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Conference Paper

How England Unified Germany: Geography and the Rise of Prussia After 1815

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel -
Session: Economic History, No. F13-V1

Provided in Cooperation with:

Verein für Socialpolitik / German Economic Association

Suggested Citation: Huning, Thilo R.; Wolf, Nikolaus (2016) : How England Unified Germany: Geography and the Rise of Prussia After 1815, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel - Session: Economic History, No. F13-V1, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

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How Britain Unified Germany: Geography and the Rise of Prussia After 1815

Abstract

We analyze the formation of the German Zollverein as an example how geography can shape institutional change. We show how the redrawing of the European map at the Congress of Vienna—notably Prussia’s control over the Rhineland and Westphalia—affected the incentives for policymakers to cooperate. The new borders were not endogenous. They were at odds with the strategy of Prussia, but followed from Britain’s intervention at Vienna regarding the Polish-Saxon question. For many small German states, the resulting borders changed the trade-off between the benefits from cooperation with Prussia and the costs of losing political control. Based on GIS data on Central Europe for 1818–1854 we estimate a simple model of the incentives to join an existing customs union. The model can explain the sequence of states joining the Prussian Zollverein extremely well. Moreover we run a counterfactual exercise: if Prussia would have succeeded with her strategy to gain the entire Kingdom of Saxony instead of the western provinces, the Zollverein would not have formed. We conclude that geography can shape institutional change. To put it different, as collateral damage to her intervention at Vienna, “Britain unified Germany”.

JEL Codes: C31, F13, N73

*“Prussia’s relocation to the Rhine is one of the most fundamental facts in German history,
a basis for the foundation of the Empire of 1866/1871”
(Nipperdey, 1983)*

Recent work on long-run development has focused on institutions as the key to understand the rise or decline of states, including Rodrik et al. (2004), Nunn (2009), and Acemoglu and Robinson (2012). But what explains institutional change? We argue that geography can influence institutional change because it can affect the incentives of policymakers to cooperate. We distinguish between “first nature geography (features of the physical environment such as climate, distance to the coast, natural resources) and “second nature geography” (man-made features of geography such as transport infrastructure, cities or political borders) following Cronon (1992); Krugman (1991). While first nature is static, second nature can change over time. This change occurs with an explicit geographic structure and we will show that such change can be causal for institutional change. Our argument is closely related to the literature on the size of nations following Alesina and Spolaore (1997) and Bolton and Roland (1997), who emphasize a trade-off between benefits of cooperation from economies of scale and the costs of losing political control. We argue that a change in borders can trigger a cascade of changes in both dimensions.

Specifically, we consider the economic and political unification of Germany during the 19th century, which changed the European balance of power (Simms, 2013). We show that the rise of Prussia to first become the dominating power within Germany and from 1871 onwards for much of the European continent can be traced back to such a change in “second nature” geography: the redrawing of the European map at the Congress of Vienna in 1814/15. Against its own strategic plans, but enforced by Britain, Prussia gained large territories in the West. Clark (2007) claims that the consequences of these new borders were “momentous”, but “entirely unforeseen by the negotiators at Vienna, who assigned little weight to economic factors when they redrew the map of Germany” (p. 389ff.).

This change in borders had far-reaching consequences. First, Prussia consisted now of two large separated territories, which it tried to connect. Second, Prussia held sway over both large continental transport systems before the age of the railway - most of the rivers Elbe in the East and the Rhine in the West. We show how this put other German states under pressure to follow Prussia into a customs union, the “Zollverein”. After the signature of the Mainz convention in 1831, just after the Belgian Revolution, the abolition of staple rights and other shipping costs along the Rhine and at the Dutch border increased that pressure again. In consequence, by 1835 all German states between or to the South of the two Prussian territories had joined into the Zollverein. So the change in borders successively changed the incentives to cooperate.

The intuition for this result is a basic trade-off between prospective gains from joining a large customs union with economies of scale and the loss of political control. In 1815 all the German states that still existed as sovereign entities after the Napoleonic wars were in financial difficulties, including Prussia. All of them attempted to increase their state revenues, reduce costs yet keep as much of their political sovereignty as they could. Notably they were eager to stay in control over their revenue. An important area that affected both fiscal capacity and sovereignty was tariff policy. With the formation of the Prussian Zollverein in 1818 states had to weigh the potential gains from higher tariff revenue net of costs after joining into the Zollverein against the loss of control over these revenues, hence a loss of political sovereignty. The fact that Prussia controlled large parts of the German river system after 1815 considerably reduced the control that other German states had over their own tariff income, because much of their trade had to be routed over Prussian territory. Moreover, with each new member of the Zollverein, the actual loss of sovereignty from joining into the Zollverein declined, while the benefits from higher tariff revenue and lower costs increased. We use simple panel probit regressions to test this hypothesis and find that this fits the observed data extremely well.

At the heart of our empirical strategy is the construction of lowest cost paths between 106 territories in Western and Central Europe for the period 1815 to 1854. For each year and territory, we construct both the factual lowest cost paths - treating the Zollverein membership of other states at that time as given - and the counterfactual - if the state to which the territory belongs would join (resp. leave) the Zollverein. We calculate these paths using GIS-data on contemporary state borders and trade-infrastructure (streets, navigable rivers and ports), transport-mode specific cost per ton-kilometer and average tariff rates at the time. Together with population data we next calculate the expected volumes of imports and transit flows for all territories in our sample for any observed extent of the customs union. Finally, this allows us to approximate the incentives to join in terms of revenue and control. On one hand, the decision to join the Prussian Zollverein changed the expected tariff revenue and the costs to collect tariffs. On the other hand, states that joined the Zollverein had less control over their tariff

revenues than before. This change in control can be captured by the change in trade routed via own vs. foreign territory and the loss in transit trade after joining the Zollverein. We show that these changes in control over revenue have much more explanatory power than changes in revenue as such. In a counterfactual exercise we show that the German Zollverein would not have formed if Prussia would have succeeded at the Congress of Vienna and annexed the entire Kingdom of Saxony instead of Westphalia and the Rhineland. This is why we conclude that Britain unified Germany. As recently shown in Keller and Shiue (2014), the emergence of a German customs union had a very substantial effect on the integration of markets across Germany and prepared both Germany's industrial take-off from the 1850s onwards and the political unification of Germany under Prussian leadership in 1871.

Our paper is related to various strands in the literature. To start with, the large literature on the origins of economic development has stressed the role of institutions relative to that of geography. Rodrik et al. (2004), Nunn (2009), or Acemoglu and Robinson (2012) argue that the role of institutions and institutional change dominate the influence of geographical factors. However, the notion of geography in these papers is limited to static "first nature geography", similar to that in many other studies on long-run growth such as Diamond (1997), Acemoglu et al. (2001), Olsson and Hibbs (2005), Engerman and Sokoloff (2000), Dell (2010), Nunn and Qian (2011) or Nunn and Puga (2012). More recently, several authors have analyzed the direct effects of "second nature geography" on economic development, including Donaldson (2010) and Donaldson and Hornbeck (2013) on the effect of railroads on growth or Michaels and Rauch (2013) on the long-run effect of Roman roads on the development of cities across France. Few authors have taken up the idea of Smith (1776) that the size of the accessible market would matter for development. Examples include Redding and Venables (2004) who analyse the effect of market access on growth, Desmet and Parente (2010) who show how market size can affect innovation, and Chaney and Ossa (2013) who model how an increase in market size can induce a deeper division of labor and increase firm productivity. Instead we are interested in the effect of a change in borders on the formation of a customs union, hence we stress the interaction between changes in "second nature geography" and institutional change.

