Tariffs, Trains, and Trade:
The Role of Institutions versus Technology in the Expansion of Markets[1]

Wolfgang Keller
University of Colorado, NBER, and CEPR[2]

Carol H. Shiue
University of Colorado, NBER, and CEPR[3]

Preliminary - March 2007

Abstract

This paper studies the emergence of the increasingly unified commodity market in Europe in the 19th century. During this period, we observe major institutional changes in form of currency agreements and the *Zollverein* customs liberalizations as well as transport cost reductions in form of the building of railways. In assessing the relative importance of these factors, this setting has a number of clear advantages over existing studies. For one, almost all economies in our sample experience changes over the course of the 19th century. Currency or trade arrangements did not exist between any of the states in the early 1800s, whereas by the closing years of the 19th century they existed between all German states. Similarly, railroads did not exist before the 1830s, whereas by the end of the 19th century trains had arrived almost everywhere in our sample. Changes in market integration are studied in terms of the spatial dispersion of grain prices in 68 markets with about 10,000 observations, located in five different countries and fifteen different German states. We find that the emergence of integrated commodity markets in 19th century Europe is in a major part due to the transportation revolution in form of the railways. Over a relatively short time horizon, the effect of customs liberalization is comparable in size, whereas in the long run, the impact of railways is larger. We do not estimate a significant effect of currency agreements on market integration. These results suggest that as significant as institutional factors were for the expansion of markets, technology factors may have been even more important.

[1] We thank Lee Alston, Jörg Baten, Ann Carlos, Rainer Fremdling, Murat Iyigun, Michael Kopsidis, Larry Neal, Kevin O'Rourke, and the audience at the 2006 NBER/CEPR conference in Lund for useful comments, and Michael Kopsidis as well for providing us with data. NSF support under grant number SES 0453040 is gratefully acknowledged.
[2] Department of Economics, University of Colorado, Boulder, CO 80309; Wolfgang.Keller@colorado.edu
[3] Department of Economics, University of Colorado, Boulder, CO 80309; shiue@colorado.edu

1. Introduction

The growth of Europe, and indeed of the world, has been linked to the scope of market transactions. In fact, it has been said that economic development *is* the history of the origins and the spread of the market economy (Braudel 1992, 225). While it is uncontroversial to claim that trade liberalization, monetary arrangements, and new technologies that reduced transportation costs all could potentially benefit commercial exchange, to date little is known about the relative importance of these factors. How and when did markets expand? What is it that allows markets to perform well? How important are institutional and technological factors in producing more integrated trade relations? This paper sheds new light on this issue by studying the functioning of commodity markets in Europe throughout the 19th century. Our primary goal is to compare the importance of institutional versus technological factors affecting market integration.

The setting of 19th century Europe presents a unique opportunity, we argue, to address this issue. During this period, we observe institutional changes (tariff and monetary agrements) as well as for transport cost reductions (the building of railways). The key features of our analysis present clear advantages in these respects. In particular, almost all economies in our sample experience 'treatments' over the course of the 19th century. Currency or trade arrangements did not exist between any of the states in the early 1800s, whereas by the closing years of the 19th century they existed between all German states. Similarly, railroads did not exist before the 1830s, whereas by the end of the 19th century trains had arrived almost everywhere in our sample. Thus, we observe changes in all major dimensions for a constant set of economies, which is quite different

from observing, for example, a trade agreement for some, and a currency agreement for some other economies.

A key institution that emerged during the 19th century was the German *Zollverein*, the classic example of a customs union (Viner 1950, 97). Starting in the year 1828, the *Zollverein* treaties successively liberalized trade by abolishing tariffs among some thirty-five member states that would later constitute Germany. Also, the first major international monetary arrangements, the fixing exchange rates between several major currencies, were created in the first half of the 19th century.

The institutional framework provided by these laws governing commodity and foreign exchange transactions was a clear break from centuries of relatively chaotic conditions. The question we ask is how the *Zollverein* liberalizations and monetary agreements stack up in their effect on market integration compared to that of the key technology of the 19th century, the steam train.

Market integration is studied in terms of the spatial dispersion of grain prices in 68 markets in Europe with close to 10,000 observations. These markets are located in five different countries and fifteen different German states, including Prussia. The area corresponds approximately to the location of today's Austria, Belgium, Czech Republic, France, Germany, Italy, the Netherlands, Poland, and Switzerland. We find that the emergence of integrated commodity markets in 19th century Europe is in major part due to the transportation revolution in form of the railways. Over a relatively short time horizon, the effect of customs liberalization is comparable in size, whereas in the long run, the impact of railways is larger. We do not estimate that currency agreements had a significant effect on market integration once we control for the other factors. Overall,

these results suggest that technology factors were more important than institutional (e.g. monetary) factors in creating integrated commodity markets.

Our paper contributes to the literature on the effects of trade and currency agreements on market integration and trade. This question of obvious importance has spawned an immense literature, with authors studying both contemporaneous (Rose 2000, Frankel and Rose 2002, Rose 2004, Subramaniam and Wei 2006, Baier and Bergstrand 2007) and historical experiences (Eichengreen and Irwin 1995, Flandreau and Maurel 2001, Lopez-Cordova and Meissner 2003, Estevadeordal, Frantz, and Taylor 2003). Baier and Bergstrand (2007) in particular find that membership in a free trade agreement raises the volume of trade by about 100% in the post-World War II era. And in estimating the effect of currency agreements on trade, Lopez-Cordova and Meissner (2003) as well as Estevadeordal, Frantz, and Taylor (2003) show that if both trade partners were on the gold standard, this raises trade by 40% to 60% during the period of 1870 to 1939.

At the same time, there is no consensus yet on qualitative, let alone quantitative findings.[4] This is partly due to the fact that typically, only a small fraction of any sample has ever been part of a trade or currency agreement. Moreover, the trade and currency arrangement effects are often identified largely from cross-sectional variation, as for example in a comparison of economies on the gold standard versus those that are not. In these situations, it is difficult to find an appropriate control group. Consequently, estimation results may vary strongly, and in fact, identification may fail altogether.

In this paper, the customs union, currency agreement, and trains effects are estimated from time-series variation: there are systematic differences in the timing of when European economies became members of the *Zollverein*, agreed on currency

[4] For example, Rose (2004) finds no effect of trade agreements on post-World War II trade.

arrangements, and became part of the expanding railway network. Perhaps the paper closest to ours in terms of using time-series variation for identification in a major way is Estevadeordal, Frantz, and Taylor (2003). Our specific contribution relative to this work lies primarily in estimating the effect of transportation improvements using actual data on bilateral transportation technology, as opposed to data on geographic distance.[5]

Why do we focus on institutions and technology? It goes without saying that technological innovation has a major impact on living standards—as defined by one text, modern growth is the point after which new technological innovations are expected to routinely lead to major improvements in living standards (DeLong 2002, 125). Similarly, we emphasize institutions since recent work has shown that they have a major effect on economic performance (La Porta, Lopez-de-Silanes, Shleifer, and Vishny 1997, Acemoglu, Johnson, Robinson 2001; Rodrik, Subramaniam, Trebbi 2002). To the extent that recent research establishes a link between trade and growth (Frankel and Romer 1999), our analysis of institutional and technological factors on market integration provides new information on their effects on economic welfare more broadly.

The recent literature on the major determinants of market integration in world history also associate a number of additional factors to market performance, including the disruptive effects of wars (Glick and Taylor 2005, Jacks 2006), the role of geography in determining the viability of ship transport and in turn the attractiveness of trade versus storage (Shiue 2002), and transport costs (Ejrnaes and Persson 2000). The impact of railways has been the focus of classic work by Fogel (1964) and Fishlow (1965) who

[5] Our paper also relates to Shiue (2005) who has compared border effect estimates from the 1834 and 1836 *Zollverein* liberalizations to the contemporaneous estimates by Engel and Rogers (1996).

study their importance for industrialization in the U.S. using the social savings approach.[6] More recently, work by O'Rourke and Williamson (1999) has examined the impact of transport costs, factor prices, domestic inequality, and political influence among Atlantic economies of the late 19th century.

In this paper, rather than tackling a global sample of the late 19th century, we adopt a more constrained sample in terms of the number of countries or market integration determinants considered. We do so to be better able to estimate the causal effects of customs unions, currency agreements, and trains. While we do not link railroads directly to growth, our analysis is also more comprehensive in that it allows us to quantitatively compare the effects of railroads with that of the institutional framework of customs union and currency agreements. Another distinctive feature of this paper is that it examines changes in both intra-national and international market integration, and, moreover, it covers the early 1800s on which generally less is known than on the past-1870 period.

The next section 2 introduces our empirical methodology, while section 3 provides a short historical background on customs unions, currency agreements, and railway transportation in Europe. Estimation results are found in section 4, and section 5 provides a summary and concluding discussion.

2. Modeling Market Integration

[6] The German case has been examined by Fremdling (1977). See also O'Brien (1983) for studies on other countries.

Market integration is analyzed by analyzing the gap in prices for two homogeneous goods, wheat and rye, across geographic space. Let p_{it} be the price in market i at time t, i = 1,…,I, and t = 1,…,T. The absolute percentage price gap between two markets i and j, $pdif_{ijt}$ is defined as

(1) $$pdif_{ijt} = \left| \ln(p_{it}) - \ln(p_{jt}) \right|.$$

Our approach of studying market integration by tracing out systematic differences from the Law of One Price has been employed in various forms by a large number of authors (Engel and Rogers 1996, Parsley and Wei 1996, O'Rourke and Williamson 1999, Shiue 2005). In the simplest case, $pdif_{ijt}$ in equation (1) gives the price difference that, given current trade barriers of all types, cannot be eliminated through the process of arbitrage. Thus, $pdif_{ijt}$ is a measure of the trade barriers that exist between i and j at time t. In the presence of supply and demand shocks affecting autarky prices in i and j, this will be true subject to a stochastic error, e_{ijt}.

We study the effect of trade and currency agreements as well as transportation technology by augmenting (1) with variables that measure these changes:

(2) $$pdif_{ijt} = \beta X' + \gamma_1 CU_{ijt} + \gamma_2 LT_{ijt} + \gamma_3 TR_{ijt} + e_{ijt},$$

where CU_{ijt} and LT_{ijt} are 0/1 variables indicating whether at time t a customs union or a currency agreement between i and j existed (*LT* is mnemonic for legal-tender, see below). The variable TR_{ijt} is a measure of railway activity between i and j in year t, and *X* is a vector of other measures that might influence price gaps, to be specified below.

The leading alternative framework to studying these issues is the gravity model, which has been employed in a great number of papers (e.g., Estevadeordal, Frantz, Taylor

2003, Rose 2004). There are good reasons for choosing the gravity framework, including that it is possible to give sound microfoundations for the estimating equation in a number of cases (Anderson 1979, Helpman and Krugman 1985, Evenett and Keller 2002). In contrast, the Law of One Price framework of equation (1) is very general, applying to any trade model where the force of price arbitrage is present. We use it here because arguably price gaps measure the strength of market integration better than the volume of trade. In addition, comprehensive trade statistics do not exist for the early 19th century.

The next section provides some historical background for our analysis.

