

Master's Thesis

Market Integration: German Unification  
and the Zollverein in the 19<sup>th</sup> Century

(市場統合：19世紀ドイツ統一と関税連合)

Graduate School of Economics  
Department of Economics (UTIPE)

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# Abstract of Master's Thesis

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Market integration is one of leading factors relating to growth of economies and has been the focus of study for economists since Adam Smith's *Wealth of Nations*. Integrated markets are characterized by the law of one price, as well as higher degrees of co-movement in prices and lower volatility due to the reduced impact of local shocks on total market conditions. For food markets or other essential goods, such changing market conditions can be important not only from an economic distribution perspective but also in terms of survival and security. Studies have generally focused on identifying periods of market integration and found institutions and infrastructure to be the main drivers of integration. The literature has identified a border effect, which is a significant deviation from the law of one price when looking at markets separated by a national border. While borders today are relatively stable, this was not necessarily the case in the past, with wars and other territorial changes occurring regularly. In addition, national and state borders are not the only borders that can be considered important in terms of trade, as economic zones, areas with a common culture or language and even religious bounds could be considered borders and present barriers to trade.

This study seeks to analyze the market integration that took place in 19<sup>th</sup> century Germany. Germany provides a unique case to study the dynamics of market integration, given the history of its unification process in the 19<sup>th</sup> century. Political regimes changed numerous times over the course of the century, starting from the Holy Roman Empire until 1806, the

Confederation of the Rhine until 1813, the German Confederation until 1866 and the North German Confederation until 1871, when the German Empire was founded. At the same time, starting in 1818, various customs unions were formed and merged, starting with three different unions competing until the 1834 formations of the Zollverein and the Steuerverien, which would compete until the full merger of the latter with the former in 1854. Importantly, not all German states were part of the same institutions at the same time, with some excluded from certain ones while others joined later. Certain regions, such as Bremen or Hamburg, were even part of the politically unified German Empire before joining the joined customs area. This yields an opportunity to compare groups of cities within a given union to those outside, treating each union as a border and identifying border effects across these different boundaries. By testing the significance of differences in price and return gaps between within border and across border city-pairs, the goal is to identify which institutions captured the state of market integration in Germany, as well as capture which ones may have improved the integration between markets.

This thesis studies the dynamics of market integration by analyzing the price of wheat from 49 different cities in the territory of the German Empire of 1871. Auxiliary data in the form of geography, railways as well as importantly, the political and customs status of each city is collected for these 49 cities. By observing the differences in prices and returns of wheat between city pairs over the course of the century, two measures of market integration for that city pair are constructed. Using these measures, the study confirms previous findings that taken as a whole, wheat markets in Germany did indeed integrate over the course of the 19<sup>th</sup> century. Looking at the role of institutional changes, custom unions as a whole are found to be significantly and positively related to market integration. This indicates that the geographical boundaries of the unions captured integrated markets well. In addition, using a lagged specification, the custom unions are found to have a generally lasting and significant integration effect. Political entities on the other hand yield mixed results, with there being no noticeable general effect. This result adds to the debate on German unification and the border effect. It provides evidence that it was the customs unions that played the key role in economically integrating Germany and that political unifications were generally ineffective in doing so.

The study takes the analysis one step further and investigates each individual custom union and political union. Political institutions, with the exception of the fully unified German Empire, are generally negatively associated with market integration. This signifies that most of the political borders were drawn around regions that were not on aggregate well integrated to one another. Furthermore, when using a lagged treatment specification, most of these unions had no significant effect on future integration, implying that they were not the primary drivers of integration in Germany. Most customs unions on the other hand show generally favorable relationships with market integration. While some prior research has focused on the importance of the Zollverein in terms of economically unifying Germany, these smaller unions cannot be dismissed and likely assisted in integrating smaller clusters of markets throughout Germany, which in turn were integrated with each other through their merger into the Zollverein. Future work in market integration would benefit from looking beyond the narrow definition of borders at the national and state level, and including less visible borders, such as trade unions, currency areas or even linguistic or cultural areas in order to identify market integration in a broader manner.

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# 1 Introduction

As a unified nation, Germany has a rather short history compared to its neighbors, having been unified rather recently in 1871. Prior to this unification, what we consider to be Germany today consisted of various Kingdoms, Duchies and other independent states. During the 19th century, these states were at various points in time parts of different, larger confederations, or what can be considered nations, resulting in a large redrawing of the maps of Germany, with several different political entities existing and then disappearing. The first customs unions also sprung up during this period, with three union spread across almost the entire German territory competing initially until several mergers would lead to the formation of the *Zollverein* in 1834, which would grow to incorporate most German states in a unified customs area.

The nature of these political and economical shifts were generally staggered or partial, in that states joined these unions and entities over time, and some states were not members of certain unions at any time. As such, there is a large degree of heterogeneity at any point in time regarding the membership of any state to any of these institutions. This presents an ideal opportunity to study the effects that these institutional changes had on aspects of the German economy. In particular, this study focuses on the integration of markets during the course of the 19th century, using price gaps and return gaps of wheat prices between cities as measures of market integration.

Market integration has been studied intensely over the past decades. Ever since [Smith \(1776\)](#) it has been one of the most popular explanations of economic growth and correspondingly, a large amount for research has been dedicated studying the nature in which markets have integrated, both on a national and international scale. For any given good, one can consider the difference in prices of that good in two integrated markets to be bounded by what shall be termed arbitrage costs. These arbitrage costs can consist of many components, such as trade costs, transport costs, conversion costs and other more broadly defined aspects such as political, geographical, religious or even linguistic barriers which may affect the prices of a good between two cities ([Wolf, 2009](#)). As these barriers and associated costs decrease, the expectation is a decreases in price gaps between integrated markets and at the same time less sensitivity of prices to local shocks and hence lower volatility and more co-movement to those of other cities ([Federico, 2012](#)). Changes in prices across cities is also a measure of integration, and the expectation would be that integrated markets move similarly in order to maintain any equilibrium price gap that may exist. The smaller the arbitrage costs, the smaller deviations between returns in integrated markets should be, in order to maintain the equilibrium price gap condition.

Previous studies have identified and analyzed market integration in Germany (see e.g. [Uebele, 2010](#); [Uebele and Gallardo-Albarrán, 2015](#); [Keller and Shiue, 2014](#)). This is done by confirming the convergence and increasing correlation of prices and their movements across cities, as well as identifying co-integration and volatility

reduction. Regarding price differential drivers, the general literature has found a significant impact of national borders on price differentials around the globe. This decomposition is generally done using a gravity model (Anderson and Van Wincoop, 2003), using distance and national borders as explanatory variables. Using such an approach, Keller and Shiue (2014) establish a connection between mutual *Zollverein* membership and price differentials between German cities.

As shall be outlined in what follows, there were various precursors to the *Zollverein* and potential confounding factors due to the volatile nature of German statehood during the process of expansion. Studying these shifts and their impacts on price differentials adds to the debate on market integration, border effects as well as German economic history. In general, customs unions are found to have had a positive impact on market integration. This effect is not equal across customs unions and the precursors to the *Zollverein* cannot be dismissed in terms of their importance in integrating geographically separate markets. Political entities are in general found to have had a negative impact on the integration of markets, leading to the belief that the main driver of integration over the course of the 19th century was indeed the *Zollverein*. When breaking down the effect of each individual political union, it is found that some of these institutions did have significantly positive impacts on certain metrics of market integration, although in general markets within a political union showed larger price gaps. This provides evidence that for the market integration process of Germany, it was primarily the customs unions which aggregated the markets and drove integration to increase and spread. Railways are shown to have mixed results, with a connection between two cities not being significantly related to a reduction in trading costs, but the number of lines from a city do significantly reduce the price gaps associated with that city.

In what follows, the history of Germany beginning in the late 18th century (at the time, the Holy Roman Empire existed in this region under consideration) until unification in 1871 will be covered. This is separated into a political section, covering the various political entities that were made up of the German speaking states of the time, and an economic section, detailing the development of the *Zollverein* and its precursors. Section 3 briefly describes the concept of market integration and past results, and details the hypothesis that this thesis will test. The data used in this procedure is introduced in Section 4, while Section 5 presents the methods and discusses the results.

## 2 German History

This section proceeds to provide a detailed overview of the events which affected German affairs in the periods under observation, with particular focus being placed on political entities, geographical shifts in borders and customs policies that were enacted (Pierenkemper et al., 2004a). As such, this section will first describe the phases of political and territorial shifts that occurred within the German speaking territories in a near chronological order, starting with final stages the Holy Roman Empire and ending with the unified German Empire of 1871. Then, economic policies and trade agreements between member states within this area will be covered.

### 2.1 Political and Geographic History

The Holy Roman Empire (*Heiliges Römisches Reich Deutscher Nation*, henceforth referred to as HRE) was the political entity which covered the majority of the German speaking territories at the end of the 18th century. It was headed by an Emperor and had several centralized institutions yet no real central power. Roughly 300 states could be found within its borders, and these entities were various Empires, Kingdoms, Duchies and other sovereign states, which were for the most part economically and politically sovereign within their boundaries. Figure 1a shows the complex nature of the territory, with the red thick border signifying the boundaries (Kunz, 2014).

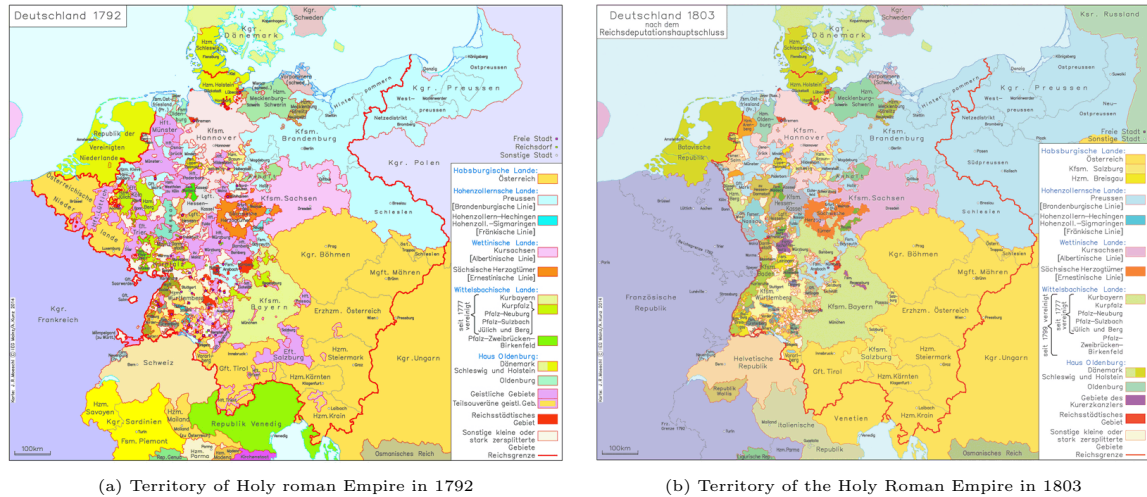


Figure 1: Maps of the Holy Roman Empire in 1792 and 1803. Source: Kunz (2014): IEG-MAPS Map 720 and Map 721

Interestingly, there were some territories belonging to foreign heads of state as part of the HRE, such as Hanover and Schleswig, which were states under the rules of the monarchs of Great Britain and Denmark respectively. At the same time, some territories of constituent states were excluded from being part of the Holy Roman Empire, such as the eastern part of Prussia (most notably perhaps the city of Königsberg, known today as the Russian city of Kalinigrad) or the Hungarian territories of Austria (Pierenkemper et al., 2004a).

The French Revolutions, and the subsequent arrival and rise of Napoleon changed the political and geographical landscape considerably. 1806 marked the official dissolution of the HRE, with the abdication Francis II, when all imperial states and officials were released from any oaths and obligations to the Empire. Prior to dissolution, one of the final major laws passed was the **Imperial Recess of 1803** (*Hauptschluss der außerordentlichen Reichsdeputation*, known also as the *Reichsdeputationshauptschluss*), which saw the number of states within the territory significantly decline. The result was a simplified, albeit still complex web of territories which can be seen in figure 1b. This law is part of what is referred to as German Mediatisation, a series of territorial restructurings that occurred within Germany until the Vienna Congress of 1815 (Wilson, 2011) and resulted in the formation of the German Confederation (*Deutscher Bund*, henceforth GC), a political union of just 39 States, covering most of the territory of the former HREs 300 states (Whaley, 2012).