Second, our paper is related to the literature on the size of nations in the wake of Alesina and Spolaore (1997) and Bolton and Roland (1997). Both studies argue that there is a basic trade-off between the benefits of larger jurisdictions and the costs of that size. Alesina and Spolaore (1997) show that the benefits from economies of scale and scope of larger jurisdictions have to be balanced against the political costs of heterogeneity. Bolton and Roland (1997) also consider the benefits from economies of scale and weigh them against the loss of control on political decisions at the local level. This is closely related to the literature on optimum currency areas following Mundell (1961), where the benefits of larger markets due to reduced trade and capital market frictions between members are compared to the costs of losing the exchange rate as a tool to adjust to the heterogeneity of member states. More specifically, several authors have tried to explain the emergence of customs unions and in particular that of the Prussian Zollverein. In his work on the economics of customs unions Viner (1950) considered the Zollverein to be the "pioneer and by far the most important customs union". One of the earliest results of the theory of customs unions was the proposition of Kemp and Wan (1976) that customs unions can be beneficial to its member states under fairly general assumptions, given that trade with respect to non-union members would not be affected by the formation of the union (Feenstra, 2003). Moreover, most of the theoretical literature on customs unions ignored possible costs related to the loss of political control over tariff revenues. Instead, the recent empirical literature on the formation of free trade agreements and customs unions (Baier and Bergstrand, 2007; Egger et al., 2011; Wolf et al., 2011) has focused on the potential endogeneity of trade agreements and ex ante patterns of trade, income and trade costs but never controlled for political or other characteristics of trading partners.

Third, there is a small but prominent historical literature on the formation of the Zollverein. In his seminal work on the Zollverein, Dumke (1976) considered several possible motives for joining the Zollverein. He argued that by joining the Zollverein German states could hope to benefit from economies of scale in the collection of tariff revenues, benefit from a larger market for industrial products (i.e. Smithian growth), while simultaneously staying in control over these revenues. However, his main point here was that most states were ruled by Princes that had to fight off attempts to subject all income to parliamentary control. As tariff income was treated as non-tax income and hence not subject to parliamentary control, the Princes had a peculiar interest in increasing tariff revenues. Dumke (1976) provides several pieces of descriptive evidence to support his argument but cannot directly test it. Next, Ploeckl (2010) explores in an insightful study the negotiations over Zollverein membership and argues that Prussia could act as an agenda setter in a bargaining game. In particular he provides descriptive evidence for the hypothesis that Prussia negotiated sequentially with German states over their membership in order to maximize coalition externalities on states still outside the union. Finally, Keller and Shiue (2014)

estimate the effect of the Zollverein on the integration of grain markets, taking into account that the incentives to join were endogenous to ex ante trade, similar to Baier and Bergstrand (2007). They use a state's average distance to the coast relative to average distance to the coast of non-member states as an instrument to control for the endogeneity of Zollverein membership and find that joining the Zollverein had a substantial effect on the integration of grain markets.

Our paper builds on this existing literature and makes three distinct contributions. First, we contribute to the literature on the origins of growth by showing that a change in second nature can cause institutional change and hence economic growth and development. Second, we present a new method how to use historical GIS data, which is widely available also in historical settings, to calculate data on expected trade, tariff revenue and changes in control. And third, we provide an explanation for the formation of Zollverein in terms of a trade-off between gains in revenue and losses of political control that fits the data very well. Moreover we show empirically that the change in borders in 1815 was causal for this.

We proceed in this paper as follows. In section one we present some brief historical background on the Congress of Vienna, the economic and political situation in Germany around 1815, the trade regime and the role of river navigation before the age of the railway. Section two presents our main hypotheses about the motives to join the Zollverein in terms of a trade-off between economies of scale and loss of control. In section three we discuss our empirical strategy, describe our data and explain how we used historical GIS data to calculate variables on expected revenue and revenue control. In section four we present and discuss our benchmark results together with various robustness checks. Section five contains the counterfactual—using our previous benchmark results together with an alternative set of political borders. We conclude in section six.

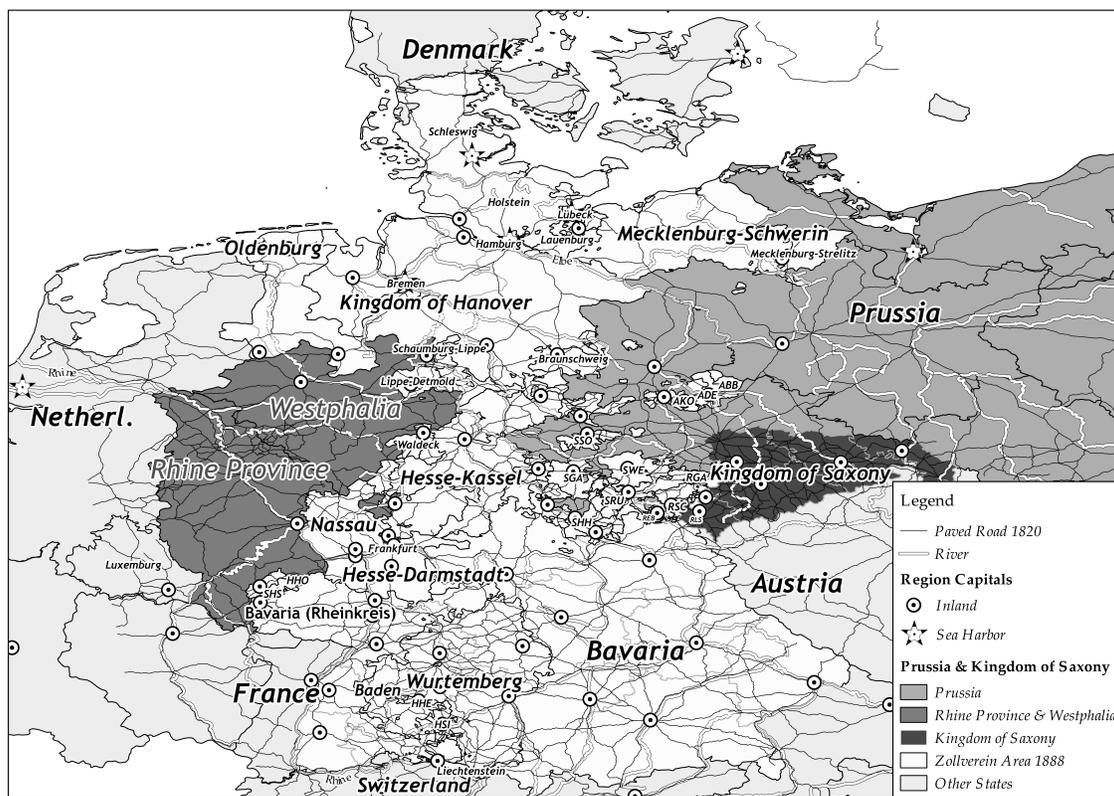


Figure 1: Map of the German lands after the Congress of Vienna including the rivers and the 1820 road network¹

¹Abbreviations: ABB: Anhalt-Bernburg, ADE: Anhalt-Dessau, AKO: Anhalt-Köthen, HHE: Hohenzollern-Hechingen, HHO: Hess-Homburg, HSI: Hohenzollern-Sigmaringen, REB: Reuß-Ebersdorf, RGA: Reuß-Gera, RLS: Reuß-Lobenstein, RSC: Reuß-Schleiz, SGA: Saxony-Gotha-Altenburg, SHH: Saxony-Hildburghausen, SCS: Saxony-Coburgurg-Saalfeld, SRU: Schwarzburg-Rudolstadt, SSO: Schwarzburg-Sondershausen, SWE: Saxony-Weimar-Eisenach.

