Fiscal Capacity, Railway Federalism, and German Railway Development 1835-1885

Paul Lowood November 19, 2024

Abstract

This paper analyzes the relationship between fiscal capacity and railroad development in Germany. German states understood the benefits of railroads but faced budget constraints when supporting network construction. Using newly constructed fiscal capacity and railroad ownership datasets, I estimate the effect of state revenue growth on the decision to grant concessions to private companies or expand public firms. I find that increases in government revenues led to a significant switch away from public construction towards a concession based system without changing the overall rate of construction. I hypothesize that this is because revenue shocks were not large enough to fund new public railroad projects, but could subsidize significant private investment. This may have allowed states to meet capital demands for consistent levels of construction while issuing less debt.

For the most recent version, please visit my website: https://sites.uci.edu/plowood/

1 Introduction

Fiscal capacity is an important determinant of economic development, as increased fiscal capacity allows governments to support the provision of public goods such as infrastructure or contract enforcement.[1] The specific channels connecting fiscal capacity to development are less understood. For example, states face choices about how they choose to utilize their capacity, and it is not *a priori* obvious that state fiscal capacity will support or crowd out private enterprise. On one hand, fiscal capacity allows governments to subsidize, guarantee the returns of, or directly invest in private companies providing key public goods. On the other hand, fiscal capacity can also be used to invest directly in public enterprise or cover the costs of nationalization. In this paper, I explore how fiscal capacity shaped 19th century German states' policies supporting railroad investment.[2] Understanding the drivers of railroad construction in Germany is of particular importance, because, as Fremdling (1977) shows, rail was the leading industry in the industrial revolution that transformed Germany into Europe's manufacturing powerhouse.

Germany is also unique because there was no cohesive central planning of the railroad network. Each German state (e.g., Prussia, Bavaria, Saxony) made their own railroad policies; even after unification in 1871, there was no central railroad authority and attempts to impose one all failed miserably until the first world war. Each state faced its own incentives and constraints that were tied to their political cultures, locations on trade routes, and endowments of key resources that could be exploited in the rapidly globalizing economy.

The common view (e.g, Millward (2004)) that German railways were mostly public hides a substantial amount of regional variation in early railroad policy. While it was true in 1910 that 94% percent of railroads were publicly owned in Germany (the highest among all states studied in Bogart (2010)), there was little indication that public firms would end up playing

[1] See Besley and Persson (2011); Besley, Ilzetzki, and Persson (2013); Dincecco (2011); Dincecco and Prado (2012); and Johnson and Koyama (2017).

[2] For other studies connecting fiscal capacity to railroad expansion, see Bignon, Esteves, and Herranz-Loncán (2015) (Latin America), Dincecco and Katz (2016) (Europe), and Bogart and Chaudhary (2012) (India).

such a large role when the first railroad line between Nuremberg and Fürth was laid by the private *Ludwigs-Eisenbahn Gesellschaft* in 1835. Prussia, Saxony, and many of the smaller states had entirely private networks until the late 1840s. In fact, the first year that the German state railway authorities would lay more miles of track than private firms would not be until 1850, and private construction outpaced public construction in 37 out of the 51 years between 1835 and 1885 observed in this study.

By tracking what percentage of railroad miles within each state was owned by that state over time, one can see different state ownership policies for railroad construction. The full range of percentages exists in all periods, and while the percentage was increasing over time for most states, it decreased for others. This paper is the first to explore how fiscal capacity may have been a key determinant of ownership policy, and lays the groundwork for more detailed analysis on how that policy may have influenced network efficiency and development in a wider sense.[3]

This paper focuses on a state-level analysis of the effect of fiscal capacity on railroad construction, and crucially it allows private and state railway networks to react differently. By matching entries in primary sources that list which companies constructed each rail line in Germany to existing GIS data of rail line locations, I construct a new dataset that tracks the state ownership policies of the different states over time. Combining this with data on nationalizations and privatizations, it is possible to calculate how many miles of railroads in any state were publicly or privately owned in any given year.

Through dynamic panel regressions based on a partial adjustment model (and an instrumental variable strategy exploiting sequential moment restrictions) I estimate the effect of increased state revenues on the growth rates of the public and private railroad networks within eight of the largest German states. I propose several channels linking state revenues to railroad construction: First, state revenues could be used to directly invest in state-owned

[3]The consequences of such policy for construction costs and operating efficiency in Britain are well explored by Foreman-Peck (1987), but Germany lacks a comparable analysis. Appendix 1 provides an extremely preliminary view.

enterprise. Second, revenues could be used to subsidize private firms. Though the exact scale of subsidization is currently unknown, there are numerous examples of states guaranteeing returns for investors or simply buying shares directly. Third, revenue growth might make the state a more credible debtor, raising its capacity to issue bonds for railroad construction. I hypothesize that the second and third channels were particularly important, as railway construction required staggering amounts of capital that states simply could not provide on their own.[4]

My results suggest that increases in government revenues are associated with reductions in public construction and corresponding increases in private construction. However, these changes cancel each other out and do not result in any increase to the overall railroad network growth rate. These results are consistent with my hypothesis that the channel leading directly from state revenues into state railroad construction is not utilized. I speculate that this is because year-to-year revenue changes were not large enough to fund new lines for state railways, but were sufficient for insuring private investors against the risks of investing in private firms. It is more difficult to explain why the overall effect on construction is null. If the pace of railroad construction was constrained solely by the availability of capital, having more free cash available for subsidies and interest rate guarantees should have increased private construction while public construction stayed stable. Instead, windfalls predict a substitution.

Dividing state revenues into two components provides possible answers to this puzzle. One of the most important sources of state revenues were the state railroads themselves. When these are considered separately, we see that the substitution effect is driven entirely by non-rail revenues, i.e., tax and demesne revenues. On the other hand, increases in state rail profits strongly predict increased state railroad construction with little to no countervailing effect on private construction. One possibility is that as state railroads grew, their

[4]Using data from Fremdling et al. (1995), one can show that annual investments in fixed capital stock for state owned firms were frequently more than 20% of the size of the states' budgets, and sometimes even two to four times as large. Furthermore, state owned firms only accounted for half of all fixed capital stock until the 1880s.

growth became increasingly self-sustaining. Increased profits mean more capital available for reinvestment. Another possibility is that the increasingly reliable stream of revenues from railroads was easier or more politically acceptable to borrow against than earlier revenue streams. In a final extension, I look at debt capacity directly and find that issuing new debt is strongly associated with increased public construction.

My approach offers a different perspective on fiscal capacity compared to other studies which use only indirect or approximate measures. To my knowledge, the only other estimate of the relationship between fiscal capacity and railroad construction in Europe can be found in Dincecco and Katz (2016), which finds that fiscal centralization and contitutional reform led to greater economic growth. The estimation strategy is not causal, nor can it be applied to the German states, since most of them had already introduced constitutions with parliamentary oversight of the budget in the fallout of the Napoleonic wars. Prussia was one of the only major states in Germany to delay implementing a constitution until the mid 19th century, and fiscal centralization occurred far earlier with the development of cameralism in the 16th century (Cantoni, Mohr, and Weigand 2021). In an extension, Dincecco and Katz look at tax revenues per capita as a measure of fiscal capacity, but I will show that this is a very incomplete measure for Germany, where much of the innovation in generating state revenues came from state enterprise, as first documented by Fremdling (1980).

Bignon, Esteves, and Herranz-Loncán (2015) cleverly estimate plausibly causal estimates of the relationship between fiscal capacity and railroad construction in Latin America by exploiting the fact that the majority of state revenues there came from tariffs. This allows them to address the reverse causality issue arising from the fact that railroad construction encourages economic activity, expanding the tax base. However, this approach also has limited value in Germany, where trade taxes were typically remitted to central authorities (the *Zollverein*, then the *Reich*). Furthermore, the mechanisms linking fiscal capacity to railroad construction may have been quite different in Latin America and Germany. For one, the scale of subsidization in early 19th century Germany is not well established. Subsidies

certainly existed, but the role of government financing is often obscured by many states' tendencies to make direct investment into private companies through the purchase of stock.

The German context is also different because there is little evidence to suggest that a lack of access to capital was ever a serious constraint on construction, and my results provide new cliometric support for this view. Earlier scholars like Fremdling (1983) argue that demand for transportation was sufficient for private investment, and the only real constraint was the hesitancy of the states to grant concessions. Mitchell (2000) emphasizes the fact that railway construction began at a much faster rate in Germany than in France and argues that state intervention was just as likely to have spurred investment as to have constrained the private sector.[5]

My results also speak to the open question of whether public and private firms were complements or substitutes. State and private actors may have very different motivations for laying miles of track. For example, it is generally accepted that the development of state railroads in Eastern Prussia was motivated by military concerns. The state was required to enter the market here, because even with subsidies the lines would not have been profitable enough to entice private investment. On the other hand, private companies focused on constructing lines on established trade routes where high demand was easy to see. While this may have been broadly true, the fact that some states chose not to allow private construction even along high-demand lines in favor of a totally public railway system challenges the generalization that states only got involved for strategic concerns.

Sections 2 discusses which German states were included the sample. Sections 3 and 4 provide background information on the historical development of the German states' railroad networks and fiscal capacity. Sections 5 and 6 discuss the empirical specification and data. Section 7 reports results and section 8 concludes.

[5]State interventions may actually have led to an *overbuilding* of the network, as neighboring states competed to build lines that would attract traffic to routes through their own states and not neighbors. Analyzing the potential costs of this overbuilding and competition is beyond the scope of this paper.

2 Sample Selection

The existing literature does not provide a satisfactory explanation for the varying degrees of state involvement in the railway industry. While it is possible that such decisions were largely the result of idiosyncratic ideological differences, this view has been refuted by Millward (2013) who emphasizes the role of geopolitics and the desires of states to develop their capacity and control of key industries. Millward also considers the importance of expanding the state's participation in business to raise revenues, similar to Fremdling (1980), but suffers from the same problem of basing those conclusions entirely on Prussian data. Furthermore, the literature does not agree on whether the net effect of intervention was typically to facilitate or delay railroad construction.[6]

To better understand how state intervention and state capacity influenced the development of the German railroad network, it is necessary to broaden the usual scope of study, which generally focuses primarily on Prussia, and only occasionally includes Baden, Wuerttemberg, Bavaria, and Saxony (the largest and most influential of the states in the "Third Germany" that divided Prussia and Austria). However, it is also important to establish some criteria for noteworthiness; most of the 44 observed states were insignificant, and many were so insignificant that they would be annexed before ever constructing a single mile of railroad. Therefore I use a simple cutoff: the state must construct at least 150 miles of railroad during the observation period of 1835 to 1885. This gives 11 states: Baden, Bayern, Braunschweig, Hanover, Hessen-Darmstadt, Mecklenburg-Schwerin, Oldenburg, Preussen, Sachsen, Sachsen-Weimar-Eisenach, and Wuerttemberg, whose area makes up 96.4% of the total area of Germany, as shown in Figure 1.[7]

[6]Fremdling (1983) argues that there was more than enough demand for railroads, and the influence of state intervention was purely to slow construction. On the other hand, Mayntz and Hughes (1988) believe that, at least in the earliest years, raising funding was difficult for both state and private actors. Mitchell (2000) takes a middle position, and argues that the effect of state intervention was ambiguous and could have gone other way depending on the context. Millward (2004) takes a positive view of state intervention, arguing that it occurred in cases when the German states were impatient with the slow pace of private investment. None of these arguments are based on a robust cliometric approach.

[7]Of these, data has been collected for 8: Baden, Bavaria, Brunswick, Prussia, Saxony, Sachsen-Weimar-Eisenach, and Wuerttemberg. Results in this draft are based on the 8 state sample. This sample covers 84%

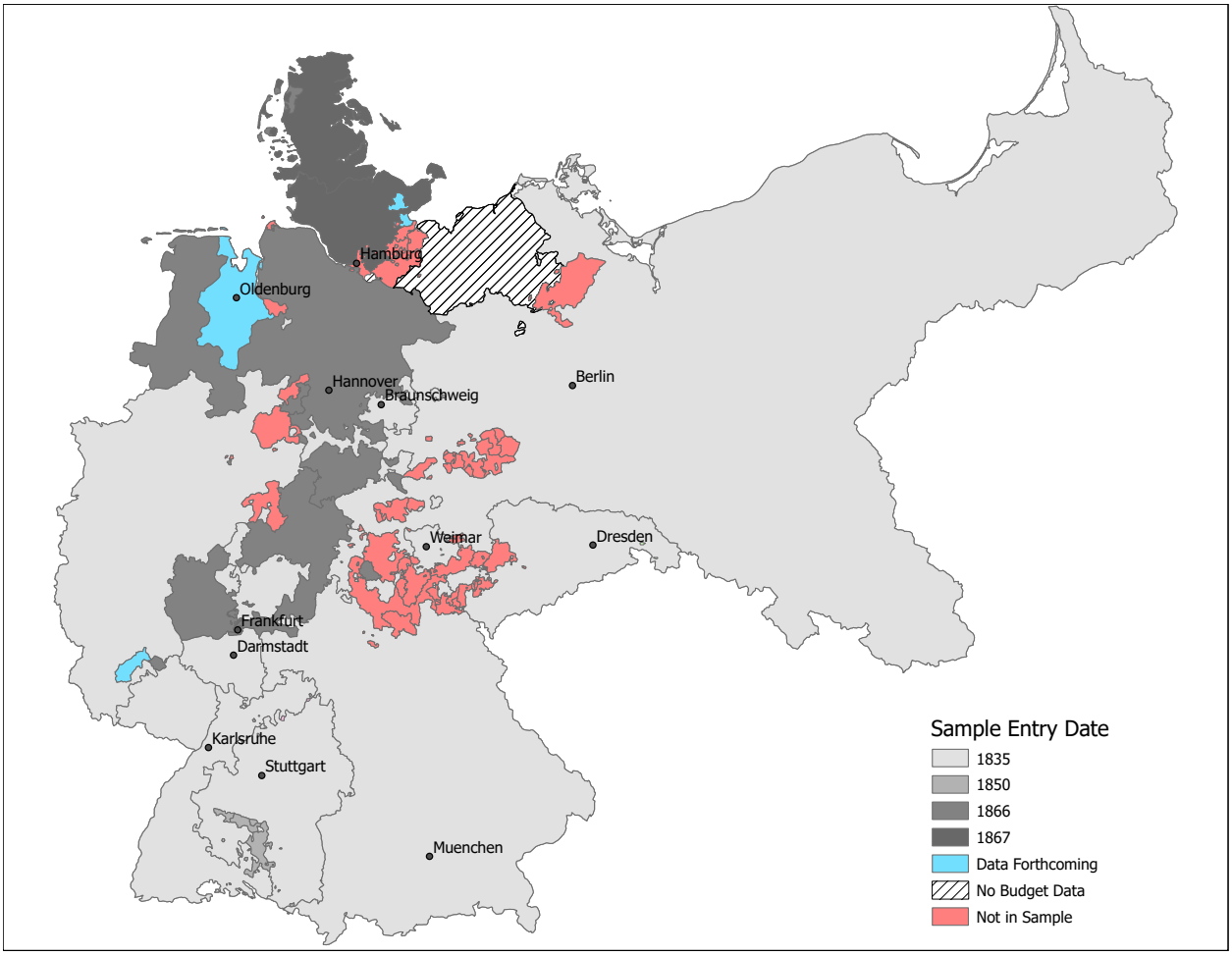


Figure 1: Sample Coverage. Late entry occurs when smaller states are annexed by Prussia.

3 Early German Railroad Development

3.1 Stylized Facts

The development of the German railroad network is illustrated in Figure 2. The first 3.6 miles of track were laid in 1835 between Nuremberg and Fürth by the *Ludwigs-Eisenbahn Gesellschaft.* In the next decade, over 1000 miles of track would be laid, primarily in Prussia, Baden, Saxony. Construction rapidly accelerated, with over 7000 miles built between 1846 and 1865. It has frequently been stated that the initial phase of railroad construction did not lead to any significant new connections, but simply intensified existing trade along major routes.[8] By the end of this period, we can see that the major trunk lines had been constructed, but densification had only begun in the Ruhr.

Most trunk lines that needed to cross state borders were not built until the end of this period, as the construction of East-West lines was significantly delayed by particularism and the fear of trade diversion.[9] This was exacerbated by the challenges associated with negotiating the treaties required for a railroad to cross a border.[10] Negotiations often took many years and most were not finalized until the 1860s and 70s. It is likely that the proliferation of private firms was in some part due to the fact that joint investment by states was a workable solution when both parties wanted to retain some degree of sovereignty and control; in fact, over 70% of border crossings were opened by private firms. These points highlight the role of federalism in the development of German railways.

Accelerating densification and a reduction in particularism following Prussia's territorial expansion in the aftermath of the Austro-Prussian War and German Unification massively increased the rate of construction in the next decade. Between 1866 and 1875, over 8000 miles were built, doubling the size of the network. In Prussia, densification of the Ruhr network proceeded at pace, and massive trunk lines connected Berlin and East Prussia. Densification

of Germany from 1835-1865, then 94% after Hanover is annexed by Prussia.

[8] Fremdling (1983), Mayntz and Hughes (1988).

[9] Described by Mitchell (2000), Hoffman (1969), and Fremdling (1983).

[10] Hoffman (1969) is the definitive source here.

also began in earnest in the southern states. Another 5000 miles were built between 1876 and 1885, mostly increasing density in the remote northern and eastern regions, as well as politically fragmented Thuringia.