3. The *Zollverein*, Currency Agreements, and Trains in 19th Century Central Europe

The main economic impact of the *Zollverein* treaties was the abolishment of tariff barriers among member states, and the implementation of a single tariff on consumption goods for non-members. As of 1815, Germany's political structure was divided into the thirty-nine states of the German Confederation (*Deutscher Bund*), see Figure 1.[7] The confederation consisted of sovereign states in which joint action depended upon unanimity. Austria was the most powerful of the German states, followed by Prussia. Individual states tended to be highly protectionist and the tariffs that were imposed were complicated. There is no reliable information on enforcement, but it was likely that it was costly for the many small states to each monitor its own borders.[8]

In the aftermath of debts from a decade of war, and new tariffs raised by Britain, Russia, Austria, France, the Netherlands, Prussia sought to negotiate treaties with her

[7] For more details on the history of the *Zollverein*, see Henderson (1939) and Hahn (1984).
[8] Dumke (1976) presents some estimates on border control costs, p. 44.

neighbors while reforming internal tariffs. This was particularly pressing because Prussia's territories were divided into two, an eastern portion consisting of seven provinces, and a western portion that included the Rhineland provinces and the Ruhr area. In the year 1818, the *Prussian Customs Union* was formed. With few exceptions, internal dues were abolished. Foreign raw material were admitted free of duty and by 1821, only a single tariff for the entire Kingdom was levied on consumption goods and transit dues on goods passing through Prussia were reduced. The importance of the *Prussian Customs Union* stems from the fact that it served as a model for most of the *Zollverein* treaties that followed.

Enclaves within Prussia were the first to develop agreements with Prussia on how its payment of duties were to be treated—with Prussia deciding to treat the enclaves as her own territory rather than as foreign states required to pay import duties. As all of the following treaties, these were based on the principle that states that adopted the Prussian system of tariff received a share of the joint revenue based on population size. Their rights as sovereign states were maintained.

Hesse-Darmstadt was the first territorially separate state to join the Prussian Customs Union in the year 1828. It received a share of the joint tariff revenue in exchange for adopting the Prussian tariff structure.[9] In the same year, as a defensive agreement not to join the Prussian/Hesse-Darmstadt, Bavaria and Württemberg formed the South German Customs Union, while a number of central German states and cities formed the Middle German Commercial Union (see Figure 2).[10] The latter was not a

[9] Throughout, Prussia reserved the right to negotiate with foreign countries such as France, Belgium, and England for itself.

[10] The states were Hanover, Saxony, Hesse-Cassel, Nassau, Brunswick, Oldenburg, Frankfurt, Bremen, the Saxon duchies, and a couple of smaller ones. Henderson (1939, 67).

customs union, but a defensive agreement among members to commit to not joining either. The strategy was unsuccessful and the union lasted only five years. Hesse-Cassel became the next to join the *Prussian Customs Union* in 1831.[11] In the year 1834, both the Thuringian states and the Kingdom of Saxony, together with the augmented *Prussian Customs Union*, became the German *Zollverein* on January 1st, 1834. At that point the *Zollverein* had an area of about 163,000 square miles and a population of about 23.5 million people.

By stages, other states entered. Three other German states joined the *Zollverein* between mid-1835 and early 1836: Baden, Nassau, and the Free City of Frankfurt. The entry of Baden was significant because it meant that all the areas of Bavaria were joined without custom borders. The entry of Frankfurt meant that trade in manufacturing goods from Frankfurt up the Main River to Northern Bavaria in exchange for grain without paying customs duties. Later on, Brunswick became a member of the *Zollverein* in 1841, Hanover in 1851, Oldenburg in 1852, Mecklenburg and the Free City of Lübeck in 1867. Two states became members of the *Zollverein* only after Germany became politically unified in 1871, namely the Free Cities of Bremen and Hamburg in 1888. Thus, the process of customs union enlargement in 19th century Central Europe materialized over a large part of the century (the years 1828 to 1888). Austria-Hungary did not become member of the *Zollverein*. Among the main reasons are that Austria-Hungary favored too high an external tariff compared to the *Zollverein*, it was internally too diverse, and Prussia opposed the inclusion of Austria-Hungary for these and other reasons.

[11] This was significant because it meant that the East and West Prussian provinces were joined without a customs border for the first time. It also meant that British goods could not reach Frankfurt and Germany's south anymore without crossing the Prussian external tariff border; see Figure 1.

The reasons for joining were certainly in part idiosyncratic. For example, Hanover joined relatively late partly because it was governed in personal union with England, which had no interest in an all-inclusive Prussian led customs union in the center of Europe. Personal animosity between feudal lords played a role as well, and so did general fear of increasing one's ties with the relatively authoritarian Prussia (see Hahn 1984). Fiscal reasons may well have played a role for *Zollverein* accession: for many of the relatively small states, it was prohibitively costly to establish and enforce tariff borders, and they preferred joining the Prussian-led customs union in exchange for a fraction of the joint tariff revenue (Dumke 1976, Chapter 1). At the same time, this cannot be the full explanation since there were several highly indebted and small states that joined the Zollverein relatively late.

Dumke (1976) discounts the notion that that many German states initially did not want to join the *Zollverein* because they wanted to be more protectionist than Prussia's external tariff would allow, because there is evidence that Prussia's tariff levels before the *Zollverein* creation were actually higher on average than those of other states (Dumke 1976, 366-369). This is not to say that external protectionism played no role, especially in light of the movement towards infant-industry protection that was backed by Friedrich List and other writers.[12]

The general trade patterns within Germany before the *Zollverein* era was primarily grain and raw material from South to North, and manufactured products from North to South. As Dumke (1977) has shown, at least in the short term the *Zollverein* changed neither the direction nor the composition of that trade. In terms of external trade, the

[12] At the same time, small-scale producers in Bavaria or Württemberg feared that by agreeing to an internal free trade within Zollverein borders, they would be driven out of business by producers from Silesia and the Rhine-Ruhr area that were more productive.

Zollverein was, since 1834, a net exporter of manufactured products and an importer of raw materials, semi-finished products, and consumption goods (including tobacco, sugar, and wine). This was also Prussia's trade pattern before the *Zollverein* foundation (Dumke 1976, Chapter 3).

Overall, however, it appears to have been market access, not protectionism that motivated the German states to join the *Zollverein*. First of all, generally the states located further in the South joined the *Zollverein* earlier. This is because not joining implied having to pay hefty tolls before reaching the Baltic or North Sea coast, to trade with the emerging industrial powers, in particular England.[13] Thus, the Southern states of Baden, Württemberg and Bavaria had all joined the *Zollverein* by 1834, whereas the Mecklenburg states, located directly on the Baltic coast, joined only in 1867, and the city states of Hamburg and Bremen, which were particularly relying on international trade, joined only in 1888. Another major reason for joining the *Zollverein*, which was shared more equally among most states, was that it gave tariff-free access to the large market of Prussia, which included the leading industrial areas of the time. We will return to the determinants of *Zollverein* accession in section 5.

Since the *Zollverein* was a customs union, joining it was not identical to a move towards multilateral free trade. Trade diversion was a possible outcome. However, most of trade of the German states at the time was with other German states. Similarly, although the external tariff of the *Zollverein* was, as noted above, higher than the pre-*Zollverein* external tariff in a number of states, relatively high *Zollverein* tariffs were mostly on consumption goods (*Kolonialwaren* [colonial imports] such as tobacco, sugar).

[13] Notwithstanding the British Corn Laws; they were repealed in 1846.

The trade diversion effect arising from these imports were most likely quite limited.[14] The basic character of the *Zollverein* was likely to have been trade-liberalizing.

Currency Agreements In the first decades of the 19th century, Germany was replete with coins issued by the many different states. The diversity was immense, in sharp contrast to the unified monetary conditions in Great Britain and France, for example.[15] In the Southern states, the currency tended to be called *Gulden*, as in the empire of Austria-Hungary, while in the Northern states the currency was typically called *Thaler*. Irrespective of similarities in the name, each state minted its own currency, and initially currencies did not have legal-tender status outside of a given state. The currencies were linked to silver by the currency unit expressed in equivalent to a certain quantity of silver weighted in *Cologne Mark*.[16] Comparability of coins even of the same denomination, like *Gulden*, was difficult because the mints in different states had different coinage fees. This meant that the net silver weight of *Gulden* from different states would actually differ. During the 1820s, the state of Nassau for example went as far as to melt down high-silver content coins issued in Bavaria to produce its own low-silver content coins, and pocket the difference. The dividing line between full-value specie money and debased coins was therefore fluid.

The Southern states put an end to this through the *Munich Coin Treaty* of 1837.[17] It stipulated that the silver content of the *Gulden* should be the same, no matter which

[14] Also see Dumke (1976), Chapter 3.
[15] Holtfrerich (1989, 1993); also see these references for further details regarding the following.
[16] The exception is Bremen which was from 1863 to 1871 on the gold standard, due to its strong overseas connections.
[17] These Southern states are Bavaria, Baden, Württemberg, Nassau, Hesse-Darmstadt, and the Free City of Frankfurt.

state minted it (nine-tenth of face value). This effectively meant the fixing of exchange rates among the Southern states' currencies from this date on. Importantly, *Gulden* coins minted in any of the Southern states would have legal-tender status in all signatory states. One year later, the *Dresden Coin Convention* in 1838 effectively led to fixed exchange rates between all *Zollverein* currencies by requiring that each state was obliged to mint coins according to the common metal-content specifications. However, the 1838 *Dresden* agreement fell short of the 1837 *Munich* agreement among the set of Southern states. First of all, the *Dresden* agreement left the Northern *Thaler* bloc and the Southern *Gulden* bloc intact, even though currencies in both blocs were linked to the *Cologne Mark* at a fixed exchange rate of 1 *Thaler* = 1.75 *Gulden*. Moreover, the *Dresden Coin Convention* agreement did not specify that the *Zollverein* members were obliged to accept the coins of other signatory states as legal tender.

The fact that the *Dresden Coin Convention* did not give full legal tender status to all currencies throughout the *Zollverein* created an important barrier to commercial exchange for the Northern *Zollverein* states.[18] It was recognized at the time that a generally accepted medium of exchange is important for facilitating trade between the *Thaler* and the *Gulden* blocs. The states agreed on the minting of a common coin worth 2 *Thaler* or 3.5 *Gulden* that would have full legal tender status throughout. In part because its denomination was too large for everyday small-scale business, this coin never played the role for which it was introduced. [19] Instead, the Prussian one-*Thaler* piece was

[18] This affected trade between Northern *Zollverein* states, and trade between a Northern and a Southern state, since the Southern states had agreed on full legal tender status among themselves in the 1837 *Munich* agreement.

[19] The goal in 1838 was that by the year 1842, the common coin (*Vereinsthaler*) would account for 1.2% of the total coin circulation in Germany. In fact, *Vereinsthaler* circulation fell well short of this; Holtfrerich (1993).

increasingly used for commercial transactions after 1838. Indicative of the fact that a generally accepted medium of exchange was needed is the fact that the Prussian one-*Thaler* coin even gained *de facto* acceptance to some extent in the *Gulden* states of Southern Germany. This was remedied only twenty years later, in the *Vienna Coin Treaty* of 1857, where all *Zollverein* currencies were given full legal tender status throughout the Zollverein (even retrospectively to those coins minted between 1838 and 1857).[20] The states that remained outside the *Vienna* currency agreement of 1857 in our sample are Mecklenburg-Schwerin and the Free Cities of Bremen, Hamburg, and Lübeck (Willis 1896).

Monetary unification was achieved with political unification of Germany soon after the year 1871. The newly created *Reichsmark* had full legal tender status in all German states. Also, Germany moved from the silver to the gold standard after the year 1871, in line with the international trend at the time.[21]

Railways European economic growth from the 19th century on coincided with a series of innovations in transportation.[22] These innovations included paved roads, improvements in waterways, railways, in materials such as iron and steel, and later on, steam power, but the rapid increase of railway construction were particularly important. In the 1840's British suppliers of locomotives dominated the market, and railway iron exports were an important iron export for Britain. Gradually, countries on the continent started to produce

[20] The main purpose of the *Vienna Coin Treaty* was to extend these currency arrangements to include Austria; however, it failed to do so; see Willis (1896) for an analysis.
[21] In our sample, the Netherlands was on the gold standard by 1875, while Belgium and France were on the gold standard by 1880 (Lopez-Cordova and Meissner 2003).
[22] A good survey can be found in O'Brien (1983). On the debate concerning the contribution of railways, see Fogel (1964), Fishlow (1965), and Williamson (1980).

their own railway inputs. In Germany, for instance, first domestic locomotives began to be produced and substituted for British locomotives, and then iron processing plants using British technology were established, and by the 1850's German iron industries were supplying rolled rails, and eventually also exported rails. The effects of these innovations appeared as price differentials between regions (and sectors) in the European economy, and contributed to regional specialization and trade.