1. Historical Background

“Berlin failed to get what it wanted and got what it did not want.[...] The creation of a large Western wedge along the river Rhine was a British, not a Prussian, idea.”
(Clark, 2007, p. 389)

At the end of the Napoleonic wars 1792–1815 only Russia and Great Britain had emerged as major military powers. Habsburg, Prussia and the defeated France attempted to consolidate their position at the expense of the many still existing smaller states, notably the former allies of Napoleon such as Saxony or Poland. A central object of the negotiations at Vienna was the redrawing of the European map, especially the Polish-Saxon question. Alexander I. of Russia aimed for a double-monarchy of Russia and Poland. This expansion of Russia to the West met stiff opposition from Britain and Habsburg. Britain’s ambassador Castlereagh warned his Prime Minister that this “would have the colour of an attempt to revive the system we all united to destroy, namely one colossal military Power holding two powerful States in a species of dependence and subjection, and through them making her influence in the remotest parts of Europe” (Müller, 1986). Prussia’s chancellor Hardenberg who led the Prussian delegation at Vienna pursued predominantly military-strategic aims²: In order to ease the defense of its territory and capital, he intended to finally annex the Kingdom of Saxony (Clark, 2007, p. 389). Castlereagh consented under the condition that Prussia would support the British position in the Polish Question³, so does Metternich⁴. Under the leadership of Castlereagh, the three form an informal coalition against Russia but Prussia leaves this alliance under pressure of Alexander, as Russian troops had occupied Saxony (Burg, 1993, p. 12ff.). In a desperate move, Hardenberg offers in late 1814 to remove the entire Kingdom of Saxony to the Rhine including “a city pleasantly situated at the Rhine, suitable for a residence” for the Saxon king (Müller, 1986, p.262). As this offer was rejected Hardenberg, seeing the Prussian position decaying between the Tsar’s plans and ‘British interest’, threatened with a new war—and gained a defense alliance between Great Britain, Austria and France against Prussia and Russia (Burg, 1993, p. 27). Hence, the Congress ended as a big compromise, shaped very much by the attempt of Great Britain to contain Russia’s move to the west. Poland was divided (again) between Russia (‘Congress Poland’), Prussia and Austria. Saxony was divided in two parts. The Kingdom of Saxony was shrunk to its southern part, while the northern part formed the new Prussian province of Saxony. As compensation, Prussia was also given the Rhineland and Westphalia in the West, to become the “warden of the German gate against France”(Clapham, 1921, p. 98). The German Bund was established as a loose federation of German countries under the joint leadership of Habsburg and Prussia (Hahn, 1982, p. 127).

While the Congress of Vienna settled the large geopolitical issues, most German states still faced existential threats after 1815. To start with, after years of war and territorial changes back and forth and indeed after financial difficulties inherited from the pre-Napoleonic era, state finances were out of control (Borchard, 1968). What was needed was fundamental administrative reform and new sources for revenue. Prussia, pressed very hard after the defeat in 1806, had started a series of reforms, including a fundamental reorganization of the administration, agrarian reforms, reforms of the educational system and some first attempts to reform taxation. But still in 1821, six years after the war, the ratio of Prussia’s government debt to total state income stayed above 400% (Mieck, 1992, p. 124). A major step towards a new financial system was Prussia’s tariff law of 1818, which abolished all internal tariffs and established one common tariff along the external border following the examples of France and Britain Onishi (1973)]. Right after 1818 Prussia started to invite other German states to join into this customs union, which later will be known as the “Zollverein”. This and the introduction of a class-wise income tax system helped to consolidate Prussia’s state finances in the following decades. For most states however, both administrative reform and access to new revenue came at the risk of losing political sovereignty. On the one hand, there are economies of scale and scope in fiscal administration. An efficient fiscal system required a minimum size of the administrative apparatus and many German states were simply too small to implement this. Maybe the clearest illustration of this is the observation by Kühne (1836) that the cost of a tariff system rise in proportion to the length of tariff borders, while tariff revenues rise roughly in proportion to the area enclosed. Consequently, small states, often with several non-contingent territories had difficulties to generate substantial net-income from tariffs (see also Borchard (1968). According to Dumke (1976) this was one main motive for smaller states to give

²This military-strategic argument was already developed by Friedrich II (1712–1786), probably during the Seven Years War (1756–1763). In his notes “par droit de bienséance”, he outlines the territory of Saxony as key for the defense of Berlin (cited after (Mittenzwei, 1985, p. 209).

³Note from Castlereagh to Hardenberg, October 11th 1814 (Müller, 1986, p. 211).

⁴In his note, Metternich consents under condition on inner-German questions. Note to Hardenberg, October, 22nd (Müller, 1986, p. 214 f.).

up their tariff autonomy and join the Zollverein. On the other hand, the attempt to gain access to new sources of revenue came at the risk of losing political control. The main source of new revenue had to be taxation, given that the revenue from state monopolies and state-owned farms or factories could not be easily increased at the time (Ullmann 2005, p.34). But as a rule, new taxes were a source of political conflict. Those subject to taxation would try to bargain for political rights in exchange for their consent to pay the new taxes (a good example of this is the study by Krüger on Hesse during the 16th and 17th century, Krüger (1987). As argued by Dumke (1976), this might have been an incentive more to join the Zollverein for those German princes who faced a constitutional constraint, because the tariff-revenue from the Zollverein were treated as non-tax revenue (Dumke, 1976, chapter 1). But his evidence on this is anecdotal and his argument seems to be incomplete at best. More importantly, smaller states must have feared that by joining the Zollverein, they gain revenue at the risk of giving up sovereignty towards Prussia. Habsburg's chancellor Metternich always considered the Zollverein as a tool to establish Prussia's dominance in Germany and tried to prevent its formation (Mieck, 1992, p.163). Therefore, the decision to join the Zollverein was mainly a trade-off between an expected increase in tariff revenue against the risk of losing political control over those revenues and ultimately losing sovereignty. All this happened against the background of smaller states struggling to finance their debt.