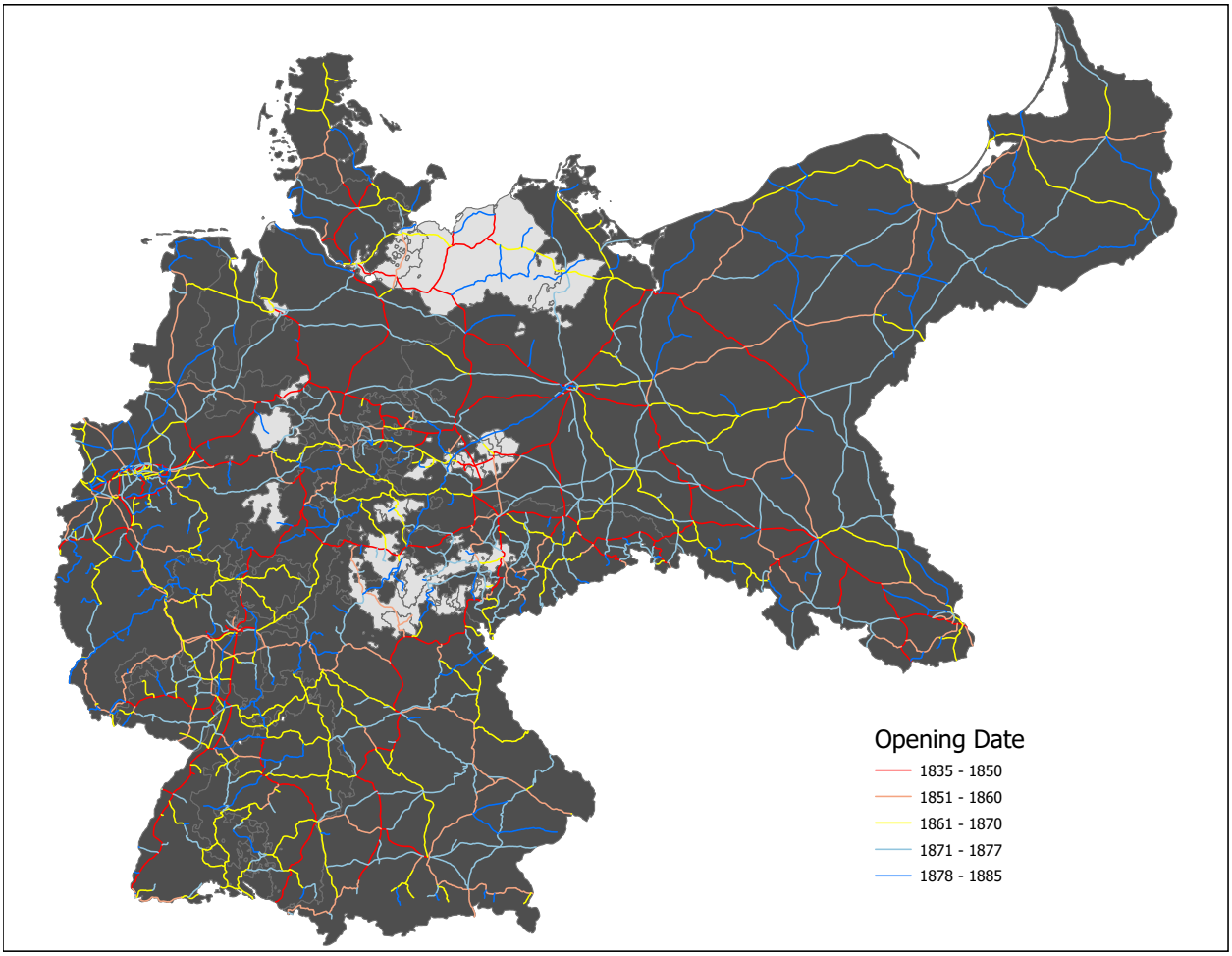


Figure 2: Timing of Railway Construction. Shapefiles: Kunz & Zipf 2008. Graphic by author.

Table 1 presents the size and density of the ten largest state railway networks in 1885. One can see that, although the absolute size of the networks varies substantially, the density measures all fall within a reasonable distance of each other. This is not to say that all states achieved the same level of density; whether measuring density by area or per capita, the most dense network is roughly twice as dense as the least dense and the remainder fall relatively evenly between these two extremes.

Table 1: State Railroad Network Size

State	Miles	Rank	Per Capitax1000	Rank	per square mile	Rank
Prussia	12994	1	.46	8	.10	8
Bavaria	2817	2	.54	4	.10	7
Saxony	1118	3	.35	10	.19	1
Wuerttenberg	840	4	.42	9	.11	5
Baden	751	5	.47	7	.13	4
Hessen-Darmstadt	475	6	.50	6	.16	2
Mecklinburg-Schwerin	374	7	.65	1	.08	10
Oldenburg	219	9	.64	2	.09	9
Brunswick	214	10	.58	3	.15	3
Saxony-Weimar-Eisenach	156	11	.50	5	.11	6

3.2 Public and Private Railways

To analyze how ownership policies varied across Germany and within states it was necessary to construct a new dataset. Before describing the construction of that dataset and the stylized facts that emerge, it is important to clarify how railroad mileage is divided into different categories, and why those categories mattered. Contemporary sources such as Vereins Deutscher Eisenbahn-Verwaltungen (1868) and Kühn (1882) divided firms into three types: First were the *Staatsbahnen*, or state railroads, which would later become known as the *Länderbahnen*. These were fully incorporated into the bureaucracy of the state; administration was handled by the state and profits were treated as state revenues. Second were the *Privatbahnen*, or private railways.

It is important to emphasize that public and private railways were financed differently. State railroads were primarily financed by the issue of bonds. These bonds established railway construction funds administered by the relevant ministries in charge of regulating railways. Further bonds could be issued as desired to provide new capital injections. The interest payment on these bonds was part of the ordinary expenses of the state, and in almost all cases the profits of the state railroad system were treated as ordinary revenue (the exception being Baden, where railroad revenues were part of a separate "Special" budget). Private railroads, on the other hand, were financed by the sale of stock. This allowed private

capital to supplement government debt. Mayer (1891) writes that granting concessions to private firms to sell stock was particuarly common in the early years of construction, when states were more fiscally constrained. As time went on, and states had more reliable income, but developing new lines became increasingly risky, states had two tools they could use to encourage additional private capital investment in railroads. First, they could purchase shares of stock themselves, supporting asset prices and signalling the soundness of the investment, as well as the state's desire to keep that particular line running, perhaps through favorable legislation or additional support. Second, they could offer guaranteed returns on investment, socializing all of the risk if the line turned out to be unprofitable.

States were keenly aware of the tradeoffs they faced when deciding whether to bear the burden of financing railroads themselves or seek out private capital. In the stenographic records of the Bavarian parliament from 13. July 1850 (Bayerischer Landtag 1850), we can find a spirited debate over whether state investment in railroads was responsible for problematic budget deficits. The first camp argued that state investment could not be responsible for the deficit because past investment in railroads creates income without further spending, since the railroads are profitable. As the proposed budget under discussion does not include any funds for state construction, it is instead the recurring funds that must be held in reserve for guaranteed returns to private investment that create persistent deficits. The second side retorted that the deficit would be smaller if no money was ever spent on railroads, since the state could have easily attracted foreign capital to cover all construction costs with small guarantees and instead used all of the money it spent on construction for more fruitful pursuits. This debate highlights that, in addition to being uncertain of which avenue was truly more efficient, Bavaria also faced binding short run budget constraints that it preferred not to resolve by simply issuing more debt.

A complete classification of all German railroads must also note that private railways were further subdivided into those administered by a state bureaucracy (which typically fluctuated around 10% of total railway mileage), and those which were administered privately. To my

knowledge, there is no strict definition of "state administration", but we can understand through an example:

The *Bergisch-Märkische Eisenbahn-Gesellschaft* was founded in 1843 as a private railway, with a quarter of the founding capital provided by the Prussian government. In 1849, the railway failed to repay a government loan, and the Prussian government would not agree to provide further loans unless the company agreed to turn over operations to the Prussian state ("Bergisch-Märkische Eisenbahn-Gesellschaft" 2023). From then on, the state handled operation of the railway, and presumably profits were distributed to shareholders through dividends; there is no evidence that profits from this firm were treated as part of the state's budget in the way that state owned firms were. Unfortunately, I have also not found any evidence to suggest whether operating expenses were borne by the state or if the state was compensated as if it were a contractor.

For my analyses, I do not retain the distinction between publicly and privately administered private railways to emphasize two points: First, granting a concession to a private company implies the state either needed or preferred for the line to be financed at least partially by private capital, even though it had the administrative capacity to run the line. Second, the budget of a private firm is at arms length from the state it is located in, even when it is publicly administered. Because there is no data on the shares of stock owned by each state, it is impossible to know precisely how the performance of private firms would have influenced state budgets.[11]

In the empirical analysis, it is important to recognize to recognize that state-owned companies also operated in other states. For simplicity, I use "State" miles to refer to *state owned* railways operating *within that state* (e.g., the Bavarian State Railway constructing miles within Bavaria). In contrast, "Other" miles refer to state railways operating in some

[11]The complexity of untangling the flow of funds between governments and JSCs is highlighted by an example that can be found in Fremdling and Knieps (1993). Prussia purchased about 15% of the outstanding stock of the Cologne-Minden railway in 1843, while also guaranteeing a minimum dividend to the other investors in exchange for a share of excess profits (among other privileges). The complexity of the relationship and lack of accounting data make it impossible to determine the direction of the net flow of capital between the state and the company.

other state (e.g., a Prussian state railway operating within Oldenburg). Thus, the ownership of rail lines fits into one of three categories: State, Private, and Other.

The railway GIS data used to classify mileage by type begins with shapefiles from Kunz and Zipf (2008). The railroad shape files within do not contain any qualitative data about individual line segments besides the year of opening. Thus, it is necessary to match these segments to a different source with qualitative information. The primary source is Dumjahn (1984), which notes the company responsible for construction of the segment, the length of the segment, and, if the segment was nationalized, by which state and in what year. Matching was successful in nearly all cases, and the remainder were matched using Kühn (1882). It is important to note that the methods used by Kunz and Zipf (2008) to simplify the drawing of the rail network introduce minor inaccuracies. For example, no distinction is made between different stations of most cities (with the exceptions of Berlin and some major industrial cities on the Rhine). The effect of the measured length of track is negligible, but this does ignore the important costs of trans-shipment from one company's station to another that often existed before the construction of smaller connecting lines as the number of companies fell. Furthermore, Kunz generally omits small lines connecting city centers to ports, as well as all of the narrow gauge track (roughly 300km) which was utilized primarily used for short haul industrial purposes (typically under 20km).

It is also important to note that Dumjahn does not record privatizations or mergers. Mergers or sales of lines from one private firm to another are not coded, but it is important to note privatizations. Kleeberg (1990) provides data on the timing of the privatization of the Brunswick state railways and eventual sale to the Prussian state railways. Reliable information on the privatization and renationalization of railways in Mecklenburg-Schwerin is harder to find, and not all sources agree on the timing. I follow the timing given by Fremdling and Kunz (2011). I am not aware of any other privatizations.

Figure 3 presents which types of firms constructed the railroads in each state. Because policies varied from state to state, an individual treatment is necessary to explain contextual

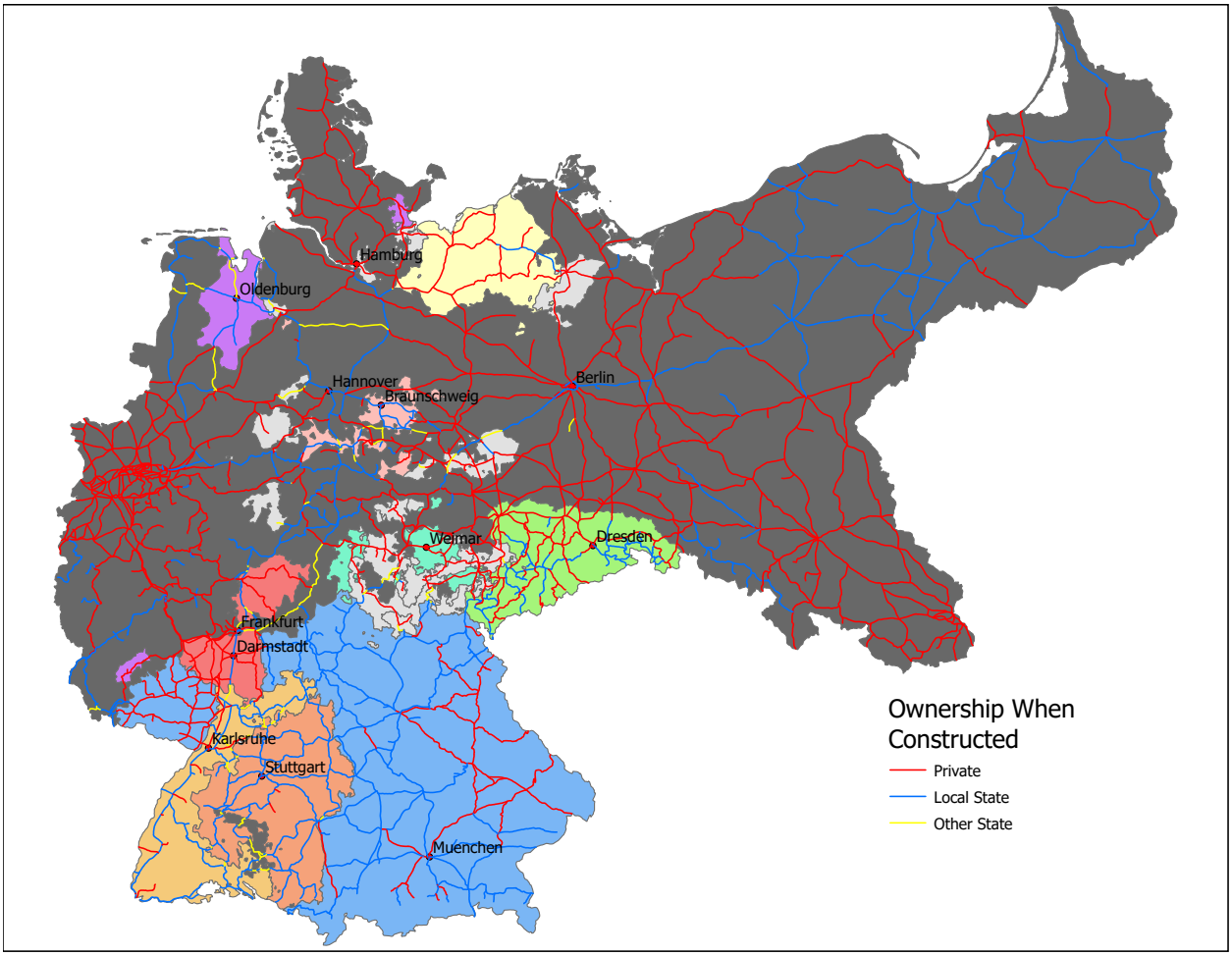


Figure 3: Ownership of railway at the time it was opened. Sources: Shapefiles for state borders and railroad lines from Kunz and Zipf (2008). Ownership classifications by author based on Dumjahn (1984).

factors; this is presented in Appendix 2. However, some broad patterns do emerge. State construction was much more widespread in the South, which likely contributed to the delay in East-West lines connecting the southern states. These were the states whose administrations were most intensely particularistic and least willing to make any concessions that could be considered ceding sovereignty. It is harder to make generalizations about the connection between industrial regions and state construction from a purely visual inspection. While Prussian state intervention was common in the Saar and Silesia, railroads in the Ruhr were constructed almost entirely by private firms. Discontiguous territory, however, appears to be highly correlated with favoring private firms. With the exception of the Saar, and some connections with Hannover, railroad construction in the Rhineland and West Prussia is dominated by private firms. Hessen-Darmstadt's territory was also divided in two, and her network was primarily constructed by private firms as well. Bavaria and Oldenburg preferred state construction in their core territory, but left construction in their exclaves exclusively to private firms.

Despite these observable trends under specific circumstances, and in particular because a "one size fits all" explanation that state railways emerged in regions with infant industries does not match our observations, a substantial amount of variation in state railroad construction within and across states remains unexplained. Explaining how a portion of that variation is explained by fiscal capacity is the main focus of this paper, and is discussed further in Section 9.

A digression on nationalizations is also necessary, as nationalizations may play an important role in determining state railway profitability. It has been shown by Bogart (2010) that state intervention though nationalizations had differing effects from state intervention by construction. The effect of nationalization is somewhat difficult to account for in this study for two reasons. First, most nationalizations occurred very close to the end of the observed period of railroad construction from 1835-1885, as shown in Figure 4. The early nationalizations in Bavaria and Saxony initiated state involvement, but only led to the wider

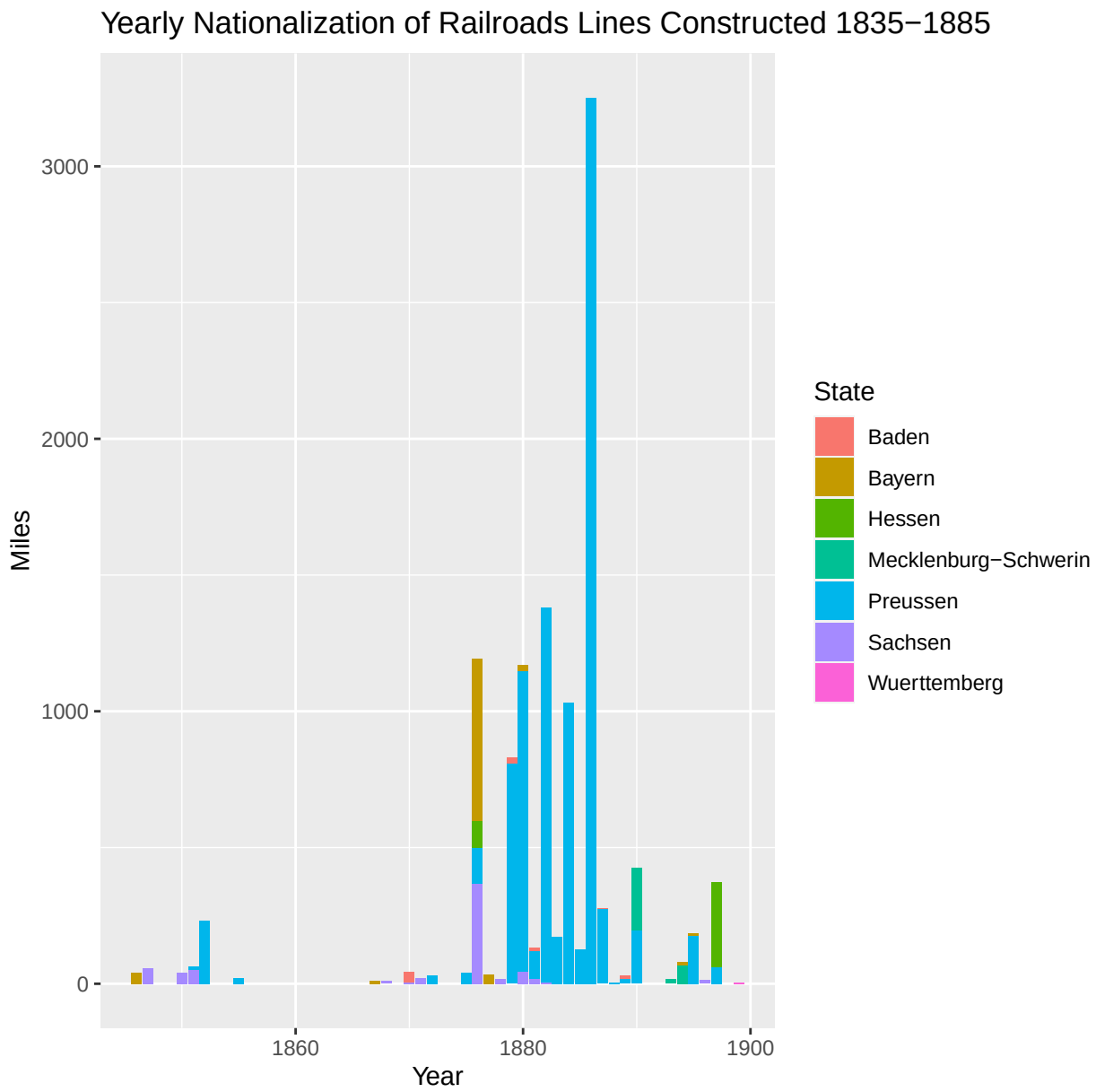


Figure 4: Nationalizations by State and Year. Source: Calculated by author from Kunz and Zipf (2008) and Dumjahn (1984)

development of state firms rather than general policies of nationalization. Second, nationalizations were largely a reaction to exogenous political pressure. Prussian attempts to create a national railway administration were complete failures and led to fears among the smaller states that Prussia would create a national administration indirectly by purchasing the remaining private railways and absorbing them into the Prussian State Railways (as would occur in Brunswick). To preempt this possibility, the south German states nationalized most of the remaining private firms within their borders in 1876. In the coming years, Prussia would begin a massive nationalization campaign to bring nearly all of its existing mileage under state ownership. After a few late nationalizations, (Mecklenburg-Schwerin in 1890, Hessen-Darmstadt in 1897, and the Bavarian Palatinate in 1908), the State Railways would control nearly all mileage in the Empire until they were finally united under the *Deutsche Reichsbahn* in 1920.

