Center for Quantitative Economics

Demand Matters: German Wheat Market Integration 1806-1855 in a European Context

Martin Uebele[†]

11/2010

† Department of Economics, University of Münster, Germany

Demand Matters: German Wheat Market Integration 1806-1855 in a European Context*

Martin Uebele†

February 2010

Abstract

This study analyzes annual wheat prices in 13 German cities in the years 1806 to 1855, together with wheat price series from 44 other European and American cities. The method used is a dynamic factor model, which allows for distinguishing common price fluctuations on international and national levels. I find a significant increase of price synchronization between German cities and international markets, between the first and the second quarter of the 19th Century. This is probably mainly due to the increased demand for food imports in Britain and the disappearance of political barriers, as well as economies of scale and gradual improvements to existing transportation technology. Within Germany, I find increasing common price fluctuations in Mannheim and Munich, which arguably reflects a customs union effect. Tree ring records as indicators of general plant growth conditions indicate that comovement was not driven by exogenous shocks.

key words: market integration; 19th Century, dynamic factor analysis, wheat prices; Germany

JEL-Codes: N70, N71, N73, C32, F15, E32

*I thank Prof. Dr. Rainer Gömmel and Prof. Dr. Ulrich Pfister for helpful suggestions. Sonja Lohmann provided invaluable research assistance. Clearly, the responsibility for remaining errors of any kind remains with me.

†Author's address: Institut für Wirtschafts- und Sozialgeschichte, Westfälische Wilhelms-Universität Münster, Domplatz 20-22, D-48143 Münster. E-Mail: martin.uebele@wiwi.uni-muenster.de

1 Introduction

Today's global economy had its beginning in the 19th century. Since 1840 exports in Europe grew at four to five percent per annum (Accominotti and Flandreau 2008, p. 156). The reason seems to be obvious: technical progress. With the steam ship, and the telegraph, according to conventional wisdom, transport and communication cost declined, such that foreign products - not only luxuries but goods for daily use - could compete with domestic produce. The railroad enabled cheap overland transport where canal and rivers were not available. The beginning of this development is frequently believed to have been around 1870 (O'Rourke 1997, p. 776), at least in the second half of the 19th century (Harley 1988a).

Alongside the technology emphasizing strand of the literature another branch concentrates on the reduction of political barriers to trade as a reason for more trade, especially the network of bilateral trade contracts (Lampe 2009, Accominotti and Flandreau 2008), but also the abolishment of the British Corn Laws (Sharp 2006), and the German customs union (Dumke 1991).

Although both attempts to explain the "First Globalization´´ are important aspects of the discussion, as sole arguments they are oversimplifying. Looking at trade in the context of the market for transport services, then technology and political barriers are cost factors on the supply side. On the demand side, however, there is income and population growth. Jacks, Novy, and Meissner (2008) show that about 50 percent of trade growth after 1870 can be attributed to demand effects. For the early 19th century, comparable research is lacking, mainly due to data problems. Therefore, in this article, I would like to discuss a historical example for the role of demand in increasing globalization. To overcome lacking trade data, commodity prices are analyzed with a novel empirical tool. It allows for decomposing common price fluctuations on the international and the national level, and thus for discriminating between competing explanations for commodity market integration.

Subject of interest is one of the most important international commodity markets of the 19th century, the market for wheat. Wheat was one of the basic food items in Europe and America, and was produced virtually everywhere in the Atlantic economy. Therefore, it is a good indicator for trade in general (see Federico and Persson (2007). In order to get an impression about the development of trade, I analyze the relative fluctuations of wheat prices in 57 European and North-American cities. I focus on 13 German cities in the first half of the 19th century because Prussia at this time was the leading wheat exporter (Jacobs and Richter 1935b, p. 273), and delivered primarily to the U.K., which became increasingly dependent of food imports (Harley 1993) and started to lower import tariffs in the late 1820s (Sharp 2006).

In the sample period Europe experienced the last years of the Napoleonic wars and the end of the continental system (Findlay and O'Rourke 2005, p. 33), Prussian reforms and the first round of the German customs union (Dumke 1991). At the same time, the railroad's and the steam ship's commercial potential for low value goods was not yet fully developed (Keller and Shiue 2008, p. 14-16), (Fremdling and Hohorst 1979, pp. 64), (Findlay and O'Rourke 2005, pp. 35-36). Any eventual increase in market integration therefore is unlikely to be caused by the transport revolution.

These historical events should have had differential and various impacts on commodity trade within and between countries. The German customs union is expected to have improved trade within Germany (in the borders of 1871), while the continental system apparently hindered international trade. It is therefore important to distinguish between intra- and international determinants of common price movements. Being able to do so allows for example for analyzing the effects of the German customs union on intranational market integration controlling for the impact of international developments such as repeal of the Corn Laws.

The synchronicity of wheat prices turns out to have been much larger in the second quarter of the 19th century than in the first but this mattered only for large North- and West- German cities such as Berlin, Hamburg, Cologne and Königsberg. Regional markets in today's Lower Saxony like Stade and Göttingen, and South-German cities such as Munich were exempted from this development. I find high price comovement among the North-German regional cities, which were not part of the Zollverein in the sample period, controlling for comovement with foreign markets. Their prices accordingly reflected mainly regional, but not international demand-supply conditions.

I attribute that, among others, higher demand for food imports in the UK contributed to price comovement between the main North-German cities and the international (i.e., European) market. I argue that the degree to which wholesale and stock market prices in Berlin, Königsberg and so forth reflected British demand grew with the potential for trade between these two regions. The transport revolution was arguably not the main reason for this, mainly because its commercial potential developed after the sample period. However, gradual improvements reduced communication and transport costs already in the first half of the 19th century (Kaukiainen 2001, North 1958). Increased volumes may also have led to scale economies and led to lower unit-transport costs (Brautaset and Grafe 2005).

The increase of international comovement is unlikely to reflect global weather shocks. Tree ring records from Briffa, Jones, Schweingruber, and Osborn (1998) show more global shocks in the first subperiod than in the second and should work against the found increase of international price comovement.

2 Empirical Model

The central argument for the method applied here is comovement; i.e. synchronous price movements. It resembles correlation insofar as it measures linear dependence but is defined over N series, and not only pairs (Kose, Otrok, and Whiteman 2003, p. 1218). This is possible by generating a reference series with which each singly series is compared. The price p_i for a homogeneous good is observed at N cities. It can be decomposed in a common component c and a local specific rest u_i:

$$p_i = c + u_i \tag{1}$$

The common component c should be chosen such that local specific deviations are minimized. These can be expressed as absolute values in percent of the original price p_i. The smaller this percentage share, the better the prices are explained by the common component.

