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ABSTRACT

This paper explores the development of market integration within the Baltic Sea region as well as between the region and England, from the early 1840s to around 1890. It exploits two new datasets on grain prices. The paper applies a new method for measuring market integration by combining a dynamic factor model with wavelet analysis. A gradual yardstick is suggested and the role of distance analyzed. Wheat and rye markets became highly integrated whereas the cheaper grains lagged. Integration progressed geographically and conclusions emphasize traded volumes and transport cost.

KEY WORDS: Baltic Sea; grain prices; market integration; wavelet analysis; dynamic factor model

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Introduction

The efficiency and geographical extent of markets are crucial for how the economy works. This is the motivation for a growing literature on the topic of market integration which considers one or both of these aspects. The extent of a market is the area where prices for the same products are about equal in level – this is a soft version of the Law of One Price (LOP) which, strictly taken, is not justified in real life (for example, Kenneth Rogoff 1996). The efficiency of a market is the degree to which relevant factors are accommodated in the price – usually this is assessed by some measure of the co-movements between prices in different locations. Giovanni Federico (2012) argues that market integration is about equality or convergence of price levels, whereas the question of co-movements or coordination of changes should be seen as a separate issue of market efficiency. However, co-movements do not tell about efficiency of markets in their isolation but precisely when the markets are integrated. Of course, integration can be more or less or, as Federico quotes D. McCloskey, it is a question of “how big is big?” If the answer cannot simply be Yes or No, the reply to “how big is big” must by necessity be arbitrary, determined by some yardstick. In this paper, dealing with grain prices in Baltic Sea ports and London from the early 1840s to about 1890, we suggest a new measure based on a dynamic factor model and wavelet analysis to measure the degree of market integration. Among the advantages with this method is that it does not impose as many restricting assumptions as most other econometric techniques and to a larger extent let the data tell. Furthermore, in a second step the degree of market integration is analyzed as a comprehensive account of market integration that includes both time and space. The empirical results show that already by the mid-nineteenth century were the Prussian ports and Copenhagen highly integrated in markets for wheat and rye but less so in markets for oats and barley. It is suggested that the difference is due to traded volumes which were lower for the cheaper grains, since these to a smaller extent could bear transaction and transport costs. From the late 1870s market integration had advanced geographically. The Prussian ports and Copenhagen had now attained a higher integration with London in West as well as with St. Petersburg in East. The significance of distance within this region of northwestern Europe, for trade in wheat and rye, had disappeared.

These results sit necessarily not well with a recent argument that the most significant market integration in Europe and the Atlantic economy took place before 1850 and thus preceded the, so called, first wave of globalization. This should, according to Karl Gunnar Persson

(2004), David Jacks (2005), Federico and Persson (2007), and Martin Uebele (2011), mean that a combination of institutional changes were more important drivers for market integration than the fall in transport cost, due to technological change, that occurred in the second half of the nineteenth century. Persson (2004) argues that the late-nineteenth century fall in wheat freights diminishes when deflated by the declining price of wheat. The argument seems a bit trivial and also misinterpreted. The point is actually that wheat, despite a declining price, could bear the Atlantic freights and without a concomitant decline of the latter, integration and price integration would not have taken place. The causality is not a one-way process and there was certainly an interaction of several factors, institutions as well as flow of information and change in transport technology. To these factors could be added traded volumes which interacted both with institutions and scale effects of transport technology. To the latter belongs, indeed, the impact of railways with the enlargement of the areas of supply that pressed down the prices of wheat and increased volumes (Knick Harley 1980; Kevin O'Rourke and Jeffrey Williamson 1999). However, the recent literature on historical market integration has much overlooked the role of traded volumes and we are unhappy to do the same but our results point out that this is a missing variable.¹

In the next section we shortly introduce the historical problem, the Baltic Sea region and the role of market integration for wheat in the 19th century. Section three presents the data which actually are two new datasets, one based on monthly price quotations in Baltic Sea ports, and another based on the weekly quotations in the Economist. Section four then presents the method, section five provides an analysis of co-movements and the role of distance in different trading points. Section six concludes with a discussion of the results and their implications.

The Baltic Sea region and the grain trade

All since the Middle Ages, grain had been shipped over the Baltic Sea to Western Europe, in particular to Amsterdam which dominated the trade through the Early Modern period. In the

¹ This overlooking seems to be rooted in a theoretical conception that price convergence will take place regardless of the quantity of trade, as once argued by McCloskey and Zecher: "At the extreme, then, if Mars were connected to Earth by the market in chewing gum alone, the two price levels would nonetheless be fixed in relation to each other" (1984, p. 129).

Baltic, Danzig, as an outlet for Prussian grain, was the dominating port and at least from the end of the 16th to the beginning of the 19th centuries price changes in these two places were highly correlated. In the 19th century England came to replace the Netherlands as the most important destination and in 1845, 75 per cent of the Baltic shipped wheat were for the British, while only 13 per cent for the Dutch. At this time, the change-over from rye to wheat was also largely complete (Milja van Tielhof 2002, p. 94, 79, 64). However, it should be added that this change-over was not once and for all – the share of rye in the exports from Danzig increased again by the end of our period. On the eve of the First World War wheat had actually been surpassed not only by rye but also by barley and oats, as regards the shipped quantities (Pjotr Franaszek 2012). This reflected a geographical diversification of the markets for Baltic grain and also that the cheaper grains could bear the cost of transport, that is, a fall in the freight rates. We will see below that the increase in the shipping of barley and oats also is indicated by growing market integration at a later point in time than for wheat and rye.

A common argument in the literature about integration is that it is a causal factor in economic growth, so-called Smithian growth which is coming from trade and specialization of production (Federico 2012; Ronald Findlay and Kevin O'Rourke 2007; Federico et al. 1998). One could as well argue that both integration and economic growth are an outcome of trade even if full integration is thinkable without large-volume trade taking place. On a general level, efficiency of markets is a condition for economic growth but when zooming in on particular commodities, integration and the role for economic growth must be seen in its context. The Baltic-Dutch grain trade of the Early Modern period was crucial for feeding the growing urban population of the "First Modern Economy", and similarly the "Grain Invasion" of the second half of the 19th century was a brick in the modernization of Europe. In this period the Baltic trade was supplemented and overtaken by imports, to Western Europe, from other sources. Russian or Ukrainian wheat was shipped from Odessa, and from the American prairies came wheat over the Atlantic (Susan Fairlie 1965; M.E. Falkus 1966; Harley 1980; Barry Goodwin and Thomas Grennes 1998). Wheat prices in England increased until the 1870s, but probably the increase would have been significantly higher without the imports and from 1874 prices fell and were in a couple of decades cut by a half.² The impact

² A related issue is the effect of the Corn Laws on prices in Britain. Traditionally these are thought to have raised the British prices and cost of living (Fairlie 1965, 1969; Williamson

on economic growth and the standard of living can scarcely be overestimated. The ensuing period witnessed a break-through, not the least in the standard of living (Carol Leonard and Jonas Ljungberg 2010), and cheaper wheat had an important role.

In this context the internal as well as external integration of the wheat trade in the Baltic Sea region was part of the first wave of globalization. Despite the early integration of a North European grain market, there was still by the mid-19th century a bit to go. In order to address the question of “how big is big”, we take a look at the measure of market integration proposed by Federico (2010, 2012), that is, the dispersion of prices as indicated by the coefficient of variation.

[FIGURE 1]

The broad picture, as told by Figure 1, did not change very much from the 1840s to the 1880s or 1890s. Apart from the big bulge during the Crimean war in the 1850s, the decline of the dispersion is smooth and there is also recuperation after a bottom in the early 1870s. This is not dissimilar from the long-run view, with a larger European sample, told by Federico (2010). Thus, in this long-run view, there was a steady decline after 1825 and a “protectionist backlash in the late 1880s and early 1890s” (Federico 2010, p. 105). A direct effect from tariffs cannot be seen in the present sample because we here, as regards the Baltic port quotations, deal with prices f.o.b. and the Sounds Customs were insignificant.³ To the extent, or if, protection reduced the shipped quantities it might have constrained the leveling of prices. Even if shipments from Danzig fell, this happened already during the 1860s, before the protectionist backlash, and was caused by a reallocation of Polish-Russian exports to other Baltic ports (Franaszek 2012). Another explanation of the increased price spread is a

1990). However, this view is contested by Bertail and Chevet (1998). Yet, it is clear from our data that customers in Mark Lane, the London corn market, could acquire Baltic wheat about a fifth cheaper after Repeal 1846 and this roughly corresponded to the British duty.

³ Since the late Middle Ages, ships passing through the Sound must pay levies to the Danish Crown until abolishment in 1857. The levy in our period was marginal and from 1842 1 per cent of the load value. To this came different charges, and from an example in 1845 it can be estimated that a ship loaded with 250 tons of wheat had to pay 1.5 per cent of its value to the Customs Office in Elsinore (Bang 1919, p. 775 ff; Alexandersson 1982).

larger diversity of the qualities of supply. This was an outcome of a growth of the trade with more suppliers involved as well as the rise of systematic breeding.⁴ The Economist in the 1870s added price quotations of new sorts of Baltic wheat and even if these had expired by end of 1883, when only “American winter” and the Gazette prices persisted, it bears evidence of an all but unchanging supply of different kinds of wheat in the market.

Another thing to notice from Figure 1 is that the monthly volatility in the dispersion of price quotations declined over time, indicating a more even supply through efficient markets. This has no bearing on the question of a protectionist backlash or increased diversity, but gives a hint that there is more information to retrieve from the shorter frequency series than from the dispersion of annual averages.

The story of the dispersion of prices between the Baltic ports is broadly the same for the other grains, with often a slightly smaller spread of rye prices, somewhat wider for barley and even more so for oats. Inevitably one concludes that the leveling of prices was related to the shipped quantities but another reason for the larger spread and less coordinated changes of prices in oats and barley might be quality differences. Cheaper fodder grains may be mixed up with both oats and barley for human consumption.

The data

The present paper uses a previously not exploited set of monthly grain price quotations contained in the Swedish consular reports from Baltic Sea ports over the years 1841-1893.⁵

⁴ As a sign of the emerging activity in the field of breeding, a crossing of a Californian and a domestic wheat got the first prize on the Agricultural Exhibition in Warsaw in 1867 (Czembor et al 2001)

⁵ We acknowledge our indebtedness to the late Gunnar Fridlitzius for informing us about this source. Fridlitzius came across the Swedish consular reports in his research for *Swedish Corn Export in the Free Trade Era* (1957) but did not construct time series from the quotations. Bertail and Chevet (1998) use British consular reports containing weekly price quotations from Danzig for their analysis of the effect of the Corn Laws but whether such reports were dispatched from other Baltic ports is not told. The monthly Swedish consular reports were from more than a dozen ports but it has not been possible to construct continuous time series from all.

As usual for such quotations, they denote maximum and minimum observations, of which we have taken the averages. It is remarkable that this information was collected over such a long time without being further disseminated in print but seems only to have been an input to the analyses in the Swedish Foreign Office. However, it is not far-fetched to presume that these quotations reflected information that was known by the community of traders and shippers. If the information was around, it was up to the traders to take it into consideration. It is not necessary to think that an arbitrage should take place directly between the different Baltic Sea ports but rather that they competed in export markets and therefore price changes became coordinated.

As mentioned, in our period most of the Baltic grain exports went to England with London as a major market. In order to analyse the co-movements between wheat prices in the Baltic ports and London, we also use price quotations published in the weekly issues of the *Economist*. Starting with the issue of 9 September 1843 and running until 22 September 1883, a series of specified quality from Danzig and Königsberg has been constructed and further extrapolated, with American Red Winter, until end of June 1888. Often referred to are the “Gazette prices” which also were reported in the *Economist*, with reference to “the London Gazette of last night”, and which give the average price of all transactions of the week in the London corn market at Mark Lane. Since the composition of the transactions varied both in the short and the long term, the Gazette prices hide a quality problem, as noted already by Thorstein Veblen (see Persson 2004). To avoid this, at least for the London series, we have constructed a series on quotations of “high mixed Danzig”, followed by “Danzig and Königsberg, high mixed and white”, and in the 1870s subsequently “Fine old” and “New” of the same origin. Given the complete integration in the London market (see Section V), we think the extrapolation with the American wheat from 1883-1888 will not distort the consistency of this series.