In order to assess the costs and benefits of joining into a customs union at the time, we need some background on the structure of trade and trade costs back then. First of all, Germany was politically fragmented and trade flows had to pass often a dozen of tariff borders even on relatively short distances. This was considered by many contemporaries to be a main disadvantage compared to politically unified territories such as France or the United Kingdom. The available historical evidence on tariff rates across Germany is patchy but suggests that crossing a state border was associated with an average tariff of 10-15 percent. Below we will explicitly model this endogenous part of trade costs as the decision to join into a customs union or not driven by considerations on economies of scale and political sovereignty. We note that the option to form a free trade area rather than a customs union, which would have allowed states to set their external tariff independently, was not viable at the time, due to difficulties to implement a rule of origin in the fragmented German state system (Ploeckl, 2010). Second, transport on water was much cheaper than transport over land. According to Sombart (1902), the average freight cost per tonkilometer during early 19th century Germany on river was between 0.6 and 1.5 percent of the average freight cost on country roads. At the time, the main instrument to improve the transport infrastructure apart from building canals was to construct paved roads with a fully developed drainage system ("Chausseen") that made them usable even during bad weather conditions. This could bring down average freight cost per tonkilometer to 25 percent of that on standard roads. Instead, railroad construction started in Germany only in 1835, where most lines were built after 1848. So navigable rivers attracted the bulk of all trade flows and control over rivers and seaports granted control over trade. In this vein, with the territorial gains in the West, Prussia should have gained control over much of the Rhine after 1815 in addition to her control over the Elbe (and Oder) in the East such that a substantial part of the trade of most other German states would have had to pass the Prussia customs border. However, trade on the Rhine was subject to a multitude of political trade costs such as tariffs and duties payable at Rotterdam or staple rights and the requirement to use specific shipping companies for parts of the voyage (Spaulding, 2011). While it was agreed in Vienna in 1815 that trade on the Rhine should be free "jusqu' a la mer", most of the existing barriers to trade were only lifted with the Convention of Mainz in 1831. A driving factor leading to this agreement was the independence of the southern provinces of the Netherlands and the rise of Antwerp as an alternative to Rotterdam, which facilitated a cooperation between the Netherlands and Prussia Klemann (2013). Therefore, the effect of Prussia's relocation to the Rhine on the geography of trade and trade routes was initially limited but became much stronger in 1831, when trade costs on the Rhine up to and including the seaport of Rotterdam declined substantially (Bouman, 1933).

2. Theoretical Framework

Our main hypothesis is that the decision to join the Zollverein was largely driven by the attempt to increase state revenue, while minimizing the loss of political control. As described earlier, for the typical German state after 1815 this decision was taken by formally sovereign princes presiding over relatively small states. In some cases their decisions were limited by constitutions and early forms of parliamentary control, in other cases they could act as absolutist rulers. Theoretically, this trade-off is inspired by the literature on the optimal size of nations following Alesina and Spolaore (1997) and Bolton and Roland (1997), where decision-makers weigh the benefits from economies of scale from larger jurisdictions against the loss of political control Bolton and Roland (1997)

or the larger costs of heterogeneity (Alesina and Spolaore, 1997). To fix ideas, consider a prince who faces the decision whether or not to join into a large existing customs union. We argue that his decision will depend on two sets of variables: first, how would joining affect expected state revenues net of costs to generate them? Second, how would joining affect expected political control over state revenues? Most generally, expected tariff revenue is given by

$$R_i = \begin{cases} t_i [\vartheta_i^U M_i + (1 - \vartheta_i^U) M_i] + t_i [\vartheta_U^i M_U + \vartheta_W^i M_W] - cost_i & \text{if } i \notin U \\ \frac{pop_i}{pop_{U'}} [t_{U'} (M_{U'} + \vartheta_{W'}^{U'} M_{W'}) - cost_{U'}] & \text{if } i \in U \end{cases} \quad (1)$$

where we have dropped for simplicity the expectations operators on all variables. We need to distinguish expected tariff revenue if the state decides to stay outside the customs union ($i \notin U$), given in the first line, from expected tariff revenue if the state decides to join ($i \in U$). In both cases, expected tariff revenue is given by the sum of three terms: tariff revenue from imports M_i , tariff revenue from transit trade $T = \vartheta_U^i M_U + \vartheta_W^i M_W$ and the $cost$ to generate tariff revenue. Consider the first case ($i \notin U$). For the term on imports, we propose to distinguish between the share of all imports into state i that have been routed over the Zollverein ($\vartheta_i^U M_i$) and all other imports ($(1 - \vartheta_i^U) M_i$). For the second term, we also distinguish between transit trade of state i , which is import trade into the Zollverein (given by the share of ZV imports routed over state i , ϑ_U^i) and transit trade of state i , which is import trade to the rest of the world. Next, consider the second case, where state i decides to join the Zollverein. We use the rule that all net tariff revenue generated by the Zollverein was distributed to its members according to their population share (reference) and apply this both to the gross revenues and the costs. Note that in this second case, the Zollverein has changed its composition, so imports and transit flows for the Zollverein and the rest of the world have to be adjusted. With this we can formulate a first simple hypothesis:

Hypothesis 1: *a state is more likely to join into the Zollverein if expected revenues increase after joining:*

$$Pr(join = 1) \sim \Delta R \quad (2)$$

However, by joining a state will give up its exclusive control over tariff revenues and delegate revenue control to the Zollverein. The formulation above suggests that we can capture this change in control as follows:

$$\Delta Control = \underbrace{\beta_1 [\vartheta_i^U - 1]}_{U's \text{ control over } i's \text{ imports}} + \underbrace{\beta_2 \left[0 - \frac{\vartheta_U^i M_U}{M_i + \vartheta_U^i M_U} \right]}_{i's \text{ share of trade flows generated by transits to } U} + \underbrace{\beta_3 [0 - \vartheta_U^i]}_{i's \text{ control over } U's \text{ imports}} \quad (3)$$

Consider the first term on the right hand side. State i loses control over revenue from imports, but this loss will be smaller the more of its imports have previously been routed via the territory of the Zollverein. In the extreme case of a small state enclaved by the Zollverein, the state had lost control over its import revenues even before joining, because it could be easily circumvented. The second and third terms capture that by joining a state will lose its revenue from transit trade. In term of revenue control this implies on the one hand, that the loss in control will be larger the larger the share of transits in the state's total trade. On the other hand, the state will lose control over the Zollverein's trade, and this loss will be larger the more imports of the Zollverein have been routed via the state's territory relative to the Zollverein's total trade. This allows us to formulate a second hypothesis:

Hypothesis 2: *a state is more likely to join into the Zollverein the smaller the expected loss in control over revenues after joining:*

$$Pr(join = 1) \sim \Delta Control \quad (4)$$

As is clear from inspecting the formulation of tariff revenue, the decision to join can lead to an increase in tariff revenue yet at the same time reduce control over revenue. We argue that decision makers considered both factors as a trade-off between benefits and costs of joining. To what extent a state could expect to gain revenue from joining and to what extent it would expect to lose revenue control are empirical questions, which we will explore below. To identify this general trade-off, we need to make two simplifying assumptions. We assume here that other motives can be ignored, such as arguments for an elimination of internal tariff borders to support

the growing industrial sector or instead the demand for protectionism against manufacturers from other states. There is evidence that such motives were discussed (Hahn, 1984, p. 20ff), but we argue that they were not driving the key decision makers at the time. Instead, the fiscal motive of generating state revenue and the political motive to stay in control over revenue as far as possible were dominant. Our other crucial assumption is that individual decision makers have very little strategic room. In fact we assume that each state is very small and faces only the decision to join an already existing large customs union or not. At first glance this is at odds with evidence for the formation of alliances between several smaller and medium sized states such as Bavaria and Wurtemberg during the 1820s, including attempts to form their own customs union. However, we know by hindsight that all these attempts failed and argue that they had little chance to succeed in the first place. As we will show in the next section, Prussia was not only by far the largest and most populous state in Germany after 1815, covering about 2/3 of the territory, but it exerted considerable influence over other states' trade routes. This brings us back to the question of the role of geography for institutional change. Both the expected change in revenue from joining and the expected change in control are influenced by the routing of trade, which in turn is shaped by the geography of trade costs and the distribution of demand. For revenues, the size of transit trade is crucial. Given that water transport cost was so cheap relative to the alternatives, we expect that states with good access to navigable rivers derived substantial revenues from other state's transit. The expected change in revenue control is even more strongly affected by the routing of trade. Both, own trade routed over foreign territory and foreign trade routed over own territory influence the degree to which decisions on trade policy can be taken. In the next section we explain how we use data on trade costs and the geography of demand to calculate trade flows and their routes and test our hypotheses.