The first German railway was opened in December 1835. With only 4 miles of tracks, it was a short suburban line located in Bavaria, between Nürnberg and Fürth. The first longer route (70 miles) was built in Saxony in 1839, some 5 years after the initial *Zollverein* treaties came into effect. Thereafter, additional miles of rail were laid down swiftly. By 1847, there were over 2,000 miles of rail in Germany (Henderson 1939, 147), and almost all main railway lines were completed by 1877 (Milward and Saul 1977, 42). Government participation in railroads differed across states (Fremdling 1977). In some states, railroads were owned and run as a public enterprise. In Prussia and Saxony, railways were primarily privately owned, and the government had a dominant shareholder role or was guarantor of minimal returns.

Railway building in the five non-German states that our analysis covers, namely Austria-Hungary, Belgium, France, the Netherlands, and Switzerland, proceeded in quite different ways. In France, railway construction in France began as early as 1828 with 23 kilometers of track opened, but its pace fell behind that of Germany in part because of resistance to the new technology from owners of other means of transportation. It has also been argued that railway building in Germany has been particularly fast because the various politically independent states competed for transport routes through their

territitories (Fremdling et al. 1995). At the same time, railway building in Belgium was also very swift. The Belgium railways were designed as a means of international transport from the beginning. This meant that negotiations among different states were necessary. In 1834, the Belgium Parliament planned for a network that allowed connections to Prussia, France, England, and the sea at Anvers, and later, an extension to Holland (Laffut 1983). In Switzerland, both the difficult geography as well as the highly federalistic (cantonal) system slowed down railway building. Also in Austria-Hungary, railway building proceeded at a moderate pace; major reasons for that include relatively little interest in the new technology among the empire's leaders, as well as empty state budgets and lost wars starting around the mid-19th century.

How important where railways as a means of transportation for grain? Generally, railways were important for low value-to-weight ratio good such as coal, construction materials, metal goods, and also grain (O'Brien 1983, 1-2). At the same time, the importance of railroads for transporting grain varied greatly across the German states. While it was cheaper to transport grain by railroads than by other means of land transport, trains could not compete with transport by ship.[23] In the late 19th century, for example, sending one ton of grain from Posen (East Prussia) to Cologne by train was at least three times as expensive as shipping it to Rotterdam or Antwerp and then up the Rhine river (Köttgen 1890, 64).

Consequently, long distance grain trade in the southeast direction, parallel to the major rivers (Elbe, Rhine, Danube), was hardly ever done by rail.[24] At the same time,

[23] On the comparison between land transport and rail transport of grain, see Fremdling and Hohorst (1979, 64).
[24] Even from Breslau (Silesia, a Prussian province), grain was shipped to Mannheim (Baden) via the Baltic Sea harbor of Stettin, Rotterdam, and then upstream on the Rhine river (Köttgen 1890, 64).

transportation of grain on railways was of utmost importance when it connected the drainage areas of the main rivers.[25] Grain transportation on railways was also of major significance whenever sea or river transport was not an option. Seuffert (1857) documents for example that the great majority of all grain exported from Bavaria to Switzerland in the early 1850s was transported on railways (Chapters 5, 6). The attractiveness of transporting grain on railways was not only affected by geographic features across Germany, i.e., whether or not ship transport was feasible. Also the freight rates per ton-kilometer mattered, and while we do not have fully detailed information on this, we know that differed both across states as well as over time (Hohorst and Fremdling 1979, 64-65). This means that the mere existence of a train connection may be only a noisy measure of the importance of a particular train track for grain trade. In terms of our estimation this means that we should expect unobserved heterogeneity in terms of the significance of railways for grain trade between different market pairs.[26]

We now turn to a description of the data.

4. Data

This study employs the prices for wheat across markets in Europe to analyze market integration. We have compiled a data set consisting of sixty-eight market locations; Table 1 provides an overview. There are 16 markets in non-German countries in the sample, or about 24% of the sample. They are located in Austria-Hungary, Belgium, France, the Netherlands, and Switzerland. The remaining 52 wheat price series

[25] For example, Fremdling and Hohorst note that the full opening of the *Köln-Mindener* railway in the year 1847 was crucial for transporting the relatively cheap Prussian grain to the emerging industrial areas of the Rhine-Ruhr (1979, 64).

[26] See also Kopsidis (2002, 1999, 1996) for a careful analysis of the impact of railways for agricultural development in 19th century Westphalia.

are for markets located in fifteen different German states.[27] The prices are averages for an entire year. Since we are interested in low-frequency changes of price gaps over an entire century, this is appropriate. All prices are quoted in terms of Bavarian *Gulden* per one Bavarian *Scheffel* (about 223 liter). To arrive at this comparable set of prices we have converted the many different quantity and monetary units that were used in 19th century Europe using the conversion rates given in Seuffert (1857) as well as in the original sources.

The overall sample period is 1800 to 1899, but data availability varies greatly across the series. For example, there are all 100 annual price observations for the Belgian city of Brugge during the 19th century, while for the market in Wiesbaden (Nassau), there is only one single observation. Since the goal is to rely on important time-series variation (before-after comparison), it is clear that we should place more weight on markets where prices are observed for a long time. The tables report the number of observations for each market as well as the year of the earliest price observation.

The price data comes from work by Fremdling and Hohorst (1979), Gerhard and Kaufhold (1990), Hanauer (1878), Seuffert (1857), as well as Shiue and Keller (2006). In addition, we are using some data underlying Kopsidis (2002, 1996). Further details on the sources and the construction of these series are given in the appendix.

[27] The German territories are (1) The Grand Duchy of Baden, (2) The Kingdom of Bavaria, (3) Duchy of Brunswick, (4) the Free City of Bremen, (5) the Free City of Frankfurt/Main, (6) the Free City of Hamburg, (7) the Free City of Lübeck, (8) the Kingdom of Hannover, (9) the Electorate of Hesse-Cassel, (10) the Grand Duchy of Hesse-Darmstadt, (11), the Duchy of Hesse-Nassau, (12) the Grand Duchy of Mecklenburg-Schwerin, (13) the Kingdom of Prussia, (14) the Kingdom of Saxony, and (15) the Kingdom of Württemberg. Some of these territories changed their name during the 19th century, for instance the Kingdom of Hannover, which was an Electorate until 1814. All of these territories became part of the German Reich after the year 1871.

The population of cities, information we employ in the instrumental variable section below, comes from Bairoch et al. (1988) and de Vries (1984), whereas figures on the denominations in the different Zollverein states is drawn from von Viebahn (1862).

The *Zollverein* was the most important element in the move towards trade liberalization in 19th century continental Europe. For each market, we have recorded the year in which it joined the *Zollverein*; this year is listed in Table 1.[28] Important accession dates are 1834 and 1836, as well as the years 1841 (Brunswick), 1854 (Hanover), 1867 (Mecklenburg and Lübeck), and 1888 (Bremen and Hamburg). Generally, joining the *Zollverein* meant that barriers for grain trade between any two of its markets would be equal to zero. Unfortunately, there is no comprehensive information on the levels of tariffs on grain that existed between markets before they joined the customs union. Instead of exploiting the size of the tariff change, we rely on the timing of the move towards zero trade barriers.

Even though within states tariffs were generally abolished in the very early 1800s, there could still have been customs borders faced by agents trading within the same state. This is because the territory of several states consisted of several non-contiguous parts, such as the Eastern and Western provinces of Prussia, or the Bavarian Palatinate area that was separate from core Bavaria around Nürnberg and Munich. For each market pair in our sample, we have thus established using maps whether a direct trade route would

[28] There have been other trade agreements, for example the customs union created between Bavaria and Württemberg in the year 1828. However, most of these were short-lived—the Bavaria/ Württemberg one lasted for five years before it dissolved in the Zollverein--, and other agreements fell well short of being customs unions to begin with (for example, the Middle German Commercial Union involving Saxony, Thuringia and other territories from 1828 until 1834 did not reduce tariffs to zero between these countries). Clearly, the *Zollverein* was the major development.

involve passing any customs borders. If the number of customs borders to be crossed is greater than or equal to one, CU_{ijt} is coded as 0, otherwise it is 1, for each market pair *ij* and year *t*. For any relationship between a German and a non-German market, CU_{ijt} is equal to 0 for all years.[29]

The major event in the area of currency agreements was that currencies were giving full legal tender status in other states. As discussed above, this occurred between the Southern states in 1837 with the *Munich Coin Treaty*. For all Zollverein currencies, full legal tender status was agreed upon with the *Vienna Coin Treaty* of 1857. Thus, the variable LT_{ijt} for the pair of Munich (Bavaria) and Stuttgart (Württemberg) up to the year 1837 is equal to 0 and 1 afterwards, for example. In contrast, the variable LT_{ijt} for the pair Berlin (Prussia) and Stuttgart is 0 up to the year 1857, and 1 afterwards. For relations between a German and a non-German market, LT_{ijt} is always 0.[30] Table 1 gives the year

[29] The *Zollverein* had at times trade agreements with other countries, including the Netherlands (in 1839, which was cancelled soon after, and another in 1851), as well as Belgium (in 1844). Because these tended to be far less comprehensive than the internal *Zollverein* treaties, our analysis abstracts from them. This is appropriate because it corresponds to the fact that we also do not factor in various tariff increases that foreign countries adopted as a response to the *Zollverein* creation, such as the Netherlands in 1834 (Hahn 1984, 111). Also these activities tended to be much more limited and temporary than the *Zollverein* agreements. Moreover, a number of European countries tried to give trade preferences to individual German states, typically with the goal of keeping them out of the Prussian-led *Zollverein*. Typically, these attempts failed, however. For example, in 1829, some French politicians tried to keep Baden, Württemberg, and Bavaria outside of the Prussian customs union by offering French trade preferences. This plan failed due to protectionist opposition in some French ministries and trade associations. Treaties between France and both Nassau and Mecklenburg were actually finalized; however, they were never ratified by French parliament (Hahn 1984, 73). This confirms that the *Zollverein* treaties between the German states were much more important than other trade treaties involving *Zollverein* members.

[30] The two Alsatian cities of Mulhouse and Strassbourg are special cases in our analysis, since they were part of France until 1871 and part of Germany from 1871 to 1918. Thus, the value of LT_{ijt} between Mulhouse and Toulouse, e.g., goes from 1 to zero after 1871. Moreover, we could in principle take into account the fact that the unified Germany and other countries in our sample went on the gold standard in the 1870s. We have not done so because being on the same commodity standard is not identical to mutually agreed upon legal tender status of currencies; in fact, all German states except Bremen for a short period were on a common standard throughout the 19th century, silver before 1871, and gold afterwards.

in which the currency used in a particular city had for the first time full legal tender status in another state.[31]

Turning to the data on trains, the last column in Table 1 gives the year in which a particular market had its earliest bilateral rail connection in our sample. For example, the rail track between the Saxony cities of Dresden and Leipzig was completed in the year 1839, and since this was the earliest connection in the sample for both cities, Table 1 give this year for Dresden and Leipzig. The first of our trains variables is then a 0/1 variable, TR_{ijt}, which for the Dresden-Leipzig pair is 0 until the year 1839, and 1 thereafter.