The monthly time series for London is calculated as the averages of the weekly quotations. In no year every issue published the “prices current of corn” and interpolations have been undertaken for up to three weeks. In 1845-47 there are also a few longer gaps, of more than a month, where extrapolations have been undertaken on the Gazette prices. According to Taylor (2001), it is preferable to let actual quotations in one week represent the month. However, even if there is a theoretical sense in this argument, it was not advisable to follow

since the missing values would make the intervals between monthly observations frequent and irregular.

For the Baltic ports, quality differences are of less importance, since we look at the co-movements and not the levels. However, to the extent that quality changed differently between the ports over time, it would lead to an under-estimation of the market integration. Now the relative price differentials between the ports, according to the Swedish consular reports, were rather stable over time and it is reasonable to take these as a reflection of the quality differences. At least in 1889, when the unit quoted changed from volume to weight, it can be checked that these price differentials rather closely were due to quality differences.⁶ With the emergence of systematic breeding, probably variations in quality became more frequent which may appear as a constraint on integration as observed in the grain prices.

Also the Baltic data suffer from missing values. Most often only one observation (month) is missing but up to three months have been interpolated. However, longer gaps or breaks of the series occur, and to obtain as long time series as possible we have divided the data into two samples. The first data sample covers the period from the early 1840s to the 1850s or 1860s and the second sample covers the period from the early 1850s to the mid or late 1880s. Some ports are included in both samples, while others are only included in one sample. For barley missing data during the early 1870s prevented the construction of a sample from the 1850s to the 1880s and we have instead constructed three samples for barley, the first sample covering the 1840s to 1850s, the second sample covering the 1850s to the 1860s and the third sample covering the 1870s and 1880s.

⁶ Until December 1888 prices were reported for a Swedish barrel (158 l) and cubic feet (25,1 l) but in January 1889 the unit became 100 kg. Some uncertainty is imposed by price changes from December to January but estimating these from the seasonal trend, the volume-weight of the wheat in different ports can be calculated. According to a contemporary Swedish manual, premium quality wheat had a weight of 88 kg per hectoliter, second class 74 kg and third class 70 kg (Martin Ekenberg and Landin 1894). According to this classification only Danzig and Königsberg delivered true premium wheat, with weights of 88.1 and 91.6 kg, respectively. Lübeck, Rostock and Wismar came close to premium class with 86-87 kg but the other ports delivered below 83 kg with St. Petersburg lowest, 79.6 kg per hectoliter.

A detailed description of the samples is presented in Table 1. A further division of sub-samples can be seen in the table. Because the different samples contain different ports we cannot test for structural changes over time by a comparison of the results from the respective samples. Instead, to take account of structural changes we split the longer second sample into two sub-samples. The first sub-sample includes the 1850s and the 1860s and the second sub-sample the 1870s and the 1880s.

Additionally, we have used sailing distances (from Lübeck) to different ports, including London. These have been taken or derived from Bartholomew (1907). The choice of Lübeck is motivated by the fact that most of the ports are on the shores of, or close to, the German Bight.

Estimating the degree of market integration

According to the law of one price, the price of identical goods must have the same price as it is otherwise possible to make arbitrage profits. We can therefore test if markets are integrated by testing if the law of one price holds. However, some price differences may persist even if markets are fully integrated due to for example transportation costs or quality differences.

An alternative test of market integration is to analyze the degree of co-movement in prices because prices share the same movements when prices are integrated even though prices are not equal.

Several different tests of market integration based on co-movement of prices have been proposed (for a summary see e.g. Federico, 2012). One of the later contributions is dynamic factor model (see Uebele, 2011). The dynamic factor model has several advantages compared to other commonly used methods. The perhaps most important advantage is that it can be used to answer the question “how big is big?”. Markets can be more-or-less integrated but most tests only test if markets are fully integrated versus not being integrated at all. By using a dynamic factor model the degree of market integration can be estimated. The factor model separates between two causes of the price fluctuations: a common component for all markets and an idiosyncratic component unique for each market. In fully integrated markets the common factor explains (close to) 100% of the price variations and in completely independent markets the common factor explains 0% of the price variations. Between 0% and

100% the markets are partially but not fully integrated. If markets become more integrated over time the share explained by the common component will increase over time, which creates a simple metric which can be tracked over time to find evidence of increase market integration and potential turning points when the potential process of increased market integration increases. In practice it is unlikely that markets are 100% integrated and we return later in the empirical section to the question how close to 100 per cent should mean “fully integrated.”

Although the dynamic factor model has several desirable properties when testing for market integration, it does not take into account one important aspect of issue of market integration – time. The flow of information about prices among markets and arbitrage trade that equalize prices takes time. It is therefore probable that markets are more likely to be integrated over the long term than over the short-term. As is indicated by Figure 1, the coefficient of variation does not just vary due to short-term monthly jumps in the data, but also shows persistent cyclical variation – cycles that appear to last at least up to two years according to the Figure. Statistically the separation between short-term and long-term effect is not trivial (Federico, 2012). Not least because the choice of data frequency influences the results once the short-term and long-term processes are different (see for example, Engle, 1974; Corbae et al., 2002; Andersson, 2008, 2011). When high frequency data (that is, weekly, monthly or quarterly data) are used the short-term processes commonly dominate the results and when low frequency data (yearly data or five or ten year averages) are used the long-term processes commonly dominates the results. The results are thus sensitive to the choice of data frequency or the length of the averages. The choice of data frequency or length of the smoothing averages is commonly made arbitrary despite their influence on the results.

Similarly to Henning, Enflo and Andersson (2011) and Andersson, Edgerton and Opper (2013), we create a test for market integration by combining wavelet analysis and a dynamic factor model. By using wavelet methods we decompose the data into different time horizons such as short-run and long-run (and potentially additional time horizons such as the medium-run). This decomposition of the data allows us to control for different degrees of market integration at different time horizons and our analysis. In our test, one dynamic factor model is then estimated for each time horizon once the data has been decomposed. We thus model the degree of market integration for each time horizon and obtain an estimate of both the degree of market integration for each time horizon and if prices are highly integrated over the

long-run how quickly they adjust to the common factor (that is, how long any short-term price variations lasts).

Separating between different time horizons is difficult in the time domain but easy in the frequency domain where each frequency or band of frequencies can be interpreted as representing a given time horizon. The high frequencies, for example, capture the short-run variation in the data and the low frequencies capture the long run variation in the data. A problem with the frequency domain is that it does not allow for structural changes in how prices and markets behave because the frequency domain contains no time resolution. An alternative domain is the wavelet domain which is a combination of the time and frequency domains (Percival and Walden, 2006).

To transform the time series from the time domain to the wavelet domain we use the Maximal Overlap Discrete Wavelet Transform (MODWT). The MODWT is essentially a band pass filter, which unlike many other filters combines both time and frequency resolution it can be applied to time series data that contain structural breaks, outliers and other non-recurring events without having to pre-whiten the data (Percival and Walden, 2006). Controlling for outliers is especially important feature of the MODWT. Outliers can impact the analysis and can in some cases be the main driver behind the statistical results. All outliers are single events that affect the highest frequencies. Due to the MODWT's statistical properties the effect of outliers will mainly affect the highest frequencies and the other lower frequencies will be largely unaffected. Using the MODWT outliers consequently will affect the results for the short-run, but not the results for more persistent price changes. For a more detailed technical account of the MODWT see for example, Crowley (2007) and Andersson (2008).⁷ⁱ

⁷ To use the MODWT, one must choose a set of basis functions. We chose to use the Haar-wavelet basis functions since these functions minimize the potential effect that boundary problems may have on the estimation results (see for example, Percival and Walden, 2006). An alternative to the MODWT is the Discrete Wavelet Transform (DWT), which does not suffer from any boundary problems when using the Haar-wavelet. The variance decomposition of the DWT is, however, less efficient than that of the MODWT in small samples. As a sensitivity test, we also analyzed the data using the DWT, but this changed none of the main results presented in this paper.

Our test for market integration is constructed in the following way: let P_{it} be the price for market i at time t and let $p_{it} = \ln(P_{it})$, such that $\Delta p_{it} = p_{it} - p_{it-1}$. With monthly data, the MODWT decomposes the price series into six frequency bands⁸. These frequency bands represents cyclical variations that represent changes that lasts 2 to 4 months (the highest frequency band), 4 to 8 months, 8 to 16 months, 16 months to 32 months, 32 months to 64 months and a trend (lowest frequency band) that captures prices changes that last 64 months and beyond⁹. Specifically the prices series are decomposed,

$$\Delta p_{it} = D_{1it} + D_{2it} + D_{3it} + D_{4it} + D_{5it} + D_{6it} \quad (1)$$

where D_{1it} to D_{6it} denote the cycles from the highest to the lowest frequency band. To estimate how integrated markets are we estimate a dynamic factor model following the procedure in Bai and Ng (2002). Price variations at the different frequency bands (D_{jit}) are modeled as a common component and an idiosyncratic component,

$$D_{jit} = \alpha_{ji} + \alpha_{jif} f_{jt} + \varepsilon_{jit}, \quad (2)$$

where α_{ji} is a market specific constant, α_{jif} are market specific loadings for dynamic factor and ε_{jit} are idiosyncratic price movements. By construction the dynamic factor and the idiosyncratic shocks are independent whereby the following decomposition of the price variation is possible,

$$var(D_{jit}) = \alpha_{jif}^2 var(f_{jt}) + var(\varepsilon_{jit}). \quad (3)$$

The more integrated the markets are the more of the variance is explained by the common component. Using the share $MI_{ji} = [\alpha_{jif}^2 \times var(f_{jt})] / var(D_{jit})$ we thus have an estimate of how integrated a market is for each frequency band (that is, time horizon). This estimate is bounded between 0 and 1 where 0 implies no market integration and 1 complete market integration. In other words the measure MI_{ji} measures the percentage level of integration for the respective markets and frequency bands. However, as the Law of One Price is only

⁸ The number of frequency bands is limited by the length of the time series. With more time observations more frequency bands can be extracted. However, given the length of our time series we can only decompose the data into six frequency bands.

⁹ The length of the respective cycles and the trend is dictated by the construction of the MODWT to ensure that the MODWT provides an orthonormal decomposition of the variance, see Percival and Walden (2006).

approached in the real world, complete market integration is indicated at less than 100 per cent.

Mark Lane as a yardstick

Before analyzing the degree of co-movement of prices in the Baltic Sea region we start with an account of the co-movement of wheat prices in the London corn market to obtain a yardstick for comparison. In Mark Lane distance was of course of no importance and information was extremely good, communicated not only in encounters among the traders but also reported in the press. We should thus expect this to be a truly integrated market and we can use the results from Mark Lane as a yardstick for complete market integration.

Table 2 reports the shares of the price variation, between six different sorts of wheat in the London corn market, explained by the common components (MI_{ji}) for different frequency bands in the 1850s, using weekly data for wheat of different origins. In order not to lose any information, due to the spread of quotations of the same kind of wheat, both minimum and maximum quotations are displayed along with the averages. A point estimate of the shares for each kind of wheat and a 95% confidence interval are presented. The median and the average of all the shares are presented at the end of the Table.

[TABLE 2]

The Table reveals two main results. First, whether minimum, maximum or average prices are used have no major effect as the results are similar. Second, the adaption of co-movements was not instantaneous and for the high frequency price movements (2 to 4 weeks long) about two thirds of the variation is explained by the common component. For the frequency band of 8 to 16 weeks, roughly corresponding to the highest, of 2 to 4 months, in the Baltic samples the common component is on average 74 per cent of the total variation. The two lowest frequency bands in the London corn market, of 32 to 64 weeks and 64 weeks and beyond, have common components averaging 85-94 per cent of the total variation. In the Baltic samples these correspond to the 8-16 months and longer frequencies. It is reasonable to take these values, from about 75 per cent in the 2-4 months band, to above 85 per cent for the trend, as a yardstick of complete market integration in the Baltic samples.

Integration of wheat and rye markets

The level of estimated market integration for wheat is illustrated in Figure 2, Panel A for Sample 1 and Panel B for Sample 2. The detailed results including confidence bounds are provided in Table 3. The ports in the Baltic Sea region are less integrated compared to the yardstick set by Mark Lane. The differences compared with Mark Lane are smaller for the low frequencies (that is, long-run price changes) and higher for the high frequencies (short-run price changes) irrespective of sample period.

Copenhagen, Lübeck and Rostock stand out compared to the other ports as approaching full integration across almost all frequency bands. Only in the highest frequency band of 2 to 4 months price fluctuations where the common component falls short of the three-fourths threshold for these ports. These three ports must therefore be seen as highly integrated with the whole region it also suggests that these cities were price leaders in the market. The ports in the geographical peripheral, both two the west (London) and the east (Riga and St. Petersburg) are less integrated compared to the other ports irrespective of sample.