The common component's explanatory power can not automatically be expressed as proof for better market integration through arbitrage. Exogenous shocks could also be the cause of comovement. Below I discuss the impact of exogenous shocks for the time and period analyzed here.

If all prices in 1 changed into the same direction this could be attributed by 100% to c. However, if some prices would move differently, a part of the variance would be collected in u_i. The dynamic formulation of 1 is therefore:

$$p_{i,t} = a_i + \lambda_i c_t + u_{i,t} \tag{2}$$

Again, c_t is the common component. The endogenous weighs λ_i connect the common component to each price and express the degree to which each price reflects common movements as compared to individual movements. The idiosyncratic component $u_{i,t}$ contains local specific price movements which may be caused by local demand and supply shocks.

Equation 2 resembles a linear regression, however all right hand side variables are unknowns, including the "regressor´´ ct. In order to estimate the model's parameters, the dynamics of c_t are assumed to follow an autoregressive process of order q:

$$c_t = \varphi_1 c_{t-1} + \ldots + \varphi_q c_{t-q} + \nu_t \tag{3}$$

Together with equation Equation 2 as an observation equation this constitutes a state-space model which allows for serially correlated local processes modeled as AR(p)-processes:

$$u_{i,t} = \theta_{i,1} u_{i,t-1} + \ldots + \theta_{i,p} u_{i,t-p} + \chi_{i,t} \tag{4}$$

All shocks are assumed to be serially and cross-sectionally uncorrelated and normally distributed with mean zero and variance σ^2 (Uebele 2009, p. 7).

In a next step, the model is extended to allow for a second common component that captures intra-national comovement that is orthogonal to international comovement:

$$p_{i,t} = a_i + \lambda_i^w c_t^w + \lambda_i^n c_t^n + u_{i,t} \tag{5}$$

Here, the superscript w (or "world´´), stands for all markets in the sample, while n (or "nation´´) represents a selected subgroup. For each "nation´´ an AR(q)-process is calculated describing price comovement of all markets of this subgroup but different from the comovements shared by all cities in the sample. That means, that "nations´´ are allowed to comove with each other, but not with the international component c_t^w.

In this model, the parameters of N linear regressions with autocorrelated error terms have to be estimated together with the common component ct. This problem is approached using Bayesian statistics which allows for decomposing the joint distribution of the parameters ϕ, θ, σ etc. and the AR-parameters of the common components into marginal distributions conditioning on each other. These are used to make iterative random draws that have Markov properties and converge to the joint posterior distribution at an exponential rate (Geman and Geman 1984).

My estimation strategy is described in detail in (Kose, Otrok, and Whiteman 2003). The number of iterative draws is 24 000, and the first 4 000 are not used for inference in order to minimize the impact of the initial conditions. Inference means here that the median and the standard deviation of each parameter's 20 000 draws are calculated ad presented in the results section. When repeating the procedure it could be shown that the results do not change and convergence occurs.

Parameter choices include the AR-orders, which is $q = 8$ for the common component, and $p = 3$ for the local specific processes, see Kose, Otrok, and Whiteman (2003). Alternative p/q-combinations have not substantial impact on the results.

There are two unidentified parameters in the model. The first is that the cases ic_t und $(-i)(-c_t)$ are observationally the same. By setting one of the weights larger than zero this problem can be solved as it determines the sign of all other weights. For the international component, I chose the weight of London to be positive implying positive correlation between London's wheat price and the "world price´´. In the nations, I set the capitals' weights to a positive number, or, if not available, New York for the U.S. and Santander for Spain. Alternative choices of anchors did not change the results (see robustness tests on my website).

The second unidentified parameter is the common components scale. If it was measured in inches and the weights in centimeters the reverse case was observationally equivalent, meaning the variance of the common component is not identified. Sargent and Sims (1977) which I follow here fix this variance with a value of 1. The estimated common component's variance therefore bears no information and is normalized by the variance of average British wheat prices (the Gazette-prices) of measure 1 per cent.

The prior distributions in this model are taken directly from Kose, Otrok, and Whiteman (2003, p. 1221).

I estimate the model in two 25 year subperiods, 1806-1830 and 1831-1855.

The variance of each price is decomposed in the following way:

$$var(p_i) = (\lambda_i^w)^2 var(c_w) + (\lambda_i^n)^2 var(c_n) + var(u_i) \qquad (6)$$

Thus, three results are calculated for each city and subperiod. To get an overview, I calculate arithmetic means of the respective variance shares across cities for all cities and among all of a given nation. As preparation, prices are first logarithmized and then trend filtered. Robustness tests for the impact of the respective trend filters can be found on my website.

3 Data

In total, there are 57 series, 13 of which are German (in the borders of 1871), see Figure 1. I took the prices from Austria-Hungary, Belgium, France, the U.S. and the U.K. from (Jacks 2005), which are presented in gold dollar per 100 kg. I checked all the transformations and applied gold-greenback exchange rates to some series which were erroneously inflated during the civil war era.

Figure 1 here

The Swedish prices are average prices for historical administrative units of the 19th century, and were collected mainly for tax purposes. Therefore they are not market prices, but should reflect them sufficiently well (Jörberg 1972, p. 8). Most are annual average, some are however November-December price, but the author put emphasis on representing intra-year price movements as well as possible. The unit is krona, a gold coin, per hectoliter.

The prices from Hamburg, Berlin, Königsberg, Cologne, Munich and Mannheim are retail, wholesale and stock market prices for various kinds of wheat (Jacobs and Richter 1935a, p. 296). Munich and Mannheim report mainly retail prices. Prices from Cologne are not complete but have been extrapolated for 1806-1815 using growth rates of the other five cities. Berlin reports retail prices until 1838, and stock prices thereafter, while Hamburg delivers only stock market prices. Königsberg (today Kaliningrad) features retail prices until 1814, thereafter wholesale prices. All prices are presented in gold mark per 100 kg. Jacobs and Richter (1935a, p. 296) discuss the conversion procedure from local silver coins to gold in much detail. They apply a universal gold-silver exchange rate of 1:15,5 for numerous reasons. I follow this procedure when converting the other German price from Lower Saxony. These I took from Oberschelp (1986). They are reported in Kuranttaler, a silver coin, per Hannoverschen Himten, which equals 23,4 kg of wheat (Oberschelp 1986, p. XVI). These prices already incorporate monetary changes that happened during the sample period, and therefore had only to be converted to gold. The coin contains 0.58 grams fine silver and was converted to gold by dividing it by 15.5, to make them comparable to the prices in Jacobs and Richter (1935a). Since in 1871 the German gold mark contained 0.358 grams of fine gold, all prices are reported in mark like in (Jacobs and Richter 1935a, p. 315).