For the purposes of this paper, nationalizations are only considered to the extent that they adjust the percentage of railroad mileage owned by the state in a given year in the descriptive results. Future research may consider why the first wave of nationalizations in the 1840s and 1850s occurred instead of states simply granting financial support in the form of subsidies; this is a particularly interesting question since it may have been the catalyst for the expansion of state owned railroad systems in Prussia, Bavaria, and Saxony. The second wave of nationalizations, being exogenously determined by political factors (at least in Bavaria, Hessen, and Saxony), may prove useful as a natural experiment for studying the efficiency of state administrations.

4 Fiscal History

4.1 New Data

Though some qualititative histories about the development of public finance in Germany exist, comprehensive quantitative data has heretofore been sparse. Andic and Veverka (1963)

only collected data on the expense side. The first effort to compile state income was made by Mauersberg (1988), who made no attempt to ensure the consistency of variable definitions across observations or time and simply reported the given figures in the regular budgets. Thus, Mauersberg's data is biased by changes in reporting from Net to Gross revenues, the occasional inclusion of fees and fines within direct taxation, and the definition of the "regular" budget, among other idiosyncrasies. Furthermore, Mauersberg does not discuss his choice of sources, leaving it up to the reader to determine which figures are projections and which are based on draft proposals rather than approved laws. Most importantly, Mauersberg did not exhaust available sources and only included a limited sample of states and years, severely hampering the data's usefulness for a quantitative study.

In my dataset, I do my best to remedy these flaws, though as we will see, limited documentation surrounding the primary sources presents a challenge. The first problem confronting the researcher interested in compiling 19th-century budget data is one of scale. There is an over-abundance of data; the tables and appendices to a "*Finanzgesetz*" (the law establishing the budget for a financial period) frequently number in the hundreds of pages. To create a complete panel of all income and expenditure would be a herculean effort. Thus, the first step is to decide on a limited number of "high-level" categories that can be consistently measured across space and time. A brief review of how these categories were defined follows. In the final draft, much of this information and more will be contained in a forthcoming data appendix.

For the current iteration of this project, I collect data on Total Income and three major income categories: Direct Tax, Indirect Tax, and Railroads.[12] Where possible, I also collect data on the associated operating expenses, which allows gross income figures to be converted to net and vice versa. When income is disaggregated, the remainder is made up of income from royal properties (such as forests), state enterprises and monopolies (such as salt mines

[12]An important omitted category is debt, which is unfortunately beyond the current scope of the project. While debt servicing expenses are typically reported consistently and simply as a line item, there is little consistency in the reporting of debt issuances. Consequently, the consideration of debt as an income source needs to be left to a future draft.

and the post), administrative fees, legal fines, transfers from state coffers (i.e., liquidation of assets), and other miscellaneous sources such as reparations.

Generally, contemporary definitions of direct and indirect taxations are consistent with modern expectations. Direct taxation is primarily made up of property, poll, income, and capital taxes whereas indirect taxation is primarily made up of customs, stamp taxes, and taxes on luxury goods. While direct taxation figures can usually be taken as given, there are two main challenges to constructing the indirect taxation figures. The first is that while indirect taxation was administered by the states, they were often remitted to a central administration to be redistributed (first the *Zollverein*, then the *Norddeutscher Bund*, and finally the *Reich*). The reporting surrounding these redistributions is opaque and it is not always clear whether the reported figures represent the pre- or post-redistribution figures. Second, there was a tendency to report fines and penalties as indirect tax revenue. While this is arguably appropriate for customs violations, it is less clear whether fines for illegal activity fit the modern conception of indirect taxation. However, because it is generally impossible to exclusively remove civil and criminal fines only, these costs remain in indirect taxation.

Defining railroad income faces similar challenges. First, I make a judgment to include all railroad related income, exclusive of specifically labeled direct "railroad taxes". Thus, railroad income includes not just profits from state enterprise, but also other miscellaneous income generated by the ministry governing railroads. This includes income from direct investments, privatization, and other general fees. The remaining challenge regarding railroad income is related to the lack of standardized reporting for the issuance of bonds. Because bond issuance is often unreported in the regular budget, this significantly overestimates net income from railroads, as debt repayment related to those bonds is folded into the general debt servicing line item. As I broaden the scope of sources used, I hope to gather more data on debt.

The first choice of primary sources for budget information are the *Gesetzsammlungen* (Law Collections) or *Gesetzblätter* (Law Gazettes). These were the official communication

channels of the states to notify citizens of new laws. The budgets presented here are preferred, since they represent a fully approved law which is no longer subject to any further debate or amendment. However, it is important to note that these were still projected figures rather than an accurate accounting of real income. An additional drawback is that many states only reported abridged budgets in these public-facing documents. For example, in Bavaria's case, between 1820 and 1871, the *Gesetzblätter* only report net income, giving an incomplete picture of state fiscal capacity.

In such cases, the next choice is to examine parliamentary proceedings. Budgets submitted for parliamentary approval typically contain far more information but are of reduced value because the figures are still subject to approval and amendments. If neither gazettes nor parliamentary proceedings are available, then secondary sources are used. Appendix 3 describes the sources used for each state. I convert all currency units to Marks, using the 1871 exchange rates of 1 thaler = 3 mark and 1 gulden = 12/7 mark (Deutsche Bundesbank, n.d.). Appendix 4 presents key stylized facts.

5 Empirical Strategy

My theoretical framework begins with the assumption that railroad construction follows a partial adjustment model.[13] In this framework, the state acts as a planner who observes the current state of the economy then decides what the optimal railword network size is. The state also has final say of how many railroad miles may be built. Private actors are able to make proposals, but ultimately the existence of all lines must be approved by the state. Thus, the evolution of the network is described by the primitive function:

$$LogRailroadMiles^{*}_{i,t} = R^{*}_{i,t} = \beta_0 + BX_{i,t} + \alpha_i + \nu_t + \epsilon_{i,t}$$

[13]My approach is similar to the model used in Bignon, Esteves, and Herranz-Loncán (2015) .

However, because proposing and constructing new lines is time consuming and furthermore there may not be sufficient capital to construct all the desired lines, the state does not instantly move to its preferred amount of railroad miles $R^*_{i,t}$. Instead, the network will partially adjust with speed δ according to the following relationship:

$$R_{i,t} - R_{i,t-1} = \delta(R^*_{i,t} - R_{i,t-1})$$

Substitution results in the standard estimating equation for partial adjustment models (which is typically then log transformed):

$$R_{i,t} - R_{i,t-1} = \delta\beta_0 - \delta R_{i,t-1} + \delta BX_{i,t} + \delta\alpha_i + \delta\nu_t + \delta\epsilon_{i,t}$$

Recall that so far I have classified railroad miles as (local) State, Other (state), and Private, according to their ownership and whether they were located in the state that owned them. To emphasize that states must make a decision to either construct miles through their own enterprises or grant concessions to outside actors, I group "Other" and "Private" into "Non-State". To model this decision to assign desired miles to State or Nonstate lines I approximate the log-differenced partial adjustment model with a growth rate that can be disaggregated without changing the interpretation across models:[14]

$$log(R_{i,t}) - log(R_{i,t-1}) \approx \frac{NewMiles^Y_{i,t}}{R^{Total}_{i,t-1}}$$

Where $NewMiles^Y_{i,t}$ is the number of miles constructed during year t by $Y \in \{Total, State, NonState\}$ firms. It is important to note that this measure only captures changes due to construction of new lines. Nationalizations are not considered new state miles. This is a deliberate choice, since the majority of nationalizations prior to 1885 were due to exogenous political shocks and not revenue concerns (as discussed above). Thus, we can write the baseline specification being estimated as follows:

[14]That is to say, $ln(A+B) - ln(C) \neq ln(A) - ln(C) + ln(B) - ln(C)$ whereas $\frac{a+b}{c} = \frac{a}{c} + \frac{b}{c}$.

$$\frac{NewMiles_{i,t}^{Y}}{R_{i,t-1}^{Total}} = \delta\beta_0 - \delta R_{i,t-1} + \delta\beta_1 Govt.Rev_{i,t-1} + \delta\beta_2 Population_{i,t-1} + \delta\alpha_i + \delta\nu_t + \delta\epsilon_{i,t}$$

The variable of interest across specifications is $Govt.Rev_{i,t-1}$, which is measured either as the sum of all government revenues less collection costs, or a disaggregated measure that separately estimates the effect of profits from state railroad enterprises.

To ensure that the LHS accurately approximates the log-differences and to limit the influence of outliers, we do not want to include years where $\frac{NewMiles_{i,t}^{Total}}{R_{i,t-1}^{Total}} > 1$, as relatively small amounts of construction can lead to abnormally large expansion rates in the early years of construction. We also do not want values from these years to be used as instruments, so the final sample begins with the fifth year after the last year with a growth rate greater than one. The median number of years dropped is 13 and the max is 16. Less than 8% of total mileage was constructed in the omitted years. It is also more believable that δ had a consistent value over this shortened period.

5.1 Identification Strategy

Because of the obvious feedback effects between railroads, the economy, and government revenues, OLS regression results are immediately suspect. To address the endogeneity problems, I adapt IV strategies from the dynamic panel modeling literature (the most common treatment of these methods can be found in Wooldridge (2002)). The identifying assumption is that the RHS variables are "sequentially exogenous", that is:

$$E(\frac{NewMiles_{i,t}^{Y}}{R_{i,t-1}^{Total}} | X_{i,t}, X_{i,t-1}, ..., X_{i,1}) = E(\frac{NewMiles_{i,t}^{Y}}{R_{i,t-1}^{Total}} | X_{i,t})$$

Where $X_{i,t}$ includes existing railroad mileage, government revenues, and economy variables. Put simply, this means that the history of the endogenous system is irrelevant and current growth rates are fully determined by the current state of the world. In my model of

railroad construction, this means that the state does not care about past values of income and only cares about projected revenues in the year that construction is occurring. This assumption is violated in years with budget surpluses, but surpluses are in fact quite rare.

Because historical values of endogenous variables do not determine current values of y, but are good predictors of the current values of endogenous variables, this makes them valid and appropriate instruments. The typical approach here is to use the so called Arellano and Bond estimator which maximizes the number of lagged values of endogenous variables. Due to the nature of my panel (N groups $<$ T years) this leads to an overidentification issue. Instead, I use only the values of endogenous variables from $t-3$ and $t-4$.[15] Wald tests show that this is enough instruments to avoid a weak instrument problem while Sargan tests show that there are few enough to avoid overidentification.

6 Summary Statistics

6.1 Railroad Ownership

The construction of the original dataset used to track how the development of public and private railroad networks differed is detailed in Section 3.2. With this data, I construct a panel of railroad miles constructed by each company in each state, as well as a running measure of what percentage of existing mileage is owned by each set of actors in any given year. This running measure of mileage is adjusted to account for nationalizations, privatizations, and annexations so that $Miles_t - Miles_{t-1}$ can be different from $NewMiles_t$ which only measures construction. Summary statistics for the total construction and the expansion rates ($\frac{NewMiles^Y_{i,t}}{Miles^{Total}_{i,t-1}}$) in the unbalanced sample panel are displayed in Table 2. Summary statistics for individual states and all years are included in Appendix 2.

[15] Lags $t-1$ and $t-2$ are not valid instruments due to Nickell bias.

Table 2: Summary Statistics: Railroad Construction

Statistic	N	Mean	St. Dev.	Min	Median	Max
TotalRate	298	0.06	0.09	0.00	0.02	0.65
StateRate	298	0.02	0.05	0.00	0.00	0.37
NonStateRate	298	0.03	0.08	0.00	0.000005	0.65

6.2 Public Finance

The public finance data panel is generally balanced, with a few exceptions. In the sample period from 1835 to 1885, only 23/357 rows are missing total net income data. Because there is generally no reason not to, I interpolate the missing values. This is most likely harmless, although there is likely some small upward bias from interpolating the often missing budgets during the crisis years of 1848-1849. Summary statistics for the final panel are presented in Table 3.

Table 3: Summary Statistics: Public Finance and Economic Activity

Statistic	N	Mean	St. Dev.	Min	Median	Max
NetIndirectTaxRev	298	16,605,610	23,197,881	297,745	7,903,325	104,063,607
NetDirectTaxRev	298	20,093,180	34,176,058	1,168,399	7,333,579	151,563,350
RailIncome	298	10,339,136	21,532,065	0	3,480,564	202,458,916
NetOtherRev	298	26,661,667	49,790,361	−252,052	8,474,962	269,761,656
NetGovt.Rev	298	73,656,569	112,958,943	3,060,476	28,700,573	617,007,982
Debt.Service	298	15,816,971	24,383,226	328,484	3,083,940	182,322,836
Population	298	4,418,730	7,136,182	262,524	1,696,430	28,318,470

Sources: Population from Kunz and Zipf (2008).
See text for Public finance statistics.
Im-Pesaran-Shin tests show that none of the variables have a unit root when measured in logs except for debt service payments. After differencing, the debt service series is also stationary.

It is also important to include controls that account for the general level of economic and commercial activity, since these influence both the supply and demand for railroads, as well as the size of the tax base. I code a dummy variable for the common shocks of war. The war dummy variable is based on Clodfelter (2017), who mentions specifically the major participants in 19th century wars in Western Europe. The state of the economy is simply

proxied by state population from Kunz and Zipf (2008).[16] Extensions use data on industrial production from the same source.

7 Results

7.1 Baseline

Table 4 presents the baseline results when all government revenue sources are pooled. First, note that the coefficient on $TotalMiles_{i,t-1}$, which is the δ coefficient measuring the speed of convergence, gives a very reasonable value. Each year, the network gets roughly 20% closer to its conditionally optimal size. The slight majority of this convergence is due to NonState construction, which is appropriate since private firms constructed slightly more than half of all miles constructed between 1835 and 1885.

Population does not seem to be a consistent driver of within-state variation in railroad construction in either direction, though this is perhaps unsurprising since population growth tended to be stable across Germany in this period, except in Prussia which experienced a major population shock after annexing Hanover and other states following the 1866 Austro-Prussian War.

Interestingly, government revenues do not have a significant relationship with overall railroad network growth rates. Even more surprisingly, the IV specification suggests a slightly negative relationship. One possibility is that a major driver of railroad construction was the need to raise government revenues. It is possible that as revenues increased this demand fell proportionally, since the constitutional structure of many German states tended to limit revenue generation to only what was needed to cover planned expenses.

The more interesting result appears in columns 3-6, which show how construction was allocated to state or nonstate firms. The results are highly significant and show that revenue

[16]Kunz also includes data on production of a subset of industrial goods, however, the limited sample of goods included leads to significant bias when trying to include this data, limiting its value in this application. Lack of good data on state level productivity remains a significant bottleneck for this project.

increases led to a reduction in state construction and corresponding increase in nonstate construction. It appears that as government revenues increased, regular budget spending on state railroad firms was reduced in favor of granting subsidies or other support to private firms.

However, this is not the only explanation. Another explanation could be that as revenues increased, so did the ability of the state to raise debt. This idea is explored more in the next section. First, I consider what happens when disaggregating revenue into rail and non-rail sources.

We can see in Table 5 that disaggregating revenue tells a consistent but slightly more nuanced story. Nonrail incomes still seem to lead a switch from state to nonstate construction, further supporting the hypothesis that regular revenues were more easily used on subsidies or interest rate guarantees to support private construction than transferred to state firms. Rail incomes, unsurprisingly, predict increased state construction. The more profitable the state enterprise was, the more it expanded.

7.2 Extension: Debt

Since railroad projects were exceptionally capital intensive projects, it is unreasonable to think that marginal year-to-year increases in the regular budgets of any German state would be sufficient to fund new railroad lines. Thus, any complete study of railroad construction should also account for the issuance of railroad debt, typically in the form of bonds.

Unfortunately, data on the debt of German states is limited. Laws for the sale of particular bonds were idiosyncratic, which makes data difficult to collect. Furthermore, none of the states here studied published figures for outstanding debt in their budget reports (although data for some years can be found in British statistical abstracts). The only consistent time series data available is data on debt servicing payments.

Including debt service payment data leads to additional empirical issues. To remain consistent with the baseline models and identification strategy, it would be necessary to

Table 4: Baseline Results

Dependent Variables:	TotalRate		StateRate		NonStateRate	
	OLS	IV	OLS	IV	OLS	IV
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
$TotalMiles_{i,t-1}$	-0.1991***	-0.2346***	-0.0742**	-0.1119***	-0.1249***	-0.1227**
	(0.0420)	(0.0505)	(0.0304)	(0.0282)	(0.0390)	(0.0463)
$Population_{i,t-1}$	0.0440	0.0200	0.0339	0.0242	0.0101	-0.0042
	(0.0697)	(0.0756)	(0.0426)	(0.0500)	(0.0538)	(0.0546)
$Govt.Rev_{i,t-1}$	-0.0046	-0.0217	-0.0573***	-0.0957***	0.0527**	0.0740*
	(0.0382)	(0.0525)	(0.0206)	(0.0284)	(0.0260)	(0.0391)
War	-0.0295	-0.0380	-0.0053	-0.0120	-0.0242	-0.0260
	(0.0270)	(0.0298)	(0.0194)	(0.0190)	(0.0157)	(0.0193)
Fixed-effects						
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	298	298	298	298	298	298
R^2	0.43936	0.43551	0.25452	0.23810	0.51789	0.51683
Within R^2	0.14527	0.13940	0.06478	0.04419	0.10486	0.10290

Driscoll-Kraay (L=2) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*
Note: Italicized variables have been asinh transformed.