There was however an intermediate step before the GC could be formed. The dissolution of the HRE followed the defeat of Austria to France at the Battle of Austerlitz and subsequent secession of many vassal states of the HRE. After the aforementioned Imperial Recess of 1803, borders were redrawn and new political entities were formed via mergers, as well as French whims (Wehler, 1987). Several newly independent states allied themselves with Napoleon’s France, and would found the Confederation of the Rhine (*Rheinbund*, henceforth CoR)<sup>1</sup>(Schmitt, 1983). The Austrian Empire and Kingdom of Prussia still remained independent of the CoR, although they each had to make major territorial concessions. Figure 2a shows this initial state of affairs.

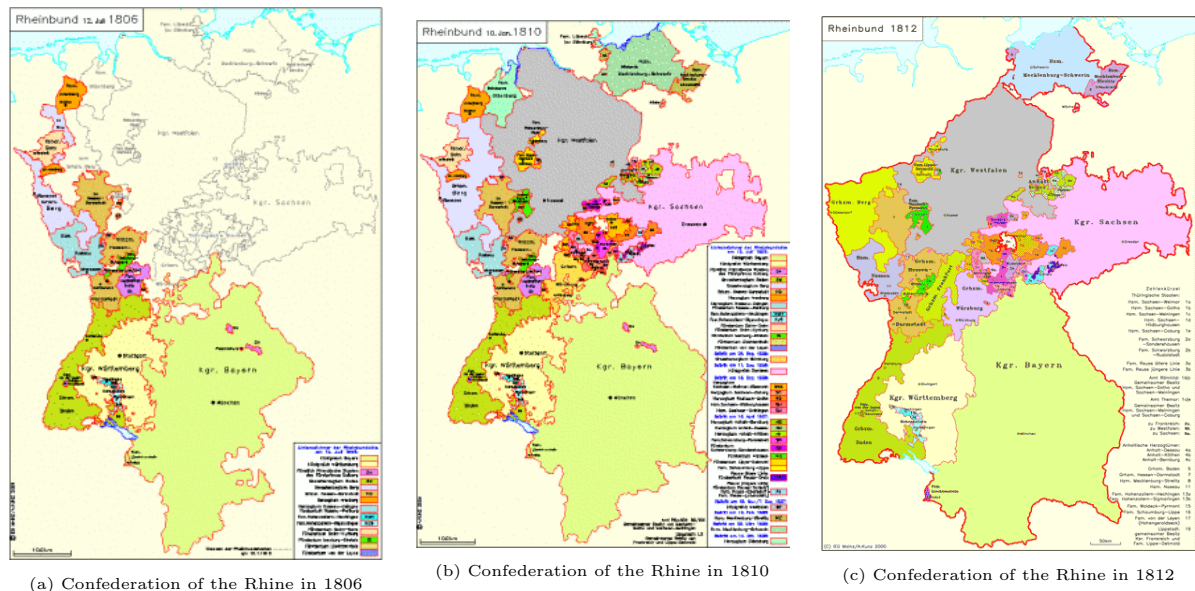


Figure 2: Maps of the Confederation of the Rhine in 1806, 1810 and 1812. Source: Kunz (2014): IEG-MAPS Map 553, Map 555 and Map 002.

<sup>1</sup>The states were: Bavaria, Württemberg, Baden, Hesse-Darmstadt, Nassau-Usingen, Nassau-Weilburg, Frankfurt, Berg, Würzburg, Hohenzollern-Hechingen, Hohenzollern-Sigmaringen, Liechtenstein, Isenburg, Salm-Salm, Salm-Kyrburg, Arenberg and Leyen

The CoR expanded and at its zenith, 18 more states joined the ranks to make a confederation of 35 states. As a political entity, the CoR may be considered to be the first precursor to the modern German State, and has been considered a significant milestone in terms of unification of the German people under a single nation state (Schmitt, 1983). Many institutional changes were enacted in these territories, which for the most part have been found to be significantly impactful on economic development in these regions (Acemoglu et al., 2011). Figure 2b and Figure 2c show the expansion process, and comparing these maps with modern Germany provide a large overlap of the territories within its current western parts. With this, the former HRE was essentially split into 3 political entities, the CoR, Prussia and Austria. Such a situation would continue until the defeat of Napoleon and the subsequent dissolution of the CoR in 1813.

Upon the defeat of Napoleon after over 20 years of near continuous war and the collapse of the French Empire, the Congress of Vienna was called upon between 1814 and 1815 in order to discuss and reconstitute the political order in Europe (Pierenkemper et al., 2004b). The result most relevant for this particular study was the establishment of the previously mentioned GC (German Confederation)<sup>2</sup>. Figure 3a shows the state of this new entity in 1820, with the external borders being nearly identical to those of the the HRE. Looking within however, reveals noticeable changes; as mentioned, a result of the German Meditisation process was the reduction in the number of states within the territory from around 300 to only 39 and this would be reduced to just 33 states by the end of the confederation in 1866 (Henderson, 2013).

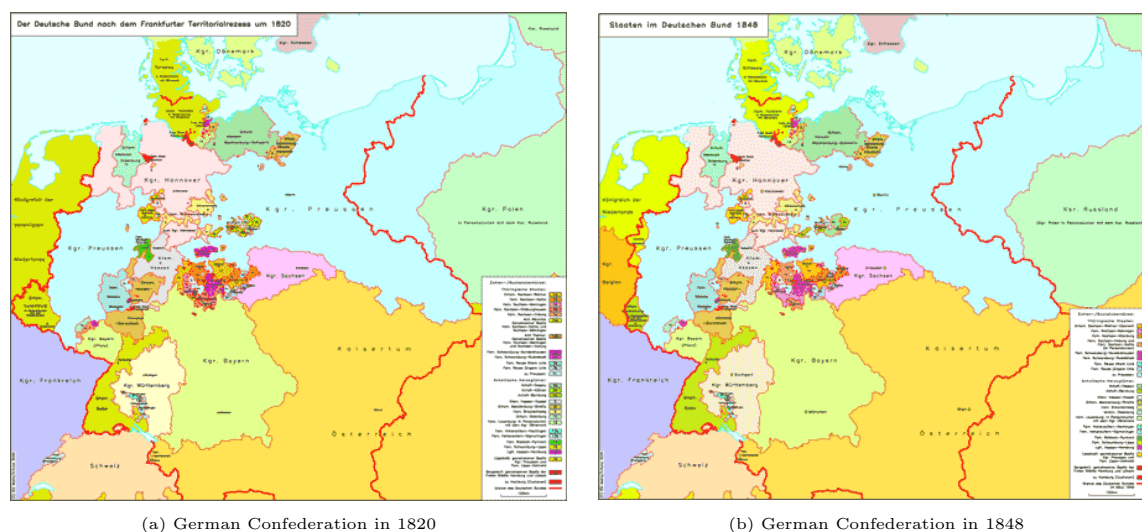


Figure 3: Map of the German Confederation in 1820 and in 1848. Source: Kunz (2014): IEG-MAPS Map 004 and Map 005.

With the territorial consolidation, as well as some changes enacted by Napoleon, the power structure within the GC could be divided among the major powers of the

<sup>2</sup>Given its 56 years of existence, the GC has a considerably more detailed history than depicted in this thesis. A more detailed history of the legal and political structure of the Confederation can be found in literature surveying the issue more closely (Huber, 1969; Rumpel, 1990)

Kingdoms of Prussia and Austria, the central and southern states, such as Bavaria, Württemberg or Hanover, which were medium sized powers and the remaining, smaller states which represented the smaller powers within the region, many of which were actually enclaves of the larger states around them. This state of affairs proved to be a rather stable situation. As can be seen by comparing figure 3a to figure 3b, little changed in the interior of the GC over the course of its existence. On the western border, several changes took place to facilitate the establishment of the Kingdom of Belgium.

Similar to the prior HRE, some territories were excluded from this confederation. The confederation itself served as a unification mechanism, but was required unanimity from the member states to take any form of collective action. Assessment of the GC has generally been unfavorable (von Treitschke, 2012), and to this present day it is considered more to be a confederation borne out of the concern of security and peace in Europe than any attempt to unify the German people under a single nation state (Graaf et al., 2019; Breuille, 1996). Political representatives of the member states at the time were confused as to where borders of their respective states, and in fact even of the confederation itself, lay. Most religious and political matters were also left to the states themselves, making it very difficult for the confederation as a whole to work effectively (Henderson, 2013).

The rivalry between the major powers in the confederation, Prussia and Austria, would lead to tensions throughout the course of the century. Prussia, becoming increasingly aggressive within the GC, forced some of the medium sized states to align themselves with Austria for the sake of their continued independence (Burg, 1992). Through the course of the 2 Schleswig wars in 1848 and 1864, the GC, led by Prussia and Austria, would annex the states of Schleswig and Holstein. The two powers jointly administered these two regions until 1866, when Prussia would annex the entire territory, starting and winning the short but important Austro-Prussian war and effectively dissolving the GC.

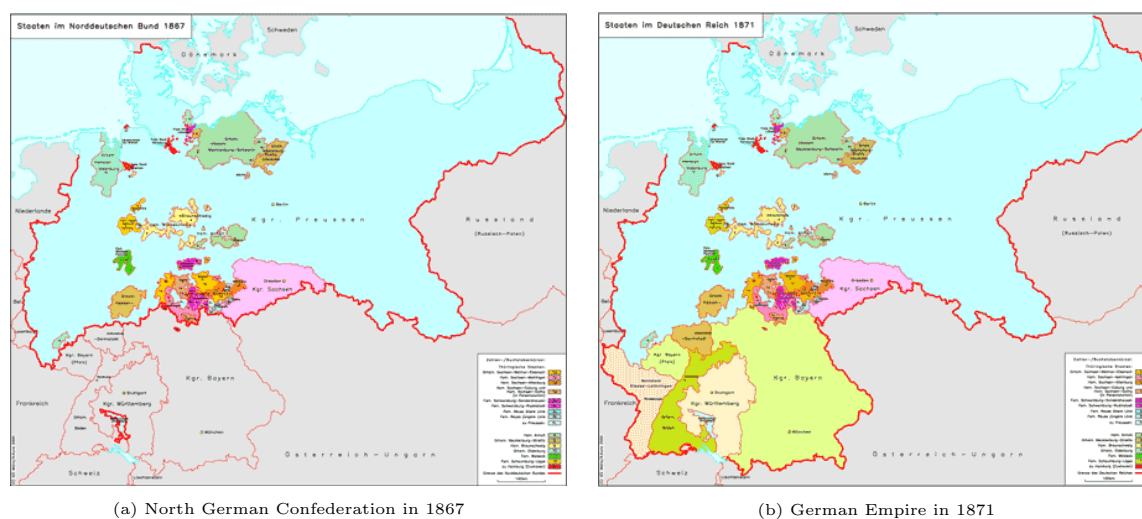


Figure 4: Map of the North German Confederation in 1867 and the German Empire in 1871  
Source: Kunz (2014): IEG-MAPS Map 006 and Map 007

The war would result in the balance of power tipping in Prussia's favor and would split the German states once more, with Prussia and other northern states forming the North German Confederation (*Norddeutscher Bund*, henceforth NGC), while the southern states and Austria would become fully independent Kingdoms not belonging to any union. Many territories and states in the central and northern German territories, which had aligned themselves against Prussia in the war, were annexed and incorporated into the NGC. Prussia, having exerted its dominance within German affairs, effectively forced Austria out of all German matters. Figure 4a shows the borders of the NGC. The territories of Prussia, which had thus far been excluded from the GC, were now included as part of this new confederation.

The states in the south, as losers in the war, were forced into an effective military alliance with the NGC. This became important when, in 1870, France declared war on Prussia. With the exception of Austria, the remaining states joined the NGC, and after a swift victory against France, in 1871, the German Empire (*Deutsches Kaiserreich*, henceforth GE), was born. This empire would, in its form exist until 1914, with the onset of WW1. The territory it covered can be seen in Figure 4b; in addition to the southern states joining in 1870, the GE consisted of the territory of Alsace, annexed from the French upon victory in the decisive war.

## 2.2 Customs Unions

A customs union is an area in which free trade is possible, with a common external tariff connecting the customs union area with any external economic activity. This means that, in order to set this external tariff, all member states have to negotiate and cooperate, unlike a free-trade area, in which there is also free trade, but where there does not exist an external tariff and instead, members are free to negotiate their own agreements with third states and entities. The *Zollverein* (henceforth ZV), established in 1834 is considered by many researchers and historians to be the prototypical attempt to form customs union (Viner, 2014).

