Railroads of the Reich

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Abstract

What is the contribution of state capacity to democracy? To answer this question, we study the influence of Imperial Germany's (1871 - 1918) infrastructure expansion on voter participation. Because rail and waterway construction in this period was largely motivated by military concerns, it constitutes a quasi-exogenous shock to trade exposure. Using a novel panel dataset synthesizing constituency-level data on voting, population, wages, and inter-constituency trade costs to discipline a canonical spatial equilibrium model, we find that infrastructure improvements raised welfare by 3-5%, mitigated migration from rural areas, and increased voter participation in national elections by about 0.25%.

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1 Introduction

Is the polity legitimated among its citizenry by virtue of the actions it takes on their behalf, or is the legitimacy of the polity among its citizens a necessary condition for the sustained exercise of state capacity? Infrastructure, broadly defined, lies at the heart of this debate. To make matters concrete, we point to two examples of physical infrastructure widely considered as prestige projects for their respective regimes. Advocates for autocratic development can point to the construction of the Three Gorges Dam as strengthening the legitimacy of the Communist Party of China; alternatively, advocates for democratic development have the Hoover Dam as an glimmering example of 20th century American democracy. Because of endogeneity between state legitimacy and state capacity, identifying the causal effect of one on the other is difficult; to make progress, we study Prussia between 1871 and 1912.

The unification of Germany under the Prussian House of Hohenzollern in 1871 reduced political and regulatory barriers to infrastructure construction. In that year, the German rail network was approximately 20,000 km in length. This had more then trebled to 65,000 km in 1913. Concurrent with railway expansion was the construction of a series of canals intended to connect Germany's natural waterways to the great North Sea ports, in particular, Hamburg. Between 1871 and 1900, Germany built 1,091 kilometers of inland canals and improved river navigation such that Cologne, a city 150 miles inland, could receive oceangoing traffic. Importantly, much of this infrastructure expansion was state-led and motivated by military considerations (Wehler, 1995). The Kiel Canal, for instance, which connected the Baltic to the North Sea, would be widened between 1907 and 1914 to permit the transit of the German High Seas Fleet's growing fleet of dreadnought battleships. Hence, these construction projects were largely delinked from local political concerns, unlike the American case (Fogel, 1964). This is one of the two reasons the Imperial German context is ideal for our empirical analysis.

Our second reason for considering Imperial Germany is the nature of its democratic institutions. Although the German Empire was not a modern parliamentary democracy, its parliament, the *Reichstag*, was a progressive institution for its time. The franchise never changed over the existence of the empire–any man over the age of 25 was eligible to vote for a deputy in the *Reichstag* and votes were cast by secret ballot. It also held the "power of the purse." While German chancellors were appointed by the Emperor and not responsible to parliament, they had to seek its consent for fiscal measures, including trade policy. Contemporaneous with the expansion of transportation infrastructure, the composition of the *Reichstag* changed dramatically. Traditional liberal and conservative parties lost ground, largely in the face of a socialist surge that resulted in the Social Democratic Party (SPD) winning the greatest number of votes in all German elections starting with the 1890 election.

We construct a novel panel dataset at the constituency level describing electoral outcomes and socioeconomic attributes. There were 238 Reichstag constituencies in Prussia and each constituency elected one member of parliament. We then aggregate data on day wages from the ifo Prussian Economic History Database at the county level to merge them to constituencies. We further hand-traced maps of railways and canals for Imperial Germany from 1871 - 1912, such that we could describe the state of German infrastructure for each of the 13 elections between those years.

Using a canonical general equilibrium Armington framework (Allen and Arkolakis, 2014) to analyze the influence of the new rail lines and water ways on welfare and voter participation, we calculate that this expansion increased consumption-equivalent welfare by between 3 and 5%. It also held substantial implications for the distribution of population. Since the new rail lines largely connected rural areas to existing rail networks, our model predicts that the expansion of the rail system may have stemmed the tide of migration from the rural east into the more developed west that occurred during this period. Note that much of the expansion during the Reich was for military purposes. Furthermore, reductions in trade costs, particularly for shipping, were driven by agnostic technological advances. Therefore, we interpret these estimates of market access on voter participation as plausibly causal.

Inasmuch as the economic context of a particular voter influences their behavior, the spatial distribution of voters and the material conditions they experience will matter for aggregate voter participation in national elections, which rose in Germany during this time. Given the positive relationship that we estimate between market access and population density and voter turnout, our model predicts the infrastructure expansion generates two countervailing effects on voter participation. By keeping voters in the countryside where they are less likely to vote, participation is reduced; however, by increasing market access – which is positively associated with voter turnout – it increases the propensity to vote.

We estimate that improvements to market access increased participation in national elections by approximately 25 basis points. We hypothesize that these economic measures had causal effects on individual's propensity to vote in national elections by strengthening the median voter's belief in the legitimacy of the constitutional regime of the newly unified Reich. Two points are salient. First, we argue that understanding the full, general-equilibrium effects of a infrastructure spending on political outcomes may require acknowledging that the distribution of the population is endogenous. Failing to account for mobility results in an overestimation of the political benefits of infrastructure spending as measured by voter participation. Second, we interpret our estimates as suggesting that "buying" legitimacy through infrastructure is costly – the magnitudes we estimate suggest that in the vast majority of elections any additional support for the ruling coalition garnered by better infrastructure was inframarginal for its electoral outcomes.

Our paper proceeds as follows. In Section 2, we describe the historical context of the present study. In Section 3, we describe our data. Section 4 presents our model and results; specifically, Section 4.1 describes our spatial model and computes welfare and counterfactual distributions of the population in 1893 and 1903 without post-unification infrastructure improvements, Section 4.2 describes our voting model and builds on the spatial model's results to assess the effects of the rail expansion on voter turnout at the national level, and Section 4.3 estimates counterfactual outcomes in the absence of infrastructure expansion. Section 5 concludes.