[FIGURE 2]

[TABLE 3]

To test for structural changes over time we split the longer Sample 2 into two sub samples: Sub-sample 1 covers the period 1850M3 to 1869M12 and Sub-sample 2 covers the period 1870M1 to 1888M6. These results are shown in Table 4. Both London and St. Petersburg becomes more integrated over time with the other ports. This increase in integration is most notable for the most persistent price variations and the higher frequency price movements continue to be less integrated with the other ports. It is likely that the process of greater market integration first affects the persistent price movements and these results thus indicate the process of greater market integration took place slowly during the 1850s to 1870s. In contrast, however, there is no sign of an increase in the degree of market integration for Riga.

[TABLE 4]

The results for rye are broadly similar to those for wheat, see Figure 3 and Table 5. The rye and wheat samples contain the same ports except for London, which is only included in the wheat sample. The share of the variance explained by the common component increases with

the more lasting price movements and is the highest for the trend component: averaging about 85 per cent in both samples. On average, as well as, for the peripheral Riga and St. Petersburg, the second sample shows a somewhat closer integration.

Similar as for the wheat market, the effect of structural change is tested by dividing the longer Sample 2 into two sub-samples; 1850M1 to 1869M12 and 1870M1 to 1886M2. St. Petersburg becomes more integrated with the other ports in the second-sub sample compared to the first sub-sample for the persistent price movements (64 months and beyond), see Table 6. Notable is also that contrary for wheat, Copenhagen goes from being fully integrated in the 1850s and 1860s to being less than fully integrated in the 1870s and 1880s for all price movements except for the most persistent price movements. This contradictory development for wheat and rye in the case of Copenhagen suggest that changes in the market rather than institutions were the cause.

[FIGURE 3]

[TABLES 5 and 6]

Taken together, these results for the wheat market and the rye market indicate that the ports in the geographical center of our sample from Flensburg in the west to Danzig in the east are relatively highly integrated with some ports approaching or even achieving full market integration given the Mark Lane yardstick. Ports in the geographical periphery on the other hand are less integrated with the other ports, although the integration is not zero. The results also show that the long-run price movements in these peripheral ports become more integrated overtime with the other ports.

Integration of oats and barley markets

On average, the oats and barley markets are less integrated than the wheat and rye markets and fewer ports reach full market integration irrespective of sample period, see Figures 4 to 6 and Tables 7 to 10. For both the wheat and rye markets, ports in the geographical center were relatively highly integrated for these markets compared to the periphery. Moreover, Danzig which for both wheat and rye belonged to the center of relatively highly integrated markets belongs to the periphery with less integrated ports.

[FIGURES 4 to 6]

[TABLES 7 to 10]

For oats, some contradictory changes take place over time which is seen from a comparison of the samples and subsamples. While Copenhagen and Wismar make progress and achieve figures close to those for wheat and rye are Lübeck and, to some extent, Rostock falling back from being highly integrated. Thus, integration in the oats market is patchier and the eastern ports Riga and St. Petersburg do not either become more integrated over time. Again this result suggests that other factors than institutions are important to understand changes in market integration in the Baltic Sea Region during the considered period.

For barley the specific comparisons cannot be performed with the other grains since the samples differ. It was not possible to construct a consistent set of price series covering the 1850s to the 1880s and instead we use three samples, one for 1843 to 1855, a second for 1856 to 1870 and the third from 1876 to 1888. It is therefore not possible to fully explore the effect of structural change over time. However, the pattern is even more patchy than for oats and the common component is larger in the higher frequency bands in some ports, notably Danzig and Riga, in the second period and St. Petersburg in the and third. Interestingly, for Copenhagen integration stayed high in wheat, declined in rye while it progressed in oats and made a U-turn in barley.

The dissimilar patterns for different kinds of grain lends support to our interpretation that market changes, such as consumer preferences, farming technology and transport facilities, determined the changes. For example, in the exported quantities of grain from Danzig, oats throughout our period made out less than 2 per cent (Frasaszek 2012). Meanwhile Sweden, for which we unfortunately lack comparable price data, became a major exporter but totally lost this position when out-competed by cheaper “Russian” oats in the early 1890s (Fridliziuz 1957). Also in other grains significant restructuring between exporting ports and markets took place, as briefly mentioned in the introduction. Theoretically, information and not traded volumes should have significance but in real life friction has a role and makes adjustment slower, in particular when not lubricated by actual transactions. Oats and barley are the cheaper grains, priced at less than half or only a third of wheat, and could first later bear the cost of long-haul shipping. This would speak for progressing market integration in our period. However, quality differences are big for both barley and oats, depending on whether they should be used for fodder or human consumption, in the case of barley refined to beer.

Before the growth of traded volumes gave way to standardization of supply, we can presume that quality changes had a larger impact on the price quotations and thus contributed to the patchy integration in oats and barley markets.

In summation, these results for oats and barley show that these markets are less integrated than the wheat and rye markets and few ports achieve full market integration given the Mark Lane yardstick. The results also show more variation than the results for wheat and rye, which indicate that these markets were less stable compared to the former markets. In other words, the higher the price of the grain type the more stable is the estimates of market integration across ports, time and sub-samples.

Distance

So far the results indicate that the relative geographical location of the respective cities in our sample affect how integrated these ports are with the other ports of the sample. Especially Riga and St. Petersburg are less integrated with the geographical center irrespective of sample and the kind of grain. There are primarily two reasons why distance can have an effect on the degree of integration. First, the cost of transportation increases with the distance whereby the price difference between two ports has to be relatively large for arbitrage trade to yield any profits. Second, the flow of information is slower.

To test the hypothesis that the distance has an effect we estimate the following model,

$$MI_{ji} = \alpha + \beta_1 distance_i + \sum_{n=1}^5 \beta_{1+n} d_n distance_i + d_n + \varepsilon_{ji}, \quad (6)$$

where *distance* is the distance in thousands of nautical miles from Lübeck, d_n is a dummy variable that takes the value 0 but 1 for frequency band $n=1, \dots, 5$. This dummy variable tests if the degree of market integration is systematically smaller or higher for any given frequency band (time horizon). The dummy variable is also interacted with the distance in order to test if the effect of the distance varies the frequency band – that is if the distance is more or less important for any given time horizon.

Lübeck is chosen as the benchmark city since it had for a long time been a center in the Baltic trade and our data also demonstrate that it was highly integrated with other ports in the

region. One model is estimated for each sample and Sample 2 is as in the previous analysis also divided into two sub-samples. The results are presented in Table 11.

[TABLE 11]

The frequency specific dummy, d_n , is significant for the two shortest time horizons (2 to 4 months and 4 to 8 months) irrespective of grain and time period. The effect of the dummy is negative and shows that the degree of co-movement of prices is systematically smaller for these shorter time horizons compared to the other relatively longer time horizons. For rye and oats the dummy for the 8 to 16 month time-horizon is also significant and negative, but not for wheat and barley. The time horizon thus has a significant effect of the degree of co-movement and is smaller for the shorter time horizons. For the relatively longer time horizons 16 months and beyond the average degree of co-movement is on average the same. Although the degree of market integration is smaller for the shorter time-horizons, markets are nevertheless to some extent integrated and as the average degree of integration are on average never zero. In other words, markets are integrated irrespective of time horizon but the degree of integration systematically increases until time horizons of 16 months and beyond have been reached.

For wheat and rye the distance has a negative and statistically significant effect for both samples. However, when we split Sample 2 into two sub-samples the effect of the distance from Lübeck is only statistically significant for the first sub-sample. In the second sub-sample, covering the 1870s and 1880s, the distance is no longer a statistically significant factor. For oats and barley, on the other hand, distance retains its negative and statistically significant effect throughout all periods.

There is little evidence of the distance having different effects for different time horizons (frequency bands). For wheat and rye the effect of the distance is slightly smaller for the shortest time-horizon (2 to 4 months) compared to the other time horizons. But, for oats and barley there is no such effect. In other words, the effect of the distance is more or less the same irrespective of the time horizon for all grains. And, the lower degree of market integration for the shorter time horizons is explained by other factors than distance.

Concluding remarks

Through centuries the urbanized regions of Western Europe were supplied with bread grain from the Baltic Sea region. Evidence has suggested a high degree of market integration between ports in the East, notably Danzig, and Amsterdam already through the Early Modern period. However, precisely what is meant by a high degree, and what about market integration within the Baltic Sea region?

The present study provides new methods for the analysis of market integration. Basically this is due to the application of wavelet analysis which lessens some common restrictions in econometric analysis. Further, a dynamic factor model is used for a determination of the common component of the cyclical variations in the price series. Short term and longer term can be comprehended in the same model, and instead of pairwise comparisons the interaction in larger samples can be analyzed. The element of time as well as of distance is focused and thereby it is possible to develop a yardstick or index for the degrees of market integration.

Despite centuries of Baltic grain trade, we can conclude that market integration may have been high, as for wheat and rye, but still by the mid-nineteenth century distance was a constraint and market integration was geographically limited. At this time Prussian ports and Copenhagen made out a fairly well integrated market with more eastern ports as well as London loosely connected. In other words, the Baltic Sea region was still incompletely integrated in the international or Atlantic economy. In the Prussian-Copenhagen region not much changed with integration in the second half of the nineteenth century, however, its relations with St. Petersburg and London became more integrated. This picture is corroborated by the role of distance which diminished and had disappeared after 1870, as far as wheat and rye are concerned. Thus, the death of distance occurred for the trade of grain in a market including metropolises of Northwestern Europe and the Baltic Sea region in the late 19th century.

Previous studies have shown that, for example considering Swedish butter, international integration may precede national integration (Ljungberg 1996). This point to the importance of traded volumes as a lever for market integration and price convergence. Swedish butter exports to England leveled prices between the south of Sweden, Copenhagen, and England before butter prices over all of Sweden had equalized. In grains, for which the national trade had begun earlier, Swedish market integration preceded that for butter by decades (Jörberg

1972). The contradictory development of market integration, between different grains, in the Baltic Sea region, particularly for Copenhagen, also emphasizes the role of traded volumes. Different patterns of integration, for different grains, in the same port moreover emphasize the role of demand and supply. Institutional change may well be endogenous in the historical process of market integration and not constantly the ultimate cause.

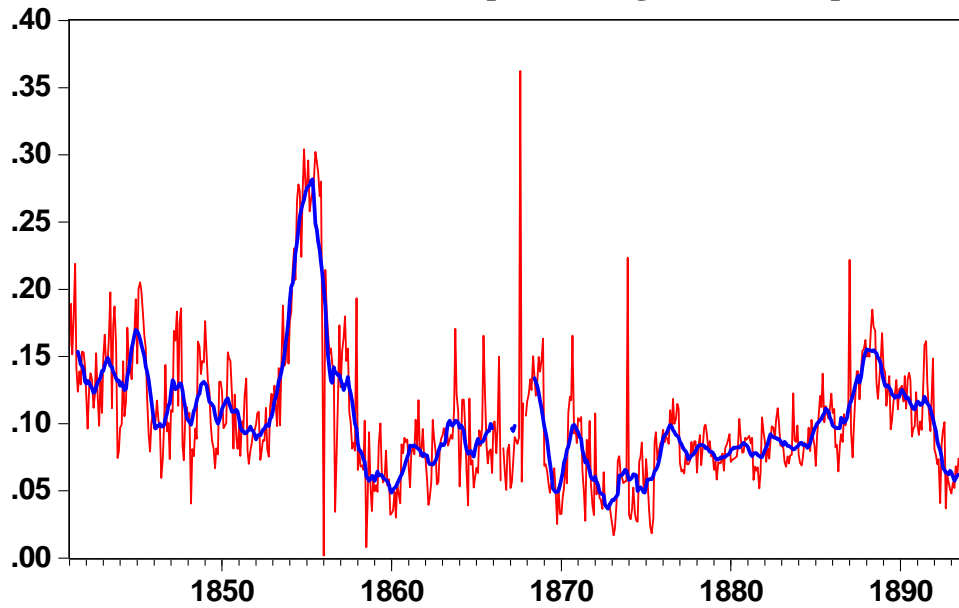
These results somewhat qualify the recent controversy about nineteenth century market integration, where the change before 1850 has been given greater weight than the changes taking place later in the nineteenth century. Market integration in the latter half of the nineteenth century progressed significantly by the inclusion of peripheral areas to already integrated markets. Crucial in this development were the railways which greatly increased the supply of grains in the exporting ports, on both sides of the Atlantic. Without the fall of transport costs by land as well as by sea, this development would not have taken place, the more so after 1870 when prices fell but nevertheless could sustain freight costs.