The ZV was established after the mergers of several prior customs unions that existed within the territories of the former HRE. The state of trade within the German territory towards the end of the 18th century and beginning of 19th century shines a light on why such customs agreements naturally arose. The HRE consisted of around 300 sovereign states, whereby each state could independently create its own legislature. Included in this freedom for creating laws was the ability of the states to dictate their own customs and trade policies. While no state had a customs border around its territory, every city essentially had customs controls at their gates (Linner and Henke, 2014). This led to chaos in terms of trade, as there were as many as 1800 customs lines within the German territories at the time of the Empire's collapse (Hahn, 1984). This state of affairs had existed for much of medieval and early modern Germany, with it being described as *miriam Germanorum insanum* (Henderson, 1934). Many states had already reduced or abolished many tariffs within their states by the time the CoR fell and was replaced by the GC. However, these were limited to areas within states, and multiregional unions would still take several years before materializing. The incentive was particularly large for Prussia

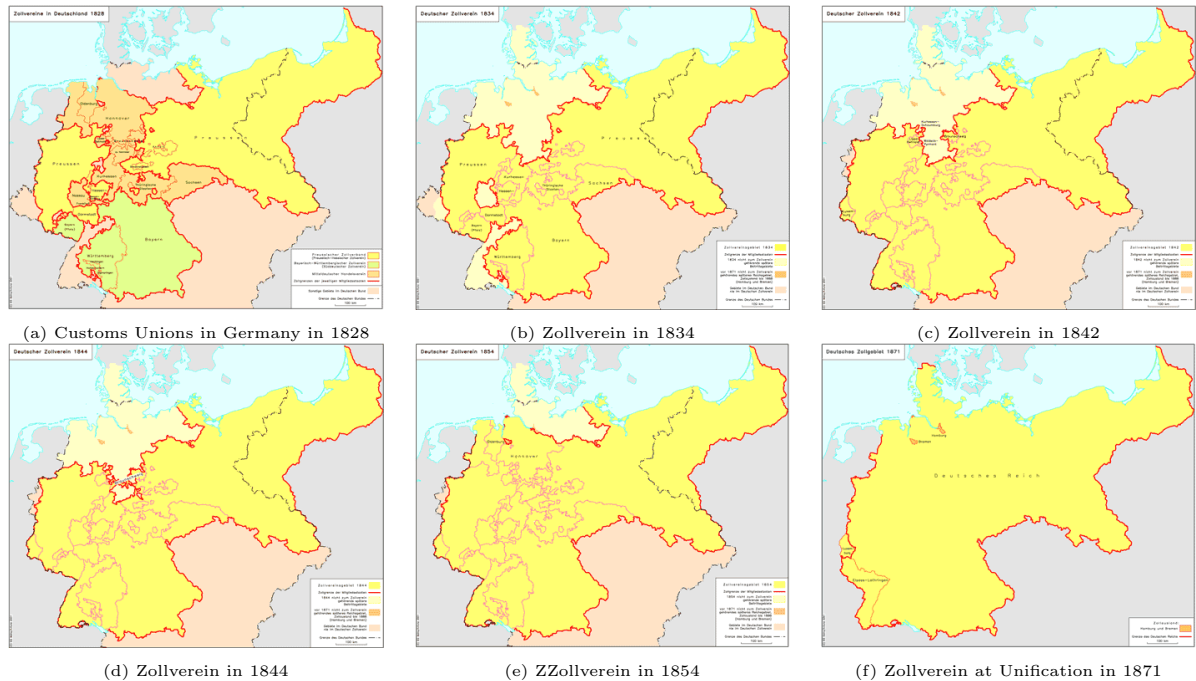


Figure 5: Maps of the Customs Unions within Germany between 1828 and 1871. Figure a) shows the competing customs unions, the PH, SG and MDHV in 1828. The maps b) - f) show the development of the ZV from 1834 until 1871.

to create a toll-free area over German territories, given the geographically separate nature of its territories (see Figure 3a, light blue areas). In 1818, the kingdom moved first and abolished all internal tariffs within its territories. This would mark the start of the customs union within the region. Over the course of the next decade, Prussia would realize the advantages of its large internal customs free area, and all states would start negotiations (Linner and Henke, 2014).

1828 marks a large shift, with 3 customs unions springing up, in direct competition to one another. Chronologically, the first union was the South German customs union (*Süddeutsche Zollverein*, or *Bayerisch-Württembergische Zollverein*, henceforth SG), which was initiated by the southern Kingdom of Bavaria and joined by its neighbor, the Kingdom of Württemberg. This was created out of an unwillingness of the Bavarian crown to join any Prussian influences. At nearly the same time, Prussia expanded its own internal customs union by having the Grand-Duchy of Hesse join it. As a countermeasure to these two unions, led and managed by two of the more powerful forces within the German Confederation, numerous central German states joined in creating the Central German Union (*Mitteldeutscher Handelsverein*, henceforth MDHV). This union was mostly created as a measure to prevent its member states from joining either of the other two unions, out of fear of a growing influence in both economical and political matters of their respective leaders (Henderson, 1934). Figure 5a depicts the competitive situation in 1828, with the MHDV notably creating a corridor between the two halves of the Prussian Kingdom.

The MHDV was effectively crippled as negotiations between the states and unions moved on, and in 1833, Prussia could convince the majority of the MHDV's mem-

bers, as well as Bavaria and Württemberg, to accept its terms of a universal tariff and join what would become the *Zollverein*. The treaty involving 18 states of the GC came in effect in 1834, with Figure 5b showing the state of affairs. Several members of the MHDV could not be convinced to join, and four of these states<sup>3</sup> would move to form the Tax Union (*Steuerverein*, henceforth SV), a new customs union to compete with the *Zollverein* (Ploeckl, 2015).

Within the ZV, duties were raised once at the border of the customs area, and all customs income was distributed to the member states on a population basis. With agreements being made with foreign powers, the allure of joining the ZV increase and states gradually joined over the course of the 1830s and 1840s. The SV came to an end in 1854, when Hanover was convinced by Prussia to join the ZV, and with it the other member states progressively joined (Figure 5e). After the political developments in the 1860s, annexed territories were included within the customs union and at the point of unification of 1871, the territory of the ZV almost coincided with that of the GE (Figure 5f). The exception were the free cities of Bremen and Hamburg, which had secured special treaties ensuring they stay out of the customs union even as members of the GE, given the higher tariff of the customs union relative to their own, as port cities. They would join the customs area in 1885 (Bremen) and 1888(Hamburg) respectively, completing the political and economic unification of German (Henderson, 1934).

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<sup>3</sup>Hanover, Braunschweig, Oldenburg and Schaumburg Lippe

## 3 Market Integration

### 3.1 Theory and Measurement

In economic literature, market integration has been a popular explanation of economic growth. Since the publication of *The Wealth of Nations* by Adam Smith (Smith, 1776), economists have emphasized the importance of trade, which allows economies to specialize and achieve a more optimal allocation of resources. Integration is a key aspect of trade, as two economies which are not trading can be considered to be non-integrated. Over the past 20 years, a branch of research has focused on analyzing the market integration process in the early modern period (Chilosi et al., 2013; Jacks, 2006a). Consensus is mixed, with various causes and timelines being suggested for the process of integration within the European markets (Federico, 2012). This study provides a slightly different approach, following in the footsteps of Keller and Shiue (2014) and using the case of Germany in the 19th century.

Other than the aforementioned Smithsonian growth as a consequence of market integration (Kelly, 1997), there may be many additional effects that are beneficial for economies and individuals, which make the study of the process of integration worthwhile (Albers et al., 2018). Integrated markets are ceteris paribus less prone to local shocks and more efficient, with prices conveying more information to participants. Food market integration and the accompanying price volatility reduction are a welcome developments for consumers. Pertaining to grains, the main focus of this study, there are empirical connections between grain price increases and mortality, as well as price volatility increases and death rate rises (Albers et al., 2018; Pfister et al., 2010). This channel is another which can lead to economic growth, as demonstrated by Kögel and Prskawetz (2001) in their model, whereby survival probability is an exogenous factor affecting sustained growth trajectories.

Cournot et al. (1897) first mentions the concept of market integration in his 1838 work (Cournot, 1838), in which he characterizes such integrated markets to be '[... an] entire territory of which the parts are so united by the relations of unrestricted commerce that prices there take the same level throughout, with ease and rapidity.' (Cournot et al., 1897, p.51-52). As Federico (2012) states, this definition can be taken to mean two things, first that prices within an integrated market must be equal, and that subject to any shock, they should revert back to this equilibrium level *rapidly*. Samuelson (1952) first formalizes a model of trade, in which market integration is based on the distribution of goods across markets, with perfect integration being achieved if they are distributed optimally given local demand and supply. Since then, many papers consider a model based on two spatially segregated markets in a two stage adjustment process. The idea is based on the prices of a good in cities  $i$  and  $j$ , denoted as  $P_i^t$  and  $P_j^t$  respectively for a given period  $t$ . The differential between these prices should, according to the Law of One price in its most strictest form, be equal to 0. If the difference were not 0, then it would be profitable for some arbitrageurs to exploit the differentials and make profits by selling the good from one city in the other.

In practice, there are some restrictions on these conditions. The most simple of which are the costs associated with the trade of goods from one city to the other, which this hypothetical arbitrageur would face and so it becomes a matter of observing whether the prices are "close" enough to each other. Given two locations  $i$  and  $j$ , we would expect that the differential of a goods price in these cities be bounded by the arbitrage cost  $\tau_{i,j}^t$ . This  $\tau_{i,j}^t$  can be thought of consisting of various things, such as transport costs, storage costs, exchange rate costs, tariffs and other factors, such as administrative or political costs. Mathematically, this means that in integrated markets, the following condition must hold:

$$|P_i^t - P_j^t| \leq \tau_{i,j}^t$$

Should the price differential exceed this, then in an integrated market, we should expect the gap to decrease swiftly to fulfill this condition. On the extremes, we would have non-integrated markets on the one hand, where prices and changes in prices in one market should have no effect on the other markets whatsoever. Changes in the factors that make up  $\tau_{i,j}^t$  should have no impact on price changes in either city, as they are by definition not integrated. In such a situation, each local market is fully dependent on its own local shocks and due to the lack of linkages, we would expect severe price volatility. On the other hand, in perfectly integrated markets, prices are fully dependent on each other and any changes in one market reflect instantly into another and are arbitrated away. Hence, for any reduction in  $\tau_{i,j}^t$ , the expectation is that prices in  $i$  and  $j$  also grow closer together. Price volatility should decrease, as markets are less susceptible to local shocks. The no arbitrage condition implies that prices between cities should not move too differently from each other in order to maintain the condition, which could result in higher co-movement of prices between cities.

Testing market integration is usually done by using measures to either test the Law of one price, or the operational efficiency of markets. The former is usually done by observing the convergence of prices over time, or the decline in absolute price differentials between two locations over time. The coefficient of variation of prices can also provide a good measure of the dispersion of prices across markets, and the expectation would be for it to decline over time. The latter measure of integration is usually tested by observing movements in prices, that is by checking co-integration of prices, correlation of prices and volatility of prices, as a consequence of the efficiency of integrated markets.

[Federico](#) ([2012](#)) provides a comprehensive overview of studies dated until the time of his publication on the state of research in this field. Studies span from studying integration within single, domestic markets, to larger economic regions categorized as Europe, or the transatlantic. The focus is generally placed on either the early modern or the modern period, with the Napoleonic Wars being considered a cut-off or starting point for these studies. General consensus is that the 19th century proved to be an era of domestic market integration within European countries and that cross country integration took place within the first half of the same century, followed by a slow down or reversal in the process as countries enacted protectionist

policies in the second half of the century (Federico, 2011, 2007; Federico and Persson, 2007; Persson, 1999; Uebele, 2011). Specifically, at a European international level, Jacks (2005) finds that European markets integrated along both dimensions of price convergence and co-movement or adjustment. This holds true within countries, as well as across the countries within the sample. Chilosì et al. (2013) also provide a comprehensive, Europe wide analysis of market integration. Their results show that integration across the plains took place gradually over a long period of time. They also group the integration that took place and find that, while some countries showed integration within borders, that there were groups of countries that seemed to integrate together.