2 Historical Context: Politics in the German Reich

In 1871, under the leadership of the "Iron Chancellor" Otto von Bismarck, Prussia united 26 independent German polities into a single federal administrative regime: the German Empire. Before unification, private and public entities seeking regulatory approval for railway construction had to do so from multiple independent states, constraining construction. Unification attenuated these barriers: between 1871 and 1913, the German rail network nearly tripled in length from approximately 20,000 km to 65,000 km. Most construction was completed by 1884: by 1875, state and private actors had completed connections between all major German cities. Railway construction continued at about 1,000 km per year thereafter to extend existing lines into rural areas and establish a feeder network (Heinze and Kill, 1988). See Figure 1 and Figure 2 for details.

Much of the railway expansion was a function of military concerns, and the Empire's constitution dictated that the newly created Reich would exercise supervisory authority over Germany's railroads "in the interest of national defense and general transportation."[1]

The Prussian General Staff granted much of the credit to its victory against the French armies in the Franco-Prussian War to the superiority of its rail network. In addition, larger and larger artillery pieces were developed to defeat improved fortress technology. These pieces were only mobile over rail. Hence, the commercially unviable trunk lines described previously served two primary purposes. First, they would allow for the rapid deployment of troops toward the French and Russian frontiers. Second, they enabled the transport of large artillery pieces up to 42 centimeters in diameter, which would be key to defeating the Franco-Belgian defensive systems (Wehler, 1995). This is to say that in contrast to the American case, satiating local political concerns was the primary motivation behind rail and water way construction during this period.

Although the German Empire was not a modern parliamentary democracy, its parliament, the *Reichstag*, was a progressive institution for its time and held the "power of the purse." While German chancellors were appointed by the Emperor and not responsible to parliament, they had to seek its consent for fiscal measures, including trade policy. Contemporaneous with the expansion of transportation infrastructure, the composition of the *Reichstag* changed dramatically. Traditional liberal and conservative parties lost ground, largely in the face of a socialist surge that resulted in the Social Democratic Party (SPD) winning the greatest number of votes in all German elections starting with the 1890 election. This is demonstrated in Table 1. The National Liberal Party, a center-right party

[1] Quantifying the precise strategic value of a particular rail line is difficult, not in the least because military authorities had an active interest in obscuring the strategic importance of particular rail lines and went to active lengths to hide their involvement in subsidization and construction of particular rail lines. For a discussion on aggregate expenditures and the limits of the historical record in the context of the Franco-German rivalry, see Mitchell (2000).

largely aligned with the chancellor throughout the Empire's existence, received 30.1% of all votes cast in 1871. By 1912, its vote share fell to 13.6%. Similarly, the conservative share of the vote, which includes the Conservative Party and the ideologically similar German Reich Party, fell from 24.0% in 1871 to 12.2% in 1912. Meanwhile, the SPD vote share increased by an order of magnitude, resulting in a SPD-plurality following the 1912 elections. Last, the Center Party, which specifically represented the interests of German Catholics, saw little change in their vote share, falling from 18.6% in 1871 to 16.4% in 1912. In all of these elections, voter participation was strong and certainly competitive with modern democracies–turnout ranged from 51% in 1871 to a maximum of 84.9% in 1912.

Our analysis focuses on electoral outcomes for the 238 single-member constituencies of the *Reichstag* located in Prussia. For three reasons, voter participation and vote shares for deputies to the *Reichstag* are an analytically convenient and tractable measure of voters' revealed preferences. First, the franchise never changed over the existence of the empire–any man over the age of 25 was eligible to vote for a deputy in the *Reichstag*. Second, votes were cast by secret ballot. Deputies actively defended the integrity of elections, successfully demanding the use of ballot envelopes and voting booths (Anderson, 2000). Third, constituency boundaries were stable. The framers of the Reich's constitution designed constituencies such that each had roughly 100,000 people at the time of unification. Urbanization in the late 19th and early 20th century necessarily implied that fixed constituency boundaries would overweight rural representation.

3 Data Sources

Our analysis focuses on Prussia, the largest state in the German Empire, home to three-fifths of its population and two-thirds of its continental land area. Data is generally available at two levels of geographic resolution: counties (*kreis*) and constituencies, which are groups of counties that form the fundamental geopolitical unit for *Reichstag* elections. We aggregate county-level data up to the constituency level, which costs us some measure of resolution (there are 453 counties in 1871 compared to 238 Prussian constituencies) but constituencies have consistent borders over time and are small enough to be considered as a single labor market. To give a sense of scale, in 1871 the average constituency had about 100,000 inhabitants.

To study the effects of improvements in transportation infrastructure, we assume that observed, cross-sectional data from a representative year reflects the steady-state of our structural model specified in Section 4.1. Given data on trade costs, wages and population for any particular year, we can "invert" the model and obtain estimates for unobserved parameters and conduct counterfactual exercises. Since we only have data on wages for the 1903 and 1893 elections, we focus on counterfactuals for these years.

Trade Costs in Election Years 1871 to 1912: We used the "Electoral District Boundaries, Germany, 1890-1912" shapefile from the Harvard Geospatial Library (digitized b Daniel Ziblatt and Jeffrey Blossom). After identifying each German constituency with its centroid, we compute trade costs in each year from every centroid i to each other centroid j in ArcGIS on the transportation network that existed in that year. This requires creating a transportation network linking all centroids in each of the 13 election years, and defining the cost of traversing that network.

To create the transportation network, we begin by hand-tracing high-quality digital maps of the Rail and Canal Networks (from the Institute for European History and the *Bibliographisches Institut in Leipzig*). We took dates for the completion of canals from Kunz, Zipf, and Böhler (2008). Shapefiles of natural waterways were obtained from the EU-Hydro dataset provided by the European Environmental Agency (European Union, 2019) assuming that all rivers wider than 50 meters were in principle navigable. These inland waterways were extended to allow for transit along the coast and sea routes approximating those in Heitmann et al. (2013). Figure 3 summarizes these changes, and Figure 4 plots, as an example, the network we use to compute trade costs for the year 1893.