3. Empirical Strategy and Data

"The long coast, the location of the Rhenish and Westphalian provinces between France, the Netherlands and Germany, make this country very suitable for transito. The greater the freedom, the more trade one will be able to seize."

*Hans, Count of Bülow
Prussian minister of finance, 1817⁵*

Our hypotheses on revenues and revenue control are based on the idea that the decision to join the Zollverein affects trade costs and thereby trade routes, revenue and control. In this section we explain our dependent variable, and how we use available data to first calculate the pattern of trade costs and expected trade routes across Germany and then use this to calculate our dependent variables on revenue and control. Finally, the probability of a state x to join the Zollverein in year y is estimated as a function of these dependent variables with a panel probit model.

a. Dependent Variable

We generate the dependent variables for each state and over time, starting in 1817, the year before the formation of the Prussian customs union. In this we limit our attention to states that in the future became part of the German Empire and we restrict our sample to the time of 1854, before the rise of the railway for commodity transportation. Hence our time-series consists of the 12 years in which any state signed a union contract with Prussia.

b. Expected Geographical Trade Pattern

The Zollverein collected some foreign trade data from the 1830s onwards, but there is no systematic evidence on trade flows between German states before the 1880s (Wolf, 2009). Given that we are interested not in actual but in expected trade, we can combine contemporary data on trade costs and road and waterway infrastructure with population data to calculate expected trade flows using a simple gravity formulation. The first step for this is the calculation of least cost paths between states. We decomposed all larger states into their regions for the trade

⁵cited after (Dieterici, 1846, p. 64); own translation.

path analysis⁶. Assume now that traders ship goods from i to j over the least cost path H_{ij} . Any path consists of sections

$$H_{ij} = (h_{ij}^1, h_{ij}^2, \dots, h_{ij}^n) \quad (5)$$

We employ a multi-modal transport network featuring sea transport, upstream river transport, downstream river transport, and the road network. GIS data on borders and waterways are provided by Kunz and Zipf (2008)⁷. We also collected GIS data on the contemporary road infrastructure. Each of the sections features three aspects of geographic information: mode of transport m , geographical distance d , and not at least the political borders crossed B :

$$s = (m, d, B). \quad (6)$$

To associate costs to each of the borders possibly crossed, we construct a tariff vector T as follows: first, we assume that the costs of crossing a tariff border were on average equivalent to 108.5 Mark per ton, based on the findings of Huning (2015). He uses a dataset on rye prices in German cities between 1820 and 1850 and finds that a 12 percent ad valorem tariff provides the best fit, given the available evidence on variable transport costs with least cost path routing. This is in line with that fact that Prussia introduced in 1818 a moderate specific tariff of up to 10 percent on foreign manufactures, with free trade on raw materials, but declining manufacturing prices. Hence, while most ad valorem rates tended to increase substantially above the initial level of 10 percent (see Onishi (1973)), other goods were non subject to any tariff at all. Moreover, we assumed above that the German states had no strategic space beyond their decision to join or not to join such that their tariffs on average followed those set by Prussia. Taken together, our assumptions imply that the cost of crossing a tariff border is equivalent to about 90 km of transport on paved roads. Thus the tariff vector is given as

$$T = \begin{pmatrix} 108.5 \\ 108.5 \\ \dots \end{pmatrix}. \quad (7)$$

In some specifications we take into account that river transport was officially often free of duty, and assume that only land transport is subject to tariff. While this was probably never strictly true, as even in the absence of duties states required traders to pay other fees (e.g. related to staple rights), we run specifications where trade on waterways is assumed to be entirely free and others where trade on waterways is assumed to be subject to the same political costs as trade over land. Therefore, we have to control for the fact that a good might enter a country via a river, and is then unloaded. The tariff will, in this case, be collected at the unloading point.

The variable costs v are calculated as the product of the per-kilometer-rate of the mode of transport⁸ and the distance. The transshipment costs g are given by the number of transport mode changes within a path; costs are taken from Gutberlet (2012). It follows that the cost function for each section $sectionCost : Section \rightarrow \mathbb{R}_+$ is given by

$$sectionCost(h) = v_h + t_h + T \bullet B_h \quad (8)$$

With the least costs trade paths, we calculate the expected trade volumes using a simple gravity formulation. We proxy regional income by their population at their 1820 levels from Kunz and Zipf (2008), given that population

⁶Larger states were decomposed according to the first territorial sublevel: Baden (6 territories), Bavaria (8), Hanover (7), Hesse-Darmstadt (3), Oldenburg (2), Prussia (9), Kingdom of Saxony (5), Saxony-Coburg-Saalfeld (2), Saxony-Gotha-Altenburg (2), Saxony-Weimar-Eisenach (2) and Wurttemberg (4). For Austria we included all 9 provinces, for France the most north western régions. The Netherlands was represented by Rotterdam. All other countries were proxied by their capital: Denmark, Great Britain, Krakov (Galicia), Liechtenstein, Luxemburg, Neuchâtel, Kingdom of Poland, Russia, Sweden, and Switzerland.

⁷The river shapes from Kunz and Zipf (2008) are checked for their floating direction, and turned if floating direction is non geographically correct. This process is necessary since the GIS shapes are collected by scanning a 2D map. The 3D information about level in heights has to be added manually.

⁸Please find the figures taken from (Sombart, 1902) in Table 4 of the appendix.

growth was uniform and did not show substantial regional variation before the 1850s. With this we derive the expected level of tariffable volumes for a country n as

$$V_n = \sum_{H_{ij}^{min} \in \Gamma_n} \frac{pop_i pop_j}{cost(H_{ij}^{min})} \quad (9)$$

c. Panel Generation & Definition of Variables

Table 1: Descriptive statistics for the period 1817–1854

(1)					
	Obs	Mean	S.D.	Min	Max
pop	390.00	387299.69	742726.93	10000.00	4246778.00
popshare	390.00	0.02	0.04	0.00	0.25
area	390.00	6.87e+09	1.48e+10	1.06e+08	7.63e+10
ownborder	390.00	671992.02	657714.30	93678.34	2919006.75
zvborder	390.00	9284481.01	2932743.33	93678.34	12425382.00
dborder	390.00	-475.36	485.75	-2725.22	428.90
owntransit	390.00	1.52e+13	1.58e+13	0.00	6.25e+13
zvtransit	390.00	1.05e+14	1.76e+13	7.91e+13	1.34e+14
ownimports	390.00	7.16e+11	1.49e+12	1.69e+10	9.53e+12
ownimportszv	390.00	4.22e+13	1.36e+13	2.72e+13	5.82e+13
dtransit	390.00	-1.31e+13	1.52e+13	-5.66e+13	9.68e+12
dvolume	390.00	-1.30e+13	1.52e+13	-5.60e+13	1.03e+13
xtransitlu	390.00	0.25	0.33	0.04	1.41
xtransitx	390.00	0.86	0.25	0.33	1.41
utransitlx	390.00	0.41e-02	0.15e-02	0.00	0.13
utransitx	390.00	0.11	0.13	0.00	0.51
transshare	390.00	0.19	0.29	0.00	0.99
constit	390.00	0.39	0.49	0.00	1.00
Observations	390				

The variables will be defined analogous to the structure of descriptive statistics provided in table 1.