Table 5: Baseline Results - Disaggregated Income

Dependent Variables:	TotalRate		StateRate		NonStateRate	
	OLS	IV	OLS	IV	OLS	IV
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
$TotalMiles_{i,t-1}$	-0.2065***	-0.2651***	-0.0763**	-0.1408***	-0.1302***	-0.1243**
	(0.0492)	(0.0537)	(0.0285)	(0.0313)	(0.0428)	(0.0505)
$Population_{i,t-1}$	0.0365	-0.0006	0.0103	-0.0284	0.0262	0.0279
	(0.0741)	(0.0929)	(0.0351)	(0.0596)	(0.0675)	(0.0659)
$NonRailIncome_{i,t-1}$	0.0113	0.0284	-0.0336	-0.0428	0.0449*	0.0711*
	(0.0384)	(0.0679)	(0.0249)	(0.0477)	(0.0243)	(0.0412)
$RailIncome_{i,t-1}$	0.0008	0.0027	0.0004	0.0030***	0.0004	-0.0003
	(0.0016)	(0.0021)	(0.0009)	(0.0011)	(0.0014)	(0.0020)
War	-0.0234	-0.0191	-0.0076	0.0014	-0.0158	-0.0206
	(0.0241)	(0.0328)	(0.0221)	(0.0290)	(0.0179)	(0.0254)
Fixed-effects						
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	298	298	298	298	298	298
R^2	0.44007	0.43219	0.24596	0.21584	0.51637	0.51399
Within R^2	0.14636	0.13433	0.05405	0.01626	0.10204	0.09762

Driscoll-Kraay (L=2) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*
Note: Italicized variables have been asinh transformed.

include debt service payments in levels. However, this series has a unit root. Taking first differences resolves this problem, but introduces a weak instrument problem since lagged levels of the other variables in the system do not predict debt service differences.

Consequently, the only statistically valid approach is to treat differenced debt service payments as exogenous. Fortunately, this is not as strong an assumption as it might seem at first glance. There are many arguments in the literature that the main determinant of early modern states' ability to issue debt was institutional. That is, politics and institutions constraining the state and demonstrating a commitment to repay debt may have been more important for determining the ability to issue debt than actual revenue streams. Furthermore, debt is much more dependent on the state of international financial markets. Barring any serious deficit crisis, the decision to issue new bonds might therefore be plausibly exogenous and determined more by the political will of the government to issue debt and its perceived credibility to not default. Regressions based on this assumption are presented in Tables 6 and 7.

Again, the results suggest that as government revenues increased, there was a shift away from state construction towards nonstate construction. The magnitude of these estimates is similar to those in Tables 4 and 5.

The coefficient on $\Delta Debt$ is positive and significant. If bonds were being issued faster than they were being paid off, this predicts an increase in state railroads. Of course, since a large proportion of the increase in state debt service payments was the issuance of bonds specifically to fund railroad construction, this relationship is largely mechanical.

The results here are still preliminary, and a more detailed exploration of the relationship between government revenues and debt is required.

7.3 Extension: Alternate Economy Measures

Section Forthcoming.

Population is only a rough proxy of economy growth, and one that becomes increasingly

Table 6: Exogenous Debt Results

Dependent Variables:	TotalRate		StateRate		NonStateRate	
	OLS	IV	OLS	IV	OLS	IV
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
$TotalMiles_{i,t-1}$	-0.1999***	-0.2335***	-0.0756**	-0.1114***	-0.1243***	-0.1221**
	(0.0419)	(0.0504)	(0.0303)	(0.0285)	(0.0391)	(0.0463)
$Population_{i,t-1}$	0.0439	0.0211	0.0337	0.0254	0.0102	-0.0043
	(0.0699)	(0.0758)	(0.0429)	(0.0500)	(0.0539)	(0.0549)
$Govt.Rev_{i,t-1}$	-0.0050	-0.0251	-0.0579***	-0.1003***	0.0529*	0.0752*
	(0.0378)	(0.0509)	(0.0197)	(0.0278)	(0.0264)	(0.0405)
$\Delta Debt_{i,t}$	0.0135	0.0169	0.0232	0.0273*	-0.0097	-0.0104
	(0.0174)	(0.0176)	(0.0138)	(0.0141)	(0.0197)	(0.0188)
War	-0.0303	-0.0383	-0.0066	-0.0127	-0.0237	-0.0255
	(0.0267)	(0.0294)	(0.0193)	(0.0189)	(0.0156)	(0.0194)
Fixed-effects						
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	298	298	298	298	298	298
R^2	0.43968	0.43599	0.25707	0.24028	0.51811	0.51697
Within R^2	0.14575	0.14014	0.06798	0.04693	0.10527	0.10315

Driscoll-Kraay (L=2) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*
Note: Italicized variables have been asinh transformed.

Table 7: Exogenous Debt Results - Disaggregated Income

Dependent Variables:	TotalRate		StateRate		NonStateRate	
	OLS	IV	OLS	IV	OLS	IV
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
$TotalMiles_{i,t-1}$	-0.2073***	-0.2622***	-0.0778***	-0.1384***	-0.1296***	-0.1239**
	(0.0490)	(0.0541)	(0.0284)	(0.0313)	(0.0429)	(0.0503)
$Population_{i,t-1}$	0.0360	-0.0002	0.0094	-0.0290	0.0266	0.0288
	(0.0738)	(0.0917)	(0.0362)	(0.0593)	(0.0678)	(0.0668)
$NonRailIncome_{i,t-1}$	0.0104	0.0241	-0.0352	-0.0502	0.0456*	0.0743*
	(0.0379)	(0.0662)	(0.0236)	(0.0452)	(0.0248)	(0.0425)
$RailIncome_{i,t-1}$	0.0008	0.0026	0.0004	0.0029***	0.0004	-0.0003
	(0.0016)	(0.0021)	(0.0009)	(0.0011)	(0.0014)	(0.0020)
$\Delta Debt_{i,t}$	0.0131	0.0163	0.0242*	0.0297*	-0.0111	-0.0134
	(0.0169)	(0.0172)	(0.0144)	(0.0152)	(0.0207)	(0.0188)
War	-0.0241	-0.0204	-0.0089	-0.0007	-0.0152	-0.0197
	(0.0239)	(0.0325)	(0.0223)	(0.0294)	(0.0181)	(0.0255)
Fixed-effects						
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	298	298	298	298	298	298
R^2	0.44037	0.43348	0.24873	0.22080	0.51666	0.51401
Within R^2	0.14681	0.13630	0.05752	0.02249	0.10258	0.09765

Driscoll-Kraay (L=2) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*
Note: Italicized variables have been asinh transformed.

inappropriate over the 19th century due to the widening gap in labor productivity between industry and agriculture. Unfortunately, GDP measures are not available at the state level for any state besides Prussia. The only extant data tracks the output of certain key industrial metals and minerals, but does not cover any manufacturing, and is thus a biased measure of economic growth.

A second possibility is to construct a gravity model based on the exposure of the different states to Germany's main trading partner: the UK.

7.4 Robustness Check: Leave One Out Regressions

Section Forthcoming.

Because the panel is low N (only 8 states), there is a significant risk of the results being driven by outliers. Leave one out regressions show that magnitudes are somewhat sensitive, but signs do not change.

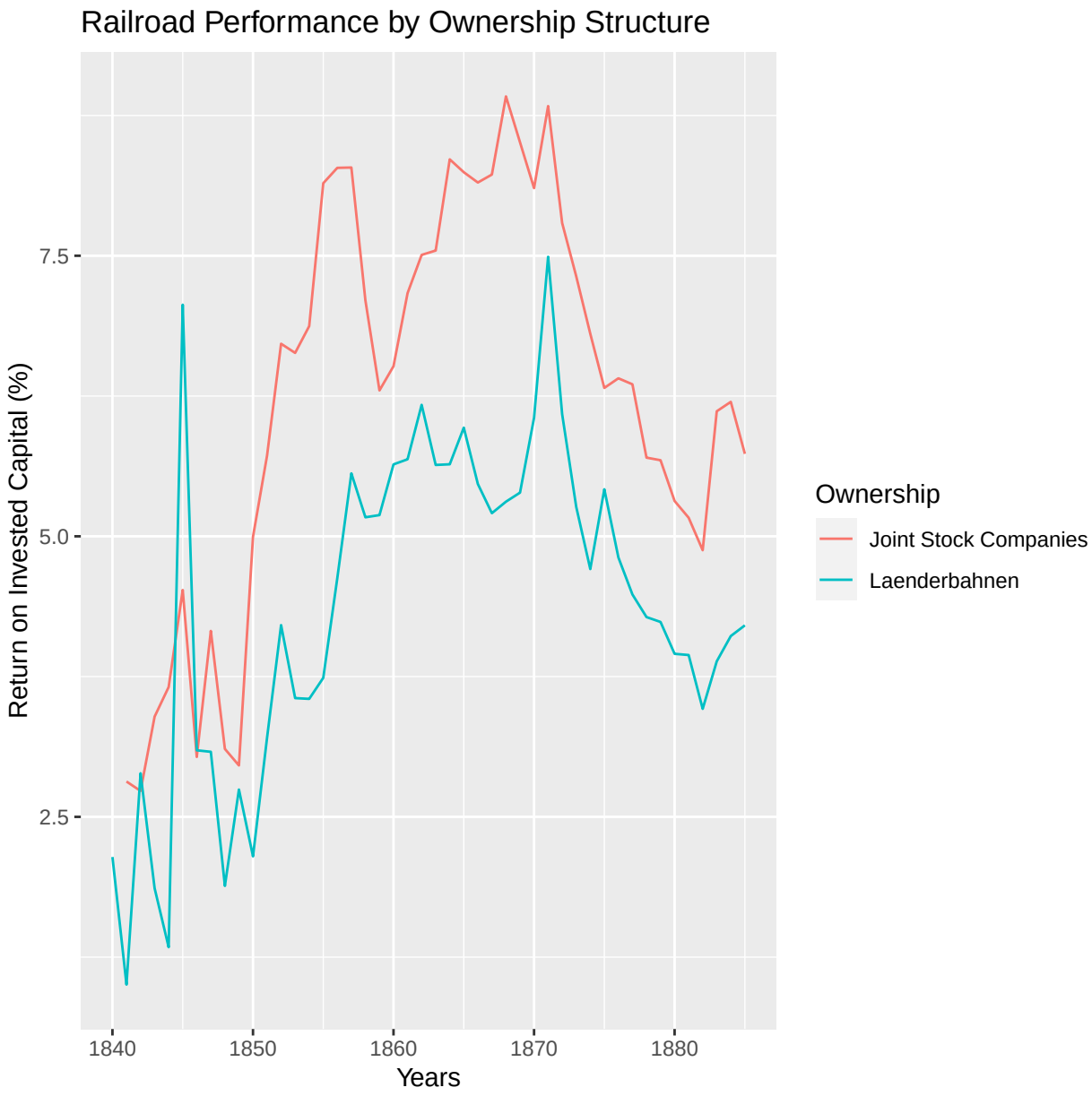
8 Conclusion

Regular government revenues did not seem to be an important factor in determining the growth rate of railroads in German states (except perhaps through their effect on states' ability to borrow, which requires more study). However, revenue shocks do have the effect of making contemporaneous construction more private. I hypothesize that this is because revenue shocks were not large enough to fund new state owned railroad projects, but did allow the states to increase subsidies enticing private investment. Further study should explore how much private capital a subsidy can attract compared to the amount of debt service an equally sized revenue stream could support.

Appendix 1: Comparing Public and Private Railway Performance

The firms for which there is at least one year of data in Fremdling and Kunz (2011) were responsible for building 75% of the railway mileage constructed between 1835 and 1885. The missing performance data is mostly in the band of Prussia between Schleswig-Holstein and Silesia. There are also significant sections of Saxony and the Bavarian Palatinate missing.

First, this appendix demonstrates that return on invested capital (ROIC) of state railways was significantly lower than private ones. Table 8 shows that for each mark of capital invested in a state railway, two fewer marks of revenues would have been generated than by the same investment in a private railway. Note that ROIC says more about operational efficiency than on return on investment, since no data is available on subsidies or dividends.



Efficiency can also be measured by looking at shipping revenues per ton-kilometer and passenger revenues per passenger-kilometer. These measures also tell us the average prices customers would have faced when using the railways. Shipping revenues for state and private firms track each other closely, both falling steadily until the early 1870s, when the measure begins to increase private firms. This divergence increases as nationalizations occur, so the higher revenues may be due to the location of the few remaining private firms.

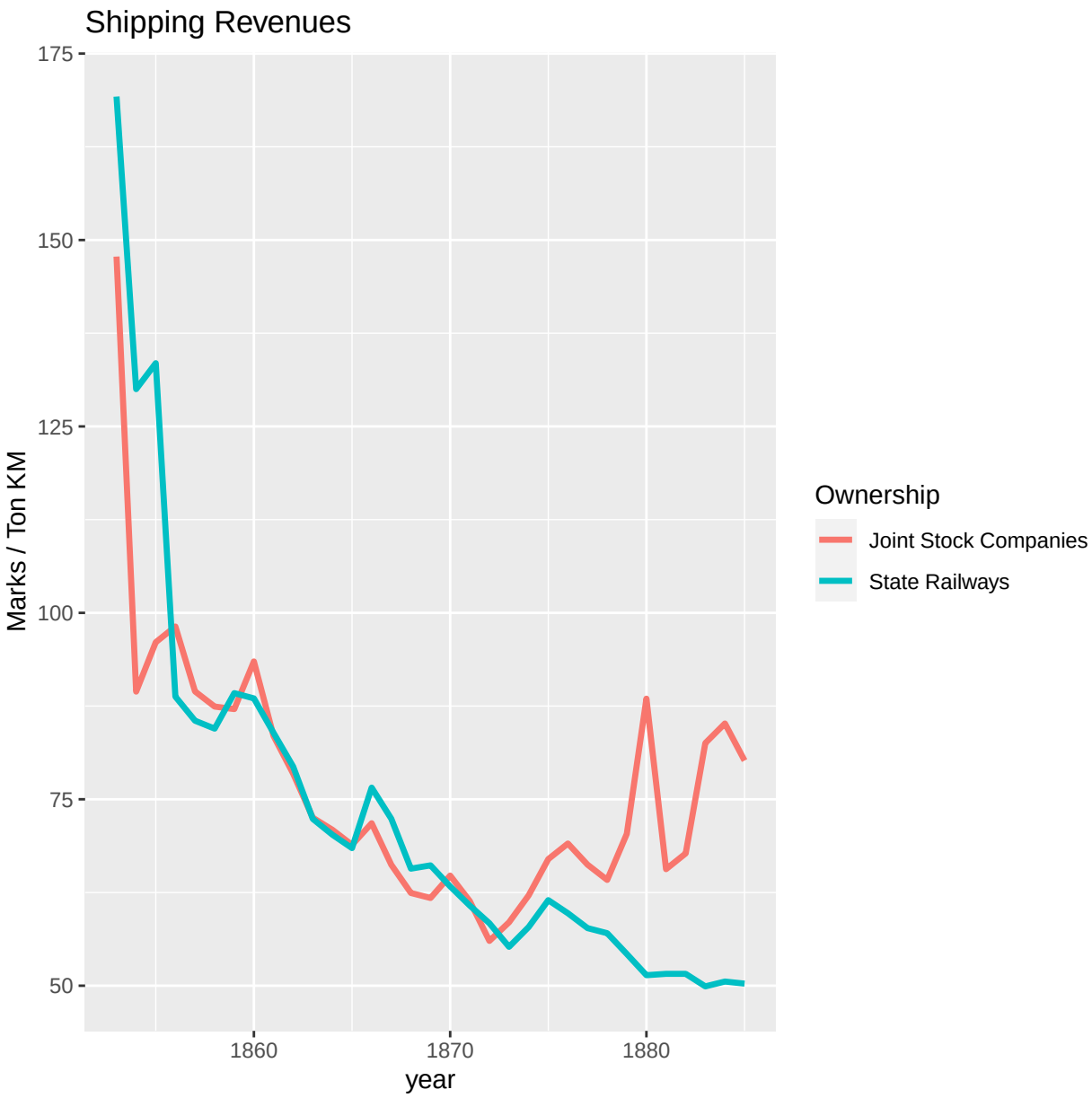
Gaps for passenger revenues are largest initially, but the absolute size of the gap is small:

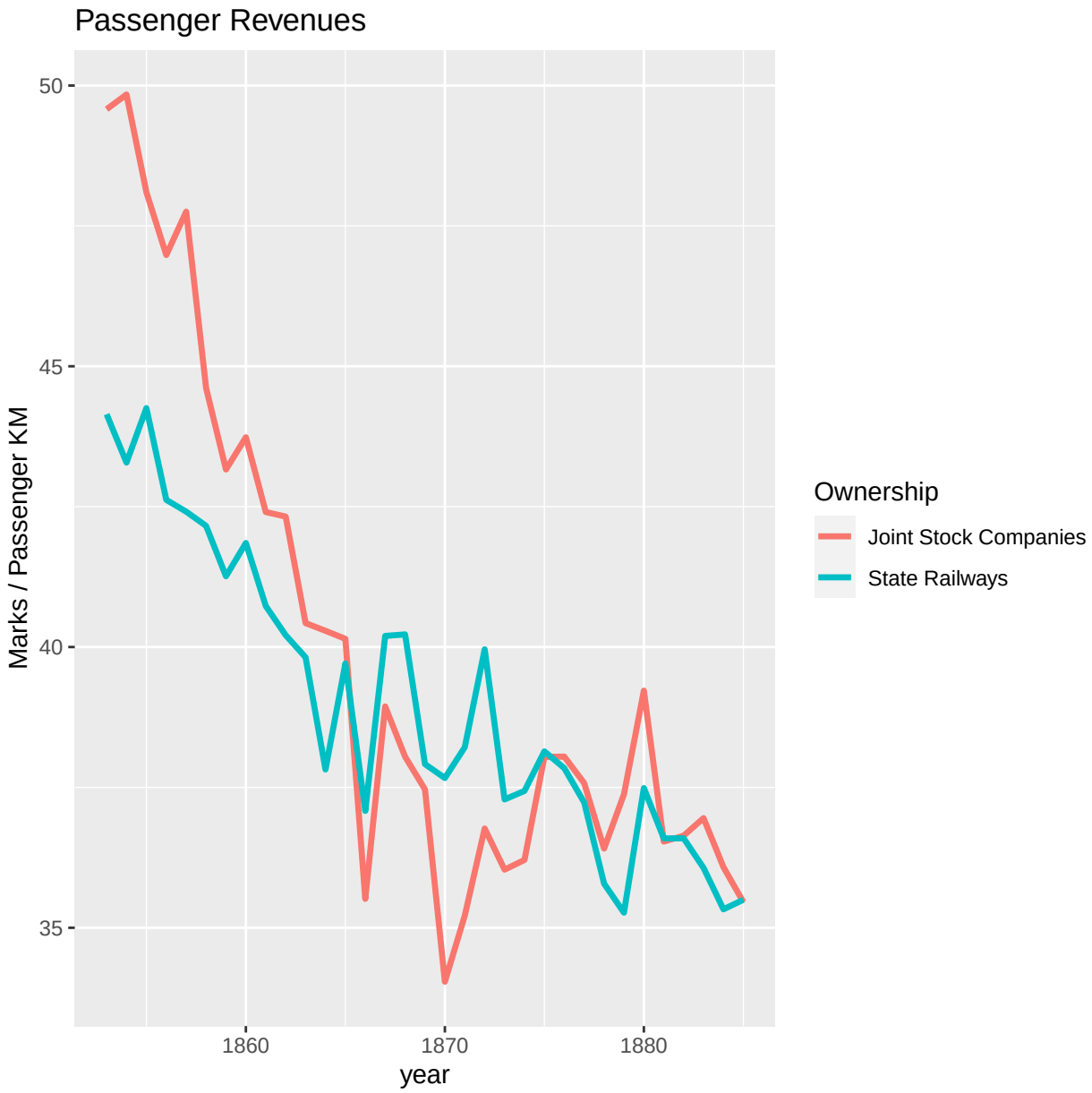
Table 8: Firm Performance by Ownership

Dependent Variable:	ROIC
Model:	(1)
Variables	
OwnershipLaenderbahnen	-1.972**
	(0.8650)
Fixed-effects	
Year	Yes
Fit statistics	
Observations	1,813
R^2	0.35332
Within R^2	0.02545