Next, we need estimates for historical shipping costs. In particular, we want our estimates to capture the massive technological changes in water transportation that occurred as sailing vessels gave way to those powered by fossil fuels.[2] We proceed as follows: given historical

[2]The Blue Riband illuminates the degree of technological progress in the Victorian and Edwardian eras. Popular newspapers would award this recognition to passenger liners crossing the Atlantic with the highest average speed. In 1871, the paddle steamer Scotia held the record, making the crossing at 14.46 knots in 8 days and 3 hours. By 1909, the four-funnel ocean liner Mauretania made the crossing at 26.06 knots in 4 days and 17 hours.

estimates of average shipping costs per Ton-km for all of Germany in 1872 by waterway and canal (Teubert (1918) accessed in Gutberlet (2013)) and by rail (Fremdling, 1996), we apply long-run average growth rates for each transportation method from 1870-1914 obtained from Klemann and Schenk (2013). Costs for shipping by Wagon and transhippment costs are held constant at 40 Pfennigs per Ton-Km. (Fremdling, 1979) and 50 Pfennigs (Fremdling, 1996) respectively.[3] The resulting assumptions for the per-Metric-ton-kilometer shipping costs for Rail and Water transport over time are shown in Figure 5.

Wages: Day laborer's wages are available for Prussian counties in 1892 and 1901 from the ifo Prussian Economic History Database or iPEHD (Becker et al., 2014); these were digitized from the Prussian Social Security Statistics used to determine mandatory contributions for day laborers. Distinction is made between urban and rural wages within a county and for men and women (and children "under 16") but we take the average of male urban and rural wages. To aggregate county level wages up to the level of a constituency, we take a weighted average using county-level population available using data from Galloway (2007). For the purposes of our counterfactuals, we identify the 1892 wages with the election year 1893, and the 1901 wages with the election year 1903.

Electoral Outcomes and Population Data: Data on electoral outcomes for the 397 German electoral constituencies, including constituency populations, registered voters, valid ballots, and votes cast come from Sperber (2005). For our purposes we restrict analysis to the subsample of 186 Prussian constituencies. Proportions of Protestants and Catholics are also available at the constituency level. This is demonstrated in Table 1. In all of these elections, voter participation was strong and certainly competitive with modern democracies–turnout ranged from 51% in 1871 to a maximum of 84.9% in 1912. Hence, Imperial German elites were constrained by the need for the voting population to see their actions as legitimate, and that population exercised that power fervently.

[3]Transshipment costs apply whenever changing modes of transportation. This number is for 1913; our estimate for wagon routes comes from 1840, assuming technological change was roughly zero for horse-powered travel via road over this time.

4 Structural Model and Counterfactuals

Our goal is to assess the full, general-equilibrium impact of our measured infrastructure improvements on welfare, the distribution of the population, and voter participation. We find that improved infrastructure increased welfare by 3-5% and kept workers in the rural east. Because of this effect on the distribution of population, naive estimates of the aggregate effects of the rail expansion on voter participation which do not take population mobility into account will over-estimate the positive effects on of the rail expansion on voter turnout.

4.1 A Spatial Equilibrium Model

We use an Armington model following Allen and Arkolakis (2014): the country consists of N discrete regions indexed i, each producing a unique, differentiated variety of a final consumption good. These are produced by a measure $\bar{L}$ of workers who are freely mobile and choose their location in order to maximize utility. Workers supply one unit of labor inelastically, earning the local nominal wage in region i, w_i. Each worker has identical CES preferences over the N tradeable varieties produced in the country, and enjoys an amenity value from their location, $Amen_i$, which we assume is multiplicative with the utility gained from the consumption bundle. Thus for any worker who chooses location i, their utility can be written as

$$u_i = \frac{w_i}{P_i} Amen_i$$

where P_i is the CES ideal price index in location i, $P_i^{1-\sigma} \equiv \left(\sum_j^N p_{j,i}^{1-\sigma} \right)$ where $p_{j,i}$ is the price of good j in i.

Within each region, all firms are perfectly competitive and produce only that region's variety. Production at the firm level is linear in labor up to region-specific productivity T_i. Trade is costly and takes the "iceberg" form so that between region i and j we assume that $\tau_{i,j} \geq 1$ is the number of units of good i that must be shipped so that one unit arrives in j. We assume these costs are symmetric ($\tau_{i,j} = \tau_{j,i}$) and we normalize $\tau_{i,i} = 1$ for all regions.

Thus, the price of any variety j in location i, $p_{j,i}$, is

$$p_{j,i} = \frac{w_i}{T_i}\tau_{i,j}$$

In equilibrium all firms maximize profits taking wages, productivity and demand as given, and all workers choose their locations optimally, taking wages and amenities as given, so that for any region i

$$u_i = U$$

for some value U which remains to be characterized (changes in U in response to changes in the transportation network are how we calculate welfare gains). Finally, we assume positive spillovers in production (agglomeration externalities) and negative spillovers in amenities (congestion externalities): letting L_i denote the measure of workers in location i,

$$T_i = \bar{T}_i L_i^{\alpha} \tag{1}$$

$$Amen_i = \overline{Amen}_i L_i^{\beta} \tag{2}$$

with $\alpha > 0$ and $\beta < 0$, where $\bar{T}_i$ and $\overline{Amen}_i$ are exogenous parameters governing location-specific productivity and amenity values, respectively. While the functional forms (1) and (2) may seem ad hoc, Allen and Arkolakis (2014) emphasize that this representation tractably represents a variety of specifications used in the literature, up to appropriate parameter restrictions.[4] Since we are ultimately interested in welfare and the distribution of the population, we refrain from specifying particular foundations for (1) and (2). Moreover, existing empirical work by Hornung (2015) for Prussia during the period 1840-1871 supports two key assumptions in the model: high factor mobility and increasing returns to scale in production.[5]

Assume our observed data on population (L_i) and nominal wages (w_i) for Prussia in a particular year (i.e. 1893 or 1903) reflect an equilibrium from this model. Then given trade

[4]The model is isomorphic to a model of monopolistic competition and free entry; a model with a fixed factor in production, or a fixed supply of housing; and a model where workers have idiosyncratic preferences over locations drawn from an extreme value distribution. See their Appendix A.2 for details.