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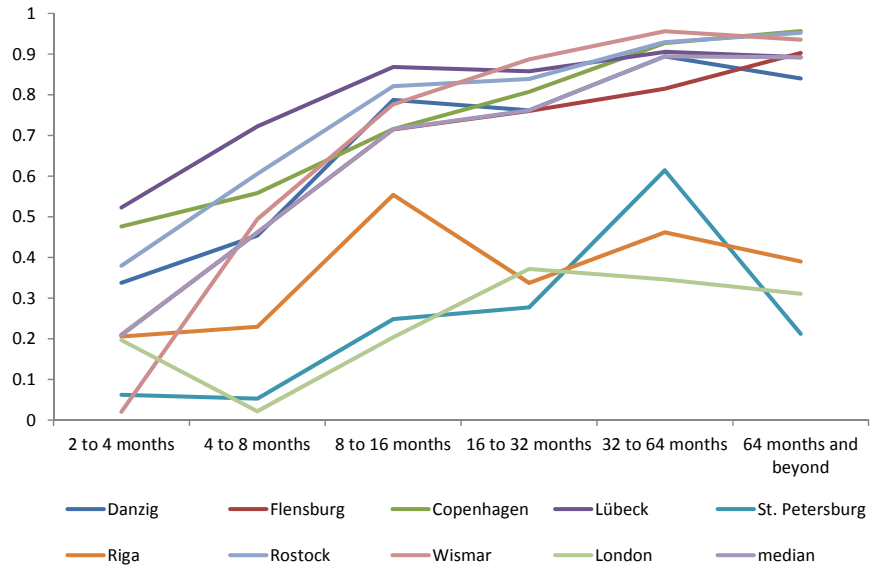
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Figure 1: Coefficient of variation for wheat prices in eight Baltic Sea ports, 1841-1893

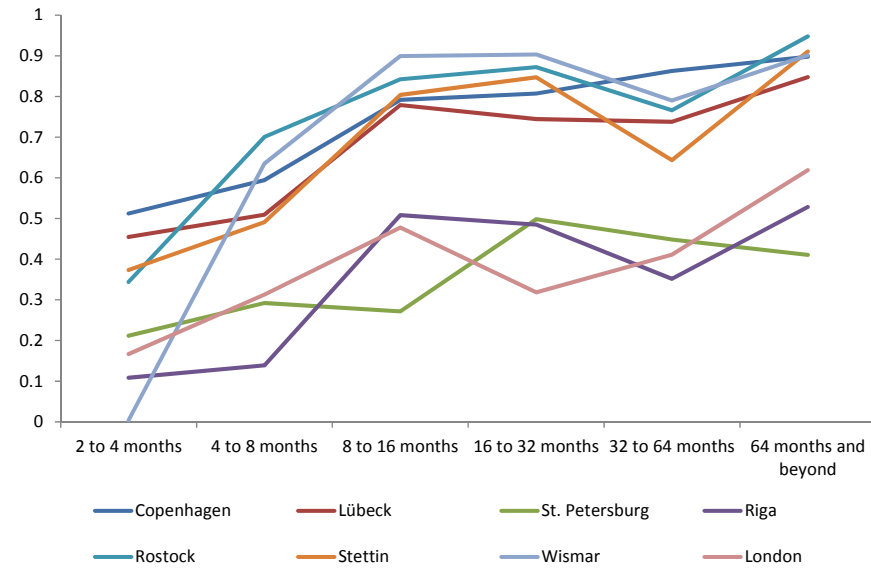


Note: the ports are Danzig (replaced by Stettin 1870:12 to 1878:06), Kiel (replaced by Flensburg 1858:08 to 1860:03), Copenhagen, Lübeck, St. Petersburg, Riga, Rostock, and Wismar. Monthly price quotations from Swedish consular reports. Curves show monthly figures and thirteen months centered moving averages.

Figure 2: Wheat market integration: shares of variation explained by the common component at different frequency bands

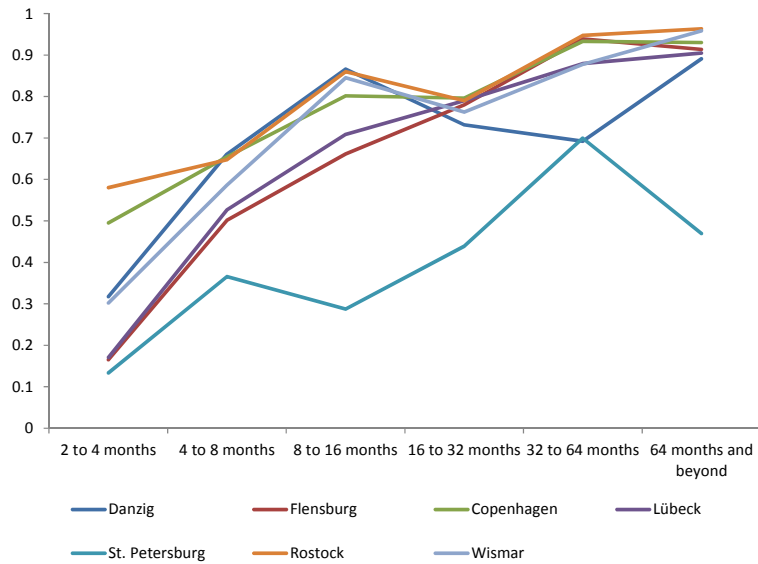


Panel A: Sample 1, 1843M7 to 1862M3

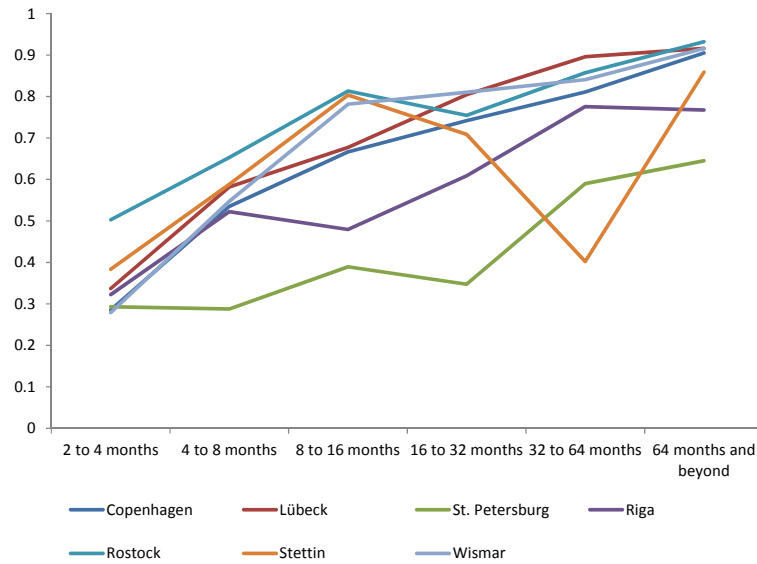


Panel B: Sample 2, 1850M3 to 1888M6

Figure 3: Rye market integration: shares of variation explained by the common component at different frequency bands

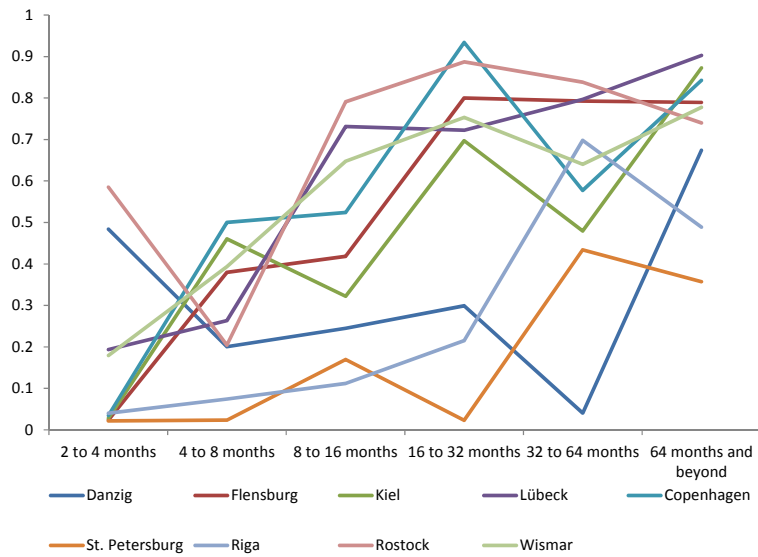


Panel A: Sample 1, 1843M7 to 1862M3

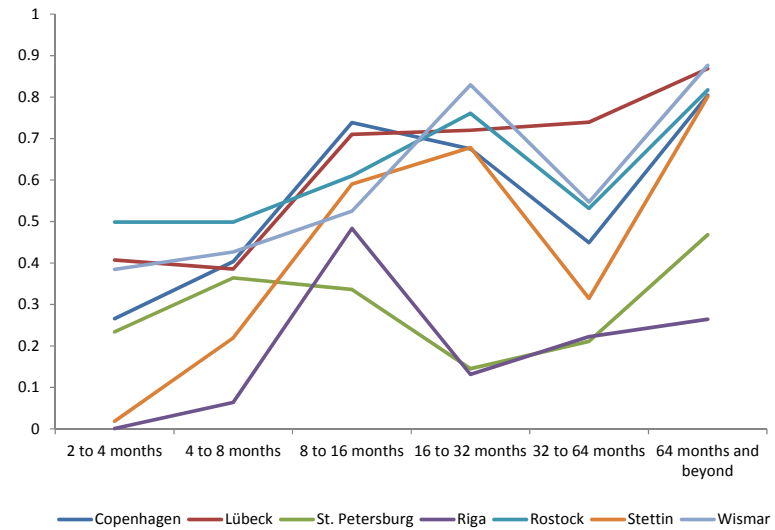


Panel B: Sample 2, 1850M1 to 1886M2

Figure 4: Oat market integration: shares of variation explained by the common component at different frequency bands

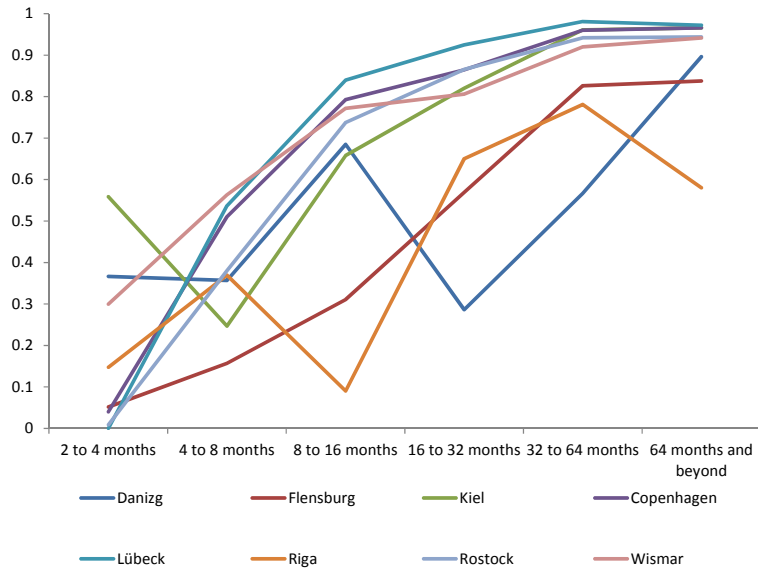


Panel A: Sample 1, 1843M3 to 1852M5

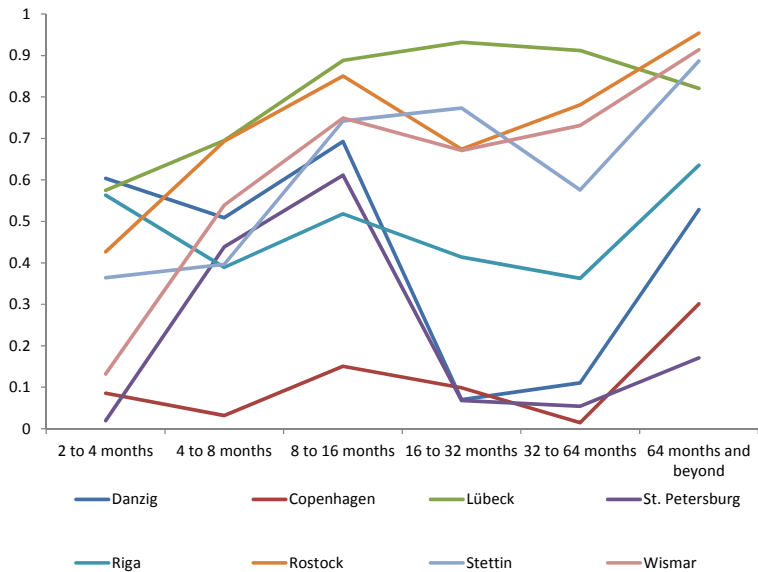


Panel B: Sample 2, 1856M1 to 1886M2

Figure 5: Barley market integration: shares of variation explained by the common component at different frequency bands