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

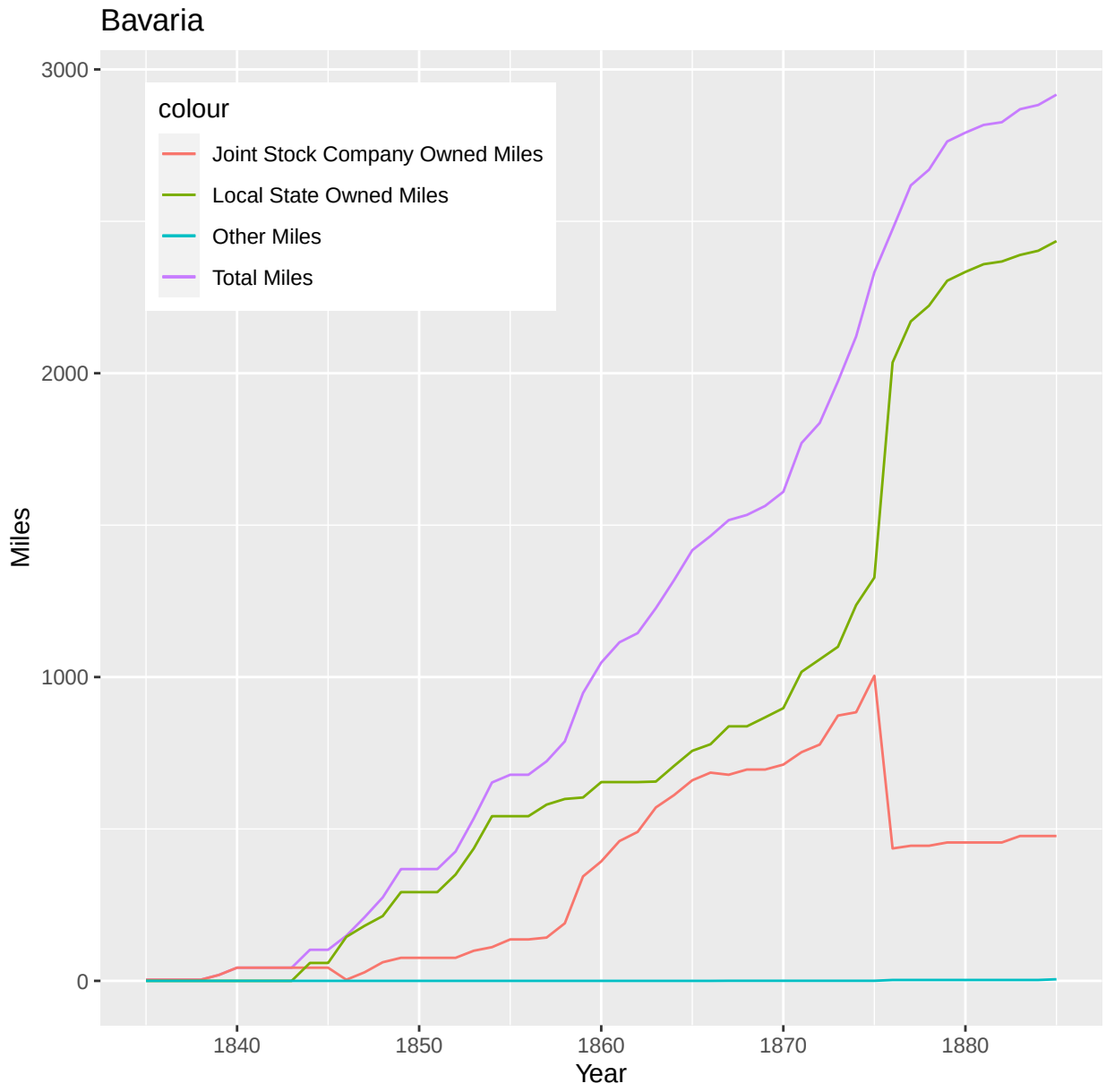
only about 5 marks per passenger-kilometer. By the 1860s this gap has vanished. This suggests that passenger travel rates were more competitive, or perhaps simply more similar across regions.


Shipping Revenues
175
150
125
100
75
50
Marks / Ton KM
1860
1870
1880
year
Ownership
Joint Stock Companies
State Railways


Passenger Revenues
50
45
40
35
Marks / Passenger KM
1860
1870
1880
year
Ownership
Joint Stock Companies
State Railways

Appendix 2: Individual State Trajectories

Bavaria



The Nuremberg-Fürth railway, the first German railroad, was built by (and remained for a long time) a private company. After 10 more years of mainly private construction, nearly all construction between 1845 and 1860 would be done by the state. From the late 1850s to 1875, there would be a resurgence in private construction in the eastern borderlands, the Palatinate, and Franconia while public construction remained dominant along the borders

with Wuerttemberg. That the approach towards Franconia was similar to the approach to the Palatinate, despite its geographic proximity and contiguity with Bavaria, is interesting, and highlights the difficulties faced in integrating these regions highlighted by Segal (2019). 1875 would see the nationalization of all rail in Bavaria except the Palatine, which would remain the largest Private railway until 1909 when it was also nationalized.

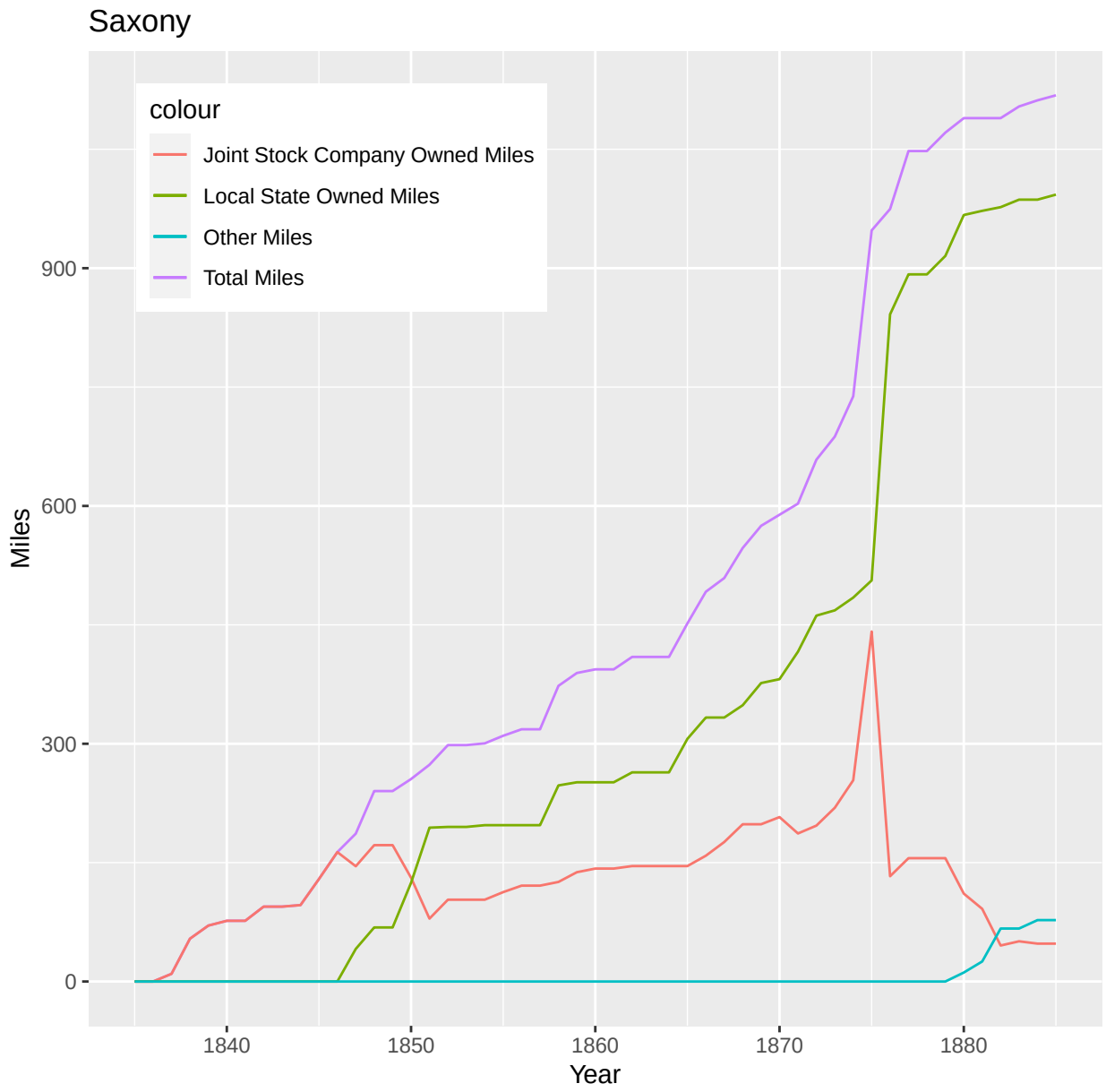
Independent railway management was perhaps more important to Bavaria than any other state. They refused to sign the constitution of the German Empire unless guaranteed "special priviliges", and one of the demands was the continued sovereignty of the Bavarian State Railway.

Table 9: Expansion Rates: Bavaria

Statistic	N	Mean	St. Dev.	Min	Max
lag5NonStateRate	51	Inf.00		0.00	Inf.00
lag6NonStateRate	51	Inf.00		0.00	Inf.00
lag1NetTaxRev	55	45,704,556.00	16,835,583.00	26,439,396.00	82,788,498.00

Sources: Derived by author from Kunz and Zipf (2008) and Dumjahn (1984).

Saxony



After 10 years of exclusively private construction, Saxony nationalized the Saxon-Bavarian and Saxon-Silesian railway companies due to their financial insolvency. Public and private construction would continue at similar rates until total nationalization in 1876.

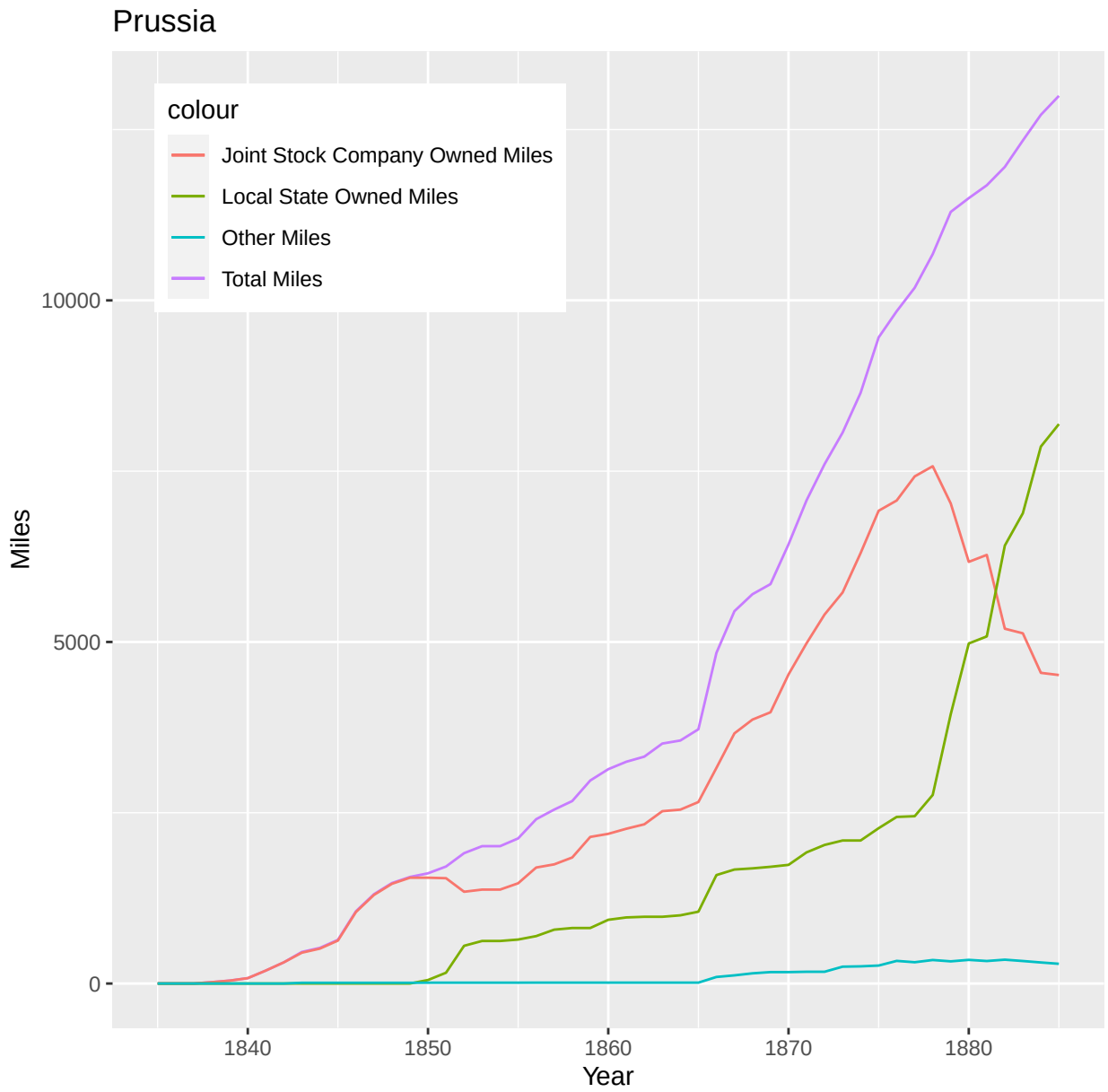
The Saxon case is of particular interest, because even though the first rail was built in Bavaria, Saxon planners and financiers were heavily involved in most early railroad plans (Beyer 1978).

Table 10: Expansion Rates: Saxony

Statistic	N	Mean	St. Dev.	Min	Max
lag5NonStateRate	49	Inf.00		0.00	Inf.00
lag6NonStateRate	49	Inf.00		0.00	Inf.00
lag1NetTaxRev	52	17,637,833.00	4,963,823.00	12,269,020	29,879,823

Sources: Derived by author from Kunz and Zipf (2008) and Dumjahn (1984).

Prussia



Mitchell (2000) emphasizes that Prussia was much more committed to liberalism than

any of the other German states, and this is why the first 1000 miles of railroad would all be by private firms. There were no public railroads until 1850, when Prussia stepped in to manage railroads in the Saarland and the connections to the Palatinate. In 1851, public railroad construction would begin at a much larger scale in East Prussia. The first nationalization would be in 1852, of the Lower Silesian railway.

The pattern that emerges is that public railroads initially emerged in areas with significant strategic concern, as well as significant exports. Interestingly, even in the Rhineland, where JSCs dominated, the state railways managed the connections into Hesse and Hannover. This is a contrast to the connections through smaller states in central Germany and Thuringia, which tended to be handled by JSCs based in Prussia. Despite this increase in public construction, JSCs still dominated and their rate of growth was faster into the 1870s.

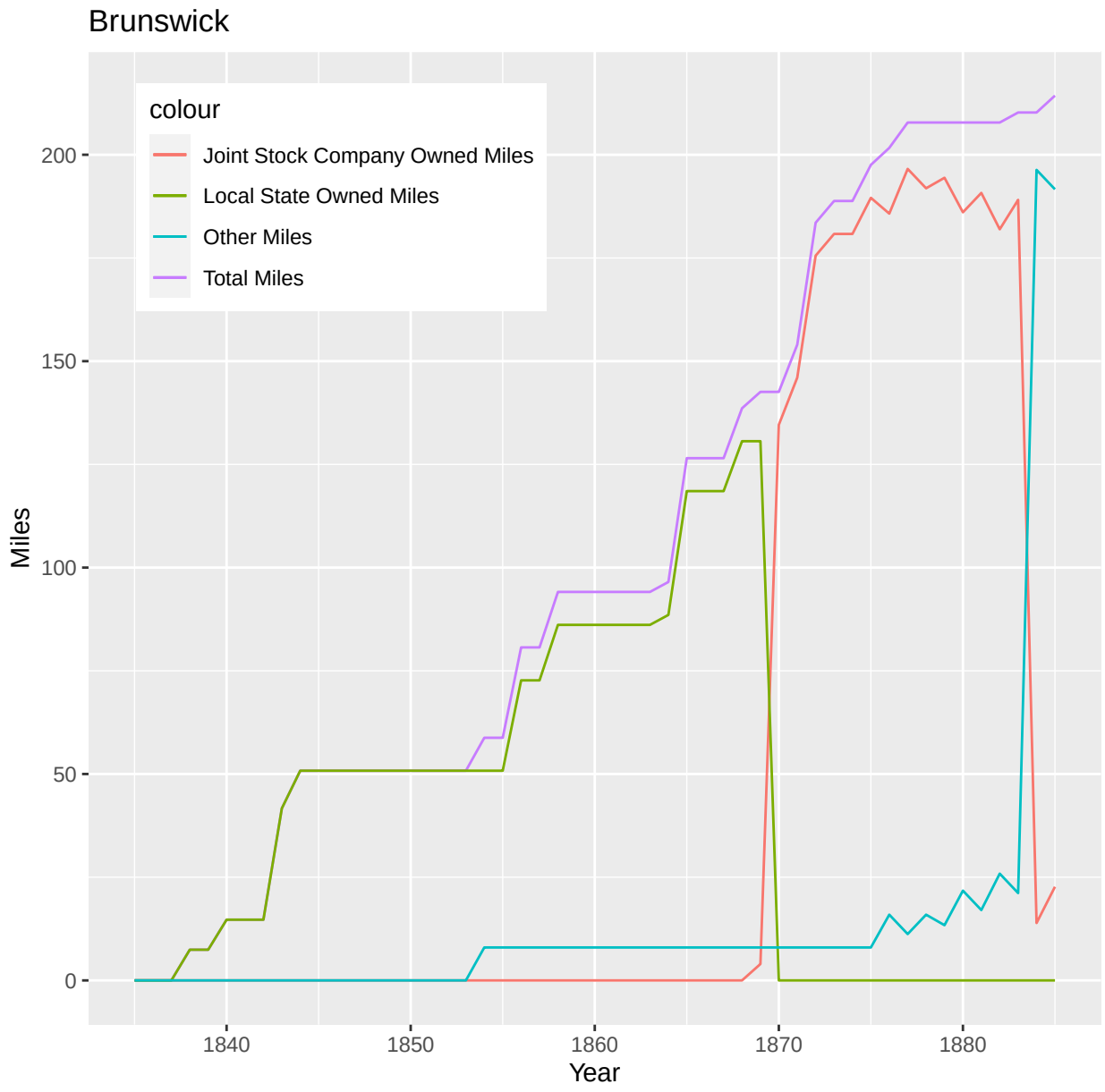
Nationalizations begin in 1875, and by 1879 JSCs are being nationalized faster than they can expand. Nationalization continues to accelerate until 1886, when nearly all remaining lines are nationalized; over 3000 miles were nationalized in one year.