Comparing the two German data sets visually, first differences become evident immediately (Figure 2). Prices in Jacobs and Richter (1935a) have about the same mean, but appear to vary much more time and have a higher regional dispersion (see also Table 1). Oberschelp's (1986) prices, in contrast, vary only slightly with a cross-sectional coefficient of variation of 0.1 averaged over the whole period.

Figure 2 here

Table 1 here

I guess that prices in Hamburg and Königsberg contain information about foreign markets, since they exported grains, especially the U.K. (Jacobs and Richter 1935a, p. 276). In contrast, regional markets in Oberschelp (1986) are more likely to reflect local and short-term demand-supply relations.

Oberschelp (1986) reports only retail prices. These were collected during the agrarian reforms of the early 1800s, when farmers could be the land that they had been cultivating for the land owner before. In order to calculate an appropriate price, the produce's value had to be calculated which created the need for market prices. I applied special care here, since this procedure potentially implied forming a moving average of a window of about 10 years, and could therefore be responsible for the smooth appearance of the prices (Bracht 2009, p. 273). Therefore I raised alternative prices from an independent secondary source which contained annual prices for sure (Gerhard and Kaufhold 1990). Visual inspection for Göttingen shows that there was no substantial higher variance in the alternative price series (Figure 3). The same applies to Lüneburg, Osnabrück and Hannover, which are not shown here.

Figure 3 here

A potential decisive difference can be found however in the intra-annual point of observation. Oberschelp (1986) presents December or November prices, while Jacobs and Richter (1935a) show annual averages. Prices after the late summer harvest usually reflect the current yields or expectations about it, while intra-year deviations can be as much as 100 per cent, as during the later month demand and supply relations develop. They depend on yields in t-1 as well as demand in t (see also Persson (1999) and (Bracht 2009)). Figure 3 shows the difference very clearly. Apart from the shifted turning points, the prices move very similarly. There are peaks in 1817 (bad harvest), the agrarian crisis of the 1820s, and again price peaks of 1846 (potato disease and bad harvests), and overall increasing prices in the wake of the Crimean War at the end of the sample period.

I draw two conclusions from this comparison: Firstly, post-harvest prices seem to result in earlier turning points. Secondly, the prices in Oberschelp (1986) are not moving averages, since otherwise they would fluctuate much less.

4 Results

Comparing the data sets shows that the prices from Lower Saxony are less volatile, geographically less dispersed and have other turning points than those Jacobs and Richter (1935a). Therefore, I will adapt the empirical setup and treat the Oberschelp (1986)-prices as if it was a separate country (which is historically correct). Doing so allows for identifying the group specific common fluctuations of these two data subsets, and their respective variance shares. Figure 4 shows in the upper part the international common price component, which represents price fluctuations common to all cities in the sample. The middle part shows the price component representing price variations common to Berlin, Munich, Hamburg, Königsberg, Cologne and Mannheim. Note that this is only that part of common fluctuations which is different from international fluctuations. The lower part shows price swings shared only by the cities of Lower Saxony.

The international component features a distinct price increase in 1816/17 (see Stommel and Stommel (1983)). This hike is shared by the international price as well as the regional specific common price components. That means that German prices rose on average even more than the international price. Different from international prices, however, the large German cities experienced heavy fluctuations in the first decade during the continental system. The price peak of 1847 was other than the 1816 peak a purely international phenomenon.

4.1 International Price Fluctuations

Table 2 shows variance shares which stand for inter- and intranational as well as local specific common fluctuations. The table presents averages over subsets defined by national boundaries. The upper part tables results from a model where all 13 German prices are defined as being within one nation. The middle and lower part features the model treating the two German data sets as different nations. For the lower part, prices were shifted by one year in order to control for the differences in intra-year observation time. Since results for other nations are virtually not affected, only German results are presented in the middle and lower parts of the table.

Table 2 here

A remarkable result is that variance share of the international component increases from 38% to 50% from the first to the second quarter of the 19th century. This means a substantial increase of common price fluctuations in the whole sample. This applies especially to the large German cities, whereas the regional cities do not reflect this development. Only about $\frac{1}{4}$ of their common fluctuations is shared with international markets or about 50% if prices of the previous year are used. This cannot be fully explained by geographical distance, see Figure 1, since there were substantial distance between some of the cities in Oberschelp's (1986) data set. I rather think that wheat in these places was not meant for export and therefore prices reflected less international but local or regional demand and supply conditions.

Before the results are interpreted economically, the possibility of global shocks should be discussed. Price comovement may be driven by common global shocks such as weather phenomena, which is of course exogenous and biases comovement upwards. In order to exclude that possibility I employ evidence provided by climate researchers (Briffa, Jones, Schweingruber, and Osborn 1998). They collected 278 tree ring data sets from the northern hemisphere. These can be understood as general indicators of plant growth conditions. If tree rings are abnormally thin, the combination of temperature, precipitation and so forth was disadvantageous for plant growth. The method has the advantage of being independent of historical records, and skipping the most likely non-linear relationship between weather variables and plant growth, since tree rings are a direct indicator of plant growth. Between 1800 and 1850 Oberschelp (1986) depict six years of abnormal average growth, four of which were in the first subperiod and two in the second. The years from 1816 to 1819 experienced possible the worst famine in the 19th century and were most likely been caused by the eruption of the volcano Tambora in Indonesia. It is not so clear what caused tree rings to grow below average in 1836 and 1837. However, if global shocks played a role, they work in favor of my results, because they should have had a bigger impact in the first than in the second quarter.

I take this as evidence that global shocks do not drive the results. What then could be the cause? On the supply side of the market for transport services transport infrastructure and political barriers such as tariffs and embargoes are important factors. On the demand side, economic growth and structural economic change may play a role.

The transport revolution is often cited as the main cause of the "First Globalization´´ and consists mainly of technological innovation such as the steam ship, the railroad and metallurgical advances (Harley 1988b). However, the explanatory power of these developments for the first half of the 19th century is in my view limited. Although railroads were being built in the 1840s and 1850s, the full commercial potential for staple goods with a low value-weight ratio was generally not reached before 1860 (Findlay and O'Rourke 2005, pp. 35-36, Fremdling and Hohorst 1979, pp. 64) . The railroad has surely played an important role before 1860 were canal and river traffic was not available, but this effect was allegedly rather limited (Keller and Shiue 2008, pp. 14-16) .