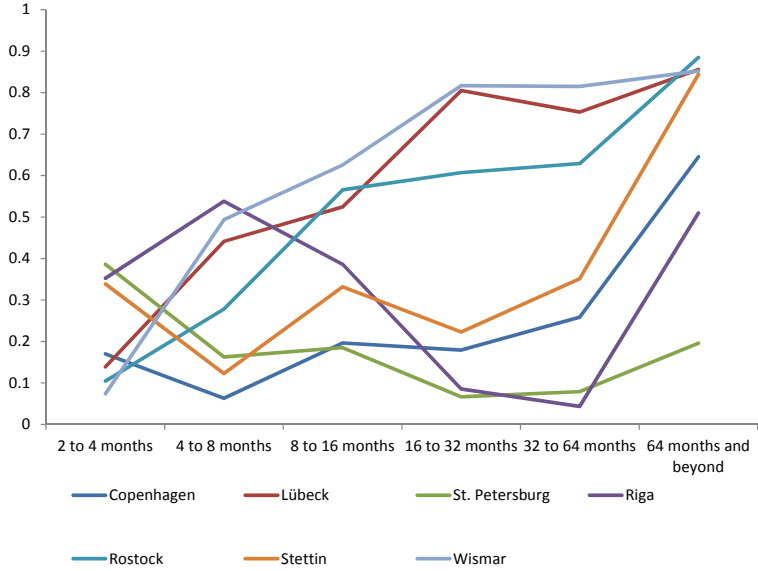


Panel A: Sample 1, 1843M7 to 1855M12



Panel B: Sample 2, 1856M5 to 1870M11

Figure 6: Barley market integration continued: shares of variation explained by the common component at different frequency bands



Sample 3: 1876M2 to 1888M12

Table 1: Sample description

		Sample 1		Sample 2		Sample 3	
Grain	Time period	Markets		Time period	Markets	Time period	Markets
Wheat	1843M7 to 1862M3	Danzig, Flensburg, Copenhagen, Lübeck, St. Petersburg, Riga, Rostock, Wismar and London		1850M3 to 1888M6	Copenhagen, Lübeck, St. Petersburg, Riga, Rostock, Stettin, Wismar and London.		
	1843M7 to 1862M3	Danzig, Flensburg, Copenhagen, Lübeck, St. Petersburg, Rostock and Wismar.				1850M1 to 1886M2	Copenhagen, Lübeck, St. Petersburg, Riga, Rostock, Stettin and Wismar.
Oats	1843M3 to 1852M5	Danzig, Flensburg, Kiel, Copenhagen, Lübeck, St. Petersburg, Riga, Rostock and Wismar.		1853M1 to 1886M2	Copenhagen, Lübeck, St. Petersburg, Riga, Rostock, Stettin and Wismar.		
Barley	1843M7 to 1855M12	Danzig, Flensburg, Kiel, Copenhagen, Lübeck, Riga, Rostock and Wismar.		1856M5 to 1870M11	Danzig, Copenhagen, Lübeck, St. Petersburg, Riga, Rostock, Stettin and Wismar.	1876M2 to 1888M12.	Copenhagen, Lübeck, St. Petersburg, Riga, Rostock, Stettin and Wismar.

Table 2: Estimates of market integration in the London Market 1853W1 to 1855W31

		2 to 4 Months	4 to 8 months	8 to 16 Months	16 to 32 Months	32 to 64 Months	64 months and beyond
Danzig and Koenigsberg mixed and white	min	0.61 [0.44, 0.76]	0.84 [0.79, 0.89]	0.71 [0.63, 0.77]	0.85 [0.78, 0.90]	0.74 [0.62, 0.84]	0.91 [0.88, 0.93]
	max	0.68 [0.47, 0.80]	0.47 [0.31, 0.62]	0.87 [0.80, 0.91]	0.88 [0.84, 0.91]	0.72 [0.64, 0.78]	0.95 [0.93, 0.97]
	average	0.74 [0.57, 0.85]	0.76 [0.66, 0.86]	0.89 [0.85, 0.93]	0.92 [0.88, 0.94]	0.81 [0.74, 0.87]	0.95 [0.93, 0.96]
Danzig and Koenigsberg mixed and red	min	0.77 [0.64, 0.86]	0.82 [0.76, 0.87]	0.92 [0.89, 0.94]	0.87 [0.82, 0.91]	0.86 [0.80, 0.90]	0.93 [0.91, 0.95]
	max	0.65 [0.46, 0.80]	0.75 [0.68, 0.83]	0.74 [0.61, 0.82]	0.84 [0.75, 0.90]	0.79 [0.69, 0.86]	0.95 [0.93, 0.96]
	average	0.75 [0.58, 0.85]	0.84 [0.79, 0.89]	0.87 [0.85, 0.93]	0.87 [0.81, 0.91]	0.84 [0.77, 0.89]	0.95 [0.93, 0.96]
Russian hard	min	0.50 [0.34, 0.67]	0.77 [0.67, 0.85]	0.60 [0.45, 0.73]	0.68 [0.57, 0.77]	0.83 [0.78, 0.88]	0.91 [0.87, 0.95]
	max	0.27 [0.15, 0.46]	0.56 [0.39, 0.70]	0.61 [0.47, 0.72]	0.80 [0.75, 0.85]	0.76 [0.68, 0.82]	0.92 [0.89, 0.95]
	average	0.40 [0.26, 0.55]	0.68 [0.55, 0.79]	0.65 [0.51, 0.75]	0.78 [0.71, 0.84]	0.80 [0.73, 0.85]	0.92 [0.88, 0.95]
Russian soft	min	0.82 [0.75, 0.87]	0.80 [0.72, 0.87]	0.68 [0.59, 0.76]	0.91 [0.90, 0.93]	0.81 [0.76, 0.86]	0.97 [0.96, 0.98]
	max	0.51 [0.34, 0.65]	0.83 [0.71, 0.88]	0.62 [0.49, 0.74]	0.91 [0.88, 0.93]	0.82 [0.77, 0.87]	0.95 [0.93, 0.97]
	average	0.73 [0.61, 0.82]	0.89 [0.85, 0.92]	0.66 [0.56, 0.75]	0.92 [0.90, 0.94]	0.84 [0.79, 0.87]	0.98 [0.97, 0.98]
Canadian red	min	0.70 [0.54, 0.80]	0.83 [0.75, 0.89]	0.80 [0.73, 0.86]	0.87 [0.82, 0.91]	0.89 [0.86, 0.919]	0.98 [0.96, 0.98]
	max	0.78 [0.67, 0.86]	0.79 [0.69, 0.86]	0.72 [0.61, 0.80]	0.85 [0.79, 0.89]	0.96 [0.94, 0.97]	0.96 [0.94, 0.97]
	average	0.77 [0.66, 0.85]	0.83 [0.77, 0.88]	0.78 [0.70, 0.85]	0.87 [0.82, 0.91]	0.95 [0.94, 0.97]	0.97 [0.96, 0.98]
Canadian white	min	0.73 [0.55, 0.84]	0.85 [0.79, 0.89]	0.75 [0.63, 0.84]	0.95 [0.93, 0.96]	0.97 [0.96, 0.98]	0.95 [0.93, 0.97]
	max	0.77 [0.67, 0.85]	0.75 [0.64, 0.82]	0.58 [0.46, 0.68]	0.91 [0.87, 0.83]	0.95 [0.93, 0.96]	0.95 [0.93, 0.97]
	average	0.80 [0.68, 0.88]	0.83 [0.76, 0.87]	0.68 [0.58, 0.77]	0.93 [0.91, 0.95]	0.97 [0.96, 0.97]	0.96 [0.95, 0.97]
Median	min	0.71 [0.60, 0.80]	0.83 [0.78, 0.86]	0.73 [0.67, 0.79]	0.87 [0.83, 0.90]	0.85 [0.81, 0.88]	0.94 [0.93, 0.96]
	max	0.66 [0.50, 0.77]	0.75 [0.67, 0.81]	0.67 [0.61, 0.74]	0.86 [0.82, 0.90]	0.81 [0.77, 0.85]	0.95 [0.93, 0.96]
	average	0.75 [0.64, 0.82]	0.83 [0.77, 0.86]	0.73 [0.68, 0.80]	0.90 [0.86, 0.92]	0.84 [0.80, 0.88]	0.96 [0.94, 0.97]
Average	min	0.69 [0.61, 0.76]	0.82 [0.77, 0.86]	0.74 [0.69, 0.79]	0.86 [0.82, 0.88]	0.85 [0.82, 0.88]	0.94 [0.92, 0.96]
	max	0.61 [0.52, 0.68]	0.69 [0.63, 0.75]	0.69 [0.63, 0.74]	0.86 [0.83, 0.89]	0.83 [0.80, 0.86]	0.95 [0.93, 0.96]
	average	0.70 [0.62, 0.76]	0.81 [0.75, 0.85]	0.76 [0.70, 0.80]	0.88 [0.85, 0.91]	0.87 [0.84, 0.89]	0.96 [0.94, 0.97]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates. The confidence intervals are obtained through wavestrapping.