[5]Hornung (2015) finds that, for the period 1840-1871, access to railroads increased both population and the share of migrants living in treated cities (finding no effects on fertility as a potential explanation for increased size). He also finds that the size of factories increases, as opposed to the number of firms, which he interprets as evidence of increasing returns to scale.

costs $\tau_{i,j}$ and values for α, β and σ the model can be inverted to recover implied values for the $\bar{T}_i$ and $\overline{Amen}_i$ that rationalize the observed distribution of wages and population.[6] With these values in hand, we can then compute counterfactuals to determine where the population alive in a particular year would have lived under an alternative set of trade costs (e.g. given by the 1871 transportation network), what wages they would have had, and what the population density and market access would have looked like. Inasmuch as these influence voting, this will allow us to evaluate counterfactual implications for voting shares as well.

For our calibration, we follow the literature and compute iceberg trade costs from total costs per ton-km of frieght scaled by the average value of freight.[7]

We follow Allen and Arkolakis (2014) in using $\alpha = .1$, $\beta = -.3$, and in choosing $\sigma = 9$. This choice of σ implies a trade elasticity on the high end of the values reported in the trade literature, which is consistent with the fact that this is an elasticity of substitution across varieties produced within a country (as those authors note).

4.2 A Simple Voting Model

We proceed by assuming that voter participation depends on two elements of each voter's material conditions, each of which is impacted by improvements to German transportation infrastructure. First, we measure market access as conventional in the trade literature $ma_i \equiv \sum_j^N \tau_{ji}^{1-\sigma} L_j$, which summarizes how connected constituency i is to the rest of Prussia in terms of trade. We hypothesize that this positively influences the propensity to vote in national elections. Second, we allow distance to the nearest major port, $dist_i$, to potentially influence

[6] Allen and Arkolakis (2014) show that there exists a unique mapping from these parameters to the distribution of wages and population given mild restrictions on α and β.

[7] Since the $\tau_{i,j}$ are unitless, we use the same value for average value of freight used for the 19th century U.S. context (Hornbeck and Rotemberg, 2019; Donaldson and Hornbeck, 2016) converted into Pfennigs at the going exchange rate (which was stable due to the prevailing gold standard). Specifically, let $t_{i,j}$ be the total cost of shipping one ton of freight from region i to region j. Given total cost $t_{i,j}$ we compute an iceberg trade cost $\tau_{i,j}$ as

$$\tau_{i,j} = 1 + \frac{t_{i,j}}{\bar{P}}$$

where $\bar{P}$ is their average value of a ton of freight (35\$) converted in Pfennigs. Note that while this assumption matters for the *level* of our iceberg trade costs, which affects the *level* of welfare, it is unimportant for the *changes* in trade costs that we calculate over time, which is what will matter for *changes* in welfare.

the decision to vote.[8] We do this to proxy for increased connectivity to the rest of the world, since this is not captured in our ma_i terms.

Specifically, assume that for an individual j living in constituency i, their decision to vote is governed by a linear probability model

$$\mathbb{1}(\text{individual } j \text{ in } i \text{ votes}) = \beta_j + \beta_{ma} ma_i + \beta_{dist} dist_i + \epsilon_j \tag{3}$$

where ϵ_j is iid mean zero. If L_i people live in i, then expected voter participation $\mathbb{E}V_i$ is

$$\mathbb{E}V_i = \beta_{ma} ma_i + \beta_{dist} dist_i + \frac{\sum_j^{L_i} \beta_j}{L_i}$$

Thus we can estimate β_{ma} and β_{dist} via OLS using constituency level data. In practice, we estimate

$$V_{i,t} = \beta_{ma} ma_{i,t} + \beta_{dist} dist_{i,t} + X_{i,t} + \gamma_i + \varepsilon_{i,t} \tag{4}$$

via OLS, where $X_{i,t}$ includes constituency level controls such as population density and the share of non-Catholics in constituency i at time t and $t \in \{1871, 1874, \ldots, 1912\}$ which permits the estimation of constituency fixed effects γ_i. We interpret these results for β_{dist} and β_{ma} as causal since the variation in these measures that we uncover is due primarily to the expansion of the rail network (which was state-led and occurred largely due to military considerations) and reduced per-km trade costs (which was driven by technological improvements) and are thus plausibly exogenous with respect to local voter participation.

We present our results in Table 2. Column 1 presents estimates the relationship between market access and voter participation for a parsimonious specification controlling only for constituency fixed effects. We estimate that a 1% increase in market access increases voter participation by 0.3 basis points. This estimate is extremely stable to the addition of additional controls. Our preferred specification is column 6, which includes controls for the log of population density, the share of non-Catholics, the interaction between those variables,

[8] This is measured as the minimum iceberg trade cost to either Stettin, or Hamburg. In 1907, Hamburg alone processed some 60 percent of the value of all German maritime commerce and 40 percent of all foreign trade. Also in that year, the nearby port of Bremen's net register tonnage was 29.7% that of Hamburg's and Stettin's was 17.9%. Danzig, the next largest port, processed shipping equal to 7.4% of Hamburg's total (Clapp, 1911).

and chancellor fixed effects.[9] Beginning with column 2, we add our proxy for foreign market access. This coefficient is sensitive to the addition of additional controls; however, we find the estimates in column 6 to be most plausible. We estimate a 1% increase in trade costs to foreign ports reduce voter participation 47.3 basis points. We believe controlling for the different political regimes is key – individuals likely faced different incentives to vote under Bismarck's chancellorship than any of Wilhelm II's four pre-war chancellors.[10] Importantly, even with the inclusion of these additional controls, the estimated effect of market access on voter participation is largely unaffected.