What fits the evolution of the international component better is the abolition of political trade barriers, especially the gradual repeal of the Corn Laws in Britain and the removal of the continental system. The continental system was allegedly responsible for Königsberg's separation from international markets before 1830 (Table 3). The repeal of the Corn Laws has to be seen in the context of the Crafts-Harley-view of the British industrialization. According to this, economic growth accelerated most in the first half of the 19th century and not in the second half of the 18th century. Also, it was characterized by a migration of factors of production into manufacturing and out of agriculture. This changed Britain's foreign trade pattern, increasing the need for food imports and exports of manufactured products (Harley 1993). Since these food imports came to the largest part from Prussia (see Jacobs and Richter (1935a, p. 276)) and (Sharp 2008, p. 2)), the increasing international price components of the large North-German cities should be interpreted as clear evidence for a demand led globalization impulse. This view is corroborated by the fact that Mannheim, situated at the upper Rhine, and thus rather marginal to external grain trade (Hardach 1967, p. 82) shows much increase of the international price component (Table 3). Munich, not connected to the Rhine-network at all, shows no significant increase at all (Table 3).

Table 3 here

Additional to the demand led increase of international trade secondary effects are likely to have had an impact on price synchronization. Scale economies in producing transport services may be one. Brautaset and Grafe (2005) show for the Norwegian trading fleet in the first of the 19th century, then the third largest in the world, that freight rates declined with increasing volumes. Their freight rate index is constructed of a much broader data set than established ones (North 1968, Harley 1988b), and therefore more reliable. Brautaset and Grafe (2005) attributed the scale effects to lower per unit wage bills on larger sailing ships, information cost reduction on established routes and network effects due to more frequent traffic.

The transport revolution in the 19th century goes hand in hand with the communication revolution caused by the introduction of the telegraph in the 1850s or, at least, so says conventional wisdom. What's more to the story, however, is that in the first half of the 19th century substantial increases of the speed of information were achieved by gradual improvements in transporting business letters (Kaukiainen 2001). He shows that international business letters to London traveled between 19 and 119 days in 1820, but only 8 to 51 days in 1860. In combination with demand effects of the British industrialization, and the abolition of political trade barriers, these developments help to paint a picture of intensifying commodity trade, which was independent of the transport- and communication revolution.

4.2 Price Fluctuations in Germany

The discussion so far concentrates on the international component of wheat prices, especially of the large North-German cities. Their "national´´ component represents common fluctuations different from international price variations, and therefore declines as the international component increases. This does not mean, however, that prices in these places had less in common with each other, but that their common fluctuations were indistinguishable from international price variations.

An important institutional change in German trade during the first half of 19th century was the customs union or Zollverein. Founded in 1834, it abolished tariffs on internal trade and raised uniform external tariffs which were allocated according to population of the member states (Dumke 1991). For some of the cities in my sample, I cannot expect any influence on their trade activity: trade between Königsberg, Berlin and Cologne was anyway tariff free at least since the Prussian tariff laws of 1818. Hamburg joined the Zollverein as late as 1818, and the regional cities in my sample were all part of the Kingdom of Hanover, which joined in 1854 (Hahn 1984).

However, Munich (from 1834) and Mannheim (from 1836) may have profited from lower tariffs. This should result in an increased "national´´ variance share and a lower local one. Table 3 shows price variance of the large German cities explained by the respective common components. Munich and Mannheim indeed show higher "national´´ shares after 1830 than before. At the same time, the local components were lower. The relatively high "national´´ shares in comparison with the low international variance shares may be connected to lower internal tariffs on the one hand, and that they were not or only remotely connected to North and Baltic Sea.

Prices in the Kingdom of Hanover, i.e. Oberschelp's (1986) prices fluctuated already before 1830 very much in rhythm with each other, thus 60-70% of their variance is explained by the "national´´ component, depending on using current or last year's prices (Table 2, II and III, "Obersch.´´). The local component, indicating price fluctuations not shared with any other place, were even smaller before 1830 than in of the larger cities. Their distance was smaller of course, but still substantial (the cities of Norden and Göttingen are about 400 km away from each other, Norden and Lüneburg about 300 km).

The close movement of prices is rather puzzling, since arbitrage does not offer itself as an explanation. In the case of major cities discussed above water transport is always available, but here overland transport would obviously to be considered.

One approach is provided by (Kopsidis 2002). He argues that if the share of marketed grain was small relative to the overall produce, the market price can easily be influenced even if transport costs are high. Even small demand or supply deviations could cause price to adjust, since even small amounts of traded grains could represent a large portion relative to the volume of grain which is actually on the market.

There are two other approaches which should be considered. One would again be "global´´ shocks, i.e. exogenous influences that affect all cities in question. Another would be price adjustment due to the threat of arbitrage rather than actual arbitrage. This would require information flow of course, and transportation needs not be economically feasible. However, when studying actual transport volumes rather than prices, arbitrage could still be possible even if goods are actually not really transported anywhere.

5 Conclusion

In this article I study annual wheat prices from 13 German and 44 European and North-American cities in the 50 years following 1806. The research question is if comovement of prices among German cities increased or decreased and what the relationship between German and international price fluctuations was. Answering these questions should yield information about what drove intra- and international market integration: transport infrastructure, the abolishment of political trade barriers or demand through increased income. The method I use is a dynamic factor model which allows for decomposing price variation into parts shared by all others in the sample (explained by the international common component), shared by some of a given group such as a nation (explained by the national common component), or not shared with any other market in the sample (not explained).

I find a substantial increase of common variations on the international level between the first and the second quarter of the 19th century. This is allegedly caused by increased British demand for food imports, and not because of the transport revolution, i.e. steam ships and railroads, since their commercial application for the transport of low value goods had its biggest impact in the second half of the 19th century. Recent research has also provided arguments emphasizing scale economies in producing transport services and gradual improvements of traditional technologies. Within Germany I find trade enhancing effects of the customs union for Mannheim and Munich.

Technological as well as political innovations influenced commodity trade in the 19th century. However, demand side effects - and therefore secondary influences of industrialization on agricultural markets - should not be disregarded. Decomposing price fluctuations into common fluctuations at different, structured levels ("international´´, "national´´, "regional´´, "local´´) allows for identifying spatial dependence structures and their changes through time, which can be interpreted using qualitative information about trade in the 19th century. Future research will however incorporate non-price information in order to produce quantitative statements about the origin of the development of market integration in the 19th century.

References

Accominotti, O., and M. Flandreau (2008): "Bilateral Trade Treaties and the Most-Favored-Nation Clause: The Myth of Trade Liberalization in the Mid-Nineteenth Century," *World Politics*, 60(2), 147–188.