This information is not necessarily based on when a particular city became part of the railway network by getting its railway station. Instead, we code the *TR* variable specific to bilateral connections in our sample. Moreover, since it clearly matters for competition between different modes of transport how circuitous a particular route between two markets is, we have set TR_{ijt} only equal to one for a given pair *ij* and time *t* when a direct and non-circuitous train connection existed.[32] This has been determined by analyzing maps that give the precise geographic location of the historical train tracks (IEG 2007).

The *TR* variable also incorporates other relevant elements of Europe's topography, such as the existence of bridges across rivers. For example, the railway line between Cologne and Aachen was an early one in Europe, completed in the year 1841, and as early as 1843 this line connected internationally to the Belgian cities of Brussels

[31] We have also considered the effects of the fixing of exchange rates among the different German currencies. Incorporating this into our analysis would not change the main findings.

[32] The leading example for this is the French railways system, which is centered on Paris. To reach Bordeaux from Toulouse during the early railway days in France, one had to ship via Paris. Given the increase in distance, it is likely that the rail connection Toulouse-Bordeaux, over Paris, was not that important for arbitrage between the two Southern cities.

and Brugge. Grain from the relatively low-price areas of Prussia could be shipped via Hanover to the emerging industrial areas of Cologne by the year 1847 via the *Köln-Mindener* line. But that was only the Cologne-Deutz part of Cologne, located on the east side of the Rhine—the railway bridge across the Rhine was completed only in the year 1859, and until then, Aachen as well as the Belgian markets could effectively not be supplied by rail with the relatively cheap Eastern European grain.

We also construct a second railway variable that incorporates information on how much freight traffic was present on a given line. Even though railway lines, as investment projects, were built first among major cities and centers of trade, the lines differed strongly in terms of their importance for freight traffic. When the *Köln-Mindener* line was started in 1847, it had about 46 freight cars for every ten kilometers of track length.[33] In contrast, the Leipzig-Dresden line had only about one fourth as many freight cars, 11 per every ten kilometers of track initially. Moreover, there is evidence that freight traffic experienced very different rates of growth on the different railway lines, which was in part due to differences in freight rates. For example, during the first 10 years of its operation, the number of freight cars per kilometer of track length quadrupeled for the Berlin-Hamburg line, whereas it grew only by 50% for the Magdeburg-Halle line.

For thirty major railway lines in the German states, we have compiled the ton-kilometers of freight that were transported in any given year, based on figures in Fremdling et al. (1995). To arrive at a freight intensity measure, this figure is divided by the kilometers of track length squared (since longer lines generate more ton-kilometers even for a given track length).

[33] Source: Fremdling et al. (1995).

Figure 3 shows these values for four major rail lines around Berlin, Hamburg, and in the Kingdom of Saxony. The freight intensity on the Leipzig-Dresden line peaked over the period of 1857-65, whereas freight traffic on the other three lines continued to grow steadily throughout the 1860s. Clearly it would be wrong to impose the same trends. There is also a blip in the freight intensity for all lines after the year 1871, due to increased economic activity associated with the German-French war of 1871.

Figure 4 shows the dynamics of freight intensity on the networks of Brunswick, Hanover, Hesse-Cassel, and the Bavarian State railways. Also here, it is apparent that the importance of freight traffic evolved differently in these territories. For example, freight traffic developments in Hanover and Hesse-Cassel appear to be much more closely related to each other than between Hanover and Brunswick, even though Hesse-Cassel and Brunswick's distance to Hanover are similar. The difference is that Hesse-Cassel is located to the South of Hanover, whereas Brunswick is towards the East. This suggests that Hanover rail traffic dynamics have more influence on the North-South trade than the East-West trade. Moreover, whereas the freight intensity for Hanover climbs more or less monotonically from 1843 to 1879, it peaked for the Bavarian railways in the year 1863. Again, this highlights that the importance of train lines for freight traffic underwent major changes over time.

To obtain a freight intensity measure for each market pair, we match each of the 68 wheat markets to the most important rail line for a particular market, given its particular geographic location.[34] This indicator of freight traffic for market i at time t is

[34] Right now, we do not have freight data for the lines outside of the German territories, so we employ the data for the most closely related German rail line. For example, in the two French cities of Strassburg and Mulhouse are most closely related to the railways of Baden along the Rhine river.

denoted by TR^{*}_{it}, i = 1,…I, and t = 1,..,T. From these, we estimate bilateral train freight indicators, denoted by TR^{*}_{ijt}, as the average of the two market-specific freight intensities:

(3) $$TR^{*}_{ijt} = 0.5 \times \left(TR^{*}_{it} + TR^{*}_{jt} \right),$$

for all i = 1,..,I, j = 1,…, I, and t = 1,..,T.

This trains variable shares exhibits the same non-linearity as the 0/1 variable TR_{ijt} in the year when railways first operate between the two markets i and j. In the following years, however, the TR^{*}_{ijt} variable captures changes in the average freight intensity for the relevant railway lines, as captures in Figures 3 and 4, whereas the indicator variable TR_{ijt} does not.

We now turn to the empirical analysis.

5. Results

Matching Estimators First, we study market integration in our sample using matching techniques. In our context, this amounts to comparing price gaps before and after a customs union agreement is signed, and analogously for currency agreements and railway connections. Matching techniques have been widely applied to compute treatment effects in a large variety of contexts where the variable of interest is a 0/1 variable, as is the case with CU_{ijt}, LT_{ijt} and TR_{ijt} here. Relative to linear regression techniques, matching estimators are imposing less parametric restrictions and will pick up non-linearities. Here, these estimators allow us to examine the variation in the data. This is because we are not

convinced that selection is based solely on characteristics observable to us, which would be necessary to estimate correct treatment effects.

Since we are primarily interested in changes over several years, perhaps decades, we restrict the samples to panels where observations are five years apart, that is, t = 1 is the year 1800, t =2 is the year 1805, and so on. Little relevant information is lost by doing this, and the procedure has the advantage that our results are less affected by serial correlation. Table 2 shows the results for the matching estimators. First, we match on the propensity score, that is, the probability that a given market pair is in the same customs union, for example. In specification (1), the conditioning variables are the log bilateral distance between the markets and the year, while in specification (2) we condition in addition on the two treatment variables currently not under consideration.[35]

In Table 2, negative entries dominate, and they also are significantly lower than zero. Therefore, all three factors may cause an increase in market integration (lower $pdif_{ijt}$), as expected. There are noticeable differences however. The trains estimate is at around -0.13 in both specifications. The customs union estimate is also significant albeit smaller in absolute terms, around -0.06, and this is even more the case for the currency agreement variable, significant at about -0.04.

The results of nearest-neighbor matching are reported in the third column of Table 2. Instead of matching on the propensity score, now the control observations are determined directly by the matching on the values of the conditioning variables. We again use log distance between the markets, the year, and the other two treatment variables as matching variables. The trains estimate is largest in absolute value, at about

[35] For example, to estimate the average treatment effect of currency agreements, specification (2) conditions on log distance, year, and the 0/1 variables for customs union (CU_{ijt}) and railway connection (TR_{ijt}).

-0.075, while the estimates for customs union and currency agreement are around -0.05. Compared to the propensity score results, the difference between the estimate for trains and the other two variables is now reduced. However, all matching results are consistent with the hypothesis that trains have a stronger impact on 19th century market integration than the customs or currency agreements.

Regression Results Table 3 shows a number of regression results. First, we run OLS regressions of the price gap on each of the 0/1 variables plus distance and time fixed effects. The coefficients on the customs, currency, and trains variables are significantly negative, in line with other recent work. At the same time, the estimates are smaller than the matching estimates of Table 2. When the three variables are introduced together, the customs and trains coefficients are significantly negative at about -0.02, whereas the currency estimate is close to zero (specification 4).

The next three columns introduce increasingly more controls for unobserved heterogeneity by adding fixed effects. First, we include fixed effects for each city (specification 5). In specification (6), we include fixed effects at the state-pair level, and in specification (7) we include a full set of city-pair fixed effects.[36] The evidence for unobserved heterogeneity is strong, as a comparison of the $\overline{R}^2$ from these specifications to the pooled OLS regression reveals. Fixed effects for each state-pair are preferred to market-specific fixed effects, which is not surprising since some omitted factors may vary primarily at the state-pair level. The strength of political ties may be one example.

[36] These are 136 city fixed effects (2 times 68 cities), 293 state-pair fixed effects, and 1551 city-pair fixed effects.

The preferred specification is to include fixed effects at the city-pair level (specification 7), which implies that one cannot estimate the effect of other city-pair specific factors, such as bilateral distance. Here, none of the three factors is estimated to significantly reduce price gaps. These results are preliminary, however, since the factors' impact varies significantly over time and by geographic distance, as we show below. For comparison purposes, Table 3 shows random effects results in column 8. The customs and trains coefficients are negative, although close to zero. In any case, a Hausman test indicates that only the fixed effects results are consistent.

We present additional fixed effects regressions with time- and distance-interactions in Table 4; column 1 shows again the linear city-pair fixed effects specification for convenience (Table 3, specification 7). Now, railways are estimated to shrink price gaps significantly (specification 2).[37] The trains results suggest that train connections that are built later contribute less to a shrinking price gap, while trains had a stronger effect on the integration of markets at longer, rather than shorter distance. Both results accord well with the historical record. Also customs unions and currency agreements have a stronger effect when markets are far apart. Interestingly, the results suggest that later currency agreements may have a stronger effect than earlier ones. This would mean that the 1871 monetary unification and the 1857 *Vienna* treating giving full legal tender status to all *Zollverein* currencies were more important than the 1837 *Munich* agreement among only the Southern states.

Another important question concerns the timing of these effects, in particular, over which time horizon do they occur? In column (3), the sample is restricted to a more

[37] The R-squared measures indicate that the interactions specification is preferred in terms of empirical fit.

narrow window around changes in the 0/1 variables: the estimation uses only observations 20 years or less before, and 20 years or less after the change in CU_{ijt}, LT_{ijt}, or TR_{ijt} occurs. This gives sharper identification at the cost of a much smaller sample, with the number of observations dropping from 9,974 to 5,753. The direct trains effect is now estimated at -0.033, lower than in the full sample, but it is the case also here that trains appear to have a larger effect on market integration over large distances. Also in the restricted sample we find evidence that the later 1857 *Vienna* currency agreement was more important for market integration than the earlier 1837 *Munich* treaty. The last column in Table 4 replace the 0/1 trains variable TR with the bilateral freight intensity indicator TR^{*}. This variable performs slightly better in terms of mean squared error, while the overall results change little. We conclude that our results are robust to different freight rates and other factors that may have led to different freight traffic intensities in different parts of the railway network.

At the bottom of Table 4, the average marginal effects of trains, customs unions, and currency agreements are reported. Focusing on the preferred specifications with time- and distance interactions, the estimates range between -4.4% and -5.3% for the trains variable. The currency estimates are around -1.5%, while the customs figures vary from 3.3% to -1.2%. Moreover, the standard errors of the customs and currency marginal effects are large relative to the means, consistent with these effects being equal to zero. A significant effect on market integration is only estimated for trains in the fixed effects regressions.

These estimates assume that the *Zollverein*, currency agreements, and train connections came about in a purely random fashion. From the historical record, this is

unlikely to be the case, so we turn now to analyzing the possible endogeneity of these factors.

Instrumental Variable (2SLS) Estimation

We need instruments that are both powerful and valid to further evaluate the question of how the results change if we allow for endogeneity. The date of a state's accession to the *Zollverein* is quite clearly related to the distance to the closest seaboard. As discussed above, not being a member of the *Zollverein* mattered more for the states in the South of Germany, since the external tariff of *Zollverein* prevented customs-free access to the seaboard, which gave relatively low-transport access to distant markets. Figure 5 shows the correlation of *Zollverein* accession with distance to the seaboard for the 68 markets of the wheat sample. With an R^2 of 0.48, it is strong.