4.3 Counterfactuals for Political Participation

To go from our cross-sectional estimates of the βs to counterfactual estimates of voter participation in 1893 and 1903 in the absence of infrastructure improvements, we will need to make use of the results in our structural model. To see this, define total voter participation in Prussia as $V \equiv \sum_i^N V_i$. Since total population is $L = \sum_i^N L_i$, this can be written

$$\mathbb{E}V = \frac{1}{L}\sum_i^N L_i \mathbb{E}V_i = \frac{1}{L}\left[\sum_i^N L_i\left(\beta_{ma} ma_i + \beta_{dist} dist_i\right) + \sum_j^{L_i} \beta_j\right]$$

Given (OLS) estimates of the coefficients, the counterfactual change in the vote share is the following, assuming identity parameters β_j are constant across the counterfactual:

$$\begin{aligned} \mathbb{E}V^{cf} - \mathbb{E}V &= \frac{1}{L}\left[\sum_i^N L_i^{cf}\left(\beta_{ma} ma_i^{cf} + \beta_{dist} dist_i^{cf}\right)\right] \\ &- \frac{1}{L}\left[\sum_i^N L_i\left(\beta_{ma} ma_i + \beta_{dist} dist_i\right)\right] \end{aligned} \tag{5}$$

[9] The Zentrum Party was the party which represented the interests of Roman Catholics in Germany. This party commanded particular loyalty among Catholics; hence, to attenuate the extent that religious motivations may bias our results, we control for the proportion of non-Catholics. Protestants and Jews were in general much less loyal to any single party (Sperber, 2005).

[10] Recall that chancellors were not responsible to the Reichstag; hence, elections did not directly determine who became chancellor. This implies that characteristics of a chancellor's tenure are not especially endogenous to the timing of elections.

Thus given β's from our regressions and counterfactuals from a structural model, (5) gives us a counterfactual prediction for election turnout in a particular year (e.g. 1893 or 1903). Since the voting model is linear, it is easy to report the contribution of each factor (market access and distance to the nearest major port) separately, and Table 3 does so.

Consider the first line of Table 3. By comparing observed participation in 1893 to the counterfactual participation, in 1871 implied by our model, we arrive at our estimates of the increase in turnout due to the improvements in infrastructure. Line one shows that the total effect is 24.4 basis points when we assume that the distribution of the population is unchanged across our counterfactuals, with roughly 1/3 of the effect coming from increases in domestic market access (ma_i) and the remainder coming from improved access to foreign ports ($dist$).

Now consider line two of Table 3, which computes the same predictions under the assumption that people move. In our context, this *lowers* the estimated effects of infrastructure on participation, as improvements are concentrated in areas that are relatively isolated (and where the model predicts people are less likely to vote). Table 4 repeats this exercise but for the 1903 election and transportation network, revealing larger effects on turnout (as the infrastructure network improves from 1903 relative to 1893, as per-km costs continue to fall).

In short, the results suggest that the ability to purchase legitimacy through infrastructure spending may be limited, as the size of these effects appears small in light of the massive increase in political participation occurring at this time observable in Table 1.

5 Conclusion

Our paper studies the effects of the German rail expansion from 1871 to 1912 through the lens of a spatial equilibrium model. Our results suggest that if the rail extensions had never been built, welfare would have been 3 to 5% lower and even more people would have migrated from the rural east into western Prussia. Given important relationships between trade interconnectedness, population density and voter turnout that we uncover, this shift in the distribution of the population and increase in the flow of goods and people may have had important ramifications for voter turnout for national elections. Our model predicts a modest *decrease* in voter turnout on the order of 25 basis points if the railroads and canals were never extended, suggesting relatively low returns to infrastructure project on popular legitimacy. More work remains to be done to support the causal interpretation of our OLS estimates and to ascertain whether the increases in openness and changes induced in the distribution *and* employment of the population due to expanded trade infrastructure could meaningfully influence voter behavior in the aggregate.

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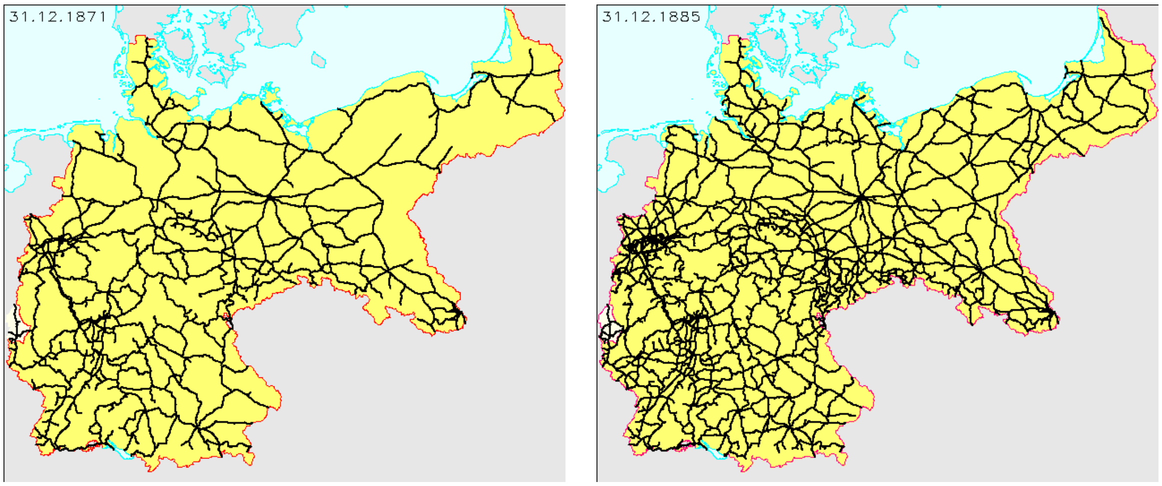
6 Tables and Figures