Table 3: Wheat market integration full samples

		2 to 4 months	4 to 8 Months	8 to 16 months	16 to 32 months	32 to 64 months	64 months and beyond
<i>Danzig</i>	1843M7 to	0.34	0.45	0.79	0.76	0.89	0.84
	1862M3	[0.12, 0.34]	[0.28, 0.60]	[0.74, 0.83]	[0.70, 0.81]	[0.85, 0.93]	[0.79, 0.89]
	1850M3 to	---	---	---	---	---	---
	1888M6	---	---	---	---	---	---
<i>Flensburg</i>	1843M7 to	0.21	0.46	0.72	0.76	0.81	0.90
	1862M3	[0.07, 0.36]	[0.26, 0.62]	[0.65, 0.78]	[0.69, 0.81]	[0.74, 0.86]	[0.88, 0.93]
	1850M3 to	---	---	---	---	---	---
	1888M6	---	---	---	---	---	---
<i>Kiel</i>	1843M7 to	---	---	---	---	---	---
	1862M3	---	---	---	---	---	---
	1850M3 to	---	---	---	---	---	---
	1888M6	---	---	---	---	---	---
<i>Copenhagen</i>	1843M7 to	0.48	0.56	0.72	0.81	0.93	0.96
	1862M3	[0.19, 0.61]	[0.43, 0.66]	[0.65, 0.77]	[0.75, 0.85]	[0.90, 0.95]	[0.94, 0.97]
	1850M3 to	0.51	0.59	0.79	0.81	0.86	0.90
	1888M6	[0.33, 0.61]	[0.52, 0.66]	[0.75, 0.83]	[0.77, 0.84]	[0.82, 0.89]	[0.88, 0.91]
<i>Lübeck</i>	1843M7 to	0.52	0.72	0.87	0.86	0.91	0.89
	1862M3	[0.09, 0.72]	[0.62, 0.79]	[0.83, 0.90]	[0.81, 0.90]	[0.86, 0.94]	[0.87, 0.92]
	1850M3 to	0.45	0.51	0.78	0.74	0.74	0.85
	1888M6	[0.12, 0.59]	[0.40, 0.61]	[0.73, 0.82]	[0.70, 0.78]	[0.68, 0.79]	[0.83, 0.87]
<i>St. Petersburg</i>	1843M7 to	0.06	0.05	0.25	0.28	0.61	0.21
	1862M3	[0.00, 0.22]	[0.00, 0.24]	[0.12, 0.40]	[0.17, 0.39]	[0.54, 0.69]	[0.08, 0.38]
	1850M3 to	0.21	0.29	0.27	0.50	0.45	0.41
	1888M6	[0.07, 0.35]	[0.15, 0.43]	[0.18, 0.38]	[0.43, 0.57]	[0.36, 0.52]	[0.29, 0.56]
<i>Riga</i>	1843M7 to	0.21	0.23	0.55	0.34	0.46	0.39
	1862M3	[0.00, 0.52]	[0.07, 0.39]	[0.44, 0.65]	[0.25, 0.45]	[0.40, 0.54]	[0.30, 0.48]
	1850M3 to	0.11	0.14	0.51	0.48	0.35	0.53
	1888M6	[0.00, 0.32]	[0.05, 0.25]	[0.42, 0.59]	[0.40, 0.57]	[0.27, 0.44]	[0.45, 0.59]
<i>Rostock</i>	1843M7 to	0.38	0.61	0.82	0.84	0.93	0.95
	1862M3	[0.20, 0.56]	[0.45, 0.72]	[0.79, 0.85]	[0.80, 0.87]	[0.90, 0.95]	[0.94, 0.96]
	1850M3 to	0.34	0.70	0.84	0.87	0.77	0.95
	1888M6	[0.15, 0.49]	[0.62, 0.77]	[0.81, 0.87]	[0.85, 0.89]	[0.72, 0.80]	[0.94, 0.96]
<i>Stettin</i>	1843M7 to	---	---	---	---	---	---
	1862M3	---	---	---	---	---	---
	1850M3 to	0.37	0.49	0.80	0.85	0.64	0.91
	1888M6	[0.09, 0.51]	[0.38, 0.59]	[0.77, 0.84]	[0.82, 0.87]	[0.57, 0.70]	[0.89, 0.93]
<i>Wismar</i>	1843M7 to	0.02	0.49	0.78	0.89	0.96	0.94
	1862M3	[0.00, 0.44]	[0.34, 0.66]	[0.72, 0.83]	[0.86, 0.91]	[0.93, 0.97]	[0.91, 0.95]
	1850M3 to	0.00	0.63	0.90	0.90	0.79	0.90
	1888M6	[0.00, 0.32]	[0.53, 0.72]	[0.88, 0.92]	[0.88, 0.92]	[0.75, 0.82]	[0.88, 0.92]
<i>London</i>	1843M7 to	0.20	0.02	0.20	0.37	0.35	0.31
	1862M3	[0.05, 0.55]	[0.00, 0.16]	[0.08, 0.35]	[0.25, 0.49]	[0.22, 0.49]	[0.17, 0.45]
	1850M3 to	0.17	0.31	0.48	0.32	0.41	0.62
	1888M6	[0.04, 0.44]	[0.20, 0.44]	[0.39, 0.56]	[0.24, 0.40]	[0.32, 0.50]	[0.51, 0.73]
<i>Median</i>	1843M7 to	0.21	0.46	0.72	0.76	0.89	0.89
	1862M3	[0.17, 0.40]	[0.36, 0.55]	[0.67, 0.78]	[0.73, 0.81]	[0.85, 0.92]	[0.87, 0.91]
	1850M3 to	0.28	0.50	0.79	0.78	0.69	0.87
	1888M6	[0.18, 0.37]	[0.42, 0.57]	[0.75, 0.81]	[0.74, 0.81]	[0.64, 0.73]	[0.86, 0.89]
<i>Average</i>	1843M7 to	0.27	0.40	0.63	0.66	0.76	0.71
	1862M3	[0.21, 0.35]	[0.35, 0.46]	[0.60, 0.67]	[0.62, 0.69]	[0.72, 0.79]	[0.68, 0.74]
	1850M3 to	0.27	0.46	0.67	0.68	0.63	0.76
	1888M6	[0.22, 0.35]	[0.42, 0.50]	[0.65, 0.69]	[0.66, 0.71]	[0.59, 0.65]	[0.73, 0.79]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 4: Wheat market integration second sample sub-samples

		2 to 4 months	4 to 8 months	8 to 16 months	16 to 32 months	32 to 64 months	64 months and beyond
Danzig	1850M3 to 1869M12	---	---	---	---	---	---
	1870M1 to 1888M6	---	---	---	---	---	---
Flensburg	1850M3 to 1869M12	---	---	---	---	---	---
	1870M1 to 1888M6	---	---	---	---	---	---
Kiel	1850M3 to 1869M12	---	---	---	---	---	---
	1870M1 to 1888M6	---	---	---	---	---	---
Copenhagen	1850M3 to	0.47	0.62	0.77	0.74	0.85	0.93
	1869M12	[0.08, 0.61]	[0.53, 0.70]	[0.72, 0.82]	[0.68, 0.79]	[0.79, 0.89]	[0.91, 0.94]
	1870M1 to	0.49	0.55	0.83	0.93	0.89	0.84
	1888M6	[0.17, 0.64]	[0.41, 0.66]	[0.77, 0.88]	[0.92, 0.95]	[0.85, 0.92]	[0.81, 0.88]
Lübeck	1850M3 to	0.58	0.52	0.83	0.77	0.72	0.88
	1869M12	[0.01, 0.69]	[0.35, 0.64]	[0.78, 0.87]	[0.71, 0.82]	[0.64, 0.79]	[0.85, 0.90]
	1870M1 to	0.30	0.54	0.68	0.69	0.77	0.83
	1888M6	[0.07, 0.56]	[0.37, 0.66]	[0.57, 0.77]	[0.62, 0.76]	[0.69, 0.83]	[0.78, 0.87]
St. Petersburg	1850M3 to	0.21	0.21	0.19	0.56	0.38	0.25
	1869M12	[0.04, 0.44]	[0.06, 0.40]	[0.08, 0.33]	[0.46, 0.64]	[0.27, 0.48]	[0.12, 0.43]
	1870M1 to	0.03	0.48	0.45	0.40	0.63	0.82
	1888M6	[0.00, 0.19]	[0.38, 0.58]	[0.34, 0.55]	[0.29, 0.51]	[0.53, 0.72]	[0.76, 0.87]
Riga	1850M3 to	0.28	0.23	0.60	0.38	0.55	0.51
	1869M12	[0.00, 0.57]	[0.11, 0.39]	[0.48, 0.70]	[0.26, 0.50]	[0.46, 0.65]	[0.40, 0.61]
	1870M1 to	0.02	0.04	0.34	0.67	0.00	0.53
	1888M6	[0.00, 0.26]	[0.00, 0.19]	[0.25, 0.43]	[0.58, 0.74]	[0.00, 0.50]	[0.44, 0.61]
Rostock	1850M3 to	0.29	0.73	0.86	0.86	0.78	0.95
	1869M12	[0.06, 0.51]	[0.63, 0.81]	[0.82, 0.89]	[0.82, 0.89]	[0.73, 0.82]	[0.93, 0.96]
	1870M1 to	0.26	0.61	0.83	0.90	0.72	0.96
	1888M6	[0.02, 0.50]	[0.47, 0.73]	[0.78, 0.87]	[0.87, 0.93]	[0.64, 0.78]	[0.95, 0.97]
Stettin	1850M3 to	0.44	0.44	0.77	0.83	0.56	0.92
	1869M12	[0.00, 0.59]	[0.27, 0.58]	[0.71, 0.82]	[0.79, 0.87]	[0.46, 0.64]	[0.90, 0.94]
	1870M1 to	0.35	0.61	0.87	0.88	0.87	0.91
	1888M6	[0.07, 0.61]	[0.51, 0.71]	[0.84, 0.90]	[0.85, 0.90]	[0.83, 0.91]	[0.88, 0.93]
Wismar	1850M3 to	0.03	0.63	0.89	0.89	0.79	0.93
	1869M12	[0.00, 0.58]	[0.49, 0.75]	[0.85, 0.92]	[0.87, 0.92]	[0.74, 0.84]	[0.90, 0.95]
	1870M1 to	0.16	0.62	0.92	0.92	0.78	0.86
	1888M6	[0.01, 0.57]	[0.46, 0.74]	[0.89, 0.94]	[0.90, 0.94]	[0.72, 0.82]	[0.82, 0.90]
London	1850M3 to	0.08	0.31	0.48	0.34	0.34	0.49
	1869M12	[0.00, 0.48]	[0.16, 0.49]	[0.36, 0.60]	[0.22, 0.45]	[0.20, 0.47]	[0.33, 0.64]
	1870M1 to	0.34	0.34	0.49	0.30	0.58	0.89
	1888M6	[0.05, 0.57]	[0.20, 0.48]	[0.40, 0.58]	[0.18, 0.41]	[0.49, 0.67]	[0.86, 0.92]
Median	1850M3 to	0.29	0.48	0.77	0.76	0.64	0.90
	1869M12	[0.19, 0.46]	[0.37, 0.58]	[0.73, 0.81]	[0.70, 0.81]	[0.60, 0.71]	[0.88, 0.91]
	1870M1 to	0.28	0.54	0.75	0.79	0.74	0.85
	1888M6	[0.10, 0.31]	[0.46, 0.61]	[0.68, 0.80]	[0.76, 0.82]	[0.69, 0.79]	[0.82, 0.88]
Average	1850M3 to	0.30	0.46	0.67	0.67	0.62	0.73
	1869M12	[0.23, 0.40]	[0.41, 0.52]	[0.64, 0.70]	[0.64, 0.70]	[0.59, 0.66]	[0.70, 0.77]
	1870M1 to	0.24	0.47	0.68	0.71	0.66	0.83
	1888M6	[0.18, 0.51]	[0.43, 0.51]	[0.64, 0.71]	[0.68, 0.75]	[0.63, 0.68]	[0.80, 0.86]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 5: Rye market integration full samples

		2 to 4 months	4 to 8 months	8 to 16 months	16 to 32 months	32 to 64 months	64 months and beyond
Danzig	1843M7 to	0.32	0.66	0.87	0.73	0.69	0.89
	1862M3	[0.02, 0.54]	[0.56, 0.74]	[0.82, 0.90]	[0.68, 0.78]	[0.58, 0.77]	[0.86, 0.92]
	1850M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Flensburg	1843M7 to	0.17	0.50	0.66	0.78	0.94	0.91
	1862M3	[0.02, 0.47]	[0.36, 0.63]	[0.56, 0.74]	[0.73, 0.82]	[0.92, 0.95]	[0.88, 0.94]
	1850M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Kiel	1843M7 to	---	---	---	---	---	---
	1862M3	---	---	---	---	---	---
	1850M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Copenhagen	1843M7 to	0.50	0.65	0.80	0.80	0.93	0.93
	1862M3	[0.19, 0.63]	[0.52, 0.75]	[0.73, 0.86]	[0.73, 0.82]	[0.91, 0.95]	[0.90, 0.95]
	1850M1 to	0.29	0.54	0.67	0.74	0.81	0.91
	1886M2	[0.13, 0.44]	[0.45, 0.62]	[0.61, 0.72]	[0.68, 0.79]	[0.77, 0.84]	[0.89, 0.92]
Lübeck	1843M7 to	0.17	0.53	0.71	0.79	0.88	0.90
	1862M3	[0.00, 0.51]	[0.34, 0.67]	[0.60, 0.79]	[0.72, 0.86]	[0.84, 0.91]	[0.87, 0.93]
	1850M1 to	0.34	0.58	0.68	0.80	0.90	0.92
	1886M2	[0.12, 0.51]	[0.50, 0.65]	[0.61, 0.73]	[0.75, 0.85]	[0.87, 0.92]	[0.90, 0.93]
St. Petersburg	1843M7 to	0.13	0.37	0.29	0.44	0.70	0.47
	1862M3	[0.00, 0.37]	[0.20, 0.51]	[0.16, 0.43]	[0.33, 0.54]	[0.62, 0.77]	[0.34, 0.59]
	1850M1 to	0.29	0.29	0.39	0.35	0.59	0.64
	1886M2	[0.13, 0.45]	[0.17, 0.42]	[0.27, 0.53]	[0.26, 0.43]	[0.52, 0.65]	[0.55, 0.74]
Riga	1843M7 to	---	---	---	---	---	---
	1862M3	---	---	---	---	---	---
	1850M1 to	0.32	0.52	0.48	0.61	0.78	0.77
	1886M2	[0.12, 0.51]	[0.41, 0.62]	[0.36, 0.58]	[0.53, 0.67]	[0.73, 0.82]	[0.72, 0.81]
Rostock	1843M7 to	0.58	0.65	0.86	0.79	0.95	0.96
	1862M3	[0.40, 0.72]	[0.56, 0.72]	[0.82, 0.89]	[0.74, 0.83]	[0.94, 0.96]	[0.95, 0.96]
	1850M1 to	0.50	0.65	0.81	0.75	0.86	0.93
	1886M2	[0.36, 0.63]	[0.58, 0.72]	[0.77, 0.85]	[0.68, 0.81]	[0.83, 0.88]	[0.91, 0.95]
Stettin	1843M7 to	---	---	---	---	---	---
	1862M3	---	---	---	---	---	---
	1850M1 to	0.38	0.59	0.80	0.71	0.40	0.86
	1886M2	[0.11, 0.45]	[0.49, 0.68]	[0.76, 0.84]	[0.66, 0.75]	[0.32, 0.49]	[0.83, 0.88]
Wismar	1843M7 to	0.30	0.59	0.85	0.76	0.88	0.96
	1862M3	[0.13, 0.50]	[0.45, 0.69]	[0.79, 0.89]	[0.73, 0.80]	[0.84, 0.91]	[0.94, 0.97]
	1850M1 to	0.28	0.55	0.78	0.81	0.84	0.92
	1886M2	[0.22, 0.45]	[0.46, 0.62]	[0.73, 0.83]	[0.76, 0.85]	[0.81, 0.87]	[0.90, 0.93]
London	1843M7 to	---	---	---	---	---	---
	1862M3	---	---	---	---	---	---
	1850M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Median	1843M7 to	0.30	0.59	0.80	0.78	0.88	0.91
	1862M3	[0.18, 0.45]	[0.48, 0.67]	[0.73, 0.86]	[0.73, 0.80]	[0.85, 0.91]	[0.89, 0.94]
	1850M1 to	0.32	0.55	0.68	0.74	0.81	0.91
	1886M2	[0.22, 0.45]	[0.45, 0.62]	[0.63, 0.73]	[0.69, 0.78]	[0.77, 0.84]	[0.89, 0.92]
Average	1843M7 to	0.31	0.56	0.72	0.73	0.85	0.86
	1862M3	[0.26, 0.38]	[0.47, 0.64]	[0.67, 0.76]	[0.69, 0.76]	[0.82, 0.88]	[0.84, 0.88]
	1850M1 to	0.34	0.53	0.66	0.68	0.74	0.85
	1886M2	[0.27, 0.43]	[0.48, 0.58]	[0.63, 0.69]	[0.65, 0.71]	[0.71, 0.77]	[0.83, 0.87]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 6: Rye market second sample sub samples