Focusing on domestic German markets and intra-national integration, the focus of this study, results are similar. Studies focusing on smaller regions within the territories of Germany today find rising market integration (Fremdling and Hohorst, 1979; Gerhard and Engel, 2000; Kopsidis, 2002). Looking at a broader territory, integration is confirmed to have taken place in the 19th century, and the German market as a whole also integrated with the global markets during this period (Uebele, 2010; Uebele and Gallardo-Albarrán, 2015; Jacks, 2005).

## 3.2 Drivers of Market Integration

Despite the large amount of attention placed on market integration, most research focuses on whether markets integrated and do not consider drivers or consequences of the integration. As with any causal analysis, this is fraught with difficulties, made all the more difficult by the fact that data of various variables during the periods under consideration are at best sparse, and for the most part incomplete, inaccurate or just unavailable. Nonetheless, results that do exist have identified several drivers (Federico, 2012). The first is the technological progress and innovation that took place, in particular the development of railways, that made transportation of goods across vast distances substantially more affordable and possible to scale. The second is that of institutions. Increased centralization, trade policies and other agreements are also found to be large drivers of a reduction in trade barriers and thereby influences on market integration (Federico, 2007; Keller and Shiue, 2008, 2007).

Over time, advances in infrastructure and technology, as well as changes in policies aimed to reduce trade barriers have undoubtedly had an impact on the arbitrage costs  $\tau_{i,j}^t$ . The implication of this is that, the bound on the price differential has reduced, meaning that price differentials should decline in tandem with these changes. At the same time, this narrowing of the permissible price gaps means that changes in prices across markets must also become more similar in order to not violate the no arbitrage condition. Hence, analyzing the relationship between potential factors making up the arbitrage costs and the price or return gaps can shed some light on the drivers of the integration process, as by Cournot (1838)'s conditions.

### 3.3 Borders and Market Integration

Related to institutional market integration, the border effect is a phenomenon commonly found in the literature, whereby two cities that are on different sides of a border (both international and within a nation but e.g. across states, provinces etc.) show signs of lower trade volume and are less integrated than their counterparts on the same side of the border (Schulze and Wolf, 2009; Shiue, 2005). Put simply, these are noticeable deviations from the law of one price when one compares prices across a border. This can be fairly large an effect even for developed countries borders, such as the case of the US Canada border, with effects found ranging between 20 and 50% reductions in trade (Anderson and Van Wincoop, 2003).

Yet this approach raises the question of which borders one should consider when analyzing the border effect, as many countries have historically had shifting borders over the course of their history. A border can exist based on national, intra-national lines, as well as under other more nuanced definitions such as those created by agreements based on trading policies or special economic zones. Cultural aspects, such as language or a common religion, may also factor into this distinction. For any arbitrary border, consider some "within border" city-pairs, that is both cities are on the same side of the border, and "cross border" city-pairs, that is the cities are on opposite sides of a border. If there were a significant larger price differential on average among the cross border pairs, we would conclude that there is a border effect. This means that, the border captures market integration well, in the sense that markets are not integrated well across the border, compared to those within border city pairs. On the other hand, if there were not significant effect, then it is not possible to conclude that the border has any explanatory power in distinguishing the bounds of an economically integrated area. Should the already present border effects persist, it would be acceptable to conclude that, the border did serve as a boundary for cross border integration. If over time, a difference were to develop between the cross border and within border pairs, then that would even lead evidence to the hypothesis that the border was a driver of integration among the within border pairs.

Wolf (2009) outlines the importance of borders when measuring market integration, as a form of aggregation can take place when defining a large border, such as a national one. He finds that based on 1914 borders, Germany was actually poorly integrated as a whole, with older borders and state lines better capturing local clusters of integration. Although Germany is relatively young, many countries have also experienced volatile territorial shifts and changes to external and internal boundaries, some of which are in fact rather arbitrary. Using such shaky political boundaries as a border is obviously fraught with difficulty, and despite the relatively lengthy tenure of current nation states, present borders may be equally problematic in this regard. In addition, it is perfectly possible that a border runs through an economically integrated area, which would not allow for the detection of a border effect, and combined with an overall increase in integration metrics, lead to the wrong conclusion that the entire area integrated as a whole across borders.

In the second part of their study, (Chilosi et al., 2013) rely solely on price patterns to determine regions with integrated economies based on co-movement. These local clusters do not necessarily conform to the national borders at the time, with some clusters being present within countries. Aggregating such local, integrated clusters may then lead one to conclude that integration took place over a larger area than in actuality. Research boils down to comparing groups of regions within an area to those outside, and seeing if there is a significant difference in trading volume or prices between these two groups. If a border effect exists, then on average, any city-pair across the border should on average be less integrated than a city-pair within the border. Using a border for this purposes can be thought of as testing whether the political boundary captured the economic boundary.

## 4 Hypothesis and Data

### 4.1 German Market Integration Drivers Hypothesis

The previous sections have outlined the concepts of market integration and illustrated the various institutional shifts Germany has experienced throughout the 19th century. Exploiting these institutional changes in tandem with transport and infrastructure related information, this study attempts to shed the light on the drivers of market integration that occurred within the observed territories over this period of time (Federico, 2012; Jacks, 2006b).

Keller and Shiue (2014) and Shiue (2005) are closest to this study in terms of research approach and setting. Exploiting the heterogeneity in the accession of German states into the *Zollverein*, they find a significant effect akin to a border effect between states within the union and outside of it. While the *Zollverein* can be considered reasonable to test given the direct economic implications of a custom union on their members market structure, the complex history of the region under consideration and the numerous political and economic shifts that occurred within the territory provide several different sets of borders to test. These developments resulted in Germany essentially having two sets of borders at any given time, those based on the political unions and those dictated by the customs agreements. Brou and Ruta (2011) create a model in which political and economic integration are separated and find that both can interact in a complimentary manner. However, this finding relies rather obviously on the political and economic integration actually taking place in the region. But, as discussed here, it is not necessarily the case that a politically integrated area is also economically integrated. Work on market integration and the border effect may hence become a matter of checking whether the political unification of a region matched economic reality. Taking into account of the various other unions that existed prior to the *Zollverein* in 1834, as well as the political hierarchy and possible borders that may have existed at the time comes as a natural extension of Keller and Shiue (2014)'s work.

Important for the analysis is that there is the variation in the bilateral "membership" of two cities at various points in time, giving rise to significant homogeneity in the panel. Exploiting the differences in the timing of "membership" to customs unions<sup>4</sup> and political institutions<sup>5</sup> at any given time. As such, they can effectively be considered as shifting borders of a parent political and economic organization, and the analysis is focusing on comparing within border city pairs to cross border city pairs.

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<sup>4</sup>States gradually joined the *Zollverein*, while e.g. Hanover was initially part of the Prussian Customs Union but then not a member of any union until it decided to join the *Zollverein* in 1843

<sup>5</sup>For example, the city of Königsberg is not part of the Holy Roman Empire, the Confederation of the Rhine or the Temporary German Empire, but part of the others, while while the city of München is part of the Holy Roman Empire, Confederation of the Rhine and German Confederation but not in the Temporary German Empire or the North German Confederation. For the Confederation of the Rhine, states initially founded it but more states were gradually added over the years until its demise in 1814.

This study proposes an approach similar to the models of Keller and Shiue (2014) and Missiaia (2009), as well as Uebele (2010). A measure of bilateral city-city market integration is regressed onto variables indicating bilateral membership to various unions. The hypothesis are that firstly, market integration should take place as a whole across the sample of cities. When testing the institutions, a border effect should exist between within border city pairs and cross border city pairs. More precisely, any within union city pairs should, *ceteris paribus*, exhibit smaller price gaps and return gaps. An insignificant difference on the other hand would indicate that the border being used has no explanatory power in marking the edge of an integrated markets geographical reach. A significantly higher price or return gap among within border city pairs would indicate that for that metric of integration, the border was actually not a good approximation of where the cluster of integration was, as cross border pairs are better integrated than their within border counterparts. Looking further, by expanding the analysis using a lag, the development of markets can also be studied. If a border effect exists in future for a border, then this would add evidence to the hypothesis that this border aided in the integration of the within border city-pairs relative to their cross-city counterparts. Should the within border pairs exhibit higher gaps after a certain number of periods, then this would suggest that the border was actually detrimental to integration of the within border pairs.

## 4.2 Price Data

As is common in market integration literature, this study employs the use of grain price data. Wheat is considered a representative good for the analysis of prices at the time, given its role in consumption and trade (Chilosi et al., 2013). Due to this, and the fact that prices are the most readily available out of any commodity for long periods of time in various locations throughout the globe, many past works rely on the wheat price. Specifically, the main data is the historical series of wheat prices from various German cities starting at the end of the 18th century. Appendix A lists all the cities for which this was possible, along with the periods for which the data are available and the sources used.

The study focuses on the period 1790-1900. This period covers all of the regimes discussed in section 2, starting with the final decade of the Holy Roman Empire and ending with the first several decades of a unified Germany. 1790 was chosen as a starting date, partially because of data constraints and also as the year following the French Revolution, it can be considered the first year of a new era in European history.

Making all series comparable across locations and time is complicated given the fact that many states and kingdoms at the time used different, local measures of volume when it came to grain, as touched upon in Section 2. Using historical tables provided by Gerhard et al. (1990) regarding the silver content of local currencies and volume of local units, these series have been converted to be expressed in grams of silver per 1000kg of wheat, as is de-facto standard in this form of study (Chilosi et al., 2013; Keller and Shiue, 2014; Jacks, 2006b; Federico, 2012).

After unification in 1871, all regions under observation with the exception of Vienna switched to the national Reichsmark as a currency, which was backed by gold and under the authority of the Reichsbank. However, the silver coins of the states still circulated as legal tender well into the 20th century, making the monetary situation a rather complicated affair (Theurl, 1998; Lotz, 1893). For this study, the gold-silver ratio and gold content of the Goldmark is used after 1871 to convert all Goldmark prices into silver prices. This is to ensure that continuity and comparability is maintained in the price series over the entire period in terms of units. As a final step, the natural logarithm of the prices are taken, in order to allow the first differences to be interpreted as log-returns and to scale the prices, making interpretation of any further results possible in terms of log percentages, so that we have  $Price_i^t$ . Given the demonetization of silver, the gold-silver ratio starts to rapidly decrease after 1880, so one must be cautious in the interpretation of these results after this period. Nonetheless, as all series are denominated in the same, global commodity, comparing the development of prices across cities should not be an issue.

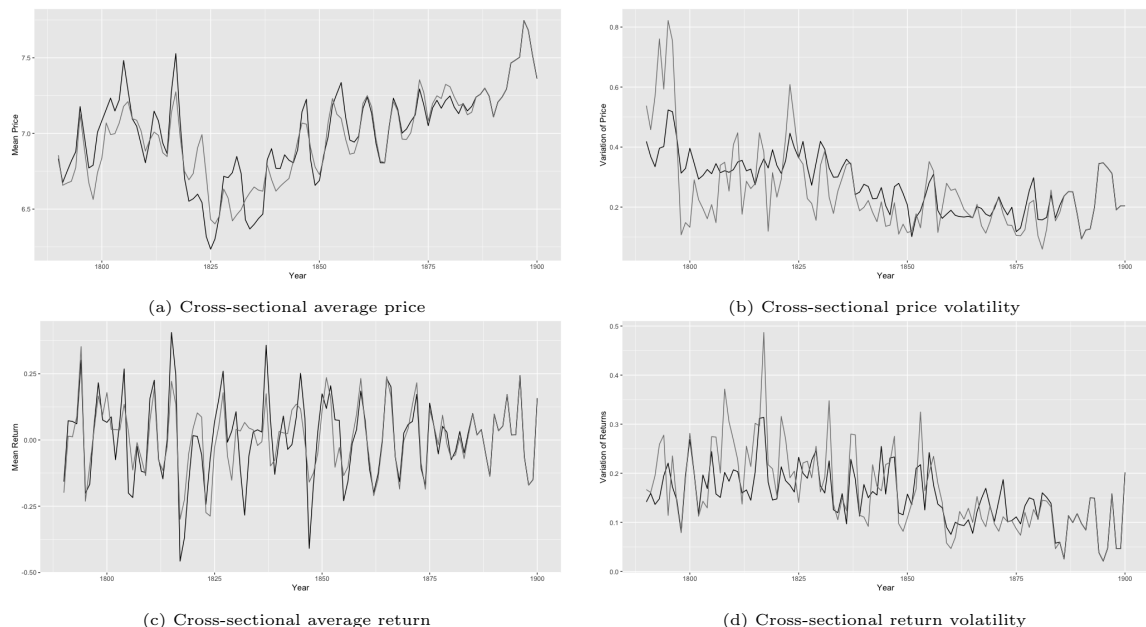


Figure 6: Cross-sectional plots of the mean and standard deviation of the wheat prices and returns. In black is the measure computed across the entire sample, while gray is the measure computed for the sub-sample consisting of the cities Berlin, Hamburg, Köln, Königsberg, Leipzig, Mannheim, München and Vienna.