Bracht, J. (2009): "Geldlose Zeiten und überfüllte Kassen – Vermögenstransaktionen westfälischer Bauern auf frühen Kapitalmärkten (1830-1866)," Ph.D. thesis, Westfälische Wilhelms-Universität Münster.

Brautaset, C., and R. Grafe (2005): "The Quiet Transport Revolution: Norway's Sailing Fleet and 19th Century Transport Costs," *Oxford University Economic and Social History Series No. 62*.

Briffa, K. R., P. D. Jones, F. H. Schweingruber, and T. J. Osborn (1998): "Influence of Volcanic Eruptions on Northern Hemisphere Summer Temperature over the Past 600 Years," *Nature*, 393, 450–455.

Dumke, R. H. (1991): "Tariffs and Market Structure: The German Zollverein as a Model for Economic Integration," in *German Industry and German Industrialisation*, ed. by W. R. Lee, pp. 77–115. London: Routledge.

Federico, G., and K. G. Persson (2007): *The New Comparative Economic History: Essays in Honor of Jeffrey G. Williamson*chap. Market Integration and Convergence in the World Wheat Market, 1800-2000. MIT Press.

Findlay, R., and K. O'Rourke (2005): "Commodity Market Integration," in *Globalization in Historical Perspective*, ed. by J. G. W. Michael D. Bordo, Alan M. Taylor, p. 13. University Of Chicago Press.

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

Geman, D., and S. Geman (1984): "Stochastic Relaxation, Gibbs Distributions, and the Bayesian Restoration of Images," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, PAMI-6, 721–741.

Gerhard, H., and K. Kaufhold (1990): *Preise im vor-und frühindustriellen Deutschland: Grundnahrungsmittel*. O. Schwartz.

Hahn, H. (1984): *Geschichte des deutschen Zollvereins*. Göttingen: Vandenhoeck und Ruprecht.

Hardach, K. (1967): *Die Bedeutung wirtschaftlicher Faktoren bei der Wiedereinf "uhrung der Eisen-und Getreidez "olle in Deutschland 1879*. Berlin: Duncker und Humblot.

Harley, C. (1988a): "Ocean Freight Rates and Productivity, 1740-1913: The Primacy of Mechanical Invention Reaffirmed," *The Journal of Economic History*, 48(4), 851–876.

Harley, C. K. (1993): "Reassessing the Industrial Revolution: A Macro View," in *The British Industrial Revolution: an Economic Perspective*, ed. by J. Mokyr, pp. 171–226. Boulder Colorado: Westview Press.

Harley, K. (1988b): "Ocean Freight Rates and Productivity, 1740-1913: The Primacy of Mechanical Invention Reaffirmed," *Journal of Economic History*, 48(4), 851–876.

Jacks, D. (2005): "Intra- and International Commodity Market Integration in the Atlantic Economy, 1800-1913," *Explorations in Economic History*, 42(3), 381–413.

Jacks, D., D. Novy, and C. M. Meissner (2008): "Trade Costs, 1870-2000," *American Economic Review*, 98(2), 529–534.

Jacobs, A., and H. Richter (1935a): "Die Getreidepreise in Deutschland seit dem Ausgang des 18. Jahrhunderts," *Vierteljahrshefte zur Statistik des Deutschen Reichs*, 44(273).

Jacobs, A., and H. Richter (1935b): *Die Großhandelspreise in Deutschland von 1792 bis 1934*, vol. 37 of *Sonderhefte des Instituts für Konjunkturforschung.* Hamburg: Hanseatische Verlagsanstalt.

Jörberg, L. (1972): *A History of Prices in Sweden, 1732-1914*. Lund: Gleerup.

Kaukiainen, Y. (2001): "Shrinking the World: Improvements in the Speed of Information Transmission," *European Review of Economic History*, 5(1), 1–28.

Keller, W., and C. Shiue (2008): "Institutions, Technology, and Trade," *NBER Working Paper.*

Kopsidis, M. (2002): "Der westfälische Agrarmarkt im Integrationsprozeß 1780-1880. Phasen und Einflussfaktoren der Marktentwicklung in historischen Transformationsprozessen," *Jahrbuch fur Wirtschaftsgeschichte*, 2002(2), 169–198.

Kose, A., C. Otrok, and C. H. Whiteman (2003): "International Business Cycles: World, Region and Country-Specific Factors," *American Economic Review*, 93(4), 1216–1239.

Lampe, M. (2009): "Effects of Bilateralism and the MFN Clause on International Trade: Evidence for the Cobden-Chevalier Network, 1860-1875," *The Journal of Economic History*, 69(4), 1012–1040.

North, D. C. (1958): "Ocean Freight Rates and Economic Development 1750-1913," *Journal of Economic History*, 18(4), 537–555.

——— (1968): "Sources of Productivity Change in Ocean Shipping, 1600-1850," *Journal of Political Economy*, 75(5), 953–970.

Oberschelp, R. (1986): *Beiträge zur niedersächsischen Preisgeschichte des 16. bis 19. Jahrhunderts.* Hannover: Verlag August Lax.

O'Rourke, K. H. (1997): "The European Grain Invasion, 1870-1913," *Journal of Economic History*, 57(4), 775–801.

Persson, K. G. (1999): *Grain Markets in Europe, 1500-1900: Integration and Deregulation.* Cambridge: Cambridge University Press.

Sargent, T. J., and C. A. Sims (1977): *Business Cycle Modeling Without Pretending to Have Too Much A-Priori Economic Theory.* Minneapolis: Federal Reserve Bank of Minneapolis.

Sharp, P. (2006): "1846 and All That: The Rise and Fall of British Wheat Protection in the Nineteenth Century," *University of Copenhagen Discussion Paper No. 06-14*.

——— (2008): "Pushing Wheat: Why Supply Mattered for the American Grain Invasion of Britain in the Nineteenth Century," *University of Copenhagen Discussion Paper No. 08-08*.

Stommel, H. M., and E. Stommel (1983): *Volcano Weather: The Story of 1816, the Year Without a Summer*. Newport: Seven Seas Press.

Uebele, M. (2009): "International and National Wheat Market Integration in the 19th Century: A Comovement Analysis," *CQE Working Paper 4/2009, University of Münster*.

Abbildung 1: Die 13 deutschen Märkte (in den Grenzen von 1990). Schwarze Markierungen: Oberschelp (1986), rote Markierungen: Jacobs und Richter (1935a).