(i) Demographics & Basic Geography

For any state x in our sample, we use the GIS shapes and 1820 population figures for pop_x from Kunz and Zipf (2008). We generate the GIS border length for the case of x being an independent country $ownborder_x$ and for the whole Zollverein in case x is a member $uborder_x^y$. We calculate the population share of x of the Zollverein in case x is a member as $popshare_x^y$. The difference between border length as independent state and as Zollverein member ($popshare_x^y * uborder_x^y$) – $ownborder_x$ is reported as $\Delta border_x^y$.

(ii) Expected Trade Flows

We employ a standard algorithm⁹ to calculate least cost paths. We compute these between all 106 regions in our sample¹⁰.

With any of these actual changes of the geography of the Zollverein, the joining probability of the remaining states adjusts. We assume that decision makers take these changes into account and thus we calculate the trade flows for 12 years \times 39 members \times (a) independent or (b) as part of the Zollverein. This yields 468 trade flow maps of Central Europe¹¹.

⁹We used the algorithm outlined by (Dijkstra, 1959). We are grateful for the free implementation by the contributors of pgRouting (pgrouting.org), the PostgreSQL database (postgres.org) and its spatial extension PostGIS (postgis.org).

¹⁰A list of all members of the Zollverein providing the year they signed the contract is provided in table ?? of the appendix.

¹¹Please find our sample of countries in figure 1 and its description.

The generation of the panel is computational intensive. Least cost path computation is complex to begin with: The limiting behavior of the applied algorithm's runtime is a function of the number of nodes N and sections S of the network in the form of $O(|S| + |N| \log |N|)$. Our network consists of 49,840 sections and 9,156 nodes. We can compute around 320 least costs path per second. The justification of such computational intensive analysis rather than proxy trade costs by distance as in Harris (1954) is justified by the fact that the actual trade path is essential for the construction of our dependent variables. Our empirical strategy increases this complexity further: A shift of one state's membership can have consequences for *all* trade routes. As the predictability of this behavior is limited, a common approach of GPS navigation systems, reducing the complexity by using only parts of the transport network is therefore ruled out. Another approach that could decrease the computational intensity is Highway Hierarchies (Sanders and Schultes, 2005). However, this approach disregards any political costs during routing and is therefore not suitable for our question. A further complexity-increasing feature of our analysis is that the cost-function is non-trivial. The costs of all paths have to be re-calculated for each geographical state of the Zollverein. We thus calculate as many as 7,735,350 least costs paths.

With this approach we calculate state x imports in the case of being independent ($ownimports_x^y$), the Zollverein's imports assuming that state x joins ($uimports_x^y$), the transits that pass through as state ($owntransit_x^y$) as well as the transits that pass through the Zollverein in case of joining ($utransit_x^y$). From comparing these figures analogously to the border lengths (see "Expected Trade Flows"), we derive $\Delta transit$. The overall difference of trade revenue, proxied by tariffable trade is retrieved by computing $\Delta volume = popshare_x^y * (zimports_x^y + ztransit_x^y) - (ownimports_x^y + owntransit_x^y)$. The imports of the Zollverein in the case that u is *not* part of the Zollverein is given as $ownuimports_x^y$.

(iii) Revenue Control

The calculated trade paths allow us to calculate the key variables revenue control. First, we calculate the volume of state x 's imports passing through the territory of the Zollverein and their share in state x 's total imports ($xtransitu$), as well as the volume of the Zollverein's imports passing through the territory of state x . The latter can be expressed as a share of state x 's total trade ($transshare$) and as a share of the Zollverein's total trade ($utransitx$).

d. Probability Estimation

The probability of a state x joining in a year y , $Pr[joined_i^y = 1]$ is estimated using a panel probit model of the form

$$Pr[joined_i^y = 1] = F(x_i^y \beta) \quad (10)$$

In the next section we present results for an estimation of the effect of changes in trade revenue (H1), changes in revenue control (H2) and a combination of the two on the probability that a state joined the Zollverein.

4. Results

"The analogy between the King of Prussia and some robber baron of the middle ages could not but occur to the least learned pamphleteer."
(Clapham, 1921, p. 99)

We first show that our method to generate expected trade flow data produces plausible results before we discuss the tests of our hypotheses. Figure 2 presents the expected trade flows in the form of a network graph, as starting point of our analysis. Its nodes are all trading states, connected by the borders over which we observe trade according to the least cost paths. It is clearly visible that Prussia functions as the center of the network; taking out Prussia, the graph would only be connected by Hesse-Kassel.

How would changes in trade costs affect the expected flows and thereby expected changes in tariff revenues and revenue control? Consider the predicted effect of the Convention of Mainz in 1831, which opened the Rhine at Rotterdam. Before this a considerable amount of trade was routed over land via Hesse-Kassel to the Weser. Table

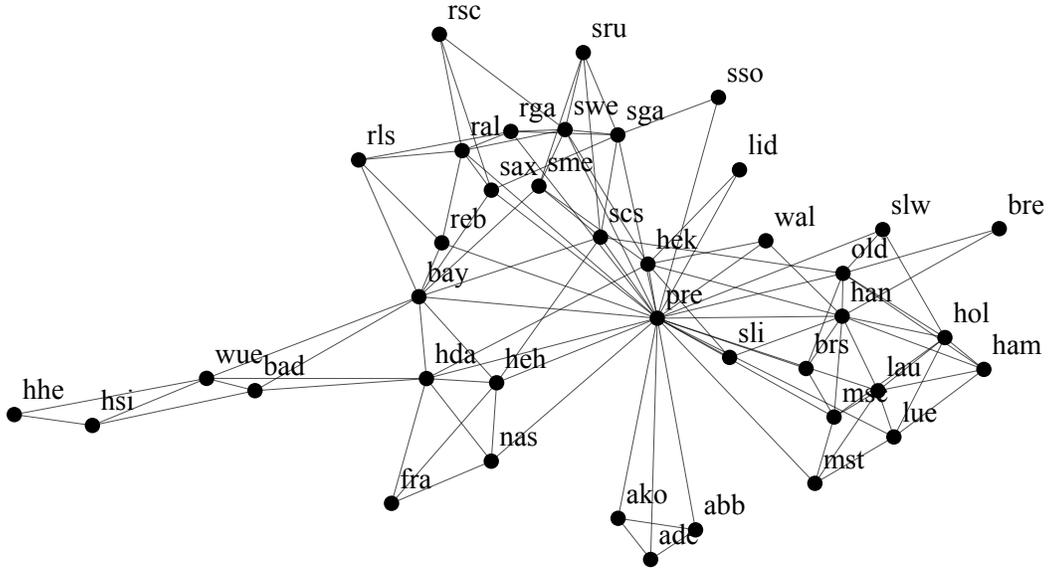


Figure 2: Generated Trade Network in 1817. Only Prussia and Hess-Kassel connect North and South Germany

Table 2: Change in transit on major rivers (Rhine 1817=100)

Year	Rhine	Elbe	Danube	Weser
1817	100.000	93.187	59.789	99.684
1824	100.000	93.187	59.802	99.684
1826	100.002	93.221	59.804	99.660
1828	99.649	93.216	59.804	99.693
1831	238.916	91.425	78.629	65.882
1833	237.607	89.912	78.531	63.444
1835	237.470	90.150	78.899	62.067
1836	238.264	90.162	78.973	62.107
1841	238.405	90.247	78.960	62.085
1842	238.547	90.249	78.966	62.072

2 shows how expected traffic on the four main rivers Rhine, Elbe, Danube and Weser changed according to our model in 1831. With the traffic volume on the Rhine in 1817 = 100, we see that before 1831 our model predicts about the same volume for the Weser, slightly lower volumes for the Elbe and substantially lower volumes for the Danube. Instead, in 1831 the model predicts a large increase for the Rhine as now a lot of trade in South-North direction would be routed on the Rhine instead of the Weser. The opening of the Rhine at Rotterdam poses a fundamental challenge to Hesse-Kassel: as transport via the Rhine becomes more affordable, the route via the Weser loses relative attractiveness and so does the connecting land routes via Hesse-Kassel. The model also predicts that the Danube would gain as a knock-on effect because it is now more often part of the cheapest cost path for long-distance trade between North and South Germany.