The obtained panel of prices is unbalanced, with some cities exhibiting severe gaps towards either the beginning or the end of the sample. Over the full sample period spanning from 1790-1900, out of the expected 5439 observations, there are 3224 available, with coverage thinning out towards the end of the sample period. The first row of Table 1 provides simple summary statistics on the price data across the entirety of the panel. The variation in prices is rather large, and the mean and median are rather close. Figure 6a shows the cross-sectional mean price across the period. An initial fall until the mid 1830s is followed by a steady increase towards the end of the sample, although the year-to-year volatility in mean prices seems to reduce in this increasing section. Volatility in the cross-section is also declining over

time, as can be seen in figure [6b](#).

The second measure of integration is based on the first differences of prices, the returns. As prices are already expressed in logarithms, by taking first differences for each city's series, a panel of log returns  $Return_i^t$  is constructed. This panel has exactly one fewer period than the price panel by nature of its construction. The second row of table [1](#) details the summary across the entire panel. As expected for a series of returns, both the mean and median are around 0. Figures [6c](#) and [6d](#) show how the cross-sectional mean and variation of the return series. It is clear that the dispersion of returns reduces over time, just as for prices. This implies that across all of our cities, the percentage changes in prices from year to year become similar over time, that is year-to-year changes in prices between cities seemed to converge. While this alone is not evidence for market integration, taken together with the reduction in price volatility, this is one aspect that points to integration taking place on average in 19th century Germany.

**Table 1: Summary Statistics of data used**

	Description	N	Mean	Standard Deviation	Median	Min	Max
<i>Price</i>							
$Price_i^t$	Logarithm of the price of wheat, normalized across all cities to be equal to the grams of Silver needed to purchase 1000kg of wheat in a local market	3224	6.888	.427	6.897	5.543	8.909
$Return_i^t$	First Difference of Log Price	3166	.006	.242	.000	-.917	.875
$PriceGap_{i,j}^t$	Absolute value of the difference of logarithms of wheat prices multiplied by 100 in two different markets	116925	.323	.299	.2361	0	2.196
$ReturnGap_{i,j}^t$	Absolute value of the difference of returns of logarithms of wheat prices in two different markets	113573	.193	.174	.143	0	1.358
<i>Baseline</i>							
$Distance_{i,j}$	Distance measured in KM between two cities $i$ and $j$ in the sample	1176	348	201.177	9	315	1198
$State_{i,j}^t$	Dummy variable taking on the value 1 if two cities $i$ and $j$ are in the same state in period $t$ and 0 otherwise	116972	.161	.368	0	0	1
<i>Infrastructure</i>							
$Connection_{i,j}^t$	Dummy variable taking on the value 1 if two cities $i$ and $j$ are connected via a railway at time $t$ and 0 otherwise	116972	.096	.295	0	0	1
$RailLines_i^t$	Number of railway lines in city $i$ at period $t$	3224	1.067	2.433	0	0	12
<i>Customs</i>							
$Union_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are in the same customs union in period $t$ and 0 otherwise	116925	.243	.429	0	0	1
$PH_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are both in the Prussian-Hessian Customs Union in period $t$ and 0 otherwise	116925	.008	.089	0	0	1
$SG_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are both in the South German Union in period $t$ and 0 otherwise	116925	.011	.102	0	0	1
$MHDV_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are both in the Middle German Customs Union in period $t$ and 0 otherwise	116925	.008	.096	0	0	1
$SV_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are both in the Steuerverein in period $t$ and 0 otherwise	116925	.015	.121	0	0	1

Variable	Description	Observations	Mean	Std. Dev.	Min	Max	Other
$ZV_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are both in the Zollverein in period $t$ and 0 otherwise	116925	.193	.395	0	0	1
<i>Political</i>							
$Political_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are in the same political union in period $t$ and 0 otherwise	116925	.797	.402	0	1	1
$HRE_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are in the Holy Roman Empire in period $t$ and 0 otherwise	116925	.097	.296	0	0	1
$CoR_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are in the Confederation of the Rhine in period $t$ and 0 otherwise	116925	.026	.161	0	0	1
$GC_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are in the German Confederation in period $t$ and 0 otherwise	116925	.653	.476	0	1	1
$NGC_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are in the North German Confederation in period $t$ and 0 otherwise	116925	.005	.069	0	0	1
$GE_{i,j}^t$	Dummy variable taking the value of 1 if two cities $i$ and $j$ are in the German Empire 1871 in period $t$ and 0 otherwise	116925	.015	.122	0	0	1

Table 1: Summary Statistics of data used

Each row represents a different variable used for the analysis. The first column denotes the variable name as well as the script to denote the dimensions over which the data is covered.  $i$  and  $j$  refer to cities (49 in total), while  $t$  refers to the period (111 periods, 1790-1900 at an annual frequency). The second column briefly describes the data in words. The final 6 columns show the number of observations and summary statistics for the variable in question

### 4.3 Institutional Variables

As discussed in detail in Section 2, the cities under consideration have undergone several institutional shifts, the effect of which are the core focus of this study. Linking these changes to market integration is the core focus of this study and to this end, this section describes how the historical shifts introduced in Section 2 will be analyzed. To summarize, the changes can be viewed from 2 angles. Politically, there have been 5 distinct structure:

1. -1806 Holy Roman Empire
2. 1806-1815 Confederation of Rhine
3. 1815-1866 German Confederation
4. 1867-1870 North German Confederation
5. 1871- German Empire

Economically, there is also a shift, from no customs union, to the introduction of 3 competing customs unions (1818-1834), the establishment of the *Zollverein* (1834-) and *Steuerverein* (1834-1854), and the gradual joining of the other states of the former union.

#### 4.3.1 State

For any two cities  $i$  and  $j$ ,  $SameState_{i,j}^t$  a dummy variable is constructed to indicate whether they are part of the same state. For example, the cities of München

and Würzburg are part of the Kingdom of Bavaria while Berlin has been part of the Kingdom of Prussia for the whole sample period. Hence, we would have  $SameState_{München,Berlin}^t = 0$  and  $SameState_{München,Würzburg}^t = 1$  for all periods in the sample. As can be seen in table [1](#), around 16% of the sample consists of city-pairs where both cities are in the same state.

Given the significance of the border effect discussed in Section [3](#), cities within the same state bounds should exhibit larger trade volumes and ceteris paribus be more integrated. With this dummy, controls can be made for this. Any coefficient associated with this variables onto a measure of market integration is expected to be negative, as we would expect cities within the same state to be more integrated.

### 4.3.2 Customs Union

As described in section [2](#), the areas under observation have gone through several customs unions before ultimately slowly merging towards the singular and expansive Zollverein. These range from no unions during the period of the Holy Roman Empire, up to 1828, where 3 competing unions were established, covering the near entirety of the territory, until the establishment of the *Zollverein* in 1834, which was gradually joined by the majority of the states originally part of the Holy Roman Empire.

The variable  $Union_{i,j}^t$  is equal to 1 if both cities  $i$  and  $j$  are members of the same customs union in period  $t$  and 0 otherwise. This variables captures a pooled memberships status into unions, pooled across all customs unions discussed. Around 24% of the city-pairs in the panel are in the same customs union.

It is perfectly possible that, some unions were more associated with integrating markets than others, while some may have had no effect whatsoever. Distinguishing this study from that of [Keller and Shiue \(2014\)](#) is the separation of the customs unions. Instead of blindly testing whether the association of two cities in *any* customs union affects their respective degree of integration, in a separate specification, instead of pooling all unions as a single dummy, a dummy is constructed for each union. These are denoted as  $PH_{i,j}^t$ ,  $MDHV_{i,j}^t$ ,  $SG_{i,j}^t$ ,  $SV_{i,j}^t$  and  $ZV_{i,j}^t$ , corresponding to the Prussian-Hessian Customs Union (1818-1834), Central German Union (*Mitteldeutscher Handelsverein*, 1828-1833), South German Customs Union (*Süddeutscher Zollverein*, 1828-1833), Steuerverein (1834-1854) and the Zollverein (1834-), with it being equal to 1 if both cities are part of the union and 0 otherwise.

### 4.3.3 Political Affiliation

Similarly to the change in customs unions, the cities in the sample have seen a considerable amount of change in the political institution of which they were a member. While the  $State_{i,j}^t$  effectively is used to capture in country across state border effects, it is also crucial to check for border effects in a higher hierarchy of political border.  $Political_{i,j}^t$  is constructed to capture this, a dummy variable which takes on the value of 1 if the two cities are within the same political institution, as

defined at the beginning of this section, in a period and 0 if otherwise. From Table 1, we can see that 80% of the sample of city-pairs is covered by one of political entity

As with the customs unions, there is data available on precisely which institution each city was a part of and a natural question becomes whether different institutions exhibited differences in terms of market integration. This makes it possible to break down the effects of each political entity, and for each, a dummy variable is constructed to a similar manner as those for the individual customs unions. The are denoted as  $HRE_{i,j}^t$ ,  $CoR_{i,j}^t$ ,  $GC_{i,j}^t$ ,  $RGE_{i,j}^t$ ,  $NGC_{i,j}^t$  and  $GE_{i,j}^t$ , for the Holy Roman Empire (-1806), Confederation of the Rhine (1806-1814), German Confederation (1815-1848, 1851-1865), Revolutionary German Empire (1848-1849), North German Confederation (1866-1870) and German Empire (1871-).

#### 4.4 Distance

For every city pair, the distance is retrieved as calculated by the straight line distance between the two cities. Given that there are  $49 * 48/2 = 1176$  possible city pairs, this gives precisely that many observations. Intuitively, this should have a large impact on transport costs between two locations, and hence work its way into the degree of market integration. The source and method used to retrieve distance data is described in Appendix B.

#### 4.5 Railways

Given the consensus in the literature on the importance of railways in integrating economies (Jacks, 2006b), there is a strong case to include data on this dynamic in this analysis, to prevent any omitted variables. Data on railways is collected from Cima and Cima (2008). The site is a database of 2600 European cities and their respective rail history. The site consists of year by year maps of all railways and station in Europe, as they appeared within that year. For each city in the database, details are provided on each railway line that was built.

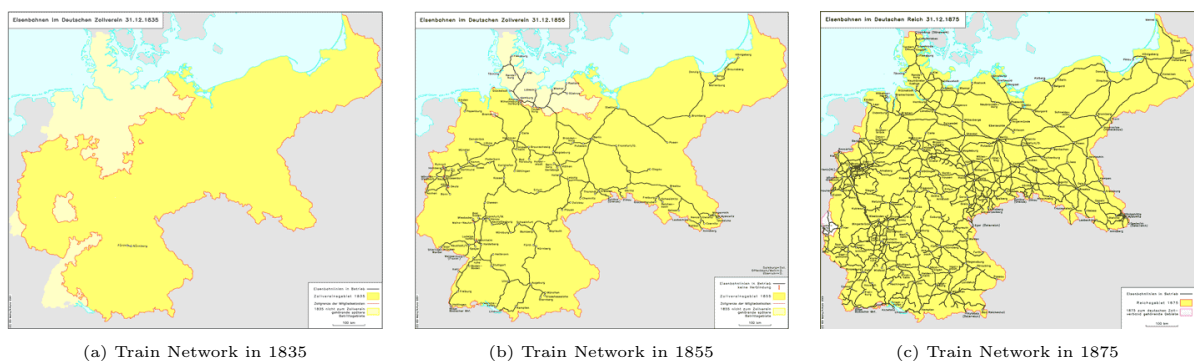


Figure 7: Map of the train network in the German Confederation and after 1871 the German Empire  
Source: Kunz (2014): IEG-MAPS Map 060 , Map 134 (figure b; doi: 10.25359/ISSN.1614-6352.134) and Map 157.

The first railway made its appearance in Germany in 1835, connecting the cities of Fürth and Nürnberg. From then on, the network rapidly expanded, covering nearly

the entire country by the end of the century (Reichsbahn and Deutschland, 1935). Figure 7 shows the development every 20 years.