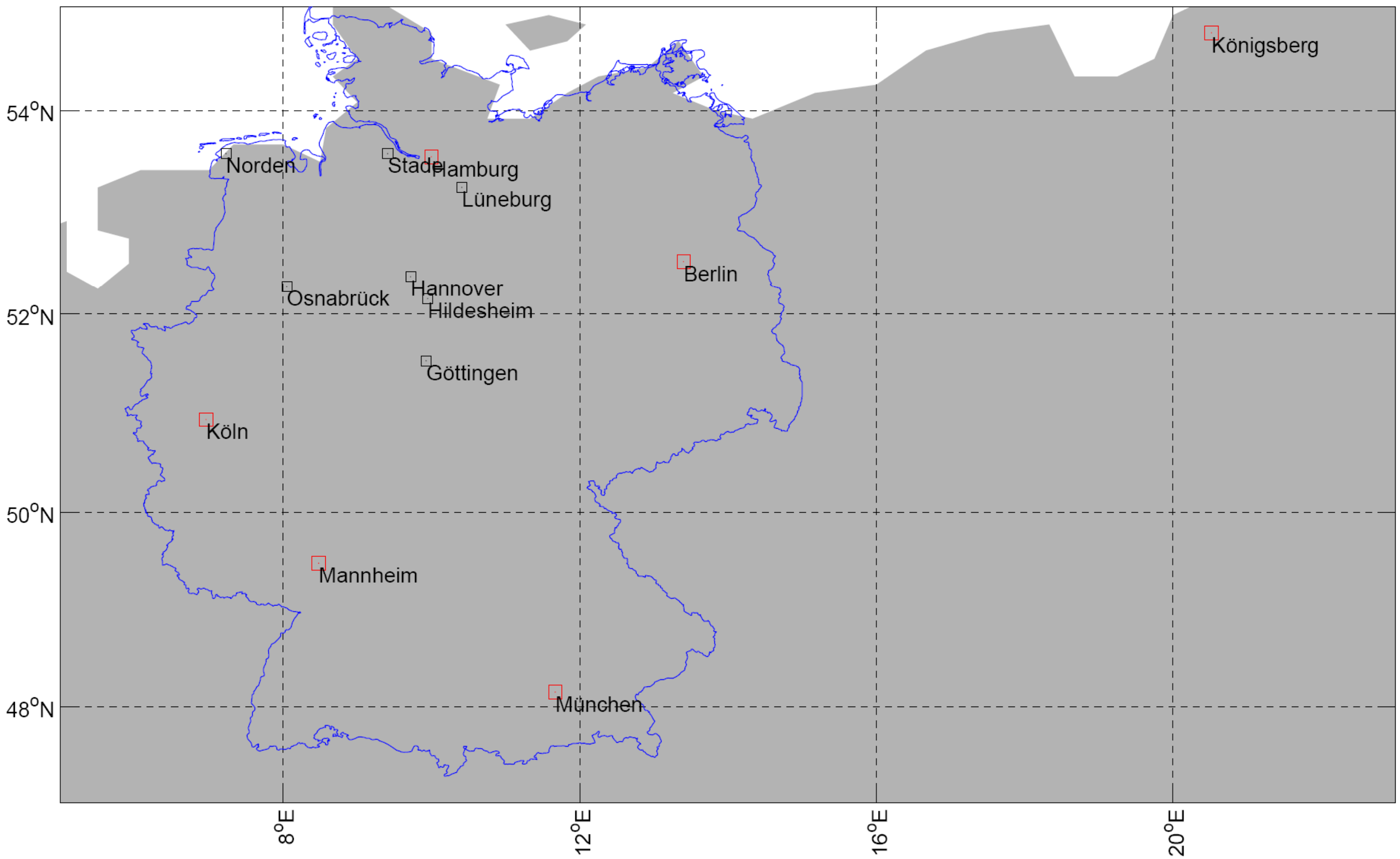

Figure 1: 13 German Cities (in the borders of 1990). Black squares: Oberschelp (1986), red squares: Jacobs und Richter (1935a).

Abbildung 2: Deutsche Weizenpreise in Mark pro 100 kg, 1806-1855.