Table 11: Expansion Rates: Prussia

Statistic	N	Mean	St. Dev.	Min	Max
lag5NonStateRate	48	Inf.00		0.00	Inf.00
lag6NonStateRate	48	Inf.00		0.00	Inf.00
lag1NetTaxRev	65	143,182,545.00	25,878,625.00	107,573,550.00	195,824,640.00

Sources: Derived by author from Kunz and Zipf (2008) and Dumjahn (1984).

Brunswick



100% state operated until the 1850s, when a small portion of mileage owned and operated by Hannover is allowed. All remaining construction is by the Brunswick State railway until the late 1860s, when some JSC activity occurs.

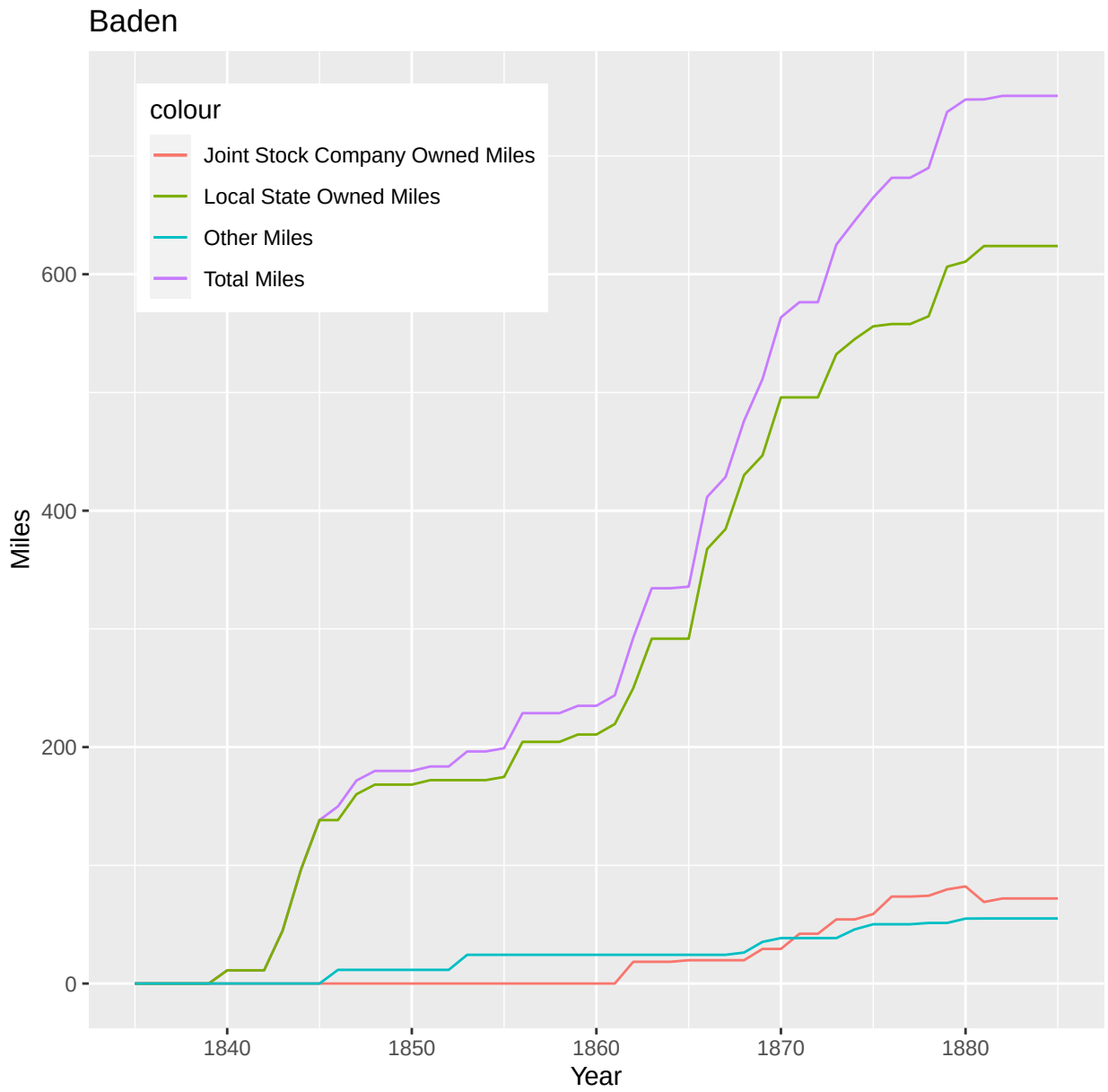
The Brunswick State Railway was privatized in 1870 (see Kleeberg (1990) for reasoning), then purchased by Prussia in 1884.

Table 12: Expansion Rates: Brunswick

Statistic	N	Mean	St. Dev.	Min	Max
lag5NonStateRate	47	0.01	0.04	0.00	0.19
lag6NonStateRate	47	0.01	0.04	0.00	0.19
lag1NetTaxRev	54	2,717,574.00	364,418.70	1,981,192	3,162,000

Sources: Derived by author from Kunz and Zipf (2008) and Dumjahn (1984).

Baden



First 150 miles were all constructed by the Baden State Railway, and nearly all subse-

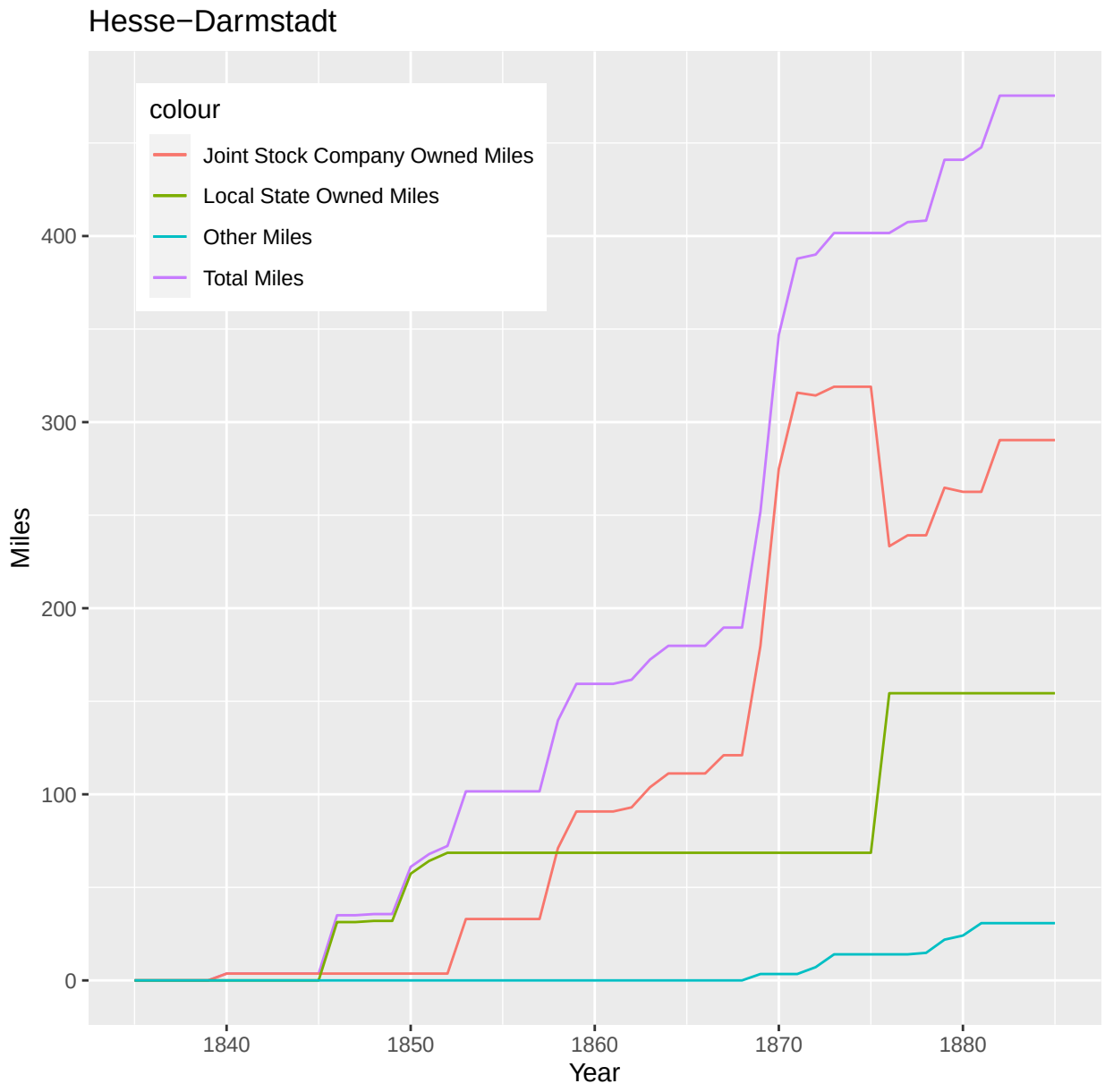
quent miles were as well. Baden does have an above average amount of municipal railways (Karlsruhe, Mannheim, Freiburg & Altbreisach, and Waldkirch). Baden is also noteworthy for being the only state to initially adopt a non-standard gauge, but did eventually switch to conform to the rest of Germany.

Table 13: Expansion Rates: Baden

Statistic	N	Mean	St. Dev.	Min	Max
lag5NonStateRate	45	0.01	0.02	0.00	0.08
lag6NonStateRate	45	0.01	0.02	0.00	0.08
lag1NetTaxRev	66	12,903,344.00	4,074,955.00	7,119,943.00	21,195,067.00

Sources: Derived by author from Kunz and Zipf (2008) and Dumjahn (1984).

Hesse-Darmstadt



One of the few cases where JSCs dominated. First miles were JSC, and except for a short stint from 1845-1857, JSCs owned the majority of railway miles. Even after the nationalization of the Upper Hessian company, JSCs remained the major player.

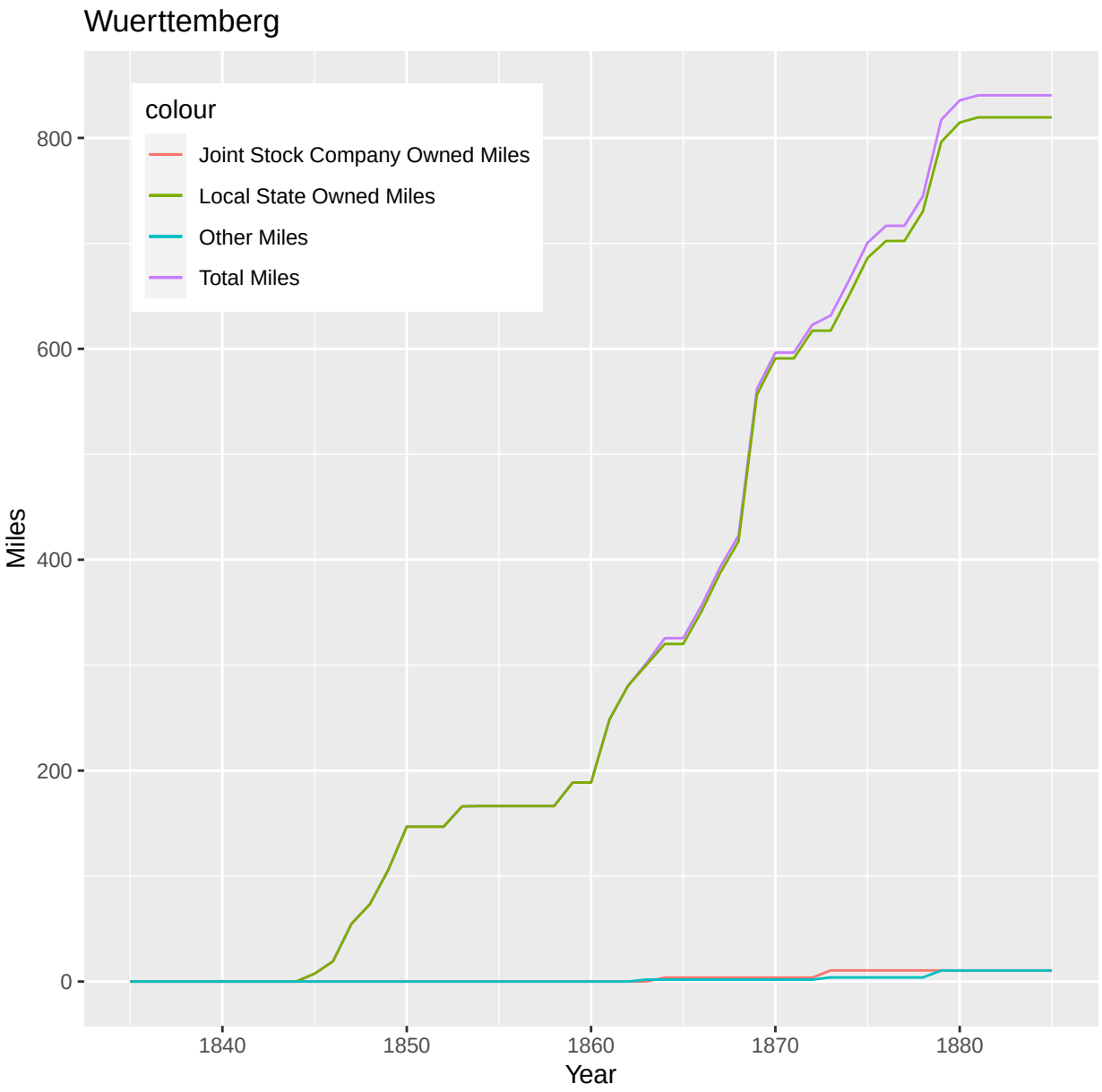
Caveat: I treat the Main-Neckar railway as being one of the state railways of Hessen-Darmstadt, however this is not entirely true. It was grouped with state railways by contemporaries (*Deutsche Eisenbahn Statistik Für Das Betriebs-Jahr 1850* 1851), but the headquar-

ters was placed in Hessen-Cassel, although there is a note that it was jointly administered by Hessen-Cassel, Hessen-Darmstadt, and Frankfurt. However, Dumjahn (1984) does not mention the Main-Neckar company by name, and instead treats it as a state railway, noting only whether particular lines were constructed by "Hessen", "Hessen and Frankfurt", or "Hessen und Kurhessen"[17] Because none of the lines attributed solely to Hesse-Cassel lay within Hessen-Darmstadt, treating remainder as the state rail of Hessen-Darmstadt seems accurate, except to the extent that Frankfurt was involved.

% Error: Data frame must have at least one row and one column.

[17]In this context, Hessen refers to Hesse-Darmstadt and Kurhessen to Hesse-Cassel.

Wuerrtemberg



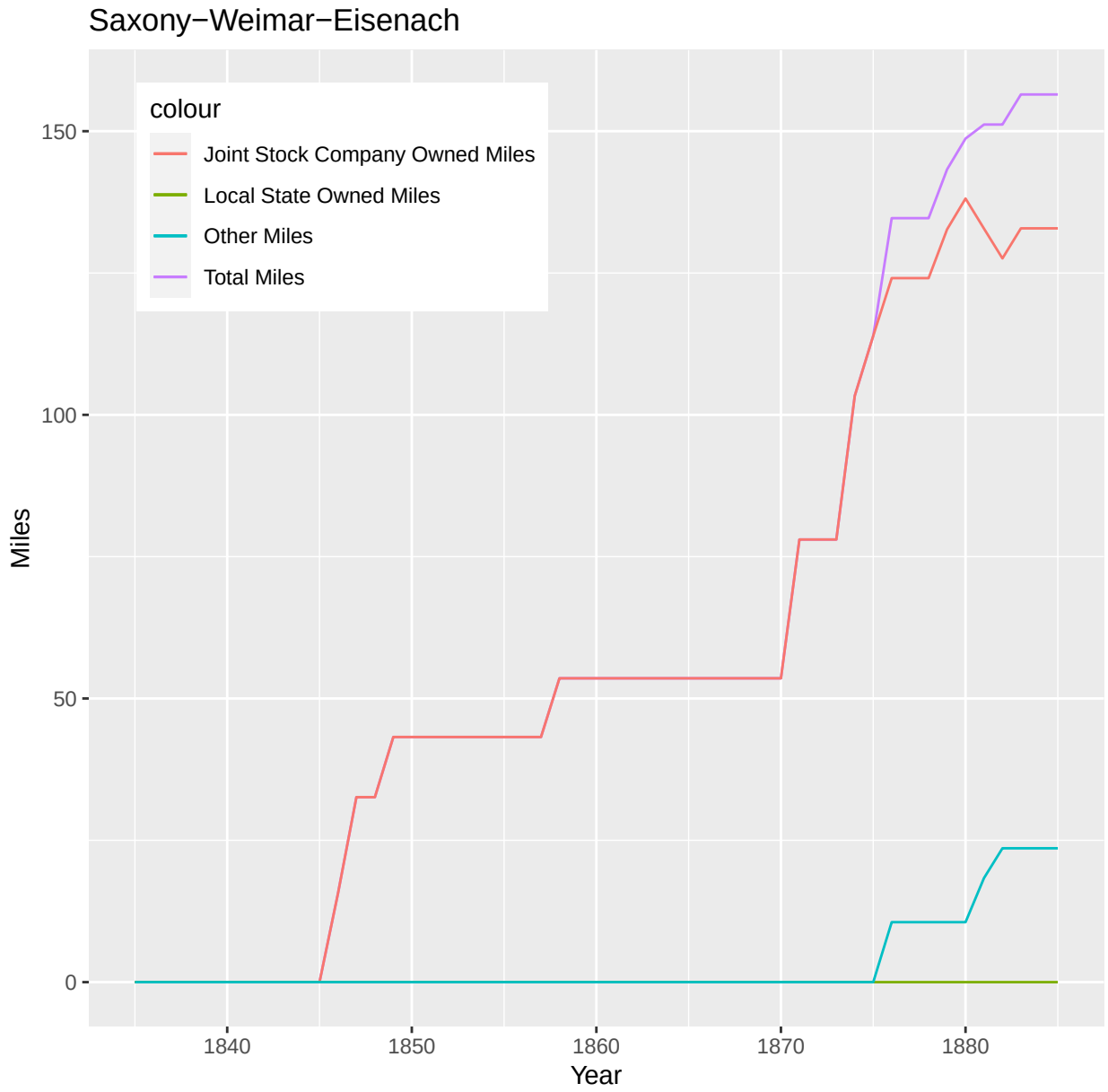
The purest example of a state system. Only two short lines operated by JSCs, and the "Other" miles are rounding errors from border crossings. Hoffman (1969) explains why.