Table 1: Summary Statistics for *Reichstag* Elections

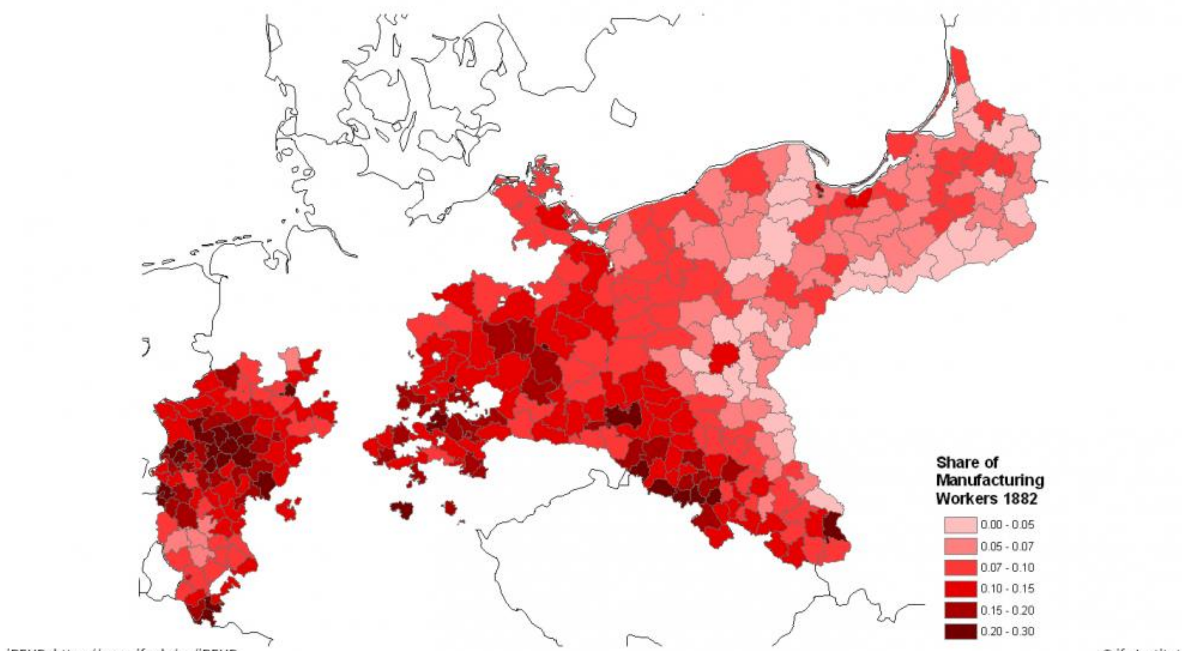
Year	Socialists	Liberals	Conservatives	Center	All Votes	Turnout
1871	3.2%	30.1%	24.0%	18.6%	4,163,500	51.0%
1874	6.8%	29.7%	14.2%	27.9%	5,219,900	61.2%
1877	9.1%	27.2%	17.7%	24.8%	5,422,600	60.6%
1878	7.6%	23.1%	26.6%	23.1%	5,780,900	63.3%
1881	6.1%	14.6%	23.7%	23.2%	5,118,400	56.3%
1884	9.7%	17.6%	22.0%	22.6%	5,681,700	60.6%
1887	10.1%	22.3%	25.0%	20.1%	7,570,700	77.5%
1890	19.7%	16.3%	19.1%	18.6%	7,261,600	71.6%
1893	23.3%	13.0%	19.2%	19.1%	7,702,300	72.5%
1898	27.2%	12.5%	15.6%	18.8%	7,786,700	68.1%
1903	31.7%	13.9%	13.5%	19.8%	9,533,800	76.1%
1907	29.0%	14.8%	13.6%	18.8%	11,303,500	84.7%
1912	34.8%	13.6%	12.2%	16.4%	12,260,600	84.9%

Note: The "Socialists" column refers to the Social Democratic Party. The "Liberals" column refers to the National Liberals. "Conservatives" column displays the sum of the Conservative Party and the closely-aligned German Reich Party vote shares.



(a) 1871 Rail Network (b) 1884 Rail Network

Figure 1: **Expansion of the Imperial German Rail Network, 1871-1884.** Unification in 1871 attenuated barriers to rail construction, and by 1875 all major cities were connected. Construction continued at about 1,000 km/year, extending existing lines into rural areas.



(a)

Figure 2: **Distribution of Urban vs. Rural Prussian Counties** The railroad extensions above importantly connected the more rural east with the existing rail network. We focus on Prussia, the largest state in the German Empire, and aggregate counties up to constituencies – the fundamental geopolitical unit for *Reichstag* elections – in our analysis.

Election Year	Date of Most Recent Major Change In: Rail Network	Canal Network	Notes
1871	1871	1871	
1874	1874		
1877	1877		
1878	1878		
1881	1881	1872	Rhine-Marne, Saar, Rhine-Rhone Canals completed
1884			
1887			
1890			
1893	1884	1891	Oder-Spree Canal completed
1898		1895	Kiel Canal completed
1903			
1907		1900	Dortmund-EMS Canal completed
1912			

Figure 3: Sources: we digitized Rail and Canal Networks by hand from high quality maps (Institute for European History and the *Bibliographisches Institut in Leipzig*). Canal construction dates were taken from Kunz, Zipf, and Böhler (2008). Shapefiles of natural waterways were obtained from the EU-Hydro dataset provided by the European Environmental Agency (European Union, 2019) and waterways were extended to allow for transit along the coast and sea routes approximating thouse in Heitmann et al. (2013)