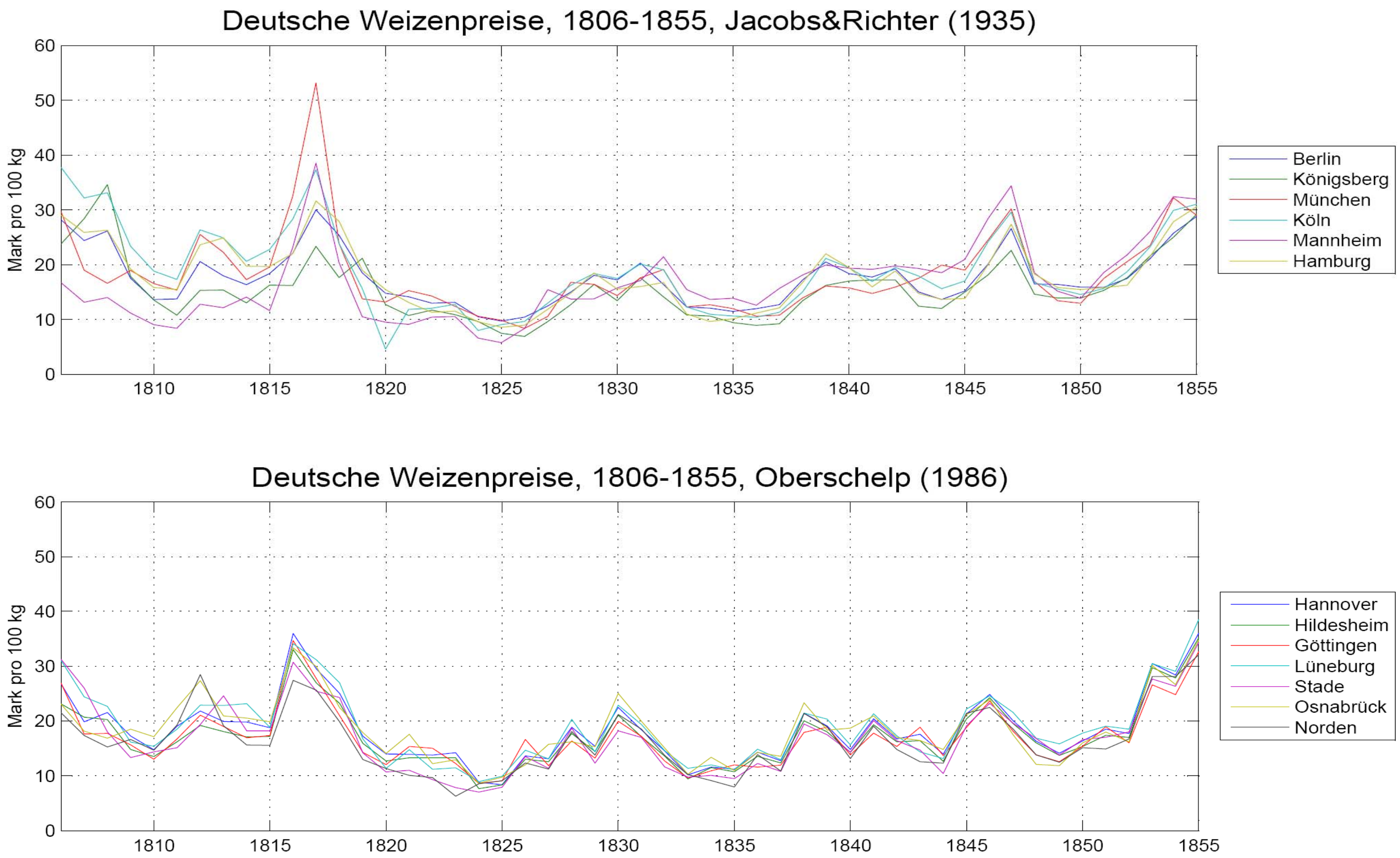

Figure 2: German wheat prices in mark per 100 kg.

Abbildung 3: Weizenpreis in Göttingen 1801-1855 aus Oberschelp (1986) und Gerhard/Kaufhold (1990, Index 1801=100).

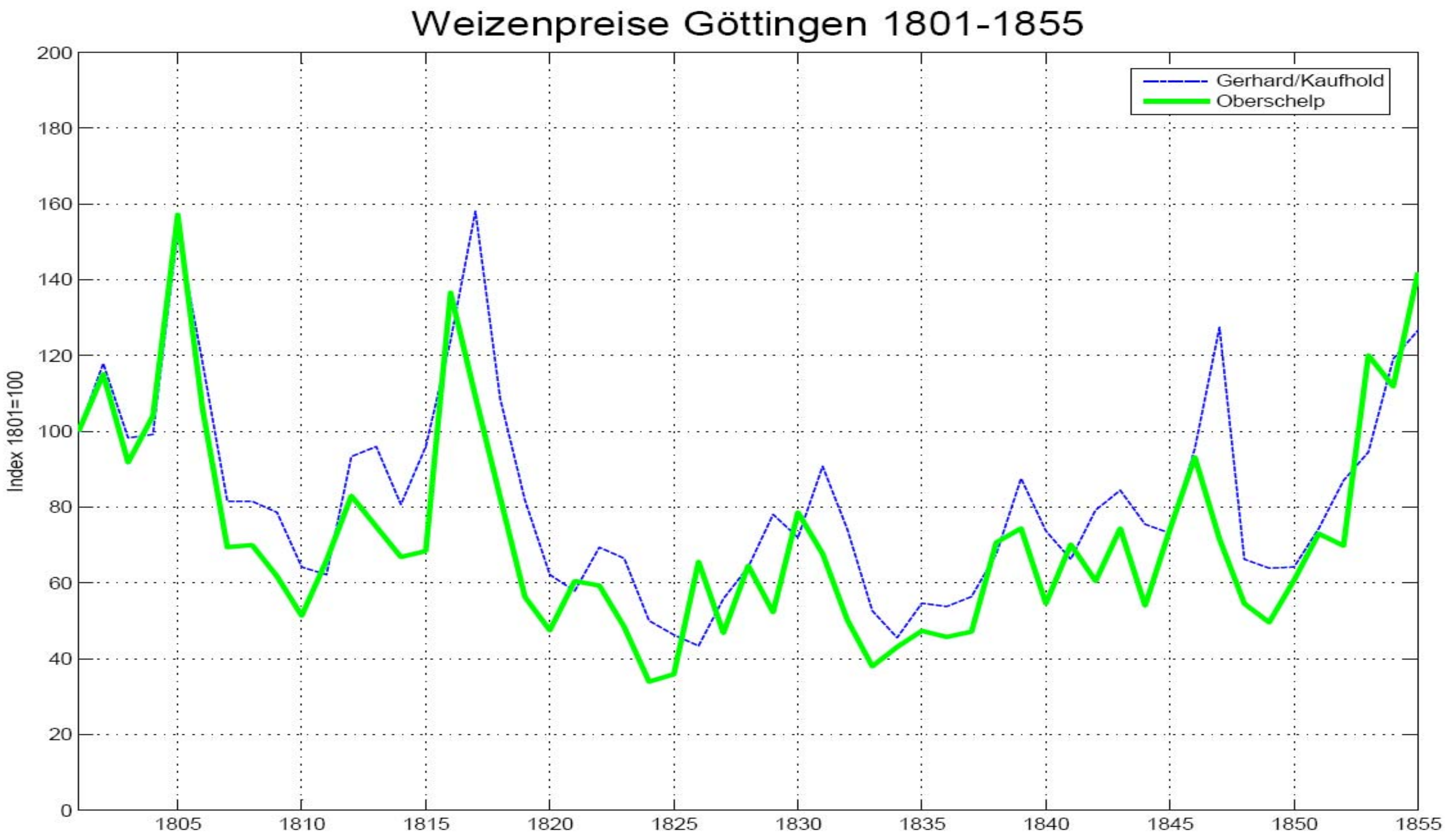

Figure 3: Göttingen wheat prices from Oberschelp(1986) and Gerhard and Kaufhold (1990), Index 1801=100.

Abbildung 4: Gemeinsame Komponenten von Weizenpreisen 1806-1855. Prozentuale Abweichungen vom langfristigen Trend. *Weltpreis*: Gemeinsame Komponente von 57 Preisreihen in Deutschland, Europa und den USA. *Nationaler Preis*: Davon abweichende gemeinsame Komponente in den jeweiligen deutschen Städten. Median (durchgehend) und Median plus/minus eine Standardabweichung (gestrichelt).