Based on these expected trade flows, let us now turn to our two hypotheses. How did expected changes in tariff revenue and revenue control affect the decision of the smaller German states to join the Zollverein? The results are shown in table 3. We start with a simple test of hypothesis 1: a state is more likely to join if expected revenues increase after joining. We capture the change in expected revenue by calculating for each state and each year the difference in expected trade revenue less costs after joining compared to the decision to stay out. As shown in column (1) of the table, an expected increase in revenue (captured by $\Delta volume$) and a decrease in costs (captured by $\Delta border$) make it more likely that a state decides to join. This is close to the argument of Dumke (1976).

However, while both variables in column (1) are significant, the overall fit of this model based on H1 alone is

	(1)	(2)	(3)
	joined	joined	joined
joined			
dvolume	1.20e-14 (1.13)	—	—
dborder	-0.000351 (-1.12)	-0.000566 (-0.74)	-0.000362 (-0.46)
xtransitlu	—	18.09*** (5.66)	17.95*** (5.23)
utransitlx	—	-10.36 (-0.99)	-8.698 (-0.76)
transsharel	—	-6.184* (-1.75)	-5.387** (-2.07)
constit	—	—	2.479** (2.28)
_cons	-0.469* (-1.87)	-8.131** (-2.10)	-9.660*** (-4.22)
lnsig2u			
_cons	-0.237 (-0.57)	3.189*** (7.65)	3.109*** (6.59)
McFadden R ²	0.0043	0.5110	0.5294
N	390	390	390

t statistics in parentheses

* p_i0.10, ** p_i0.05, *** p_i0.01

very poor. A first indication is the low McFadden Pseudo R^2 . When the predictions of column (1) are plotted against the observed joining dates (figure 3), it is revealed that the model is far from insightful: the joining of states is systematically underpredicted.

Next, we turn to hypothesis 2: a state is more likely to join into the Zollverein the smaller the expected loss in control over revenues after joining. We capture this with several variables based on equation (3). The larger the share of a state's imports that is routed via the territory of the Zollverein (*xtransitu*), the less that state will lose in terms of control by joining and the more likely it is to join. Next, we add a variable that captures the expected loss of revenue from transit flows after joining (*transshare*). Our prior is that states with a high share of transits in total trade are less likely to join, because they will lose control over a larger share of their revenue. Finally, we add the share of the Zollverein's imports that are routed via the state in question (*utransitx*). Our prior here is that the larger this share, the more that state would give up in terms of control over the Zollverein by joining, hence the less likely it is to join. We also control for the expected reduction in border length to capture economies of scale in tariff collection. Column (2) shows the results. As hypothesized, a state is more likely to join, the less it expects to lose control over revenues by joining. We find strong support for this idea: those whose trade flows were heavily dependent on Prussia joined, while states that feared to lose revenue from their transit trade did not. Instead, we do not find evidence that losing control over the Zollverein (*utransitx*) mattered. And again we find that the expected change in border length comes with the expected negative sign. The fit of this still rather parsimonious model is excellent with a McFadden R^2 around 0.47. When the prediction is plotted against the observed joining dates we find a remarkable fit. The model of column (2) predicts that after 1831 many more states had incentives to join than before. The reason for this is that with the opening of the Rhine the cheapest cost paths adjusted such that several states lost transit flows while more and more trade was routed over Prussia. Both effects reduced the possible loss of revenue control and increased the likelihood of joining. As an extension we also test for the effect of constitutional constraints on the probability of princes to join suggested by Dumke (1976). Dumke argued that in smaller states, princes who faced constitutional constraints, were more willing to join into the Zollverein, because the redistributed tariff revenue was treated as non-tax revenue and not subject to parliamentary budget control. In column (3) we extend our framework by a dummy for constitutional monarchies and indeed find a strong positive effect, in addition to the variables from equation (3). While the effect of this variable is statistically significant, the fit of the model is only marginally improved.

5. Counterfactual

We have shown that the decision to join the Prussian Zollverein can be explained by expected changes in control over revenues and to some extent expected changes in revenues, notably reduced costs of the tariff system. Put differently, decision makers faced both costs from losing political control and benefits from cooperation, which changed over time. Earlier we argued that it was the change in political borders after 1815 that triggered a cascade of change in these dimensions: because Prussia controlled most of the trade routes (more specifically most of the cheapest cost paths) some smaller states joined early on, which in turn affected the remaining trade routes. With the opening of the Rhine at Rotterdam in the wake of the Belgian revolution in 1831, the incentives changed again and all states south the Main joined the Prussian Zollverein. But can we argue that the border change in 1815 was causal for this? In this section we want to explore how the incentives to join the Prussian Zollverein would have looked like, if Britain would not have enforced the solution to give the Rhineland to Prussia, but instead Prussia would have gained the entire Kingdom of Saxony. Hence, we assume a counterfactual set of political boundaries in 1815, where Prussia consists of all territories except the Rhineland and Westfalia, but with the entire former Kingdom of Saxony, while we also assume that there is an independent state on the territory of the Rhineland and Westfalia (that can be thought of a "New Saxony" as in the suggestion by Hardenberg from late 1814). Naturally, this new counterfactual map of Germany implies a whole set of new counterfactual cheapest cost paths between all regions. Using the regression coefficients from column (3) in table (3) and the population distribution of 1820 we now estimate for each year and state the new incentives to join the counterfactual Zollverein. Table 3 shows, which states would join the Zollverein in this counterfactual setting.

We conclude that under the counterfactual borders, no state in southern or western Germany would have had an incentive to join Prussia into a customs union. The expected loss from losing control over revenue would have been far too large compared to the potential gains from cooperation. To put it differently, without Britain's intervention to relocate Prussia to the Rhine, it would have been very unlikely that Prussia would have gained