Two variables are used to measure the railway infrastructure of the panel, similar in style to Uebele and Gallardo-Albarrán (2015)'s manner of encoding road connections. First, for each city-pair, the dummy variable  $Connection_{i,j}^t$  is set to 1 if there exists a rail route between the two cities and 0 otherwise. The second is the variable  $RailLines_{i,j}^t$ , which is the average number of rail connections the cities  $i$  and  $j$  have at period  $t$ . The former captures the possibility that two markets are connected and hence more likely to be integrated. The latter captures how connected a city is in general and hence how many other markets may factor into it. Across the panel, around 10% of the city-pairs years are connected by rail. The average number of connections a city has is 1 line. Larger cities such as Vienna, Berlin or München have up to 12 connections within the sample period.

## 5 Analysis and Results

### 5.1 Market Integration

Before delving into analysis of the determinants of market integration, initial price data is analyzed to observe any patterns, as well as to confirm the fact that markets integrated over the observed periods using the traditional metrics. This study starts with typical measures of market integration discussed in section 3, the coefficient of variation in price, as well as rolling correlation in returns and the rolling average variation in both prices and returns (Chilosi et al., 2013; Federico, 2012). The first measure is the cross-sectional standard deviation in prices, divided by the cross-sectional mean.

$$CoV_t = \frac{\sum_{i=1}^{n_t} \left( X_i^t - \frac{1}{n_t} \sum_{i=1}^{n_t} X_i^t \right)^2}{\sum_{i=1}^{n_t} X_i^t}$$

Figure 8a shows the results for the series, with the black line depicting the entire sample, while the grey represents the subsample of 8 cities<sup>6</sup> for which a balanced panel is available across the entire sample period of 1790-1900. Prior to 1825, the coefficient of variation decreased significantly, before steadily increasing. There is a clear trend downwards after 1825, indicating that prices became less dispersed across the regions under as time progressed. The year to year changes in the coefficient also seems to be declining, implying that the prices across the panel seemed to stabilize along with the reduction.

The average rolling correlation measures market co-movement and is computed over a 21 year rolling window, as is standard (Chilosi et al., 2013). For each city, the correlation of its series with the average series across all cities is computed. Then, the average of all correlations is taken each year. This too is separated between the full sample in black and the 8 city sub-sample, for which data is available for the entire sample period, in gray and can be seen in figure 8b and is done on the  $Returns_i^t$  variable, to avoid any unit roots. The picture here is slightly less clear, with co-movement initially declining over the course of the first half of the century until around 1850, for both the entire and 8 city sub-samples. It is only around the midway point of the century where correlation picks up again, much more so for the sub-sample than the full sample. The degree to which correlation picks up in the sub-sample is much larger than for the full sample, although the level of correlation from around 1860 onward is similar. This could be indicative of smaller, local clusters of integration being predominant in the first half of the century, given the dispersed nature and size of the sub-sample cities. Indeed, this is consistent with previous, local studies of German market integration. Combined with the price convergence, this may also be explained by the time needed to stabilize market movements; as prices move closer together, there may inevitably be times when they move in opposite directions to narrow the price gap, leading to a period of

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<sup>6</sup>These are Berlin, Hamburg, Köln, Königsberg, Leipzig, Mannheim, München and Vienna.



Figure 8: Each of the graphs plots measures of dispersion for prices and returns respectively. In black is the measure computed across the entire sample, while gray is the measure computed for the subsample consisting of the cities Berlin, Hamburg, Köln, Königsberg, Leipzig, Mannheim, München and Vienna.

(a) Depicts the Coefficient of Variation of Prices across the entire sample. This is computed by dividing the cross-sectional variation in prices by the cross-sectional mean.

(b) Measure of co-movement, computed as an average of the correlations of each city with the average price over a rolling 21 year period.

(c) Price volatility is computed as the average of the time-series volatility of each city's price series over a rolling 11 year period

(d) Return volatility is computed as the average of the time-series volatility of each city's return series over a rolling 11 year period

declining co-movement. This should naturally taper off as the degree of correction needed to close the price gaps decreases, as was the case.

Finally, looking at volatility across the markets completes the picture. To do this, the average 11 year rolling volatility is computed. Figure 8c shows the results for prices, while Figure 8d shows the same for returns. After an initial spike in volatility of individual series until 1820, the variability of both prices and changes in prices goes down throughout the century, implying that markets became less volatile over time, another indicator of integration.

## 5.2 Price Gaps and Return Gaps

Having confirmed that by and large, wheat markets integrated in Germany, especially over the second half of the 19th century, attention is turned to the price and return gap variables. Following Keller and Shiue (2014) and Missiaia (2009), the dependent variable on which regression analysis will be based is either the  $PriceGap_{i,j}^t$  or the  $ReturnGap_{i,j}^t$ , which are the absolute value differences of the prices or returns of two respective cities  $i$  and  $j$  within a period  $t$ . These variables are constructed

as

$$\begin{aligned}
PriceGap_{i,j}^t &= |Price_i^t - Price_j^t| \\
ReturnGap_{i,j}^t &= |Return_i^t - Return_j^t| \\
&= |\Delta Price_i^t - \Delta Price_j^t| \\
&= |(Price_i^t - Price_i^{t-1}) - (Price_j^t - Price_j^{t-1})|
\end{aligned}$$

and can be the price and return differentials discussed in Section 3.

Computing these measures for all city-pairs across all periods for which it is feasible yields a panel of 116972 price gap observations and 113620 return gaps for the period of 1790-1900. The 3rd and 4th rows of Table 1 shows the summary statistics. Across the entire panel, the means for the price gap are 0.323, which can be interpreted to be roughly 32.3%, while for the returns, it is roughly 16.1%. Plotting the cross-sectional mean across time, a downwards trend can be observed in figure 9a, with a possible spike coinciding with the increases in the coefficient of variation seen in the prior subsection around 1830. After this point, mean price gaps gradually decrease. This also holds true for the return gap, depicted by Figure 9b, adding evidence to the increase in integration that took place across Germany over the course of the observed period, as measured by these variables.

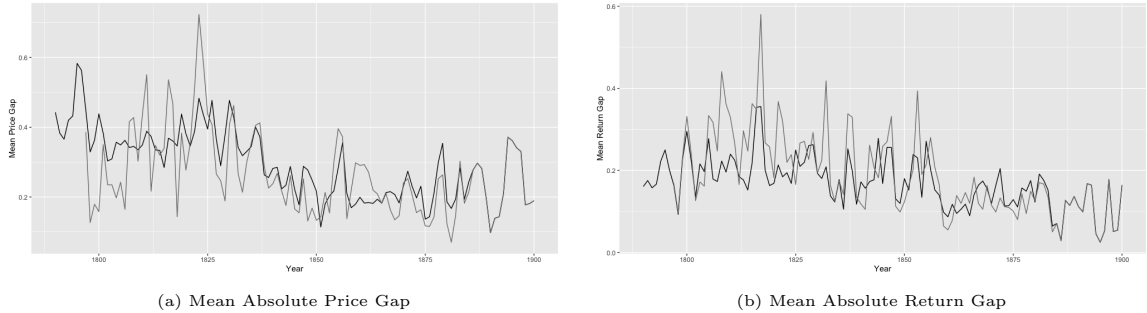


Figure 9: Cross Sectional Mean Price Gaps and Returns Gaps. Each series is computed by averaging all price and return gaps within a period across the sample of city pairs. This is repeated for each period.

### 5.3 Determinants of Market Integration

With the main dependent variables presented, the method of market integration decomposition is now introduced. Work on market integration is typically conducted based on the gravity model of Engel and Rogers (1996):

$$V(P_{j,k}) = \beta_1 r_{j,k} + \beta_2 B_{j,k} + \sum_{m=1}^n \gamma_m D_m + u_{j,k}$$

where the dependent variable is the standard deviation of the price ratio in cities  $i$  and  $j$ ,  $r_{i,j}$  denotes the distance between the two cities and  $B_{i,j}$  the presence of a border between the two, with indicators being included for each city within the sample. This analysis follows Jacks (2006b) and employs a same technique to regress explanatory variables onto a measure of market integration. The measures used are

the  $PriceGap_{i,j}^t$  and  $ReturnGap_{i,j}^t$  variables constructed as defined in the previous section. Following [Jacks \(2006b\)](#) and [Federico \(2007\)](#) closely, the baseline in this case is given by the regression,

$$Integration_{i,j}^t = \beta_1 Distance_{i,j} + \beta_2 State_{i,j}^t + \sum_{T=1}^{111} \gamma_T D_T + \sum_{N=1}^{49} \sum_{M \neq N}^{49} \lambda_{N,M} D_{N,M} + u_{i,j,t8} \quad (1)$$

which includes time and city-pair fixed effects ([Uebele and Gallardo-Albarrán, 2015](#); [Keller and Shiue, 2014](#)), with errors clustered at the city-pair level. A regression is run for  $PriceGap_{i,j}^t$  and  $ReturnGap_{i,j}^t$  respectively, with each measuring the first and second of [Cournot \(1838\)](#)'s market integration conditions respectively. The variables are as defined in Section [4](#) and Table [1](#).

The results of running the baseline on price gaps are given in the first column of Table [2](#). As expected, a border effect at the state level is confirmed with the coefficient for  $State_{i,j}^t$  being significantly negative<sup>7</sup>. This can also be observed in Figure [10a](#), which shows the cross-sectional average price gaps over time, split between the same state city-pairs and different state city-pairs. For return gaps, a border effect across state lines is also present, and the distance of states between each other is also positively correlated with the measure of integration<sup>8</sup>. Figure [10b](#) shows the cross-sectional means of return gaps separated by state status and the regression results for the return series can be found in the first column of Table [3](#).

Distance is also found to have a significant, positive effect on both price and return gaps, which is in line with the literature. In aggregate, this initial result can be taken to mean that, at a state level, markets tended to be rather well integrated when measured by the price gap. These borders constitute good approximation for clusters of market integration, as has been found in Germany ([Keller and Shiue, 2007, 2014](#)) and for other countries with this empirical approach, notably Italy ([Federico, 2007](#)).

## 5.4 Custom Unions and Political Unions

Proceeding to the institutional variables defined in section [4.3](#), the cross-sectional averages over time shine more light on the situation. Splitting the sample by the political and customs union status of the city-pairs  $i, j$ , a generally lower average price gap can be observed for some but not all of these institutional groupings. Figures [10c](#) and [10d](#) show the average measures of integration, segregated by color for city-pairs which are in a specific customs union, with the none category consisting of all city-pairs where the cities are not in the same union at period  $t$ . Although subtle, in general, the customs unions seem to be at a lower level than the non-category, although the general trend downwards is the same for all categories. Figures [10e](#)

<sup>7</sup>This variables is codified in the opposite manner to the border variable used in the baseline and traditional model, and so has to be interpreted in inverse.

<sup>8</sup>Here, as in the specification on  $PriceGap_{i,j}^t$ , a smaller value in the dependent variable is indicative of a more integrated market and hence, a positive coefficient is an indicator of worse market integration

Table 2: Regressions with  $PriceGap_{i,j}^t$  as the dependent variable. The first column shows results for the baseline gravity model, using the entire sample of city-pair observations. The remaining columns are regressions run on the sample excluding all same state city pairs. The second and third columns show results for the case where all customs unions are pooled into a single union and all political unions are pooled into a single entity. The fourth and fifth columns separate each customs union and political union.