		2 to 4 months	4 to 8 months	8 to 16 months	16 to 32 months	32 to 64 months	64 months and beyond
Danzig	1850M1 to	---	---	---	---	---	---
	1869M12	---	---	---	---	---	---
	1870M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Flensburg	1850M1 to	---	---	---	---	---	---
	1869M12	---	---	---	---	---	---
	1870M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Kiel	1850M1 to	---	---	---	---	---	---
	1869M12	---	---	---	---	---	---
	1870M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Copenhagen	1850M1 to	0.43	0.61	0.69	0.80	0.85	0.93
	1869M12	[0.24, 0.59]	[0.51, 0.68]	[0.62, 0.76]	[0.75, 0.85]	[0.82, 0.88]	[0.91, 0.94]
	1870M1 to	0.00	0.29	0.57	0.71	0.59	0.82
	1886M2	[0.00, 0.45]	[0.14, 0.45]	[0.42, 0.69]	[0.57, 0.80]	[0.47, 0.69]	[0.80, 0.85]
Lübeck	1850M1 to	0.30	0.61	0.71	0.88	0.91	0.91
	1869M12	[0.05, 0.49]	[0.51, 0.69]	[0.64, 0.78]	[0.85, 0.91]	[0.88, 0.93]	[0.8, 0.93]
	1870M1 to	0.39	0.51	0.56	0.40	0.82	0.95
	1886M2	[0.03, 0.77]	[0.36, 0.63]	[0.43, 0.66]	[0.23, 0.54]	[0.76, 0.87]	[0.94, 0.96]
St. Petersburg	1850M1 to	0.32	0.36	0.39	0.49	0.65	0.59
	1869M12	[0.10, 0.50]	[0.20, 0.52]	[0.23, 0.56]	[0.40, 0.58]	[0.57, 0.71]	[0.46, 0.70]
	1870M1 to	0.35	0.09	0.41	0.00	0.36	0.80
	1886M2	[0.06, 0.58]	[0.00, 0.23]	[0.28, 0.53]	[0.00, 0.06]	[0.26, 0.47]	[0.73, 0.86]
Riga	1850M1 to	0.32	0.61	0.48	0.62	0.81	0.75
	1869M12	[0.07, 0.54]	[0.48, 0.70]	[0.34, 0.61]	[0.54, 0.69]	[0.76, 0.85]	[0.69, 0.80]
	1870M1 to	0.34	0.25	0.49	0.52	0.63	0.80
	1886M2	[0.02, 0.56]	[0.08, 0.43]	[0.36, 0.60]	[0.30, 0.67]	[0.55, 0.70]	[0.73, 0.86]
Rostock	1850M1 to	0.53	0.72	0.83	0.76	0.88	0.94
	1869M12	[0.39, 0.69]	[0.64, 0.78]	[0.79, 0.87]	[0.69, 0.83]	[0.85, 0.90]	[0.91, 0.96]
	1870M1 to	0.38	0.42	0.75	0.76	0.74	0.92
	1886M2	[0.04, 0.61]	[0.21, 0.59]	[0.68, 0.81]	[0.67, 0.84]	[0.67, 0.80]	[0.89, 0.94]
Stettin	1850M1 to	0.39	0.61	0.83	0.73	0.36	0.87
	1869M12	[0.16, 0.54]	[0.49, 0.70]	[0.78, 0.87]	[0.68, 0.78]	[0.25, 0.46]	[0.83, 0.90]
	1870M1 to	0.34	0.54	0.71	0.53	0.72	0.83
	1886M2	[0.01, 0.77]	[0.41, 0.67]	[0.63, 0.78]	[0.36, 0.63]	[0.65, 0.77]	[0.78, 0.87]
Wismar	1850M1 to	0.31	0.58	0.77	0.80	0.84	0.93
	1869M12	[0.11, 0.51]	[0.47, 0.68]	[0.70, 0.83]	[0.75, 0.84]	[0.80, 0.87]	[0.91, 0.95]
	1870M1 to	0.24	0.53	0.82	0.90	0.86	0.87
	1886M2	[0.02, 0.65]	[0.35, 0.67]	[0.75, 0.87]	[0.86, 0.94]	[0.83, 0.90]	[0.83, 0.90]
London	1850M1 to	---	---	---	---	---	---
	1869M12	---	---	---	---	---	---
	1870M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Median	1850M1 to	0.32	0.61	0.71	0.76	0.84	0.91
	1869M12	[0.22, 0.49]	[0.53, 0.67]	[0.66, 0.78]	[0.71, 0.81]	[0.81, 0.87]	[0.88, 0.93]
	1870M1 to	0.34	0.42	0.57	0.53	0.72	0.83
	1886M2	[0.07, 0.41]	[0.30, 0.50]	[0.51, 0.68]	[0.42, 0.66]	[0.65, 0.76]	[0.81, 0.87]
Average	1850M1 to	0.37	0.58	0.67	0.73	0.76	0.84
	1869M12	[0.29, 0.47]	[0.52, 0.64]	[0.64, 0.71]	[0.69, 0.76]	[0.72, 0.79]	[0.82, 0.87]
	1870M1 to	0.29	0.38	0.62	0.55	0.67	0.86
	1886M2	[0.24, 0.35]	[0.33, 0.42]	[0.57, 0.66]	[0.50, 0.58]	[0.64, 0.71]	[0.83, 0.88]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 7: Oat market full samples

		2 to 4 months	4 to 8 months	8 to 16 months	16 to 32 months	32 to 64 months	64 months and beyond
Danzig	1843M3 to	0.48	0.20	0.24	0.17	0.04	0.67
	1852M5	[0.00, 0.69]	[0.05, 0.42]	[0.05, 0.45]	[0.03, 0.30]	[0.00, 0.18]	[0.53, 0.78]
	1853M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Flensburg	1843M3 to	0.02	0.38	0.42	0.80	0.79	0.79
	1852M5	[0.00, 0.47]	[0.18, 0.63]	[0.23, 0.58]	[0.70, 0.86]	[0.70, 0.86]	[0.74, 0.86]
	1853M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Kiel	1843M3 to	0.03	0.46	0.32	0.70	0.48	0.87
	1852M5	[0.00, 0.50]	[0.13, 0.68]	[0.09, 0.53]	[0.56, 0.79]	[0.32, 0.62]	[0.83, 0.91]
	1853M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Copenhagen	1843M3 to	0.03	0.50	0.52	0.93	0.58	0.84
	1852M5	[0.00, 0.46]	[0.23, 0.68]	[0.30, 0.68]	[0.90, 0.96]	[0.48, 0.66]	[0.77, 0.90]
	1853M1 to	0.27	0.40	0.74	0.67	0.45	0.80
	1886M2	[0.03, 0.49]	[0.26, 0.53]	[0.67, 0.79]	[0.61, 0.73]	[0.30, 0.55]	[0.77, 0.84]
Lübeck	1843M3 to	0.19	0.26	0.73	0.72	0.80	0.90
	1852M5	[0.00, 0.63]	[0.04, 0.50]	[0.58, 0.83]	[0.61, 0.81]	[0.70, 0.87]	[0.88, 0.93]
	1853M1 to	0.41	0.39	0.71	0.72	0.74	0.87
	1886M2	[0.17, 0.59]	[0.24, 0.51]	[0.64, 0.77]	[0.66, 0.78]	[0.65, 0.80]	[0.83, 0.90]
St. Petersburg	1843M3 to	0.02	0.02	0.17	0.02	0.43	0.36
	1852M5	[0.00, 0.58]	[0.00, 0.19]	[0.02, 0.37]	[0.00, 0.15]	[0.23, 0.63]	[0.22, 0.51]
	1853M1 to	0.23	0.36	0.34	0.15	0.21	0.47
	1886M2	[0.01, 0.52]	[0.19, 0.52]	[0.24, 0.44]	[0.06, 0.26]	[0.07, 0.36]	[0.36, 0.57]
Riga	1843M3 to	0.04	0.07	0.11	0.21	0.70	0.49
	1852M5	[0.00, 0.59]	[0.00, 0.27]	[0.00, 0.32]	[0.11, 0.36]	[0.56, 0.80]	[0.30, 0.64]
	1853M1 to	0.00	0.06	0.48	0.13	0.22	0.26
	1886M2	[0.00, 0.31]	[0.00, 0.20]	[0.38, 0.57]	[0.06, 0.22]	[0.06, 0.39]	[0.10, 0.46]
Rostock	1843M3 to	0.58	0.20	0.79	0.89	0.84	0.74
	1852M5	[0.00, 0.82]	[0.01, 0.48]	[0.71, 0.86]	[0.82, 0.93]	[0.75, 0.90]	[0.61, 0.82]
	1853M1 to	0.50	0.50	0.61	0.76	0.53	0.82
	1886M2	[0.23, 0.63]	[0.35, 0.61]	[0.52, 0.69]	[0.73, 0.80]	[0.41, 0.68]	[0.77, 0.86]
Stettin	1843M3 to	---	---	---	---	---	---
	1852M5	---	---	---	---	---	---
	1853M1 to	0.02	0.22	0.59	0.68	0.31	0.80
	1886M2	[0.00, 0.21]	[0.09, 0.35]	[0.53, 0.65]	[0.62, 0.73]	[0.19, 0.45]	[0.75, 0.84]
Wismar	1843M3 to	0.18	0.39	0.65	0.75	0.64	0.78
	1852M5	[0.00, 0.71]	[0.11, 0.60]	[0.45, 0.80]	[0.68, 0.83]	[0.58, 0.73]	[0.69, 0.85]
	1853M1 to	0.38	0.43	0.53	0.83	0.55	0.88
	1886M2	[0.13, 0.65]	[0.27, 0.56]	[0.45, 0.61]	[0.80, 0.86]	[0.40, 0.72]	[0.83, 0.91]
London	1843M3 to	---	---	---	---	---	---
	1852M5	---	---	---	---	---	---
	1853M1 to	---	---	---	---	---	---
	1886M2	---	---	---	---	---	---
Median	1843M3 to	0.04	0.26	0.42	0.72	0.70	0.78
	1852M5	[0.00, 0.21]	[0.15, 0.38]	[0.29, 0.55]	[0.62, 0.79]	[0.62, 0.79]	[0.70, 0.83]
	1853M1 to	0.27	0.39	0.59	0.68	0.45	0.80
	1886M2	[0.08, 0.39]	[0.27, 0.44]	[0.52, 0.64]	[0.64, 0.73]	[0.34, 0.52]	[0.78, 0.84]
Average	1843M3 to	0.18	0.28	0.44	0.59	0.63	0.72
	1852M5	[0.04, 0.23]	[0.23, 0.33]	[0.39, 0.55]	[0.56, 0.64]	[0.58, 0.69]	[0.66, 0.77]
	1853M1 to	0.26	0.34	0.57	0.56	0.43	0.70
	1886M2	[0.22, 0.31]	[0.29, 0.39]	[0.52, 0.61]	[0.54, 0.59]	[0.40, 0.46]	[0.67, 0.74]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 8: Oat market second sample sub samples