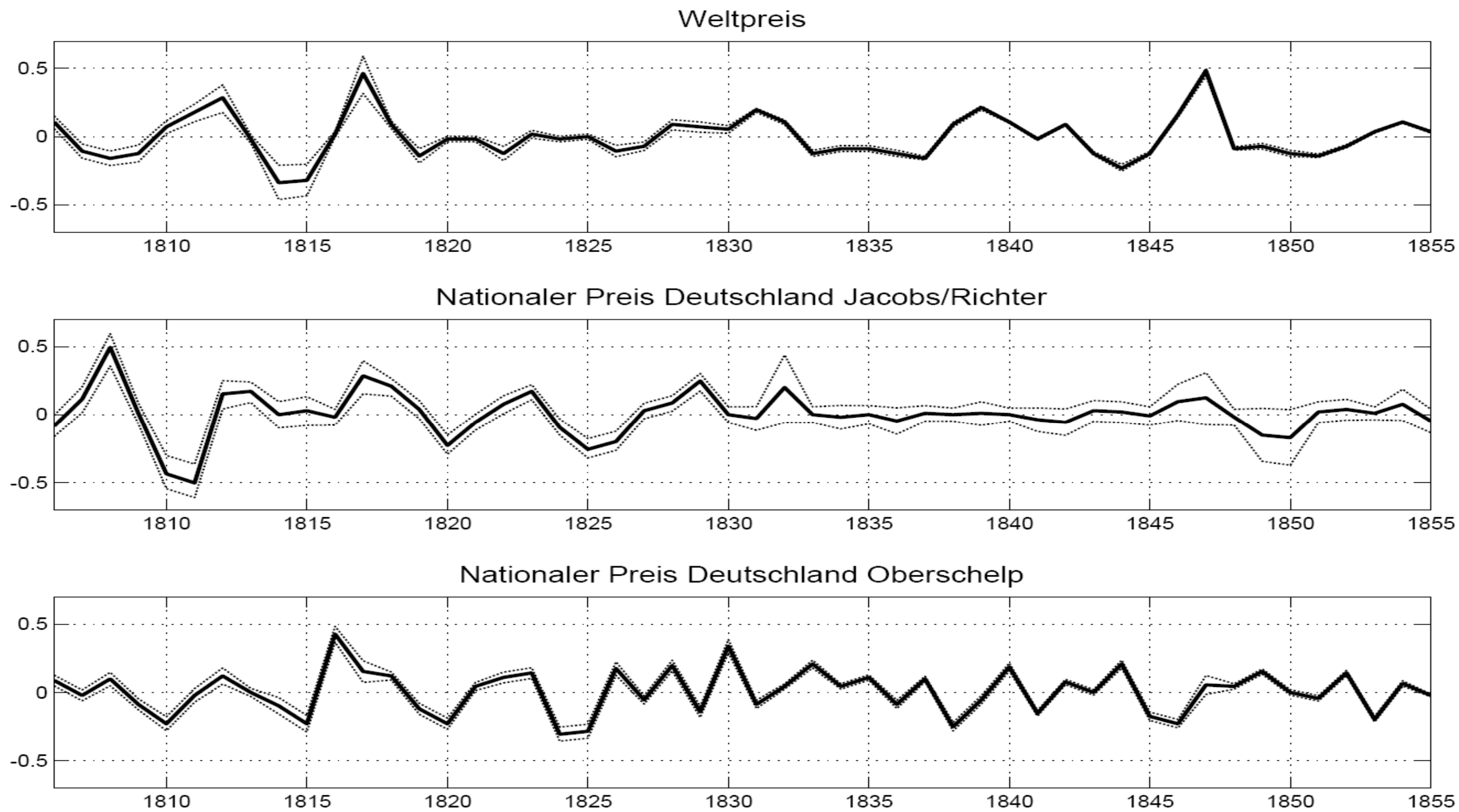

Figure 4: Common components of wheat prices 1806-1855. Percentage deviations from trend. The international component is common to all 57 markets. The national components are common to the subgroups, bit different to the international component.

Table 1: Descriptive Statistics

		Jacobs/Richter	Oberschelp
Mean[1]	1806-55	17.52	17.68
	1806-30	17.22	17.64
	1831-55	17.81	17.72
Volatility in Time[2]	1806-55	6.56	6.07
	1806-30	7.31	6.21
	1831-55	5.46	6.04
Regional Dispersion[3]	1806-55	0.16	0.10
	1806-30	0.20	0.12
	1831-55	0.12	0.08

[1]Arithm. mean of all years in all cities mark/100 kg.

[2]Arithm. mean across time of each city's standard deviation in %.

[3]Arithm. mean of each period's coefficient of variation;
i.e. cross-sectional standard deviation divided by cross-sectional mean.

Table 2: National Averages of Variance Shares

I: One German Region

	1806-1830			1831-1855		
	Int.	Nat.	Loc.	Int.	Nat.	Loc.
Austr.-Hung.	0.16	0.39	0.45	0.51	0.11	0.38
Belgium	0.77	0.19	0.04	0.91	0.06	0.03
France	0.81	0.06	0.13	0.68	0.21	0.10
Germany	0.28	0.36	0.36	0.51	0.37	0.12
Jac./Rich.	0.31	0.16	0.53	0.82	0.02	0.16
Obersch.	0.25	0.53	0.22	0.25	0.66	0.09
U.K.	0.32	0.56	0.12	0.64	0.29	0.07
U.S.A.	0.33	0.01	0.66	0.15	0.29	0.57
Sweden	0.10	0.63	0.27	0.14	0.68	0.18
All 57	0.38	0.37	0.25	0.50	0.34	0.15

II: Two German Regions

	1806-1830			1831-1855		
	Int.	Nat.	Loc.	Int.	Nat.	Loc.
Germany	0.20	0.55	0.25	0.50	0.40	0.09
Jac./Rich.	0.21	0.50	0.30	0.79	0.10	0.10
Obersch.	0.20	0.59	0.21	0.26	0.65	0.09
All 57	0.34	0.47	0.19	0.47	0.41	0.11

III: Two German Regions. Oberschelp: $p_t = p_{t-1}$

	1806-1830			1831-1855		
	Int.	Nat.	Loc.	Int.	Nat.	Loc.
Germany	0.18	0.57	0.25	0.64	0.27	0.09
Jac./Rich.	0.27	0.44	0.28	0.82	0.08	0.09
Obersch.	0.10	0.69	0.22	0.49	0.42	0.09
All 57	0.32	0.49	0.18	0.51	0.38	0.12

Table 3: Variance Shares for Germany

Germany (Jacobs and Richter)

	1806-1830			1831-1855		
	Int.	Nat.	Loc.	Int.	Nat.	Loc.
Berlin	0.20	0.74	0.06	0.95	0.00	0.04
Königsberg	0.01	0.66	0.33	0.87	0.00	0.12
Hamburg	0.20	0.68	0.12	0.83	0.03	0.14
Köln	0.09	0.41	0.50	0.90	0.06	0.04
Mannheim	0.21	0.33	0.46	0.64	0.25	0.10
München	0.54	0.15	0.31	0.57	0.28	0.14