	Dependent variable: $PriceGap_{i,j}^t$				
	Baseline Full Sample	Pooled institutions		Individual Institutions	
		No Lag	Lag 10	No Lag	Lag 10
Distance $_{i,j}$	0.0001*** (0.00002)	0.00004* (0.00002)	0.00004* (0.00002)	0.0001** (0.00002)	0.00004* (0.00002)
State $_{i,j}^t$	-0.120*** (0.010)				
Connection $_{i,j}^t$		0.007 (0.009)	0.008 (0.009)	0.009 (0.009)	0.012 (0.009)
RailLines $_{i,j}^t$		-0.005* (0.003)	-0.005* (0.003)	-0.008*** (0.003)	-0.007*** (0.003)
Union $_{i,j}^t$		-0.036*** (0.007)			
Union $_{i,j}^{t-10}$			-0.030*** (0.008)		
Political $_{i,j}^t$		0.008 (0.009)			
Political $_{i,j}^{t-10}$			-0.002 (0.009)		
PH $_{i,j}^t$				-0.027 (0.032)	
PH $_{i,j}^{t-10}$					0.059 (0.054)
SG $_{i,j}^t$				0.512*** (0.022)	
SG $_{i,j}^{t-10}$					0.516*** (0.022)
MHDV $_{i,j}^t$				-0.070*** (0.023)	
MHDV $_{i,j}^{t-10}$					-0.125*** (0.014)
SV $_{i,j}^t$				-0.170*** (0.016)	
SV $_{i,j}^{t-10}$					-0.055*** (0.021)
ZV $_{i,j}^t$				-0.034*** (0.007)	
ZV $_{i,j}^{t-10}$					-0.021*** (0.008)
HRE $_{i,j}^t$				0.062*** (0.016)	
HRE $_{i,j}^{t-10}$					0.071** (0.034)
CoR $_{i,j}^t$				-0.006 (0.014)	
CoR $_{i,j}^{t-10}$					0.076*** (0.013)
GC $_{i,j}^t$				0.017 (0.012)	
GC $_{i,j}^{t-10}$					-0.023** (0.011)
NGC $_{i,j}^t$				0.017 (0.026)	
NGC $_{i,j}^{t-10}$					-0.038 (0.030)
GE $_{i,j}^t$				-0.201*** (0.026)	
GE $_{i,j}^{t-10}$					-0.209*** (0.030)
Observations	116,972	98,075	98,075	98,075	98,075
Adjusted R <sup>2</sup>	0.289	0.683	0.683	0.686	0.686
F Statistic	297.914*** (df = 160; 116811)	1,292.079*** (df = 164; 97911)	1,290.605*** (df = 164; 97911)	1,248.330*** (df = 172; 97903)	1,249.142*** (df = 172; 97903)

Note:

\* p<0.1; \*\* p<0.05; \*\*\* p<0.01

Table 3: Regressions with  $\text{ReturnGap}_{i,j}^t$  as the dependent variable. The first column shows results for the baseline gravity model, using the entire sample of city-pair observations. The remaining columns are regressions run on the sample excluding all same state city pairs. The second and third columns show results for the case where all customs unions are pooled into a single union and all political unions are pooled into a single entity. The fourth and fifth columns separate each customs union and political union.

	<i>Dependent variable: ReturnGap<sub>i,j</sub><sup>t</sup></i>				
	Baseline	Pooled institutions		Individual Institutions	
	Full Sample	No Lag	Lag 10	No Lag	Lag 10
Distance <sub>i,j</sub>	0.0001*** (0.00001)	0.0001*** (0.00001)	0.0001*** (0.00001)	0.0001*** (0.00001)	0.0001*** (0.00001)
State <sub>i,j</sub> <sup>t</sup>	-0.052*** (0.005)				
Connection <sub>i,j</sub> <sup>t</sup>		0.002 (0.005)	0.002 (0.005)	0.0003 (0.005)	0.004 (0.005)
RailLines <sub>i,j</sub> <sup>t</sup>		-0.002* (0.001)	-0.002** (0.001)	-0.002** (0.001)	-0.003*** (0.001)
Union <sub>i,j</sub> <sup>t</sup>		-0.011*** (0.003)			
Union <sub>i,j</sub> <sup>t-10</sup>			-0.011*** (0.004)		
Political <sub>i,j</sub> <sup>t</sup>		0.028*** (0.003)			
Political <sub>i,j</sub> <sup>t-10</sup>			0.039*** (0.003)		
PH <sub>i,j</sub> <sup>t</sup>				-0.020 (0.013)	
PH <sub>i,j</sub> <sup>t-10</sup>					0.016 (0.015)
SG <sub>i,j</sub> <sup>t</sup>				-0.158*** (0.008)	
SG <sub>i,j</sub> <sup>t-10</sup>					-0.155*** (0.008)
MDHV <sub>i,j</sub> <sup>t</sup>				-0.019 (0.015)	
MHDV <sub>i,j</sub> <sup>t-10</sup>					0.005 (0.013)
SV <sub>i,j</sub> <sup>t</sup>				-0.027 (0.032)	
SV <sub>i,j</sub> <sup>t-10</sup>					-0.031 (0.035)
ZV <sub>i,j</sub> <sup>t</sup>				-0.008** (0.004)	
ZV <sub>i,j</sub> <sup>t-10</sup>					-0.010** (0.004)
HRE <sub>i,j</sub> <sup>t</sup>				-0.014* (0.009)	
HRE <sub>i,j</sub> <sup>t-10</sup>					0.044*** (0.013)
CoR <sub>i,j</sub> <sup>t</sup>				-0.023*** (0.006)	
CoR <sub>i,j</sub> <sup>t-10</sup>					0.028*** (0.010)
GC <sub>i,j</sub> <sup>t</sup>				0.052*** (0.004)	
GC <sub>i,j</sub> <sup>t-10</sup>					0.020*** (0.005)
NGC <sub>i,j</sub> <sup>t</sup>				0.017 (0.015)	
NCC <sub>i,j</sub> <sup>t-10</sup>					0.031 (0.020)
GE <sub>i,j</sub> <sup>t</sup>				-0.032* (0.017)	
GE <sub>i,j</sub> <sup>t-10</sup>					-0.041** (0.018)
Observations	113,620	95,235	95,235	95,235	95,235
Adjusted R <sup>2</sup>	0.627	0.642	0.642	0.643	0.642
F Statistic	1,187.064*** (df = 161; 113459)	1,040.794*** (df = 164; 95071)	1,043.838*** (df = 164; 95071)	1,000.221*** (df = 172; 95063)	993.061*** (df = 172; 95063)

Note:

\* p<0.1; \*\* p<0.05; \*\*\* p<0.01

and 10f depict the same for political unions. The large spikes at the end of all 4 of these plots are due to Vienna, the city within the sample of this study which was excluded from all customs treaties as well as the German Empire. As this is a singular city, it is hard to draw conclusions, but this can be taken as evidence for the fact that the degree of integration between Vienna and the other cities significantly declines.



Figure 10: Time series plots depicting the cross-sectional averages of  $\text{PriceGap}_{i,j}^t$  and  $\text{ReturnGap}_{i,j}^t$ , splitting the panel based on the mutual state, customs or political status of the city-pair  $i, j$ .

Regressions are conducted in a style similar to the model described in equation 1. First, the effects of being in any customs union and any political structure are investigated. This can be thought of as a pooled regression, whereby all customs unions are pooled into a single union and the same for all political unions, measuring the general average effect of being in a customs union versus being outside as well as being within a political union or being outside. To this end, the specification run

is

$$\begin{aligned}
\text{Integration}_{i,j}^t = & \beta_1 \text{Distance}_{i,j} + \beta_2 \text{Connection}_{i,j}^t + \beta_3 \text{RailLines}_i^t + \\
& \beta_4 \text{Union}_{i,j}^t + \beta_5 \text{Political}_{i,j}^t + \sum_{T=1}^{111} \gamma_T D_T + \sum_{N=1}^{49} \lambda_N D_N + \quad (2) \\
& u_{i,j,t}
\end{aligned}$$

which also includes the railway variables in order to assess their impact on market integration. As with model [1](#), time and city-pair fixed effects are included, along with clustered errors. The coefficients in front of  $\text{Union}_{i,j}^t$  and  $\text{Political}_{i,j}^t$  measure the average price gap and return gap differences between city pairs where both cities are in the same customs or political union and city-pairs where both cities are in different unions or at least one city is not in a union. Hence, it can be thought of as the effect of bilateral membership in a customs or political union.

Following [Keller and Shiue \(2014\)](#), having identified the border effect across state, this specification is run over the sample of city pairs which are not in the same state. The results for this specification can be found in the second column of Table [2](#). Additionally, to account for any institutional lags that may be present, the same regression is done whereby  $\text{Union}_{i,j}^t$  and  $\text{Political}_{i,j}^t$  are lagged by 10 periods<sup>9</sup>.

The first, somewhat surprising result is that being connected by rail did not significantly affect the price gap. This is true for both measures of integration. It is instead the number of stations that played a small but significant effect, with cities having more rail connections exhibiting smaller price gaps on average. This is consistent with prior findings, which find that transport accounted for very little of the trade costs observed throughout the 19th century ([Jacks, 2006b](#)), despite the intuitive nature of their significance. The results for the number of rail connections, capturing the connectivity of a city, is consistent with [Uebele and Gallardo-Albarrán \(2015\)](#).

Being in a mutual customs union had a significant negative effect on the price gap. This is in line with results from [Keller and Shiue \(2014\)](#). The pooled effect is a reduction in the price gap by 3.6% across the panel, which given the average price gap of 32% is a substantial amount. The effect is almost as strong when looking at the effects of a lagged union. Political unions on the other hand, did not have a significant effect on the price gap. Looking at the specifications with a lag, the results are nearly identical. The mutual customs union membership of a city-pair had a significantly negative effect on their price gap 10 years later, while the political union of the two had no significant effect.

Customs unions similarly had a significant effect on the second measure of integration, being significantly negatively related to the return gaps. The second column of Table [3](#) shows the results. Political unions on the other hand significantly and positively related to  $\text{ReturnGap}_{i,j}^t$ , both in the contemporaneous and lagged specifications. This implies that, measured by return gaps, political borders did not cover

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<sup>9</sup>A lag of 5 was also tested and did not lead to any different results to 10 lags.

integrated areas, and that the emergence of these borders was not associated with any reduction in the return gap. Taken as a whole, these results point to the customs unions as being relatively good indicators of where clusters of market integration occurred, while the political unions were not.

## 5.5 Individual Unions

The results regarding pooled unions and political structures strongly indicate that it was the custom unions which better captured the nature of integration in the German market. At the same time, political boundaries may have been a hindrance to the integration process, and ran through areas of integration. This result is critical, as having observed integration over the entire panel, not finding a political border effect may lead us to conclude that the entire territory was integrated. Yet when looking at another set of borders, those of customs unions, there is indeed a significant border effect. This is an example of aggregation that could lead to drawing the wrong conclusion (Wolf, 2009). Focusing on borders other than national boundaries is vital. While the set of potential borders to check is infinitely large, it is sensible to focus on administrative boundaries, given their significance on other works on market integration (Jacks, 2006b; Federico, 2012).

Having established the overall effects, analysis is now directed at observing the individual effects of each of the unions and institutions that took place. In effect, this is taking the previous argument and trying to break down further clusters of integration. While all cities within customs unions seem to be integrated with one another, it may again be an aggregation, with clusters of integration occurring within the entire area covered by these unions. Instead of using the pooled  $Union_{i,j}^t$  and  $Political_{i,j}^t$ , the dummy variables indicating common membership in each specific union and political union are used.

The fourth column of Table 2 shows the results of running such a regression, while the fifth column shows the results when applying a lag to these variables of 10 years. Similarly, the fourth and fifth columns of 3 show the results when using  $ReturnGap_{i,j}^t$  as a dependent variable. Starting with the customs unions, with the exception of the Prussian-Hessian Union (PH), all customs unions show significant relations with the Price Gap. Of these, the South German Union (SG) shows an unexpected and large positive result. This result, a price gap increase of on average 50% for cities within this union, could be an artifact of data composition, given that the union only consists of two states, and the sample has only one city from one of those states<sup>10</sup>. For the other three unions, results are as expected and in line with prior findings (Keller and Shiue, 2014). These unions show significantly smaller price gaps than their non union counterparts, both contemporaneously as well as lagged. The boundaries of these custom unions seem to capture regions following the law of one price rather well. Being part of a union is associated with future price

<sup>10</sup>The Kingdom of Württemberg is only represented by the single city of Heilbronn, such that the SG group of city-pairs only has 15 entries, with Heilbronn being part of each pair. A large deviation in the Heilbronn market's prices during the phase of the union could account for this discrepancy.

convergence, as the lagged specification indicates. For the return gaps, it is only the South German (SG) and Zollverein (ZV) that show significant results. Here, both unions show negative coefficients. Cities within these two unions had substantially lower return gaps, implying that the prices between cities changed in a more similar manner.

From a price level perspective, the South German Union (SG) was not a well integrated market, given the large average price gap of its member cities. However, using the co-movement metric, there is a significantly negative effect, signifying that the area may have integrated at two different price levels. It could be the case that these two areas were indeed very well integrated, and the arbitrage costs were high. In such a case, the high price gaps could be maintained without being arbitrated away, as it would not be profitable to do so, while any deviation from this equilibrium price gap would quickly be exploited, leading to a constant difference in price levels while returns would converge. This is of course a hypothesis which requires testing, and as the results stand now, we can conclude that the South German Union was poorly integrated in terms of following the Law of One Price, but exhibited relatively closer market movements.