Table 14: Expansion Rates: Wuerttemberg

Statistic	N	Mean	St. Dev.	Min	Max
lag5NonStateRate	40	0.001	0.003	0.00	0.01
lag6NonStateRate	40	0.001	0.003	0.00	0.01
lag1NetTaxRev	57	15,152,691.00	5,848,095.00	8,697,646.00	27,857,865.00

Sources: Derived by author from Kunz and Zipf (2008) and Dumjahn (1984).

Saxony-Weimar-Eisenach



The only state in the sample which seems to have never operated its own railway. Almost

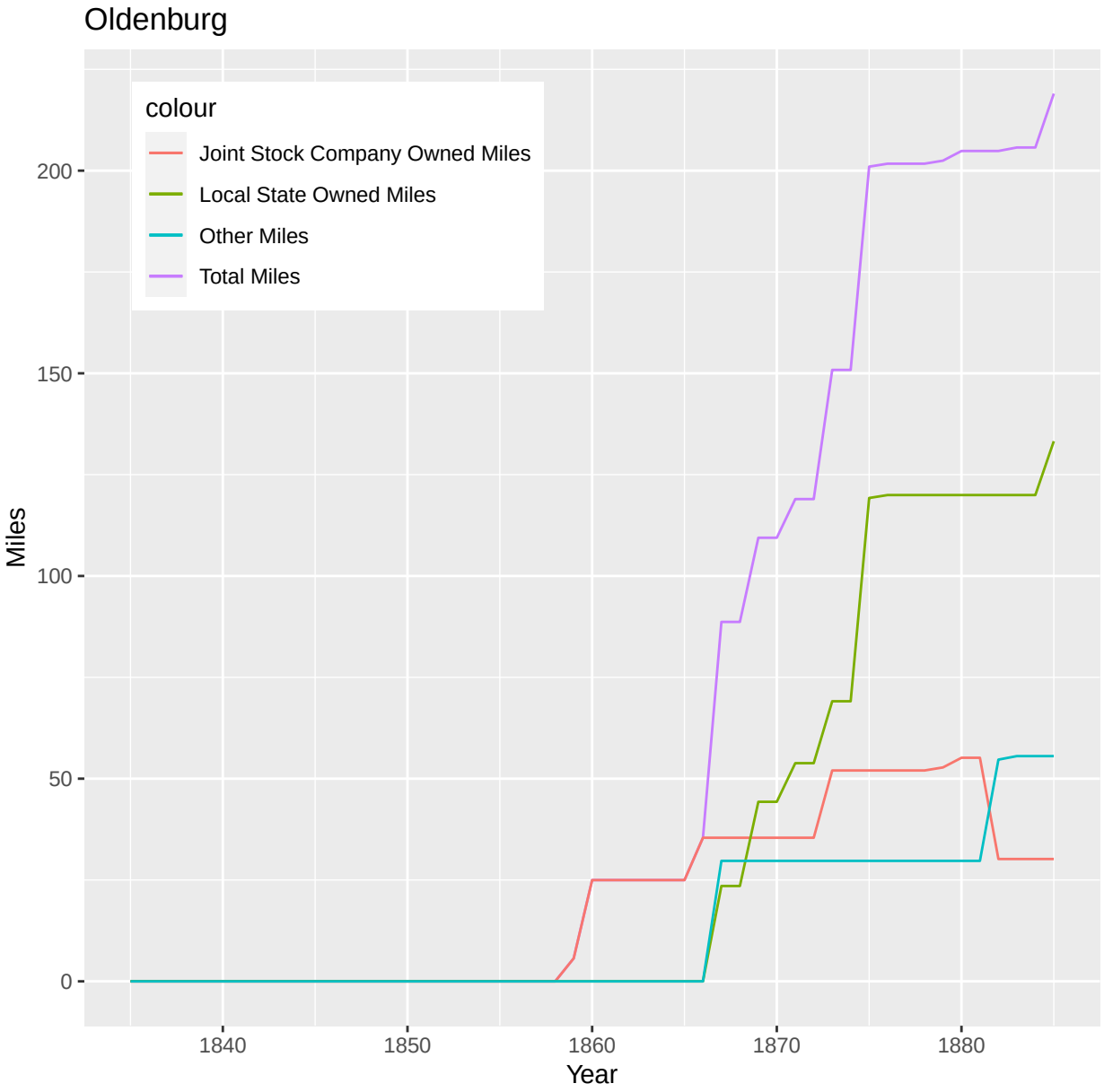
all construction is by JSCs, except for a small section operated by the neighboring state of Schwarzburg-Sondershausen.

Table 15: Expansion Rates: Saxony-Weimar-Eisenach

Statistic	N	Mean	St. Dev.	Min	Max
lag5NonStateRate	40	Inf.00		0.00	Inf.00
lag6NonStateRate	40	Inf.00		0.00	Inf.00
lag1NetTaxRev	56	2,460,080.00	610,453.90	1,545,906.00	4,072,381.00

Sources: Derived by author from Kunz and Zipf (2008) and Dumjahn (1984).

Oldenburg



By far the latest state in the sample to construct a railroad, likely as much due to its economic backwardness as its easy access to inland waterways and the North Sea. The first constructions are by JSCs in the exclaves of Birkenfeld (1859, 1860 by the Rhein-Nahe Eisenbahn Gesellschaft) and Eutin (1866, Altona Kieler Eisenbahn Gesellschaft), mirroring the Bavarian decision not to manage a state railway in the Palatinate. Railway construction in the heartland is delayed by Hannover's refusal to allow a connection (Fremdling and Kunz

2011). There was desire to build south towards Westphalia, but the first routes ended up connecting the capital the ports at Wilhelmshaven (1867), Bremen (1867), and Leer (1869) , though the route to Wilhelmshaven was owned by Prussia. In the 1880s, the railways in exclaves were purchased and nationalized by Prussia.

% Error: Data frame must have at least one row and one column.

Appendix 3: Budget Sources

Unformatted sources are legal gazzettes. Parliamentary proceedings are in bold, and secondary sources are in italics.

Baden

1820-1844: Großherzoglich Badisches Staats- und Regierungsblatt

1845-1868: Großherzoglich Badisches Regierungsblatt

1869-1885: Gesetzes- und Verordnungs-Blatt für das Großherzogthum Baden

Bavaria

1831-1837: Verhandlungen der Zweyten Kammer der Ständeversammlung des Königreichs Bayern

1837-1848: Verhandlungen der Kammer der Abgeordneten des Königreichs Bayern

1849-1871: Verhandlungen der Kammer der Abgeordneten des Bayerischen Landtages

1872-1873: Gesetzblatt für das Königreich Bayern

1874-1885: Gesetz- und Verordnungsblatt für den Freistaat Bayern

Brunswick*

1832-1885: Gesetz- und Verordnungssammlung für die Herzoglich-Braunschweigischen Lande

Hssen-Darmstadt*

1835-1885: Verhandlungen der Zweiten Kammer der Landstände des Großherzogthums Hessen

Oldenburg*

1853-1885: Gesetzblatt für das Herzogtum Oldenburg

Prussia

1821-1885: Gesetzsammlung für die Königlich-Preußischen Staaten

Saxony

1835-1885: Löbe (1889)

Sachsen-Weimar-Eisenach

1830-1850: Verhandlungen des Landtags und der Gebietsvertretung von Sachsen-Weimar-Eisenach

1851-1885: Boelcke (1906)

Württemberg

1820-1823: Königlich-Württembergisches Staats- und Regierungsblatt

1824-1885: Regierungsblatt für das Königreich Württemberg

Appendix 4: A Brief History of Fiscal Federalism in Germany

The 19th century saw a massive increase in the fiscal capacity of German states (Figure 5). After the collapse of the Holy Roman Empire, the importation of French institutions following the Napoleonic wars, and the massive consolidation of territory that followed the *Reichsdeputationshauptschluss,* German administrations were forced to undergo massive reforms in the early 19th century. As feudalism and absolutism gave way to constitutionalism, taxation became more regular and took new forms, initially leading to large increases in tax revenues per capita (Figure 6). Spoerer (2010) summarizes these changes to the direct tax regimes: The southern German states tended to follow the French model most closely, with an emphasis on direct taxation of impersonal wealth (land, buildings, and business). Prussia's tax system was more personal. Prior to 1851, a head tax called the *klassensteuer* was levied based on social standing or occupation. As the bureaucracy became more sophisticated, this was transformed into a proper income tax. Saxony and Baden introduced income taxes in 1878 and 1884 respectively, and Prussia expanded the income tax again in 1891.

Indirect taxation in Germany has a much more complicated history. The earliest forms were taxes levied on goods entering and exiting city gates, but with the near extinction of the free cities this was no longer relevant. Because of the administrative costs involved, consumption taxes were rare, and only Prussia continued to levy indirect taxes on milling and butchery in its cities (Spoerer 2010). Because of the administrative costs involved, indirect taxes were mostly levied at borders as customs duties and tariffs.[18]

Consequently, indirect taxation is one of the few policies administered by a central authority in Germany. By 1842, nearly all of the German states had joined the *Zollverein*, which eliminated customs borders between participating states. Tariffs were set and could

[18]Transit taxes were the exception, as access to rivers and railroads was relatively easy to monitor.

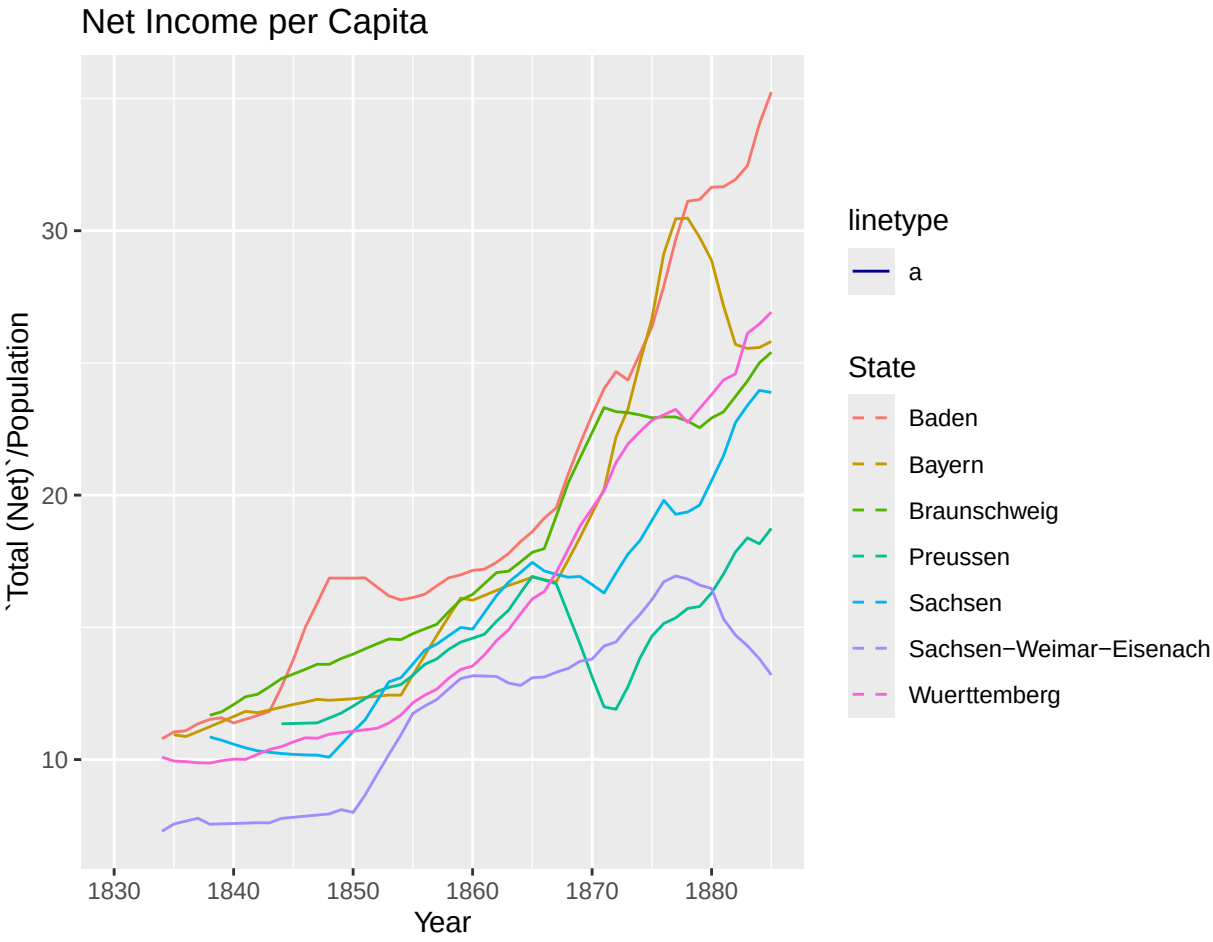


Figure 5: Net Income per Capita, 5 year moving average. Source: See Text.

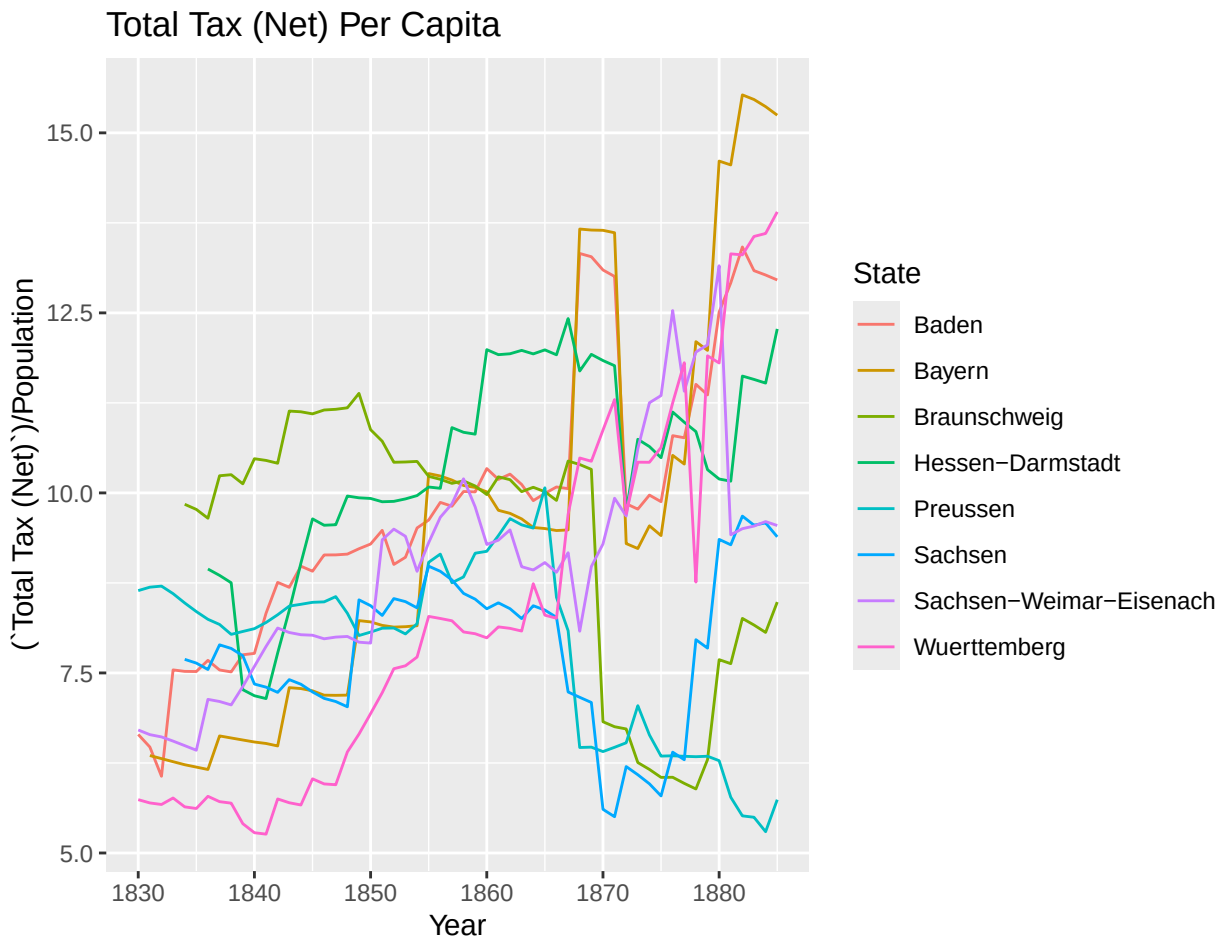


Figure 6: Total Tax less collection costs. Source:See Text. Observed years noted with thick dots.

only be changed by the unanimous consent of all members (Dumke 1976). The arrangement was relatively liberal, with low duties compared to contemporary tariffs, and no restrictive quotas. The majority of revenues came from duties on luxuries (Millward 2013). Most interesting about the *Zollverein* in the context of state fiscal capacity is how revenues were distributed: after members were compensated for the costs of customs administration at their borders, the remainder was shared on a per capita basis (Ploeckl 2010). Incidentally, the need to properly allocate revenues was the impetus for regular census-taking in many parts of Germany (Gehrmann 2009). This system is generally considered to have favored East Prussian agrarian interests over artisans and south Germany in general. On the other hand, the revenue distribution system led to lower revenues for the Prussian state, since its population was proportionately low with respect to its volume of trade. Another counterintuitive result of this system was that the smallest states with the least fiscal and administrative capacity became the most dependent on indirect tax revenue.

The *Zollverein* became obsolete after German unification in 1871, but indirect taxes generally remained the purview of central authorities. The new Imperial constitution respected the federal rights of the states to levy direct taxes, but customs and stamp duties as well as most luxury consumption taxes were reserved for the *Reich* (Millward 2013; Spoerer 2010). One would expect this to lead to a decrease in indirect direct tax revenues, since what was formerly being remitted according to population was now being allocated to the *Reich*. The states, however, were wary of this result. When tariffs began to rise in the 1870s, the states became increasingly aware of just how much revenue was being lost to the central government. In response, they passed in Franckenstein claue in 1879 which set a limit on central indirect tax revenues. All revenues from tariffs and tobacco taxes above 130m *marks* would be redistributed to the states (Hefeker 2001). Furthermore, as administrative capacity developed, indirect taxation on non-luxury goods became more feasible.

Taxation, however, is only half of the story. Prior to the development of regular taxation, the fiscal bureaucracy of the German states in the 18th and early 19th centuries was primarily

concerned with effective management of domain properties, such as forests[19] and mines.[20] The traditional models of fiscal development, from Schumpeter (1918) to Ormrod, Bonney, and Bonney (1999) have predicted that as fiscal capacity develops, the "tax state" will emerge from the "domain state". As Spoerer (2008) points out, this was not the case in Prussia, Bavaria, or Saxony, and we can see tax's share of government revenues was decreasing across all of the major German states in the 19th century (see figure 7). However, this does not mean that German states were stagnant or failing to develop more sophisticated revenue streams. Beyond the tax reforms discussed above, the German states were becoming increasingly involved in public enterprise.