The timing of railway construction was affected by idiosyncratic factors such as the support from the political leaders as well as geographic factors such as alternative means of transportation (rivers, coastal traffic). One factor that played an important role was the size of the markets that the railway connected. In Figure 6, we show the correlation between city population in the year 1800 and the earliest date at which a city had a railway connection for our 68 wheat markets. The correlation is positive, albeit less strong than between *Zollverein* accession and distance to seaboard. We are concerned that city size might have a direct effect on the price gap $pdif_{ijt}$, the dependent variable, because city size would then not be a valid instrument. However, the correlation between

the price gap and average city size in the data is actually close to zero, so this should not be a major concern.[38]

It is more difficult to instrument for currency agreements, in part because there is less time series variation. As discussed above, currency agreements were adopted among the German states in 1837 (the Southern states), in 1857 (all *Zollverein* states), and in 1871 (all German states). We choose a measure based on differences in religious denominations between cities. It is the absolute difference in the share of the population that is of Catholic denomination. With some exceptions, the Southern German states tend to be Catholic whereas the Northern states are predominantly Protestant. Specifically, the share of the population that is Catholic in the states that formed a currency agreement at the 1837 *Munich* meeting is about 57%, whereas among the states that did not participate in this agreement, it is 17%. Thus, this instrument works well in predicting whether two particular states have mutually agreed on giving each other's currency full legal tender status. Fundamental differences in religious denomination across Germany are the result of long-running developments from the middle ages, including the principle of *Cuius regio, eius religio* (whoever rules, his religion), and the potential for endogeneity is arguably small.[39] IV estimation comes at the cost of giving up the city-pair fixed effects, since none of our instruments varies over time at the city-pair level. Thus, we include state-pair fixed effects in the IV regressions.

[38] The correlation between the price gap and average city size is 0.017.

[39] The denomination data is at the state level for the relatively late year of 1858. Given that the denominations change slowly, however, the impact of this on the results will be limited. Note that even if it were the case that market integration among Protestant cities is higher, along the lines of Max Weber's argument, this would not mean that the instrument is invalid: the absolute difference in the share of the population that is Catholic is small within the Northern states but also within the Southern states.

The IV results are shown in Table 5. The customs union variable is instrumented by the minimum distance in the pair to the seaboard, the currency variable is instrumented by the difference in Catholic denomination, and the trains variable is instrumented by average city population size. We start out by obtaining IV estimates for each of the three factors one at a time (columns 1 to 3). In column 1, the estimate for the customs union effect is -0.515, significant at standard levels. This is considerably larger than the OLS estimate (Table 3). The Hausman test clearly rejects the Null hypothesis that the customs union variable is exogenous, and the likelihood ratio test for the first-stage regression indicates that the instrument is powerful.[40]

The trains effect in column 2 is negative at -0.436 and highly significant. Also this is much larger in absolute value than the least-squares estimates, where the lowest estimate is -0.053 (Table 4). These results suggest that fixed-effects estimation leads to an underestimate of the effect of customs union and trains on market integration. The currency agreement estimate in column 3 is positive although not significant at standard levels. There does not seem to be a weak-instrument problem, as the catholic denomination instrument is working well: the likelihood ratio test reject the hypothesis that the instrument does not matter in the first stage at standard significance levels. At the same time, we cannot reject that the currency variable is exogenous (Hausman test p-value of 0.833). The evidence for exogenous currency agreements is summarized in Tables 2 to 4, and in the following, the IV analysis is focused on the customs union and trains effects.

In column 4, the customs and trains variables are included simultaneously. The customs effect falls drastically, from -0.515 to -0.147, but it remains significant at

[40] The p-value of the Null that the instrument has no effect in the first-stage is less than 0.001.

standard levels. In contrast, the trains estimate is stable, with a coefficient of -0.440. The interaction specification of column 5 broadly confirms these results. The average marginal effect for customs union is relatively precisely estimated at -0.151, while the trains estimate is at -0.431 about three times as high in absolute value.

We restrict the sample to a more narrow window of 20 years before and after the change in customs, currency, and trains variables to examine more short-run effects. Column 6 indicates that the customs union and trains effects over this horizon are very similar, with estimates of -0.241 and -0.262, respectively. These conclusions do not change when we consider interactions with time and distance. As shown in column 7, the relatively short-run average marginal effect of customs union is estimated at -0.294, while the average trains effect is estimated at -0.255. This suggests that over a shorter time horizon, customs unions and trains had a comparable effect on market integration, while over a longer horizon the trains effect was considerably larger.

Overall, these IV results suggest that without taking account of the endogeneity of changes in institutional and technological trade barriers, it is highly unlikely that their true effect on market integration can be estimated. The evidence suggests that transport technology has a major effect on bringing price gaps down, and the trains effect would be underestimated without taking account of the endogenous choice of railway adoption. Over a relatively short horizon, we estimate that the *Zollverein* liberalizations triggered comparatively large improvements in market integration, while the long-run effect of the railway network appears to be considerably larger than those of customs liberalization.

6. Conclusions

In this paper, we have examined institutional and technological barriers to market integration and trade in 19th century Europe. Building on some unique features of this historical setting, we have quantatively compared the effects of the *Zollverein* liberalizations, currency agreements, and the building of the railway network.

The evidence suggests that transport technology has a major effect on improving market integration, and the trains effect would be underestimated without taking account of the endogenous choice of railway adoption. In contrast to other recent research, we do not find that currency agreements have a significant effect on market integration. This may be due to the fact that time series variation in currency agreements in our sample is limited.

We also estimate that the *Zollverein* liberalizations triggered substantial improvements in market integration. This is particularly true over a relatively short horizon. In contrast, the long-run effect of the railway network appears to have been considerably larger than those of customs liberalization.

By and large, the literature to date has emphasized the importance of institutional barriers, such as tariffs and the absence of currency agreements. Our results suggest that as important as these seem to be, they should not lead us to ignore the fact that advances in transportation technology had a major effect, and perhaps it was the major impact on the expansion of markets in the era of industrialization and the first wave of globalization.

References

Acemoglu, D., S. Johnson and J. Robinson (2001), "The Colonial Origins of Comparative Development: An Empirical Investigation", *American Economic Review*.

Anderson James E. (1979), "A Theoretical Foundation for the Gravity Equation", *American Economic Review*, LXIX: 106-116.

Baier, Scott and and Jeffrey Bergstrand (2007), "Do Free Trade Agreements Actually Increase Members' International Trade?", *Journal of International Economics.*

Bairoch, Paul, Jean Batou, and Pierre Chevre (1988), *The Population of European Cities from 800 to 1850: Data Bank and Short Summary of Results.* Geneva: Librairie Droz.

Braudel, Fernand (1992), *The Wheels of Commerce*, Volume 2. Berkeley: University of California Press.

DeLong, Bradford (2002), *Macroeconomics.* Burr Ridge, IL: McGraw-Hill

De Vries, Jan (1984), *European Urbanization 1500-1800*, Cambridge, Massachusetts: Harvard University Press.

Dumke, Rolf H. (1977), "Intra-German Trade in 1837 and Regional Economic Development", *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte* 64, 4: 470-496.

Dumke, Rolf H. (1976), "The Political Economy of German Economic Unification: Tariffs, Trade and Politics of the Zollverein Era", Ph.D. Dissertation, University of Wisconsin-Madison.

Eichengreen, Barry and Douglas Irwin (1995), "Trade Blocs, Currency Blocs, and the Reorientation of World Trade in the 1930s", *Journal of International Economics*, (February): 1-24.

Ejrnaes, M., and K. Persson (2000), „Market Integration and transport costs in France: 1826-1903", *Explorations in Economic History* 37: 149-173.

Engel, C. and J. H. Rogers (1996), "How wide is the border?", *American Economic Review* 86: 1112-1125.

Estevadeordal, Antoni, Brian Frantz, and Alan Taylor (2003), "The Rise and Fall of World Trade, 1870-1939", *Quarterly Journal of Economics*, 118(2): 359-407.

Evenett, Simon and Wolfgang Keller (2002), "On Theories Explaining the Success of the Gravity Equation", *Journal of Political Economy* 110(2): 281-316.

Fishlow, Albert (1965), *American Railroads and the Transformation of the Ante-Bellum Economy*. Cambridge, MA: Harvard University Press.

Flandreau, Marc and Mathilde Maurel (2001), "Monetary Union, Trade Integration, and Business Cycles in 19th Century Europe: Just Do It", Centre fro Economic Policy research, Discussion Paper Series No. 3087, November.

Fogel, R.W. (1964), *Railroads and American Economic Growth: Essays in Econometric History.* Johns Hopkins Press: Baltimore, Maryland.

Frankel, J. A. and D. Romer (1999), "Does Trade Cause Growth?" *American Economic Review*, 89(3), June 1999, pp. 379-99.

Frankel, Jeffrey, and Andrew Rose (2002), "An Estimate of the Effect of Common Currencies on Trade and Income", *Quarterly Journal of Economics.*

Fremdling, R. (1977), "Railroads and German Economic Growth: A Leading Sector Analysis with a Comparison to the United States and Great Britain", *Journal of Economic History*, 37: 583-604.

Fremdling, R., R. Federspiel, and A. Kunz (1995), (eds.), *Statistik der Eisenbahnen in Deutschland 1835-1989*, Scripta Mercaturae Verlag: St. Katharinen.

Fremdling, R., and G. Hohorst (1979), "Marktintegration der preussischen Wirtschaft im 19. Jahrhundert—Skizze eines Forschungsansatzes zur Fluktuation der Roggenpreise zwischen 1821 und 1865", in R. Tilly and R. Fremdling (eds.), *Industrialisierung und Raum*, Stuttgart, 56-101.

Gerhard, H.-J., and K. H. Kaufhold (1990), (eds.), *Preise im vor- und frühindustriellen Deutschland*, Göttingen.

Glick, R., and A. Taylor (2005), "Collateral Damage: Trade Disruption and the Economic Impact of War", NBER WP # 11565.

Hahn, H.-W. (1984), *Geschichte des Deutschen Zollvereins*, Vandenhoeck & Ruprecht: Göttingen.

Hanauer, A. (1878), *Etudes Economiques sur L'Alsace Ancienne et Moderne*, Vol. 2, Paris.

Helpman, E. and P. Krugman (1985), *Market Structure and Foreign Trade.* Cambridge, MA: The MIT Press.

Henderson, W. O. (1939), *The Zollverein*, Cambridge University Press, Cambridge, UK.

Holtfrerich, Carl-Ludwig (1993), "Did monetary unification precede or follow political unification of Germany in the 19th century", *European Economic Review* 37: 518-524.

Holtfrerich, Carl-Ludwig (1989), "The monetary unification process in 19th century Germany: Relevance and lessons for Europe today", in M.de Cecco and A. Giovannini, eds. *A European central bank? Perspectives on monetary unification after ten years of the EMS.* Cambridge: Cambridge University Press.

IEG (2007), Server für digital Karten am Institut für Europäische Geschichte, Mainz; http://www.ieg-maps.uni-mainz.de/ ; accessed in March 2007.

Jacks, David (2006), "What drove 19th century commodity market integration?", *Explorations in Economic History* 43: 383-412.

Kopsidis, Michael (2002), "*The Creation of a Westphalian Rye Market 1820-1870: Leading and Following Regions, an Co-Integration Analysis, Jahrbuch für Wirtschaftsgeschichte*: 85-112.

Kopsidis, Michael (1999), "Peasants and Markets: Market Integration and Agricultural Development in Westphalia 1780-1880", paper presented at the First German Cliometrics Conference, Toronto, September 1999.

Kopsidis, Michael (1996), *Marktintegration und Entwicklung der westfälischen Landwirtschaft 1780-1880*, Ph.D. thesis, Münster.