With the exception of the Prussian-Hessian Union (PH), the other unions exhibit significant price gap integration, and can be considered integrated according to Cournot (1838)'s first condition. Regarding the second condition, only the Zollverein is significant, implying that it is indeed this customs union that was the main driver of integration and best reflected the state of integration within Germany.

Political unions show mixed results. On the price gap specification, the Holy Roman Empire (HRE) shows a significant and positive coefficient in both the contemporaneous and lagged specifications. The Confederation of the Rhine (CoR) is significant only in the lagged specification, and also exhibits a positive relationship with the price gap. These two political entities did not, it would seem, capture the state of German market price integration at the time. This is plausible, given the alleged mess that trade was during the Holy Roman Empire's regime (Henderson, 1934). For the second measure of integration, the results are mixed. For both of these political institutions, the contemporaneous regression associates the unions with a negative return gap, while the lagged version indicates significantly positive return gaps. This implies that for both of these unions, price movements were on average more similar than the non-members. As was the case for the South German Custom Union, this may imply that there were significant costs associated to trade in these regions, but that any deviation from this equilibrium price gap was quickly arbitrated away, making the market efficient in the co-movement sense. However, the lagged results indicate that this integration decreased after some time, which can be interpreted to mean that integration in this manner was not robust to changes in political boundaries.

The German Confederation (GC) shows a lagged, significantly negative effect while the German Empire (GE) shows negative significant effects in both contemporaneous and lagged specifications. Measured by the law of one price, the boundaries of

the two political entities do not seem to correspond to well integrated markets. For the return gaps, the German Empire exhibits results consistent with the price gap specification, suggesting that the 1871 unification captured the state of integration the best out of the political structures. This may of course be due to the fact that at this point, the custom unions had already led to an integration across the region. As the areas of the German Empire and Zollverein become more similar, the border of the former would capture the same integration as was present in the Zollverein. As such, only at this point do the areas of economic integration and political unification match each other. The German Confederation shows significant and positive coefficients on return gaps, implying that the co-movement of prices within the region, as measured by return gaps, was lower within this boundary than across or outside. Considering that the territory of the German Confederation was nearly identical to that of the Holy Roman Empire, this may show that structurally, nothing much changed between these two regimes in terms of geographical integration of markets. Furthermore, as the customs unions within the German Confederation spread and integrated, these regions did not integrate with each other in aggregate until the Zollverein continued to expand.

All results for the North German Confederation are insignificant. This institution was rather short-lived and hence the sparsity of data may have an impact on this result. Nonetheless, it would seem that the change in borders led to a political entity, whose borders did not capture any significant market integration. Given that the North German Confederation was effectively a German Confederation cut in half, excluding the southern states and Austria, and the significantly negative lagged coefficient for the German Confederation, the new border may have cut through any regions or lines of integration. With both German Empire coefficient significantly negative, this leads evidence to the fact that, from a market integration perspective, the NGC was a failure, in that it segregated an integrated market in a political manner. The unification of Germany then restored the political boundaries of the country to match the economic integration brought about by the Zollverein.

## 6 Discussion and Conclusion

This thesis has sought to identify and decompose market integration in Germany over the course of the 19th century, exploiting the nature in which the political and economical landscape shifted over the period. In doing so, the results indicate that these institutional shifts were indeed important for market integration, although not all in the same direction as would be intuitively expected. The border effect, a significant difference in prices for a good on opposite sides of a border, is generally indicative of integration taking place within a border. Yet, as noted by [Schulze and Wolf \(2009\)](#), there are various issues associated with using national borders, especially in times when these were volatile, as in 19th century Germany. In this case, it could very well be the case that a border is drawn through an area of economic integration, in which case no border effect would be identified.

This thesis confirms the integration that took place in German market on aggregate, using metrics related to both [Cournot \(1838\)](#)'s first and second integration conditions. This is in line with the literature ([Keller and Shiue, 2014](#); [Uebele, 2011](#)). The existence of a state level border effect is also confirmed, which indicates that markets were integrated within state level borders. In addition, distance is found to be a major driver of market integration, with a larger distance implying both a larger difference in prices and returns for wheat markets between two cities. Using the custom unions and political borders in order to identify border effects and integration yields mixed results.

To summarize the institutional results, it appears that in general, custom unions were the primary driver of both price and return integration in the German economy. A significant finding is that the impact of the custom unions that existed prior to the 1834 founding of the Zollverein cannot be discounted. This lends evidence to the hypothesis that, while the Zollverein was an important driver of integration, markets in the prior, smaller customs unions were already well integrated as individual clusters and that the larger Zollverein served to integrate and aggregate these smaller clusters of markets. In addition, the Steuerverein, which competed with the Zollverein until its demise in 1854, was also an effective institution in terms of price gap integration. These unions also seemed to encompass regions that were already integrated with each other, and the effects did not seem to decrease as time went on within these boundaries.

Political boundaries on the other hand are found to generally have either no significant or even the opposite effect on both measures of market integration. With the exception of the German Empire of 1871, most coefficients are positively related to both gap measures, which show that these borders either cut through areas of economic integration, or did not assist in integrating markets after their introduction. Not all the results for political unions are negative in terms of integration, as some coefficients are found to be statistically significantly negative. However, most of these results are overshadowed by the dominant role that the customs unions took in shaping the economic landscape of Germany throughout the 19th century.

While this study has used a comprehensive data set of 49 cities to analyze the

dynamics, there can never be enough data. Some states in the sample were overrepresented, while a little over half of the German states in the German Confederation had no data associated with them. This sample composition is likely to lead to biases of some form which are yet to be addressed. Continued research should strive to expand the set of available data, in order to realize a clearer picture of the roles of institutional borders on markets. Additionally, this study used a limited set of borders, defined based on custom unions or political status, as these were expected to be the most important shifts in the German 19th century market. However, there were other boundaries which can be looked at, such as monetary boundaries, religious boundaries or linguistic differences (Wolf, 2009; Jacks, 2006b). While criticizing the somewhat arbitrary use of borders in market integration and border effect studies, the research area of this thesis itself was restricted by the political borders of Germany. Moving forward, analysis could benefit more from approaches such as Chilosì et al. (2013), by letting the data speak for themselves, and establish better criteria for defining regions with integrated markets. Doing so, while relating the findings to the historical development of economic and political unions can lead to a better understanding of the dynamics of politics and trade agreements in market dynamics, an area of study relevant today when observing institutions such as the EU, global trade agreements or even shared currencies and monetary unions.

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# Appendices

## A Price Data and Sources

Data on Prices are collected for 49 cities from a variety of sources for different periods. The details below describe the source and coverage of the data, separated by the state as well as the computations employed to standardize the units.

### Duchy of Brunswick:

*Brunswick* (1790-1863)

Source: Jacks (2004, 2005) and Oberschelp (1986)

Units converted using Gerhard et al. (1990)

### Duchy of Schleswig:

*Rendsburg* (1824-1863)

Source: Jacks (2004, 2005) and Waschinski (1952)

Units converted using Gerhard et al. (1990)

### Free City of Bremen:

*Bremen* (1673-1850)

Source: Gerhard et al. (1990); Gerhard and Engel (2000)

Units converted using Gerhard et al. (1990)

### Free City of Hamburg:

*Hamburg* (1792-1934)

Source: Reichsamt (2008, 1935)

Units converted using Gerhard et al. (1990)

### Grand Duchy of Baden:

*Hamburg* (1791-1934)

Source: Reichsamt (2008, 1935)

Units converted using Gerhard et al. (1990)

### Grand Duchy of Mecklenburg-Schwerin:

*Rostock* (1770-1870), *Schwerin* (1770-1870), *Wismar* (1775-1870)

Source: Shiue and Keller (2007); Landesamt (1873)

Units converted using Gerhard et al. (1990); Shiue and Keller (2007)

### Grand Duchy of Saxe Weimar:

*Jena* (1660-1855)

Source: Jacks (2004, 2005); Oberschelp (1986)

Units converted using Gerhard et al. (1990); Jacks (2004, 2005)

### Kingdom of Austria:

*Vienna* (1783-1912)

Source: Shiue and Keller (2007); Pribram et al. (1938)

Units converted using Gerhard et al. (1990); Shiue and Keller (2007)

### Kingdom of Bavaria:

*Augsburg, Bamberg, Bayreuth, Erding, Kempten, Landshut, Linda, Memmingen, Nördlingen, Regensburg, Straubing, Würzburg* (all 1815-1855)

Source: [Shiue and Keller \(2007\)](#); [Seuffert \(1857\)](#)

Units converted using [Gerhard et al. \(1990\)](#); [Shiue and Keller \(2007\)](#)

*München* (1790-1934) from [Shiue and Keller \(2007\)](#); [Seuffert \(1857\)](#); [Reichsamt \(2008, 1935\)](#)

Units converted using [Gerhard et al. \(1990\)](#); [Shiue and Keller \(2007\)](#)

#### **Kingdom of Hannover:**

*Celle* (1727-1871), *Duderstadt* (1672-1850), *Emden* (1796-1863), *Göttingen* (1631-1867), *Hannover* (1750-1863), *Hildesheim* (1764-1863), *Lüneberg* (1550-1863), *Osnabrück* (1624-1863), *Stade* (1764-1863), *Waake* (1749-1850)

Source: [Jacks \(2004, 2005\)](#); [Oberschelp \(1986\)](#); [Gerhard \(2015\)](#); [Gerhard et al. \(1990\)](#)

Units converted using [Gerhard et al. \(1990\)](#); [Shiue and Keller \(2007\)](#)

#### **Kingdom of Prussia:**

*Arnsberg* (1818-1866), *Berlin* (1797-1939), *Herdecke* (1820-1850), *Herford* (1771-1850), *Köln* (1797-1939), *1797-1939* (1764-1863), *Minden* (1775-1867), *Münster* (1532-1863), *Paderborn* (1640-1850), *Xanten* (1511-1882)

Source: [Jacks \(2004, 2005\)](#); [Kopsidis \(2015\)](#); [Reichsamt \(2008, 1935\)](#)

Units converted using [Gerhard et al. \(1990\)](#)

#### **Kingdom of Saxony:**

*Chemnitz* (1799-1850), *Leipzig* (1690-1939)

Source: [Jacks \(2004, 2005\)](#); [Strauss \(1963\)](#); [Reichsamt \(2008, 1935\)](#); [Dittmann \(1889\)](#)

Units converted using [Gerhard et al. \(1990\)](#)

#### **Kingdom of Württemberg:**

*Heilbronn* (1744-1832)

Source: [Jacks \(2004, 2005\)](#)

Units converted using [Gerhard et al. \(1990\)](#)

#### **Principality of Lippe-Detmold:**

*Detmold* (1744-1832)

Source: [Gerhard \(2015\)](#); [Gerhard et al. \(1990\)](#)

Units converted using [Gerhard et al. \(1990\)](#)

#### **Alsace:**

*Mulhouse-Colmar* (1798-1875)

Source: [Jacks \(2004, 2005\)](#)

Units converted using [Gerhard et al. \(1990\)](#)

## B Distance Data

As stated, distance is used as a variable for each city-pair. Given that the dataset consists of 49 cities, there are a total of  $49 \times 49/2 = 1176$  city pairs for which the distances are computed. The source for this data is "<https://www.Distances24.org>", a website which offers distance calculations between two geographical points. It offers API access to the data and a simple query in the form of

"<http://www.distance24.org/route.json?stops=CITY1|CITY2>"

returns a JSON file with various geographical information on the input cities.

In the case of Brunswick (Braunschweig), Hanover and Koenigsberg, some modifications were needed given some difficulties in recognition. Given that both Brunswick and Hanover also exist as locations outside of Germany, an added parameter was required to find the correct distances for the German cities. In this case, the query was modified whereby if *CITY1* or *CITY2* were Brunswick or Hanover, the city name was appended with the string "%20germany", which searches for such named cities within Germany. Koenigsberg, the eastern city of the Kingdom of Prussia, has since become part of Russia. The current name of the city, Kaliningrad was used for all queries.

## PLEDGE

In writing a Master's /Doctoral thesis, I carefully read "Code of Conduct for Scientific Research, The University of Tokyo" and "Guidelines for Writing Research Papers and Theses, Graduate School of Economics, The University of Tokyo", fully understand what is written there and comply with all the related rules and guidelines.

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