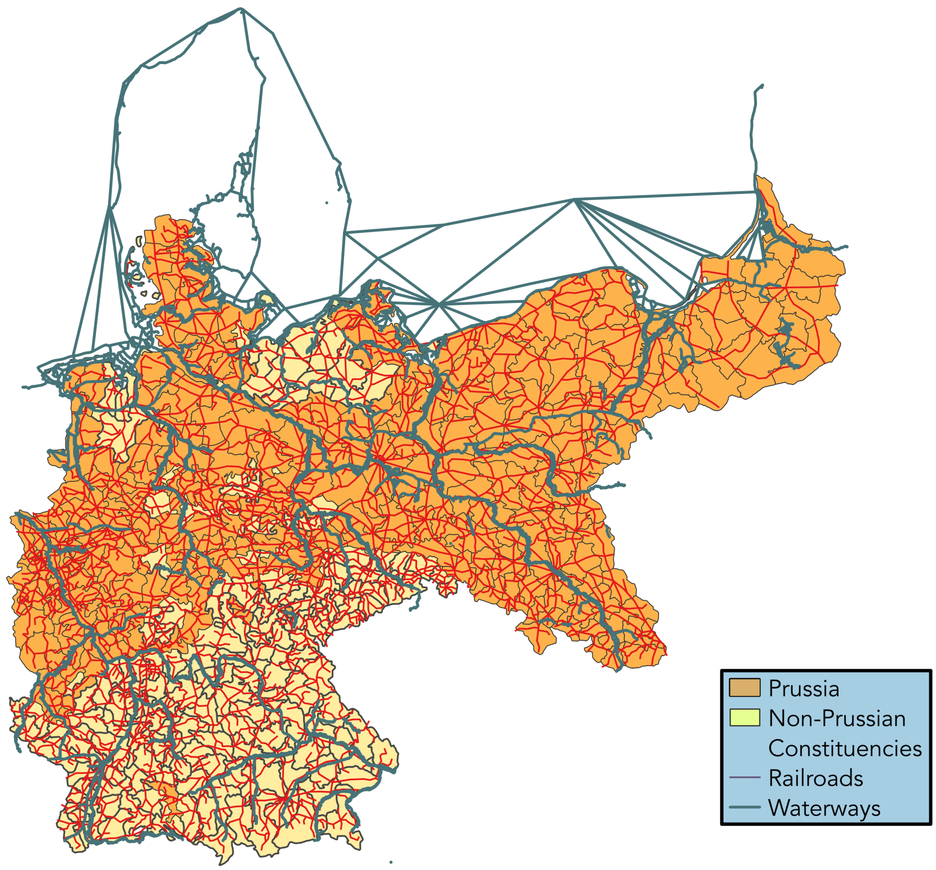


Figure 4: Example Transportation Network in 1893 (constituency centroids, roads, and non-German territory is left unmapped for legibility).

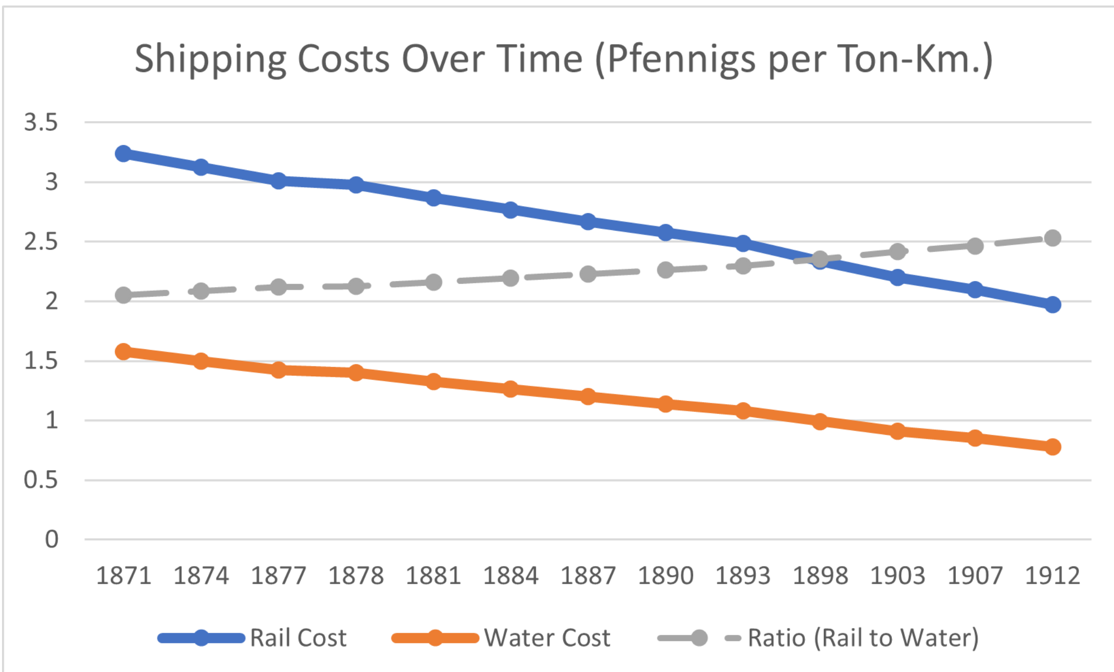


Figure 5: Sources: Given historical estimates of average shipping costs per Ton-km for all of Germany in 1872 by waterway and canal (Teubert (1918) accessed in Gutberlet (2013)) and by rail (Fremdling, 1996), we apply long-run average growth rates for each transportation method from 1870-1914 obtained from Klemann and Schenk (2013). Costs for shipping by Wagon and transhippment costs are held constant at 40 Pfennigs per Ton-Km. (Fremdling, 1979) and 50 Pfennigs (Fremdling, 1996) respectively.