Köttgen, August (1890), *Studien über Getreideverkehr und Getreidepreise in Deutschland.* Jena: Verlag von Gustav Fischer.

Laffut, Michel (1983), "Belgium", in Patrick O'Brien, ed. *Railways and the Economic Development of Europe, 1830-1914.* St. Martin's Press: New York.

La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer, and Robert Vishny (1997), "Legal determinants of external finane", *Journal of Finance* 52: 1131-1150.

Lopez-Cordova, J. Ernesto and Christopher Meissner (2003), "Exchange-Rate Regimes and International Trade: Evidence from the Classical Gold Standard Era," *American Economic Review*, 93 (1).

Milward, A.S. and S.B. Saul (1977), *The Development of the Economies of Continental Europe, 1850-1914.* Harvard University Press: Cambridge, MA.

O'Brien, Patrick (1983), "Transport Development in Europe, 1789-1914", in *Railways and the Economic Development of Western Europe, 1830-1914*, edited by P. O'Brien. S

O'Rourke, Kevin, and Jeffrey G. Williamson (1999), *Globalization and History*, Cambridge: MIT Press.

Parsley, David, and Shang-jin Wei (1996), "Convergence to the Law of One Price without Trade Barriers or Currency Fluctuations", *Quarterly Journal of Economics* 111: 1211-1236.

Rodrik, Dani, Arvind Subramanian, and Francesco Trebbi (2002), "Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development," *Journal of Economic Growth*, 9(2): 131-165.

Rose, Andrew (2004), "Do We Really Know that the WTO Increases Trade?" *American Economic Review.*

Rose, Andrew (2000), "One Money, One Market: Estimating the Effect of Common Currencies on Trade", *Economic Policy.*

Seuffert, G. K. L. (1857), *Statistik des Getreide- und Viktualien-Handels im Königreiche Bayern mit Berücksichtigung des Auslandes*, J. G. Weiss, Munich.

Shiue, Carol H. (2005), "From Political Fragmentation towards the Nation State:Border Effects of the German Zollverein, 1815-1855" *European Review of Economic History*, August.

Shiue, Carol H. (2002), "Transport Costs and the Geography of Arbitrage in Eighteenth Century China", *American Economic Review* 92(5): 1406-1419.

Shiue, Carol H., and Wolfgang Keller (2006), "Markets in China and Europe on the Eve of the Industrial Revolution", forthcoming, *American Economic Review*.

Subramanian, Avind and Shang-Jin Wei (2005), "The WTO Promotes Trade, Strongly, but Unevenly," forthcoming, *Journal of International Economics.*

Viner, Jacob (1950), *The Customs Unions Issue*, New York: Carnegie Endowment for International Peace.

von Viebahn, Georg (1862), *Statistik des zollvereinten und nördlichen Deutschlands*, Zweiter Theil (Bevölkerung, Bergbau, Bodenkultur), Georg Reimer Verlag, Berlin 1862.

Williamson, Jeffrey G. (1980), "Greasing the Wheels of Sputtering Export Engines: Midwestern Grains and American Growth", *Explorations in Economic History*, 17: 189-217.

Willis, Henry Parker (1896), "The Vienna Monetary Treaty of 1857", *Journal of Political Economy*, pp.187-207.

Table 1: Price Data Overview

Overall sample period: 1800 - 1899

No	City	State/Country	Obs	Mean	Year of Earliest Obs.	Year of Zollverein Accession	Year of Earliest Rail Connection*	Year of Earliest Legal Tender Status**
1	Prague	Austria-Hungary	8	19.47	1836		1845	
2	Salzburg	Austria-Hungary	4	29.02	1849		1860	
3	Venice	Austria-Hungary	7	15.57	1836		1856	
4	Vienna	Austria-Hungary	86	20.57	1820		1845	
5	Baden	Baden	28	16.29	1818	1836	1846	1837
6	Augsburg	Bavaria	41	16.92	1815	1834	1840	1837
7	Bamberg	Bavaria	41	16.32	1815	1834	1844	1837
8	Bayreuth	Bavaria	41	16.82	1815	1834	1853	1837
9	Erding	Bavaria	41	16.33	1815	1834	1859	1837
10	Kempten	Bavaria	41	18.81	1815	1834	1852	1837
11	Landshut	Bavaria	41	15.58	1815	1834	1854	1837
12	Lindau	Bavaria	41	19.14	1815	1834	1852	1837
13	Memmingen	Bavaria	41	18.00	1815	1834	1858	1837
14	Munich	Bavaria	56	18.69	1800	1834	1840	1837
15	Noerdlingen	Bavaria	41	16.14	1815	1834	1849	1837
16	Nurnberg	Bavaria	45	16.42	1811	1834	1844	1837
17	Regensburg	Bavaria	41	15.09	1815	1834	1859	1837
18	Straubing	Bavaria	41	14.65	1815	1834	1858	1837
19	Wuerzburg	Bavaria	41	16.41	1815	1834	1854	1837
20	Zweibruecken	Bavaria	38	16.57	1818	1834	1857	1837
21	Brugge	Belgium	100	20.62	1800		1838	
22	Brussels	Belgium	91	22.45	1800		1838	
23	Braunschweig	Brunswick	50	16.50	1800	1841	1844	1857
24	Bar-le-Duc	France	30	18.08	1825		1851	
25	Chalons sure Marne	France	30	18.55	1825		1851	
26	Luneville	France	30	19.03	1825		1851	
27	Mulhouse	France	76	22.41	1800		1841	
28	Strassburg	France	76	21.63	1800		1841	
29	Toulouse	France	100	21.40	1800		1859	
30	Bremen	Free City	11	20.53	1837	1888	1847	1871
31	Frankfurt/Main	Free City	14	22.57	1816	1836	1840	1837
32	Hamburg	Free City	54	18.48	1800	1888	1846	1871
33	Luebeck	Free City	9	17.58	1837	1867	1851	1871

Table 1, cont'd

No	City	State/Country	Obs	Mean	Year of Earliest Obs.	Year of Zollverein Accession	Year of Earliest Rail Connection*	Year of Earliest Legal Tender Status**
34	Goettingen	Hannover	68	17.12	1800	1854	1854	1857
35	Hannover	Hannover	50	17.81	1801	1854	1844	1857
36	Kassel	Hesse-Cassel	27	14.22	1822	1831	1849	1857
37	Bingen	Hesse-Darmstadt	1	20.34	1840	1828	1858	1837
38	Giessen	Hesse-Darmstadt	1	19.12	1840	1828	1850	1837
39	Mainz	Hesse-Darmstadt	3	23.68	1840	1828	1853	1837
40	Worms	Hesse-Darmstadt	1	20.68	1840	1828	1853	1837
41	Wiesbaden	Hesse-Nassau	1	18.13	1840	1836	1840	1837
42	Grabow	Mecklenburg	71	18.45	1800	1867	1846	1871
43	Boizenburg	Mecklenburg	71	18.30	1800	1867	1846	1871
44	Parchim	Mecklenburg	71	17.43	1800	1867	1880	1871
45	Rostock	Mecklenburg	71	17.57	1800	1867	1850	1871
46	Schwerin	Mecklenburg	71	17.67	1800	1867	1847	1871
47	Wismar	Mecklenburg	57	16.65	1800	1867	1848	1871
48	Nijmegen	Netherlands	93	21.46	1800		1856	
49	Utrecht	Netherlands	15	30.66	1800		1856	
50	Aachen	Prussia	61	18.88	1800	1834	1841	1857
51	Berlin	Prussia	61	18.14	1800	1834	1841	1857
52	Cologne	Prussia	61	17.15	1800	1834	1841	1857
53	Hamm	Prussia	20	20.86	1800	1834	1847	1857
54	Herdecke	Prussia	20	23.23	1800	1834	1848	1857
55	Minden	Prussia	13	21.49	1800	1834	1847	1857
56	Muenster	Prussia	64	18.91	1800	1834	1848	1857
57	Saarlouis	Prussia	20	17.70	1800	1834	1858	1857
58	Soest	Prussia	20	17.71	1800	1834	1850	1857
59	Wetzlar	Prussia	20	19.27	1800	1834	1862	1857
60	Xanten	Prussia	20	18.48	1800	1834	1880	1857
61	Dresden	Saxony	21	16.78	1832	1834	1839	1857
62	Leipzig	Saxony	21	16.74	1832	1834	1839	1857
63	Zwickau	Saxony	21	18.44	1832	1834	1845	1857
64	Basel	Switzerland	10	24.75	1845		1844	
65	Lucerne	Switzerland	9	23.94	1845		1856	
66	Rorschach	Switzerland	14	20.79	1824		1856	
67	Stuttgart	Wurttemberg	5	23.68	1850	1834	1850	1837
68	Ulm	Wurttemberg	6	22.81	1850	1834	1850	1837

Prices in Bavarian Gulden, per Bavarian Scheffel (about 223 liter)
* Rail connection in this sample
** With another currency in the sample

Table 2: Estimates of Average Treatment Effect on Price Gap from Matching Estimators[#]

	Propensity Score[#]	Propensity Score[#]	Nearest Neighbor[+]
Customs Union	-0.061 (0.004)	-0.056 (0.011)	-0.046 (0.008)
Currency Agreement	-0.032 (0.006)	-0.050 (0.016)	-0.049 (0.006)
Trains	-0.126 (0.032)	-0.126 (0.028)	-0.075 (0.016)
Matching variables	Bilateral distance (log), year	Bilateral distance (log), year, other two treatment variables[*]	Bilateral distance (log), year, other two treatment variables[*]

[#] Propensity score is estimated by probit regressions (not shown); bootstrapped standard errors in parentheses
[+] Matching to the nearest three neighbors, using the inverse variance as the weighting matrix; heteroskedasticity-consistent standard errors in parentheses
* For customs union effect, this matches on LT and TR; for currency agreement, matching is on CU and TR, and for TR, matching is on CU and LT

Table 3: Regression Analysis[*]

	(1) Pooled OLS	(2) Pooled OLS	(3) Pooled OLS	(4) Pooled OLS	(5) City FEs	(6) State-Pair FEs	(7) City-Pair FEs	(8) Random Effects
Customs Union	-0.015 (0.001)			-0.016 (0.002)	-0.005 (0.002)	0.013 (0.003)	0.008 (0.003)	-0.006 (0.002)
Currency Agreement		-0.011 (0.002)		0.002 (0.002)	-0.010 (0.002)	0.025 (0.006)	0.030 (0.006)	-0.001 (0.003)
Trains			-0.020 (0.003)	-0.020 (0.003)	-0.005 (0.003)	-0.010 (0.002)	-0.002 (0.002)	-0.009 (0.002)
Distance	0.060 (0.001)	0.062 (0.001)	0.065 (0.001)	0.060 (0.001)	0.067 (0.001)	0.032 (0.006)		0.060 (0.001)
Rbar-squared	0.216	0.215	0.215	0.216	0.305	0.335	0.444	

[*] Dependent variable: absolute value of percentage price gap ($pdif_{ijt}$). All specifications include fixed effects for each year. Weighted regression with the number of observations for a given city pair as weights. Standard errors are in parentheses. Number of observations: 9,974

Table 4: Least-Squares Regressions with Time- and Distance-Varying Effects[*]

	(1)	(2)	(3)	(4)
Customs Union	0.008 (0.003)	-0.058 (0.014)	-0.076 (0.011)	-0.057 (0.014)
Currency Agreement	0.030 (0.006)	0.095 (0.015)	0.077 (0.015)	0.095 (0.015)
Trains	-0.002 (0.002)	-0.100 (0.022)	-0.033 (0.020)	-0.067 (0.013)
Customs Union*Year		0.003 (0.0001)	0.003 (0.0002)	0.003 (0.0001)
Currency Agrmt*Year		-0.002 (0.0002)	-0.0005 (0.0002)	-0.002 (0.0001)
Trains*Year		0.002 (0.0004)	0.0005 (0.0004)	0.001 (0.0002)
Distance*Year		0.0001 (0.00005)	-0.0001 (0.0001)	0.0001 (0.00001)
Customs Union*Distance		-0.029 (0.007)	-0.009 (0.006)	-0.029 (0.007)
Currency Agrmt*Distance		-0.043 (0.009)	-0.057 (0.007)	-0.043 (0.009)
Trains*Distance		-0.018 (0.002)	-0.010 (0.002)	-0.018 (0.002)
Root MSE	0.1109	0.1105	0.0870	0.1104
CU Ø Marg. Effect	0.008 (0.003)	-0.010 (0.050)	0.033 (0.038)	-0.012 (0.048)
LT Ø Marg. Effect	0.030 (0.006)	-0.015 (0.042)	-0.018 (0.047)	-0.014 (0.042)
TR Ø Marg. Effect	-0.002 (0.002)	-0.053 (0.038)	-0.046 (0.008)	-0.044 (0.027)
# Obs.	9,974	9,974	5,753	9,974

[*] Dependent variable: absolute value of percentage price gap ($pdif_{ijt}$). All specifications include fixed effects for each year and for each city-pair. Weighted regression with the number of observations for a given city pair as weights. Standard errors are in parentheses. Specification (3) restricts the sample to 20 years before and after a change in CU, LT, or TR. Specification (4) employs the freight traffice trains variable TR_{ijt}^{*}, instead of the 0/1 variable TR_{ijt}. Details are given in the text.