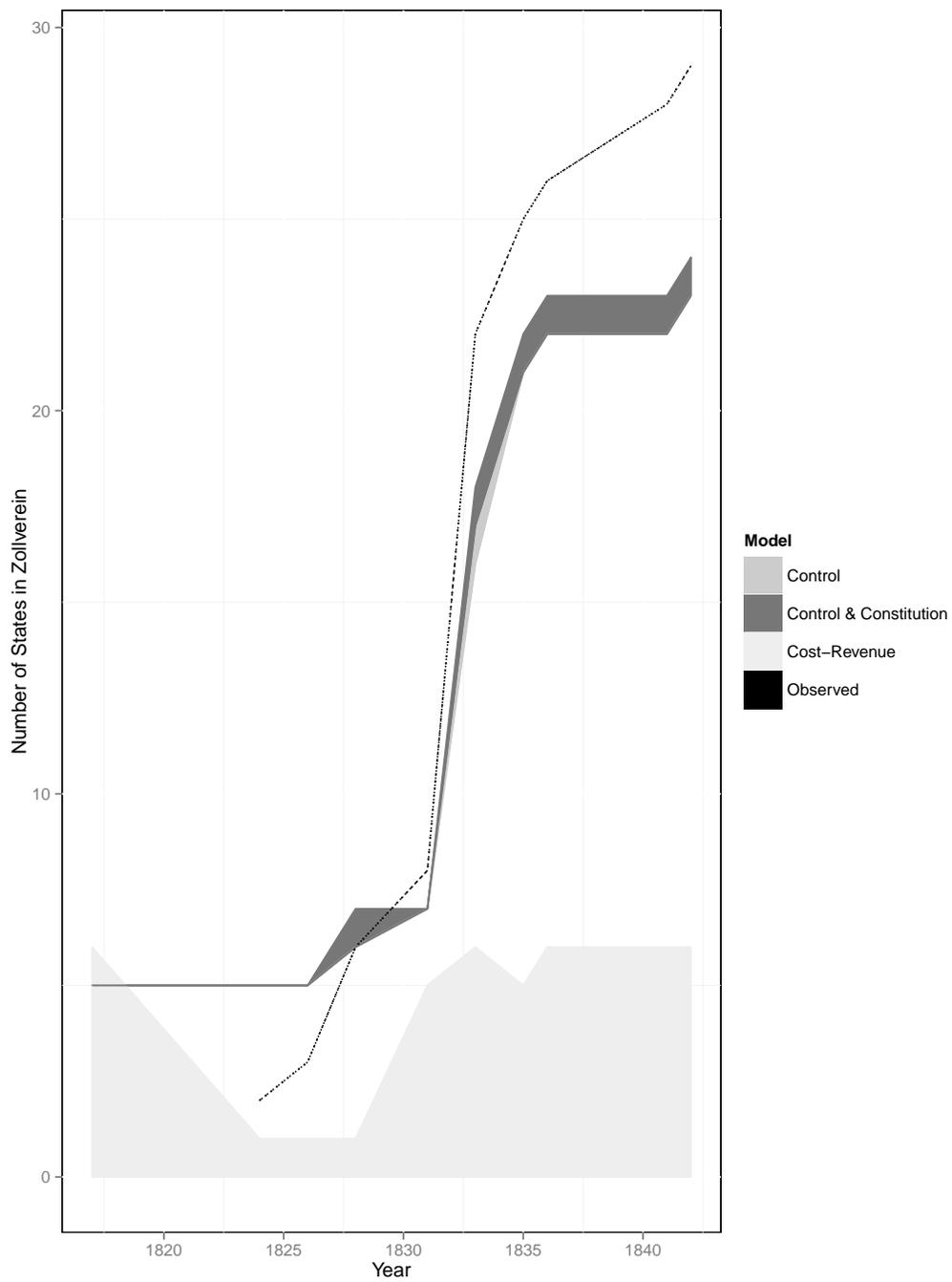


Figure 3: Number of observed (dashed line) and predicted countries in the Zollverein (40-60% probability threshold band)

Table 3: *States joining Prussia in the counterfactual map of Germany*

State	Period
Anhalt-Bernburg	
Anhalt-Dessau	
Anhalt-Köthen	
Mecklenburg-Strelitz	
Reuß ältere Linie (Reuß-Greiz)	
Reuß-Gera	
Reuß-Lobenstein	
Reuß-Schleiz	
Sachsen-Gotha-Altenburg	
Sachsen-Meiningen	
Sachsen-Weimar-Eisenach	
Schwarzburg-Rudolstadt	
Schwarzburg-Sondershausen	

so much control over the economic policy of other German states. It might have put German history on an altogether different path.

6. Conclusion

In this paper we considered the factors behind the formation of the German Zollverein as an example for institutional change. We have argued that the rise of Prussia to dominate German tariff policy can be traced back to a change in “second nature” geography, namely the redrawing of the European map at the Congress of Vienna in 1814/15. Due to the intervention of Britain, Prussia gained large territories in the West. While this was against Prussia’s intention, who wanted to gain the rich and densely populated Kingdom of Saxony, this had far-reaching consequences as Prussia was now in control of a large part of Germany’s trade routes. Over time, for more and more states the gains from cooperation with Prussia started to outweigh the costs of losing sovereignty. Our argument is closely related to the literature on the size of nations following Alesina and Spolaore (1997) and Bolton and Roland (1997), who emphasize a trade-off between benefits of cooperation from economies of scale and the costs of losing political control. We argue that a change in borders can trigger a cascade of changes in both dimensions. The intuition for this result was a basic trade-off between prospective gains from joining a large customs union with economies of scale and the loss of political control. In 1815 all the German states that still existed as sovereign entities after the Napoleonic wars were in financial difficulties, including Prussia. All of them attempted to increase their state revenues, reduce costs yet keep as much of their political sovereignty as they could. Notably they were eager to stay in control over their revenue. With the formation of the Prussian Zollverein in 1818 states had to weigh the potential gains from higher tariff revenue net of costs after joining into the Zollverein against the loss of control over these revenues, hence a loss of political sovereignty. The fact that Prussia controlled large parts of the German river system after 1815 considerably reduced the control that other German states had over their own tariff income, because much of their trade had to be routed over Prussian territory. Moreover, with each new member of the Zollverein, the actual loss of sovereignty from joining into the Zollverein declined, while the benefits from higher tariff revenue and lower costs increased. We used detailed GIS data on population, state boundaries, infrastructure and transport mode specific transportation costs to calculate first cheapest cost paths and next expected volumes of trade and transit flows between a set of 106 regions across Germany and neighbouring territories. Based on this we calculated expected changes in tariff revenue, tariff collection costs and changes in control over revenue for each sovereign state if he decided to join Prussia into a customs union compared to the situation outside the customs union. We use simple panel probit regressions to test whether these expected changes in revenue and revenue control can explain the pattern of joining decisions and find that this fits the observed data extremely well. Finally, we run a counterfactual using the estimated coefficients together with a counterfactual map of Germany in 1815: would the Zollverein have formed if Prussia would have gained Saxony instead of the Rhineland? We find were clearly, that the answer is no. While certainly unintended, Britain unified Germany.

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Appendix

A. Tables

Table 4: Estimates for per-kilometer freight rates from (Sombart, 1902)

Type	Cost [Pf/tkm]
Country road	120
Paved roads ('Chausee')	30
River, downstream	0.7
River, upstream	1.8
Sea freight	0.95

Table 5: States (partially) enclaved by Prussia ordered by decreasing share of affected territory. GIS calculations.

State	Share [%]
Anhalt-Dessau	100
Hohenzollern-Hechingen	100
Anhalt-Köthen	100
Schwarzburg-Sondershausen	61.7
Schwarzburg-Rudolstadt	19.5
Sachsen-Weimar-Eisenach	3.4
Braunschweig	3.1
Sachsen-Gotha-Altenburg	2.3
Lippe-Detmold	2
Mecklenburg-Schwerin	0.7

Table 6: Calibration of gravity model using Prussian export weights in 1828 from (Onishi, 1973, p. 234) and GIS-costs of transports, weighted by provinces' population

	Dependent variable:
	log(flow)
log(pop)	1.151*** (0.215)
log(cost)	-1.399** (0.655)
Constant	3.751 (3.044)
Observations	32
R ²	0.499
Adjusted R ²	0.465
Residual Std. Error	1.918 (df = 29)
F Statistic	14.465*** (df = 2; 29)

Note: *p<0.1; **p<0.05; ***p<0.01