Model Implied Effects of Infrastructure Improvements 1871-1893

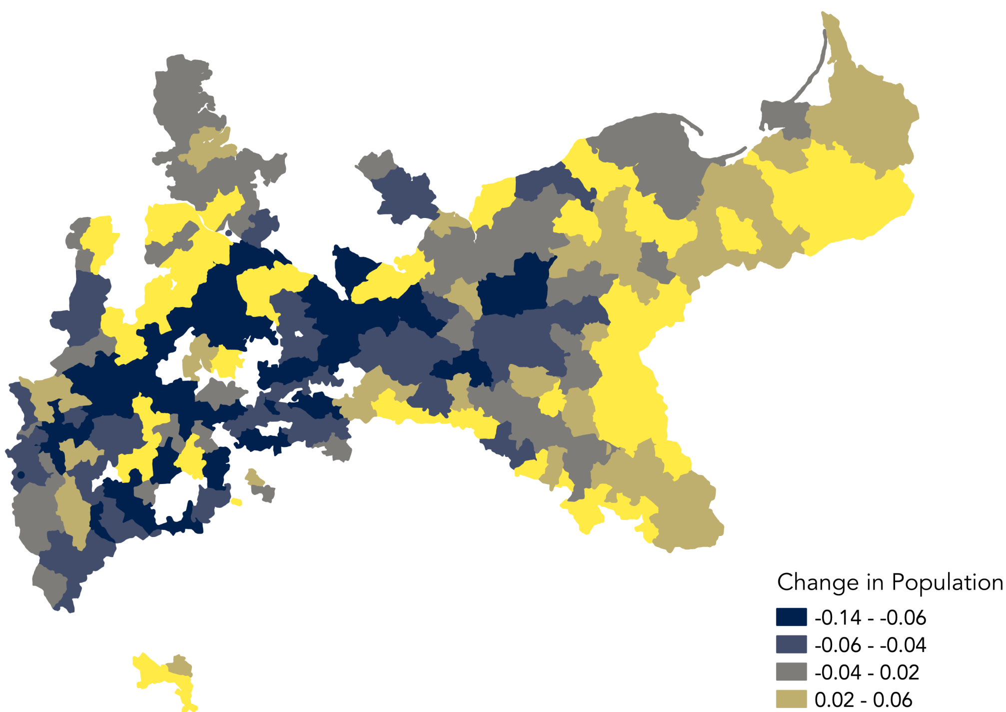


Figure 6: Improvements in 1903 raise welfare 3.5% and move people east relative to 1871.

Model Implied Effects of Infrastructure Improvements 1871-1903

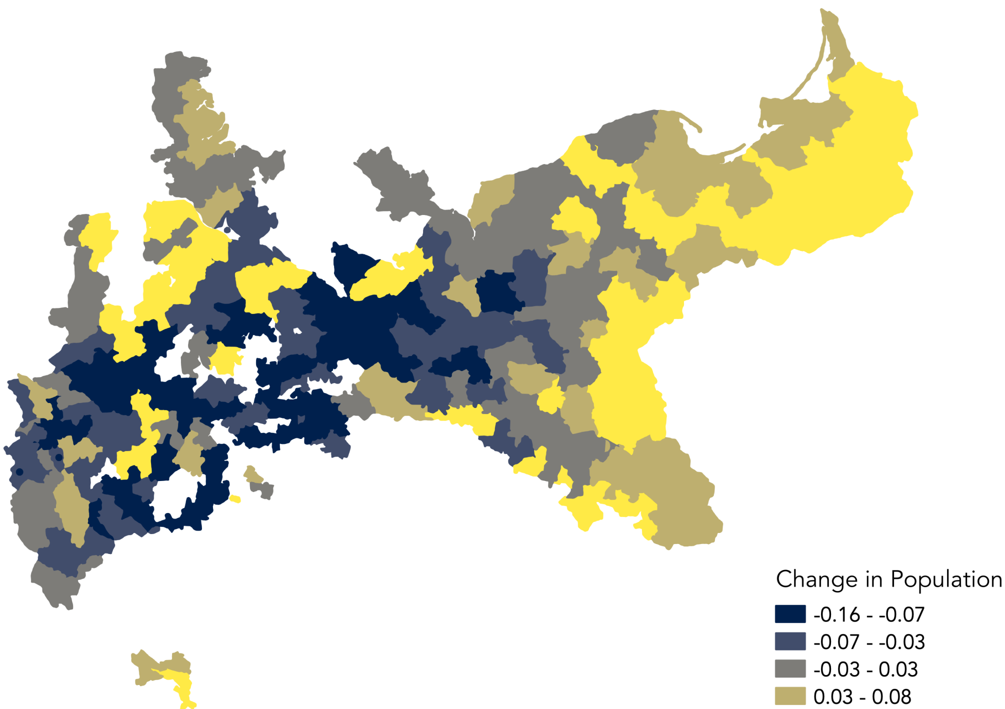


Figure 7: Improvements in 1903 raise welfare 4.2% and move people east relative to 1871.

Table 2: Effects of Market Access on Voter Participation

	(1) Voter Participation	(2) Voter Participation	(3) Voter Participation	(4) Voter Participation	(5) Voter Participation	(6) Voter Participation
Market Access	0.30***	0.30***	0.29***	0.32***	0.33***	0.31***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
Distance to		1.43***	1.52***	0.41	0.50	-4.73***
Foreign Port		(0.50)	(0.50)	(0.52)	(0.52)	(1.40)
Log Population			0.05**	0.07***	0.03	0.02
Density			(0.02)	(0.02)	(0.03)	(0.03)
Non-Catholic				-0.16***	-0.34***	-0.33***
Share				(0.01)	(0.07)	(0.07)
Density ×					0.04***	0.04**
Non-Catholic					(0.01)	(0.01)
Chancellor FE						✓
adj. R^2	0.57	0.57	0.58	0.60	0.60	0.62
N	3,091.00	3,091.00	3,091.00	3,091.00	3,091.00	3,091.00

Note: The dependent variable is the proportion of valid ballots to eligible voters. Market access and distance to foreign port are in logs. All specifications include constituency fixed effects. Standard errors are clustered at the constituency level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 3: GE Effects of Improved Infrastructure on 1893 Voter Participation

Model	(1) ma_i	(2) $dist_i$	(3) Total
1. Assumes no Mobility	9.0 bps	15.4 bps	24.4 bps
2. Assumes Mobility	8.1 bps	14.8 bps	22.8 bps

Table 4: GE Effects of Improved Infrastructure on 1903 Voter Participation

Model	(1) ma_i	(2) $dist_i$	(3) Total
1. Assumes no Mobility	10.9 bps	18.6 bps	29.5 bps
2. Assumes Mobility	9.9 bps	18.0 bps	27.9 bps

Note: Columns (1)-(2) may not sum to (3) due to rounding.
Assuming mobility implies smaller estimated increases because people move to relatively less-connected rural areas.