Table 5: Instrumental Variable Estimation[#]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Customs Union	-0.515 (0.065)			-0.147 (0.063)	-0.183 (0.053)	-0.241 (0.079)	-0.390 (0.066)
Trains		-0.436 (0.029)		-0.440 (0.003)	-0.483 (0.032)	-0.262 (0.025)	-0.127 (0.032)
Currency Agrmt			0.137 (0.146)				
Distance	0.006 (0.004)	0.016 (0.002)	0.044 (0.001)	0.009 (0.003)	0.001 (0.003)	-0.012 (0.005)	0.005 (0.005)
Customs Union*Year					0.001 (0.0001)		0.002 (0.0002)
Trains*Year					0.004 (0.001)		-0.003 (0.0001)
Dist*Year					0.0003 (0.0001)		-0.001 (0.0001)
Customs Union*Dist					0.006 (0.002)		-0.0005 (0.002)
Trains*Dist					-0.052 (0.004)		0.002 (0.004)
CU Exog Test [p-val]	108.40 [<.001]			7.495 [0.006]		7.921 [0.005]	
TR Exog Test [p-val]		307.44 [<.001]		252.38 [<.001]		36.13 [<.001]	
LT Exog Test [p-val]			0.044 [0.833]				
1st stage LR test [p-val]	173.13 [<.001]	806.74 [<.001]	61.36 [<.001]	163.114 [<.001]		68.280 [<.001]	
Cust Union Marg. Effect	-0.515 (0.065)			-0.147 (0.063)	-0.151 (0.013)	-0.241 (0.079)	-0.294 (0.033)
Trains Marg. Effect		-0.436 (0.029)		-0.440 (0.003)	-0.431 (0.072)	-0.262 (0.025)	-0.255 (0.045)
Curr Agr Marg. Effect			0.137 (0.146)				
Adj R-sq	0.335	0.337	0.335	0.338	0.342	0.298	0.306
# Obs.	9,974	9,974	9,974	9,974	9,974	5,700	5,700

[#] Dependent variable: absolute value of percentage price gap ($pdif_{ijt}$). All specifications include fixed effects for each year and for each state-pair. Weighted regression with the number of observations for a given city pair as weights. Standard errors are in parentheses. Instruments are: minimum distance to the seaboard (CU), absolute difference in share Catholic (LT), and average city population size (TR). Details are in the text.

Figure 1

Der Deutsche Bund nach dem Frankfurter Territorialrezess um 1820

Kgr. Dänemark
Kgr. Schweden
Ksr. Russland
Hzm. Schleswig
in Personalunion mit Dänemark
Hzm. Holstein
in Personalunion mit Dänemark
Freie Stadt Lübeck
Freie Stadt Hamburg
Grhzm. Mecklenburg-Schwerin
Schwerin
Grhzm. Mecklenburg-Strelitz
Neustrelitz
Grhzm. Oldenburg
Oldenburg
Freie Stadt Bremen
Kgr. Hannover
Hannover
Braunschweig
Hzm. Braunschweig
Fsm. Lippe-Detmold
Detmold
zum Kgr. Hannover
Fsm. Waldeck-Pyrmont
Arolsen
Kassel
Kfsm. Hessen
Anhalt
Dessau
Berlin
Kgr. Preussen
Kgr. Polen
in Personalunion mit dem Ksr. Russland
Königreich der Vereinigten Niederlande
Grhzm. Luxemburg
in Personalunion mit den Niederlanden
Luxemburg
Hzm. Nassau
Wiesbaden
Grhzm. Hessen-Darmstadt
Darmstadt
Freie Stadt Frankfurt
Kgr. Bayern (Pfalz)
Kgr. Sachsen
Dresden
Thüringische Staaten
Weimar
Gotha
Rudolstadt
Sondershausen
Hildburghausen
Coburg
Meiningen
Sachsen-Altenburg
Zeitz
Kgr. Bayern
München
Kaisertum Österreich
Wien
Kgr. Württemberg
Stuttgart
Grhzm. Baden
Karlsruhe
Hechingen
Sigmaringen
Hohenzollern
Kgr. Frankreich
Fsm. Liechtenstein
Vaduz
Schweiz
Fsm. Neuenburg (Preussen)

Zahlen-/Buchstabenkürzel:

Thüringische Staaten:
Grhzm. Sachsen-Weimar 1a
Hzm. Sachsen-Gotha 1b
Hzm. Sachsen-Meiningen 1c
Hzm. Sachsen-Hildburghausen 1d
Hzm. Sachsen-Coburg 1e
Amt Römhild: Gemeinsamer Besitz Hzm. Sachsen-Gotha und Sachsen-Meiningen 1b|c
Amt Themar: Gemeinsamer Besitz Hzm. Sachsen-Meiningen und Sachsen-Coburg 1c|e
Fsm. Schwarzburg-Sondershausen 2a
Fsm. Schwarzburg-Rudolstadt 2b
Fsm. Reuss ältere Linie 3a
Fsm. Reuss jüngere Linie 3b
zu Preussen: Pr.

Anhaltische Herzogtümer:
Anhalt-Dessau 4a
Anhalt-Köthen 4b
Anhalt-Bernburg 4c
Kfsm. Hessen-Kassel 8
Grhzm. Mecklenburg-Strelitz 8
Hzm. Braunschweig 9
Grhzm. Oldenburg 10
Hzm. Lauenburg: in Personalunion mit dem Kgr. Dänemark 12
Fsm. Hohenzollern-Hechingen 13a
Fsm. Hohenzollern-Sigmaringen 13b
Fsm. Waldeck-Pyrmont 15
Fsm. Schaumburg-Lippe 16
Lgft. Hessen-Homburg 18
Lippstadt: gemeinsamer Besitz Kgr. Preussen und Fsm. Lippe-Detmold 19
Bergedorf: gemeinsamer Besitz der Freien Städte Hamburg und Lübeck 20
zu Hamburg (Cuxhaven) 31
Grenze des Deutschen Bundes
100km