The most important public enterprise, of course, was the state railway. Fremdling (1980) shaped all future discussion when he convincingly argued that the Prussian government used railway revenues as a substitute for taxation, or, as Spoerer (2004) terms it, "indirect indirect taxation". One historian even referred to this as the emergence of the "railway state" (Thier 2000). Figure 8 shows clearly how revenues related to railroads were rapidly increasing in importance across Germany. It is evident that the "railway state" phenomenon was not unique to Prussia.

In summary, the 19th century saw a great expansion and sophistication of the German states' fiscal apparatuses. The old tax system relied on unpredictable and impersonal extraordinary taxes. New, modern institutions, as well as an expanding bureaucracy facilitated regular taxation that was increasingly tied to actual economic activity. Along with increased taxes, governments increasingly applied their skills managing domain assets to the expansion of public enterprise. Most important among these public enterprises by far was the railroad, which contributed directly and significantly to most states' budgets.

[19] Lowood (2020) discusses how the "cameral sciences" emerged out of the need to manage forests.

[20] See Cantoni, Mohr, and Weigand (2021) for a discussion of how the emergence of cameralism and scientific management principles influenced the growth of early German states.

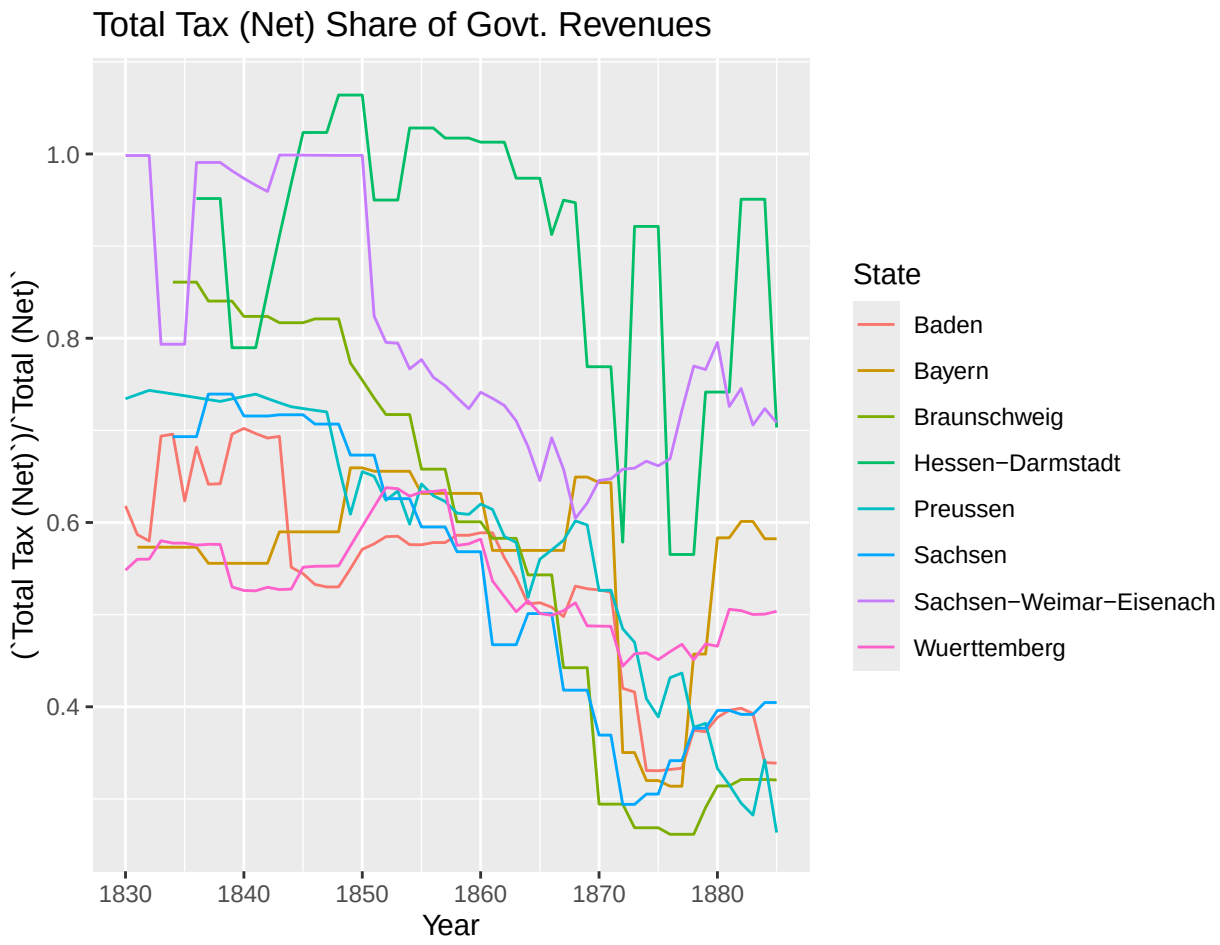


Figure 7: Tax's Share of Government Revenues. Source:See text.

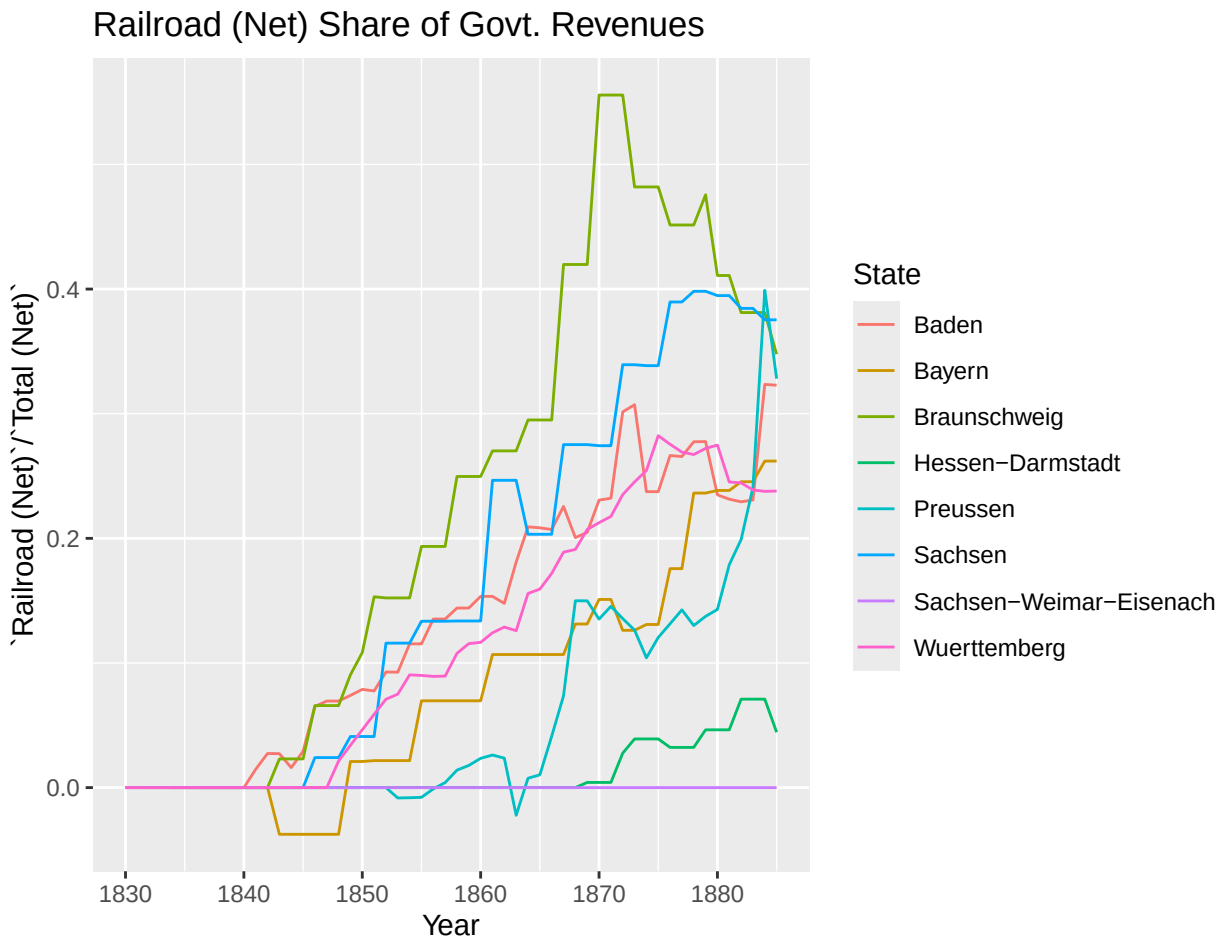


Figure 8: State Railroad Profit's Share of Government Revenues. Source: See Text.

Works Cited

Andic, Suphan, and Jindřich Veverka. 1963. "The Growth of Government Expenditure in Germany Since the Unification." *FinanzArchiv / Public Finance Analysis* 23 (2): 169–278. https://www.jstor.org/stable/40909774.

Bayerischer Landtag. 1850. *Verhandlungen Der Kammer Der Abgeordneten Des Zweiten Bayerischen Landtages Im Jahre 1849*. Vol. 5. Stenographische Berichte. Augsburg: Bayerischer Landtag.

"Bergisch-Märkische Eisenbahn-Gesellschaft." 2023. https://de.wikipedia.org/w/index.php?title=Bergisch-M%C3%A4rkische_Eisenbahn-Gesellschaft&oldid=231076276.

Besley, Timothy, Ethan Ilzetzki, and Torsten Persson. 2013. "Weak States and Steady States: The Dynamics of Fiscal Capacity." *American Economic Journal: Macroeconomics* 5 (4): 205–35. https://www.jstor.org/stable/43189566.

Besley, Timothy, and Torsten Persson. 2011. *Pillars of Prosperity: The Political Economics of Development Clusters*. The Yrjö Jahnsson Lectures. Princeton [N.J.]: Princeton University Press.

Beyer, Peter. 1978. *Leipzig Und Die Anfänge Des Deutschen Eisenbahnbaus*. Weimar: Böhlau.

Bignon, Vincent, Rui Esteves, and Alfonso Herranz-Loncán. 2015. "Big Push or Big Grab? Railways, Government Activism, and Export Growth in Latin America, 1865-1913: Railways and Governments in Latin America." *The Economic History Review* 68 (4): 1277–1305. https://doi.org/10.1111/ehr.12094.

Boelcke, Max. 1906. *Die Entwicklung Der Finanzen Im Grossherzogtum Sachsen-Weimar von 1851 Biz Zur Gegenwart*. Jena: Gustav Fischer.

Bogart, Dan. 2010. "A Global Perspective on Railway Inefficiency and the Rise of State Ownership, 1880–1912." *Explorations in Economic History* 47 (2): 158–78. https://doi.org/10.1016/j.eeh.2009.09.001.

Bogart, Dan, and Latika Chaudhary. 2012. "Railways in Colonial India: An Economic

Achievement?" *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2073256.

Cantoni, Davide, Cathrin Mohr, and Matthias Weigand. 2021. "The Rise of Fiscal Capacity," 66.

Clodfelter, Micheal. 2017. *Warfare and Armed Conflicts: A Statistical Encyclopedia of Casualty and Other Figures, 1492-2015*. Fourth edition. Jefferson, North Carolina: McFarland & Company, Inc., Publishers.

Deutsche Bundesbank. n.d. "Purchasing Power Comparisons of Historical Amounts of Money." https://www.bundesbank.de/en/statistics/economic-activity-and-prices/producer-and-consumer-prices/purchasing-power-comparisons-of-historical-amounts-of-money-795290.

Deutsche Eisenbahn Statistik Für Das Betriebs-Jahr 1850. 1851. Stettin.

Dincecco, Mark. 2011. *Political Transformations and Public Finances: Europe, 1650–1913*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139013345.

Dincecco, Mark, and Gabriel Katz. 2016. "State Capacity and Long-Run Economic Performance." *The Economic Journal* 126 (590): 189–218. https://doi.org/10.1111/ecoj.12161.

Dincecco, Mark, and Mauricio Prado. 2012. "Warfare, Fiscal Capacity, and Performance." *Journal of Economic Growth* 17 (3): 171–203. https://doi.org/10.1007/s10887-012-9079-4.

Dumjahn, Horst-Werner. 1984. *Handbuch der deutschen Eisenbahnstrecken: Eröffnungsdaten 1835 - 1935, Streckenlängen, Konzessionen, Eigentumsverhältnisse = Die deutschen Eisenbahnen in ihrer Entwicklung 1835 - 1935*. Vollst. unveränd. Nachdr. Berlin, 1935. Dokumente zur Eisenbahngeschichte 29. Mainz: Dumjahn.

Dumke, Rolf Horst. 1976. "The Political Economy of German Economic Unification: Tariffs, Trade and Politics of the Zollverein Era." PhD thesis.

Foreman-Peck, J. S. 1987. "Natural Monopoly and Railway Policy in the Nineteenth Century." *Oxford Economic Papers* 39 (4): 699–718. https://www.jstor.org/stable/2663102.

Fremdling, Rainer. 1977. "Railroads and German Economic Growth: A Leading Sector

Analysis with a Comparison to the United States and Great Britain." *The Journal of Economic History* 37 (3): 583–604. https://doi.org/10.1017/S0022050700095395.

———. 1980. "Freight Rates and State Budget: The Role of the National Prussian Railways 1880-1913." *The Journal of European Economic History* 9.

———. 1983. "Germany." In, edited by Patrick O'Brien, 121147. London: Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-06324-6_4.

Fremdling, Rainer, Ruth Federspiel, Andreas Kunz, Dietlind Hüchtker, and Angelus H. Johansen, eds. 1995. *Statistik der Eisenbahnen in Deutschland 1835-1989*. Quellen und Forschungen zur historischen Statistik von Deutschland, Bd. 17. St. Katharinen: Scripta Mercaturae.

Fremdling, Rainer, and Günter Knieps. 1993. "Competition, Regulation and Nationalization: The Prussian Railway System in the Nineteenth Century." *Scandinavian Economic History Review* 41 (2): 129–54. https://doi.org/10.1080/03585522.1993.10415864.

Fremdling, Rainer, and Andreas Kunz. 2011. "Germany's Statistics of Railways 1835 to 1989."

Gehrmann, Rolf. 2009. "German Census-Taking Before 1871." *MPIDR Working Paper 23*, 25.

Hefeker, C. 2001. "The Agony of Central Power: Fiscal Federalism in the German Reich." *European Review of Economic History* 5 (1): 119–42. https://doi.org/10.1017/S1361491601000053.

Hoffman, Donald Stone. 1969. "Railways and Railway Politics in South Germany: Defensive Particularism at the State Level, 1835-1870." PhD thesis, United States – Delaware. https://www.proquest.com/docview/302358650/citation/A08649C1AD1F4754PQ/1.

Johnson, Noel D., and Mark Koyama. 2017. "States and Economic Growth: Capacity and Constraints." *Explorations in Economic History* 64 (April): 1–20. https://doi.org/10.1016/j.eeh.2016.11.002.

Kleeberg, John M. 1990. "The Privatisation of the Brunswick State Railways in

1869–70." *The Journal of Transport History* 11 (1): 12–28. https://doi.org/10.1177/002252669001100103.

Kühn, Ernst. 1882. *Die Historische Entwicklung Des Deutschen u. Deutsch-Österreichischen Eisenbahn-Netzes Vom Jahre 1838 - 1881.*

Kunz, Andreas, and Alexander Zipf. 2008. "HGIS Germany: Historical Information System of the German States, 1820 to 1914."

Löbe, Ernst. 1889. *Der Staatshaushalt Des Königreichs Sachsen in Seinen Verfassungsrechtlichen Beziehungen Und Finanziellen Leistungen.* Leipzig: Verlag von Veit & Comp.

Lowood, Henry E. 2020. "The Calculating Forester: Quantification, Cameral Science, and the Emergence of Scientific Forestry Management in Germany." In, 7:315–42. Berkeley: University of California Press. https://doi.org/10.1525/9780520321595-013.

Mauersberg, Hans. 1988. *Finanzstrukturen deutscher Bundesstaaten zwischen 1820 und 1944.* S[ank]t Katharinen: Scripta Mercaturae.

Mayer, Arthur von. 1891. *Geschichte Und Geographie Der Deutschen Eisenbahnen. I. Band, Theil i Und II Umfassend.* Berlin: Wilhelm Baensch Verlagshandlung.

Mayntz, Renate, and Thomas Hughes. 1988. "The Development of the German Railroad System." In, edited by Renate Mayntz and Thomas P. Hughes, 1st ed., 105–34. Routledge. https://doi.org/10.4324/9780429309991-4.

Millward, Robert. 2004. "European Governments and the Infrastructure Industries, c.1840-1914." *European Review of Economic History* 8 (1): 3–28. https://doi.org/10.1017/S1361491604001030.

———. 2013. *The State and Business in the Major Powers: An Economic History, 1815-1939.* London: Routledge.

Mitchell, Allan. 2000. *The Great Train Race: Railways and the Franco-German Rivalry, 1815-1914.* New York: Berghahn Books.

Ormrod, W. Mark, Margaret Bonney, and Richard Bonney. 1999. *Crises, revolutions and*

self-sustained growth: essays in European fiscal history, 1130-1830. Stamford: Shaun Tyas.

Ploeckl, Florian. 2010. "The Zollverein and the Formation of a Customs Union," 40.

Schumpeter, Joseph Alois, 1883-1950. 1918. *Die Krise Des Steuerstaats*. Austria: Leuschner & Lubensky, 1918.

Segal, Zef M. 2019. *The Political Fragmentation of Germany: Formation of German States by Infrastructures, Maps, and Movement, 1815–1866*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-19827-5.

Spoerer, Mark. 2004. *Steuerlast, Steuerinzidenz Und Steuerwettbewerb. Verteilungswirkungen Der Besteuerung in Preußen Und Württemberg (1815-1913)*. https://doi.org/10.1515/9783050084152.

———. 2008. "The Revenue Structures of Brandenburg-Prussia, Saxony and Bavaria (Fifteenth to Nineteetnth Centuries): Are They Compatible with the Bonney-Ormrod Model?" In, edited by Simonetta Cavaciocchi. Serie II. Atti Delle "Settimane Di Studi" e Altri Convegni 39. Firenze: Firenze University Press.

———. 2010. "The Evolution of Public Finances in Nineteenth-Century Germany." In, edited by José Luís Cardoso and Pedro Lains, 1st ed., 103–31. Cambridge University Press. https://doi.org/10.1017/CBO9780511845109.006.

Thier, Andreas. 2000. "Steuergesetzgebung Und Staatsfinanzen in Preußen 1871-1893." In, edited by Gerhard Lingelbach. Köln: Böhlau.

Vereins Deutscher Eisenbahn-Verwaltungen. 1868. *Deutsche Eisenbahn Statistik Für Das Betriebs-Jahr 1866*. Rauck'schen Buchdruckerei.

Wooldridge, Jeffrey M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, Mass: MIT Press.