* in Weimar Germany.
# Distance to any highway is the distance to the nearest planned, approved, or built highway segment.

Table A.10 presents results that account for spatial correlation. We consider cities with less than 3 degrees distance (about 200km-330km) as 'neighbors,' assigning them a non-zero spatial weight.[3] The coefficients on distance to highways under construction are very similar to the main results (presented in Table 5 in the paper).

[3] One degree difference in latitude corresponds to 111 km, and one degree difference in longitude, to 69 km (measured at 50°N, the latitude of central Germany). When estimating the spatial correlation model with regional fixed effects, we use the 35 electoral districts (*Wahlkreise*) of Weimar Germany, instead of the 77 *Regierungsbezirke*; the latter is too restrictive for the estimation procedure to converge.

Table A.10: Accounting for spatial correlation
Dependent variable: change in standardized pro-Nazi votes, Nov 1933- Aug 1934

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| log(distance HW) | -0.077*** | -0.055*** | -0.079*** | -0.0380*** |
| | (0.011) | (0.013) | (0.013) | (0.0125) |
| Baseline controls | | ✓ | ✓ | ✓ |
| Additional controls | | | | ✓ |
| Electoral district (*Wahlkreis*) FE | | | ✓ | ✓ |
| λ# | 0.000*** | 0.000*** | 0.000*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Observations | 3,244 | 3,230 | 3,230 | 3,212 |

The model is estimated by maximum likelihood, using each city's geographic location to derive the weighting matrix. All cities with distance less than 3 degrees (~200km-330km) are considered spatially contiguous and are assigned a nonzero spatial weight. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Distance HW" is the distance of a city to the nearest highway segment that was under construction by August 1934. Baseline controls include log population, unemployment rate in 1933, as well as the (standardized) share of pro-Nazi votes in the November 1933 election. Additional controls include the share of blue collar workers and the share of industrial employment in 1933, as well as the share of Catholics and of Jews in 1925. Fixed effects are for 35 electoral districts (*Wahlkreise*) in Weimar Germany.
# λ is the spatial regressive coefficient. If λ=0, the spatial error model reduces to OLS. For λ≠0, OLS is unbiased and consistent, but inefficient.

## A.6: Signal Strength and Radio Listeners

Following Adena et al. (2015), we estimate a nonlinear relationship between radio subscribers and signal strength:

$$Listeners_i = A1 + e - \nu \cdot (Si - S\_0) + K$$

In this regression, we use the original county (*Kreis*)-level data on signal strength and radio subscribers from Adena et al. (2015), matched to cities in our sample. We obtain the following estimates:

| | Coefficient | Std error |
|---|---|---|
| $A$ | 0.292 | 0.111 |
| $\nu$ | 0.090 | 0.022 |
| $S_0$ | 47.81 | 7.735 |
| $K$ | 0.232 | 0.0072 |

Using these coefficients, we then predict the share of radio listeners at the city-level – based on city-level signal strength, which Ruben Enikolopov kindly computed for us, using the coordinates of cities in our sample. We use predicted rather than reported listener shares in our analysis in Section 5.c in the paper for three reasons: 1) signal strength is less subject to endogeneity concerns than reported radio ownership and subscriptions; 2) signal strength is available at the city level, allowing us to compute predicted listener shares at the city level;

3) as pointed out by Aldena et al. (2015), signal strength has the additional advantage that it proxies for the quality of radio reception.

Importantly, there exists a threshold below which signal quality was insufficient to listen to the radio. Thus, the predicted number of listeners only becomes meaningful for signal strength above this threshold. As Figure A.5 shows, this threshold is at a signal strength of about 20.[4] We use this cutoff for our analysis in Table 7 in the paper to generate the "radio reception" dummy.

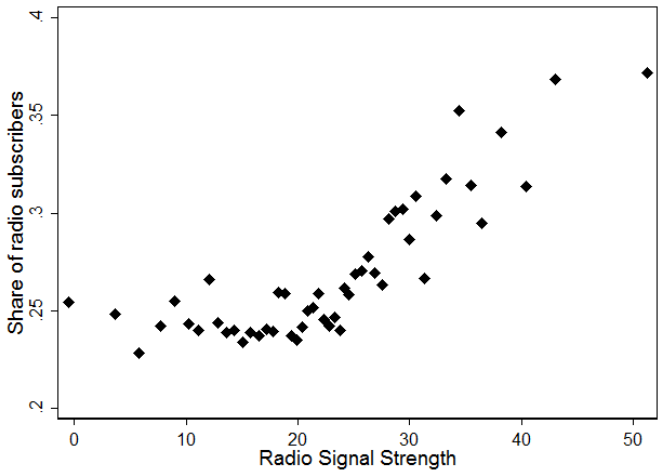


Figure A.5: Radio signal strength and radio subscribers

[4] Even below the threshold of 20, the share of subscribers is about 20%. As pointed out by Adena et al. (2015, p.1906): "all districts had above zero subscription rates. The reason is the nature of AM transmission, which allows unstable radio reception with high-quality receivers even in places with a very weak signal."