Zollvereine in Deutschland 1828

Figure 2

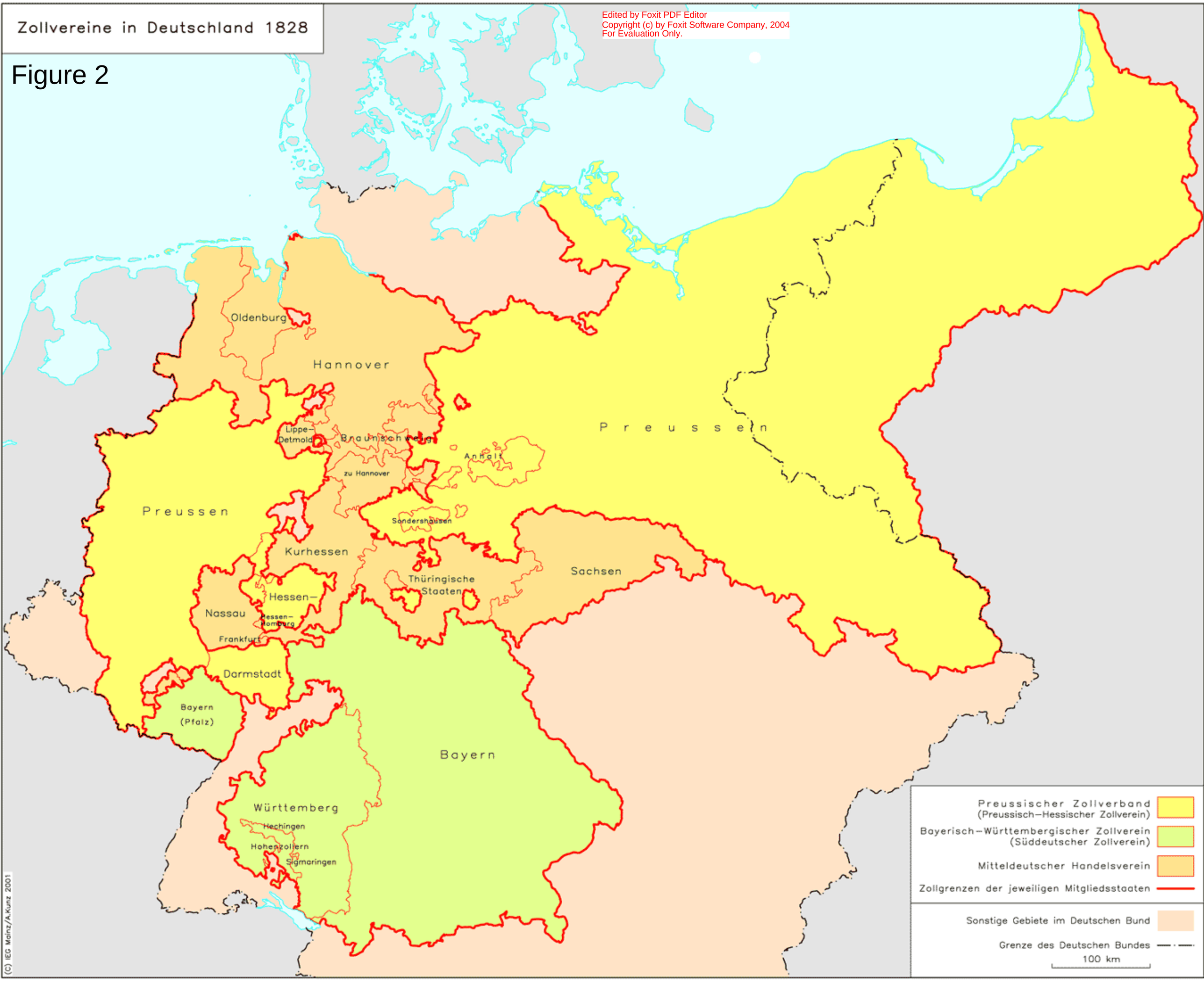

Figure 3

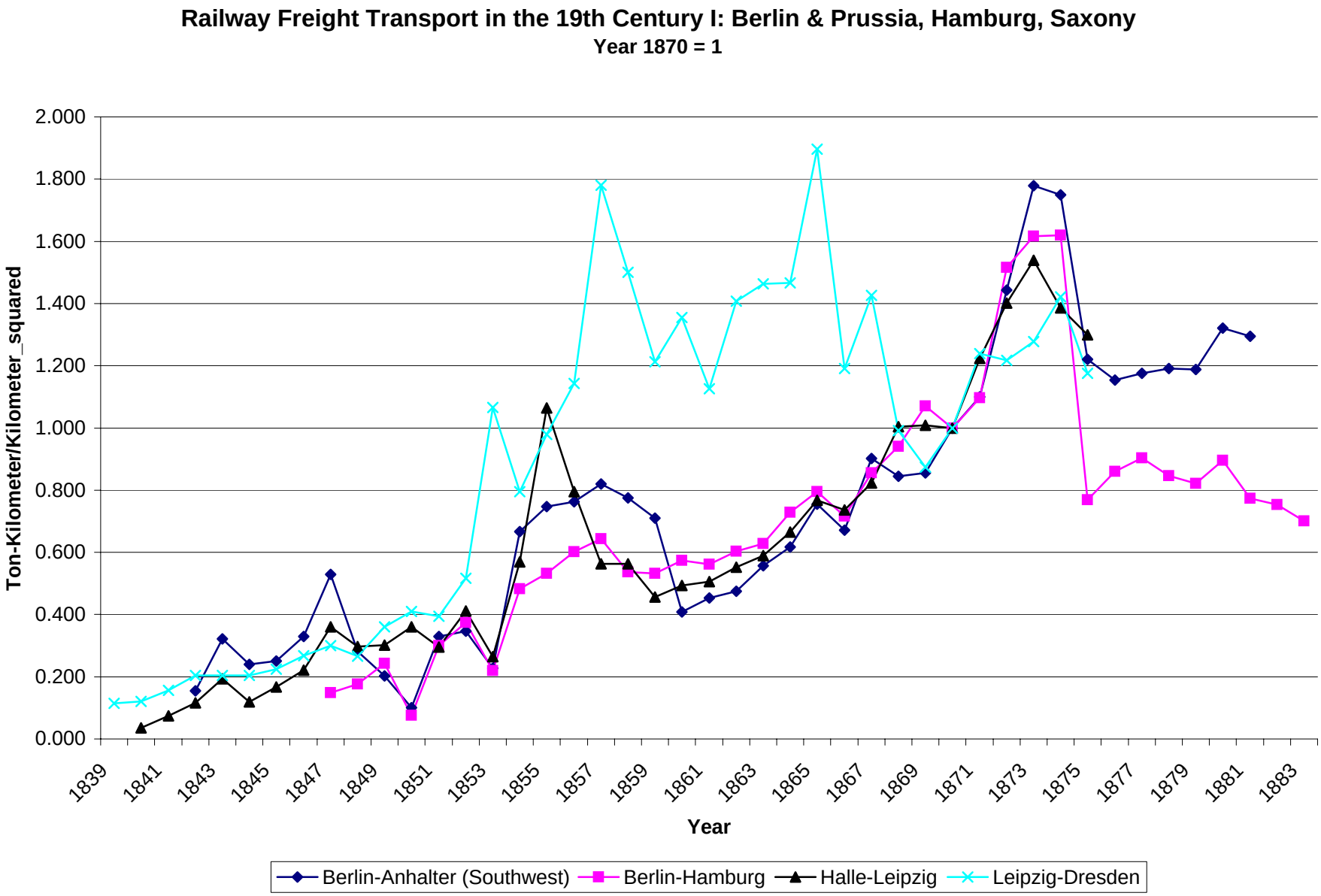
Railway Freight Transport in the 19th Century I: Berlin & Prussia, Hamburg, Saxony
Year 1870 = 1
Ton-Kilometer/Kilometer_squared
2.000
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1839
1841
1843
1845
1847
1849
1851
1853
1855
1857
1859
1861
1863
1865
1867
1869
1871
1873
1875
1877
1879
1881
1883
Year
Berlin-Anhalter (Southwest)
Berlin-Hamburg
Halle-Leipzig
Leipzig-Dresden

Figure 4

Railway Freight Transport in the 19th Century II: Brunswick, Hannover, Kassel, and Bavaria
Year 1870 = 1

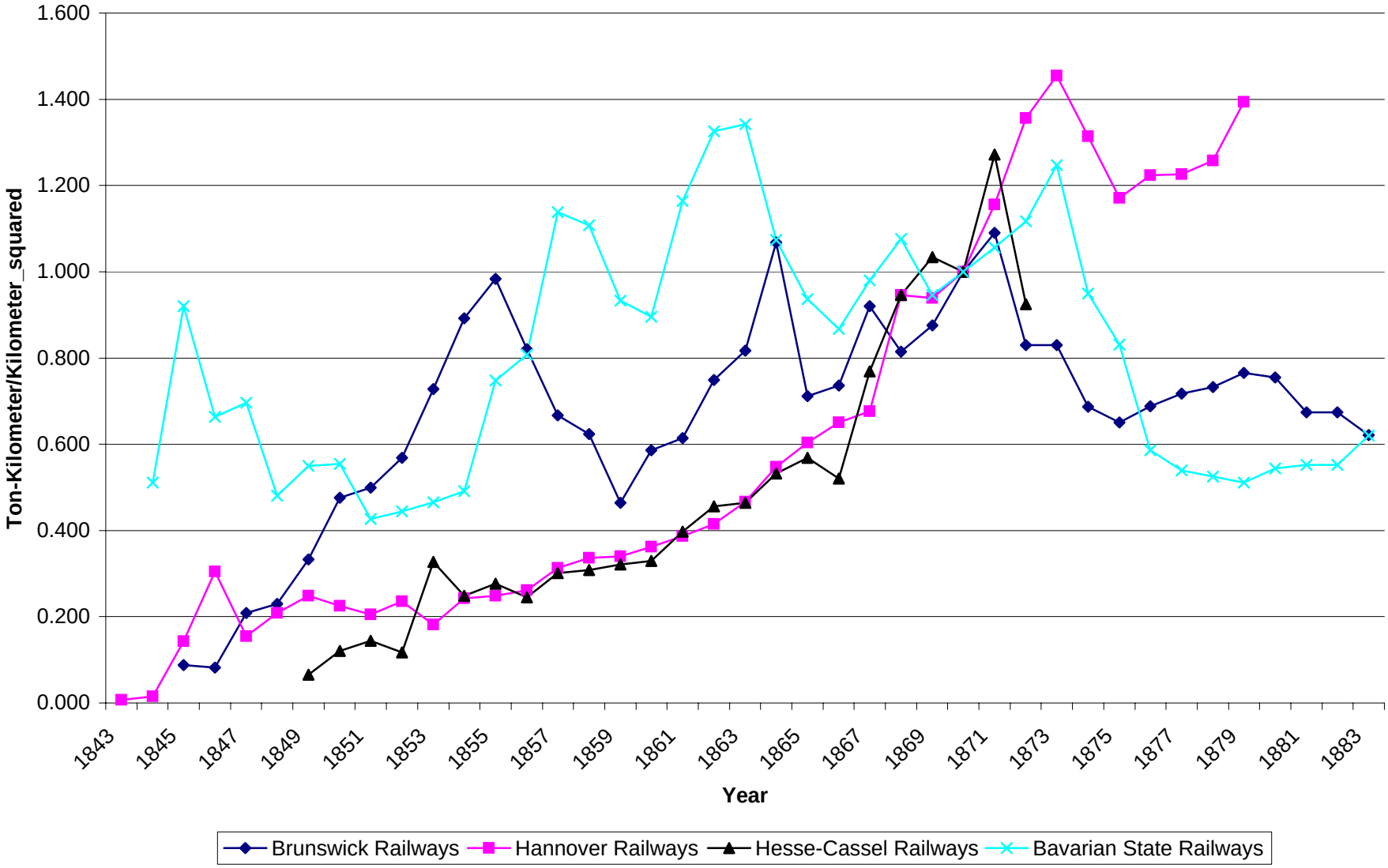

Figure 5: Cities in States further away from the Seaboard join the Zollverein Earlier

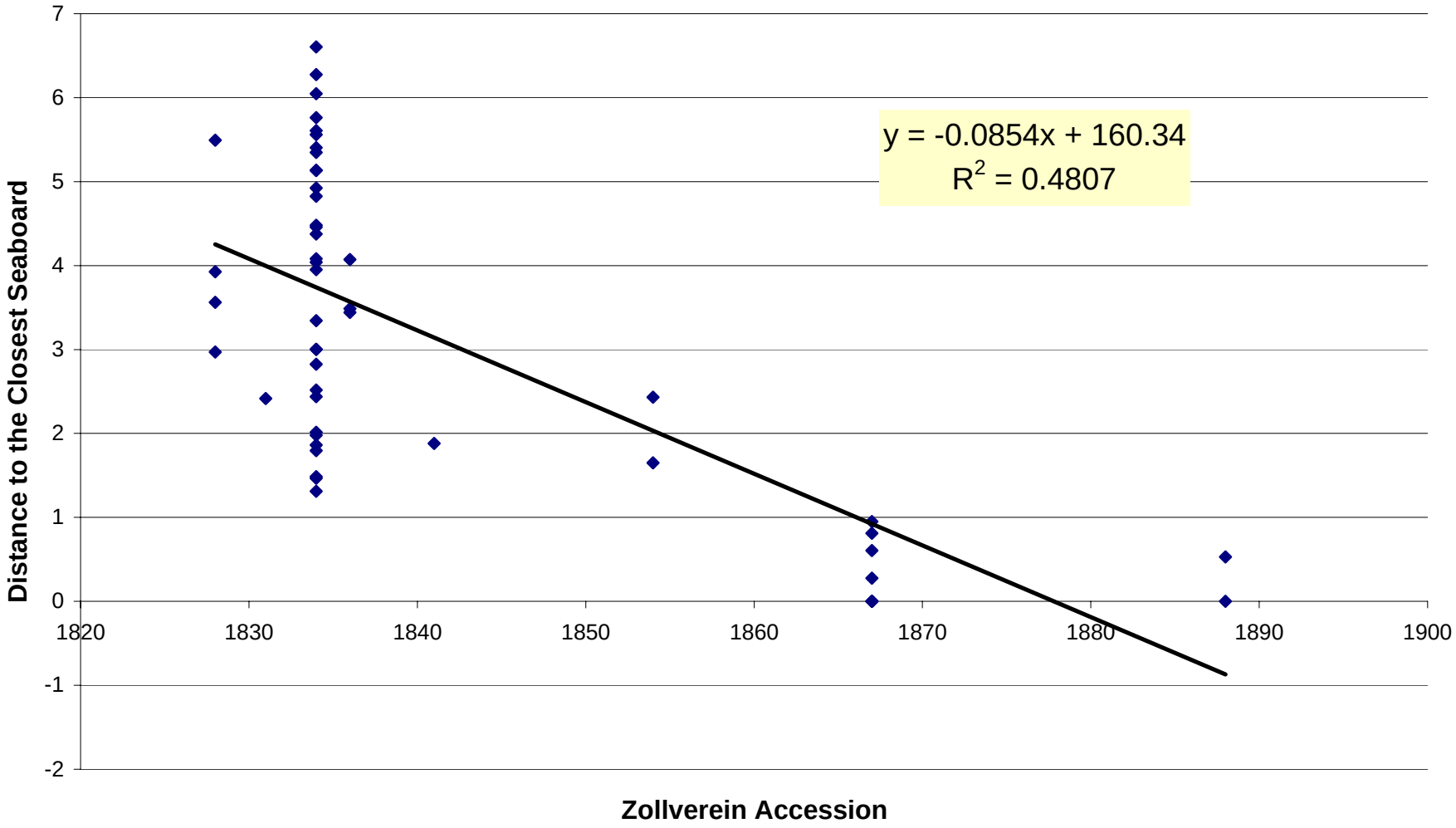

Figure 6: Larger Cities Have Railways Earlier