		2 to 4 months	4 to 8 months	8 to 16 months	16 to 32 months	32 to 64 months	64 months and beyond
Danzig	1853M1 to 1869M12	---	---	---	---	---	---
	1870M1 to 1886M2	---	---	---	---	---	---

	1853M1 to 1869M12	---	---	---	---	---	---
Flensburg	1870M1 to 1886M2	---	---	---	---	---	---

	1853M1 to 1869M12	---	---	---	---	---	---
	1870M1 to 1886M2	---	---	---	---	---	---
Kiel	1853M1 to 1869M12	---	---	---	---	---	---
	1870M1 to 1886M2	---	---	---	---	---	---

	1853M1 to 1869M12	0.31	0.34	0.74	0.59	0.50	0.81
Copenhagen	1869M12	[0.02, 0.54]	[0.17, 0.51]	[0.63, 0.81]	[0.48, 0.69]	[0.23, 0.65]	[0.76, 0.86]
	1870M1 to 1886M2	0.49	0.72	0.76	0.82	0.36	0.82
	1886M2	[0.00, 0.69]	[0.58, 0.80]	[0.67, 0.83]	[0.77, 0.85]	[0.19, 0.51]	[0.78, 0.85]

Lübeck	1853M1 to 1869M12	0.51	0.41	0.70	0.83	0.77	0.87
	1869M12	[0.23, 0.67]	[0.24, 0.58]	[0.58, 0.77]	[0.75, 0.88]	[0.64, 0.83]	[0.82, 0.91]
	1870M1 to 1886M2	0.02	0.25	0.73	0.56	0.66	0.86
	1886M2	[0.00, 0.72]	[0.08, 0.46]	[0.64, 0.80]	[0.45, 0.67]	[0.52, 0.77]	[0.81, 0.89]
St. Petersburg	1853M1 to 1869M12	0.31	0.49	0.36	0.13	0.26	0.48
	1869M12	[0.00, 0.60]	[0.23, 0.67]	[0.20, 0.51]	[0.03, 0.30]	[0.03, 0.50]	[0.34, 0.61]
	1870M1 to 1886M2	0.00	0.04	0.33	0.16	0.15	0.40
	1886M2	[0.00, 0.54]	[0.00, 0.18]	[0.21, 0.47]	[0.05, 0.29]	[0.02, 0.39]	[0.28, 0.54]
Riga	1853M1 to 1869M12	0.00	0.05	0.42	0.01	0.20	0.21
	1869M12	[0.00, 0.52]	[0.00, 0.21]	[0.27, 0.56]	[0.00, 0.09]	[0.01, 0.44]	[0.05, 0.46]
	1870M1 to 1886M2	0.01	0.17	0.61	0.60	0.38	0.45
	1886M2	[0.00, 0.86]	[0.03, 0.41]	[0.51, 0.69]	[0.51, 0.68]	[0.14, 0.60]	[0.33, 0.59]
Rostock	1853M1 to 1869M12	0.51	0.49	0.49	0.76	0.50	0.85
	1869M12	[0.20, 0.66]	[0.30, 0.62]	[0.34, 0.62]	[0.71, 0.81]	[0.31, 0.71]	[0.80, 0.89]
	1870M1 to 1886M2	0.30	0.63	0.82	0.84	0.60	0.71
	1886M2	[0.00, 0.71]	[0.49, 0.73]	[0.77, 0.86]	[0.80, 0.88]	[0.46, 0.74]	[0.60, 0.80]
Stettin	1853M1 to 1869M12	0.02	0.25	0.61	0.71	0.21	0.82
	1869M12	[0.00, 0.41]	[0.09, 0.42]	[0.51, 0.68]	[0.65, 0.77]	[0.05, 0.43]	[0.77, 0.87]
	1870M1 to 1886M2	0.06	0.10	0.57	0.58	0.53	0.75
	1886M2	[0.00, 0.80]	[0.02, 0.24]	[0.48, 0.64]	[0.47, 0.68]	[0.38, 0.65]	[0.67, 0.81]
Wismar	1853M1 to 1869M12	0.37	0.41	0.40	0.82	0.61	0.89
	1869M12	[0.05, 0.60]	[0.23, 0.59]	[0.28, 0.53]	[0.76, 0.86]	[0.40, 0.82]	[0.84, 0.92]
	1870M1 to 1886M2	0.53	0.52	0.74	0.83	0.29	0.83
	1886M2	[0.00, 0.89]	[0.33, 0.67]	[0.66, 0.79]	[0.78, 0.87]	[0.11, 0.52]	[0.78, 0.87]
London	1853M1 to 1869M12	---	---	---	---	---	---
	1870M1 to 1886M2	---	---	---	---	---	---

	1853M1 to 1869M12	0.31	0.41	0.49	0.71	0.50	0.82
Median	1869M12	[0.11, 0.43]	[0.25, 0.48]	[0.42, 0.61]	[0.64, 0.77]	[0.33, 0.53]	[0.79, 0.86]
	1870M1 to 1886M2	0.06	0.25	0.73	0.60	0.38	0.75
	1886M2	[0.00, 0.22]	[0.15, 0.44]	[0.63, 0.78]	[0.57, 0.69]	[0.34, 0.53]	[0.70, 0.81]

Average	1853M1 to 1869M12	0.29	0.35	0.53	0.55	0.44	0.71
	1869M12	[0.24, 0.35]	[0.29, 0.41]	[0.46, 0.59]	[0.52, 0.58]	[0.40, 0.48]	[0.67, 0.75]
	1870M1 to 1886M2	0.20	0.35	0.65	0.63	0.42	0.69
	1886M2	[0.08, 0.23]	[0.35, 0.39]	[0.61, 0.69]	[0.60, 0.66]	[0.39, 0.47]	[0.65, 0.73]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 9: Barley market full samples

		2 to 4 months	4 to 8 months	8 to 16 months	16 to 32 Months	32 to 64 Months	64 months and beyond
Danzig	1843M7 to	0.37	0.36	0.68	0.29	0.57	0.90
	1855M12	[0.00, 0.78]	[0.10, 0.55]	[0.50, 0.79]	[0.20, 0.39]	[0.43, 0.67]	[0.85, 0.92]
	1856M5 to	0.60	0.51	0.69	0.07	0.11	0.53
	1870M11	[0.07, 0.76]	[0.30, 0.67]	[0.56, 0.79]	[0.00, 0.33]	[0.00, 0.42]	[0.44, 0.63]
Flensburg	1843M7 to	0.05	0.16	0.31	0.57	0.83	0.84
	1855M12	[0.00, 0.45]	[0.02, 0.33]	[0.17, 0.45]	[0.44, 0.69]	[0.75, 0.88]	[0.77, 0.89]
	1856M5 to	---	---	---	---	---	---
	1870M11	---	---	---	---	---	---
Kiel	1843M7 to	0.56	0.25	0.66	0.82	0.96	0.97
	1855M12	[0.00, 0.76]	[0.07, 0.50]	[0.57, 0.74]	[0.75, 0.87]	[0.95, 0.97]	[0.95, 0.98]
	1856M5 to	---	---	---	---	---	---
	1870M11	---	---	---	---	---	---
Copenhagen	1843M7 to	0.04	0.51	0.79	0.86	0.96	0.97
	1855M12	[0.00, 0.52]	[0.26, 0.68]	[0.71, 0.85]	[0.79, 0.91]	[0.94, 0.97]	[0.95, 0.98]
	1856M5 to	0.09	0.03	0.15	0.10	0.01	0.30
	1870M11	[0.04, 0.56]	[0.00, 0.10]	[0.09, 0.23]	[0.00, 0.32]	[0.00, 0.13]	[0.20, 0.41]
Lübeck	1843M7 to	0.00	0.54	0.84	0.92	0.98	0.97
	1855M12	[0.00, 0.46]	[0.37, 0.66]	[0.78, 0.88]	[0.89, 0.95]	[0.97, 0.99]	[0.96, 0.98]
	1856M5 to	0.57	0.69	0.89	0.93	0.91	0.82
	1870M11	[0.11, 0.74]	[0.48, 0.82]	[0.84, 0.92]	[0.86, 0.94]	[0.80, .93]	[0.77, 0.87]
St. Petersburg	1843M7 to	---	---	---	---	---	---
	1855M12	---	---	---	---	---	---
	1856M5 to	0.02	0.44	0.61	0.07	0.05	0.17
	1870M11	[0.00, 0.50]	[0.10, 0.65]	[0.43, 0.75]	[0.00, 0.31]	[0.00, 0.25]	[0.06, 0.35]
Riga	1843M7 to	0.15	0.37	0.09	0.65	0.78	0.58
	1855M12	[0.00, 0.48]	[0.11, 0.56]	[0.01, 0.24]	[0.57, 0.74]	[0.74, 0.82]	[0.48, 0.69]
	1856M5 to	0.56	0.39	0.52	0.41	0.36	0.64
	1870M11	[0.01, 0.77]	[0.26, 0.51]	[0.43, 0.60]	[0.13, 0.64]	[0.10, 0.70]	[0.47, 0.75]
Rostock	1843M7 to	0.01	0.38	0.74	0.87	0.94	0.94
	1855M12	[0.00, 0.64]	[0.22, 0.57]	[0.67, 0.79]	[0.84, 0.89]	[0.92, 0.96]	[0.93, 0.96]
	1856M5 to	0.43	0.69	0.85	0.67	0.78	0.95
	1870M11	[0.15, 0.59]	[0.51, 0.79]	[0.78, 0.90]	[0.38, 0.87]	[0.45, 0.91]	[0.94, 0.97]
Stettin	1843M7 to	---	---	---	---	---	---
	1855M12	---	---	---	---	---	---
	1856M5 to	0.36	0.40	0.74	0.77	0.58	0.89
	1870M11	[0.01, 0.57]	[0.17, 0.58]	[0.67, 0.82]	[0.65, 0.83]	[0.35, 0.80]	[0.84, 0.92]
Wismar	1843M7 to	0.30	0.56	0.77	0.81	0.92	0.94
	1855M12	[0.00, 0.65]	[0.40, 0.71]	[0.72, 0.83]	[0.71, 0.87]	[0.89, 0.95]	[0.91, 0.96]
	1856M5 to	0.13	0.54	0.75	0.67	0.73	0.91
	1870M11	[0.04, 0.50]	[0.31, 0.68]	[0.64, 0.83]	[0.34, 0.87]	[0.34, 0.58]	[0.88, 0.94]
London	1843M7 to	---	---	---	---	---	---
	1855M12	---	---	---	---	---	---
	1856M5 to	---	---	---	---	---	---
	1870M11	---	---	---	---	---	---
Median	1843M7 to	0.10	0.37	0.71	0.81	0.93	0.94
	1855M12	[0.02, 0.23]	[0.27, 0.49]	[0.66, 0.77]	[0.74, 0.86]	[0.91, 0.95]	[0.92, 0.96]
	1856M5 to	0.40	0.47	0.72	0.54	0.47	0.73
	1870M11	[0.12, 0.56]	[0.32, 0.64]	[0.62, 0.77]	[0.39, 0.58]	[0.32, 0.58]	[0.66, 0.80]
Average	1843M7 to	0.18	0.39	0.61	0.72	0.87	0.89
	1855M12	[0.06, 0.23]	[0.31, 0.46]	[0.55, 0.66]	[0.68, 0.77]	[0.84, 0.89]	[0.86, 0.91]
	1856M5 to	0.35	0.46	0.65	0.46	0.44	0.65
	1870M11	[0.20, 0.47]	[0.31, 0.57]	[0.60, 0.69]	[0.43, 0.51]	[0.41, 0.48]	[0.61, 0.70]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 10: Barley market full sample continued

		2 to 4 Months	4 to 8 months	8 to 16 months	16 to 32 Months	32 to 64 Months	64 months and beyond
Danzig	1876M2 to 1888M12	---	---	---	---	---	---
Flensburg	1876M2 to 1888M12	---	---	---	---	---	---
Kiel	1876M2 to 1888M12	---	---	---	---	---	---
Copenhagen	1876M2 to 1888M12	0.17 [0.00, 0.69]	0.06 [0.00, 0.32]	0.20 [0.02, 0.42]	0.18 [0.01, 0.48]	0.26 [0.01, 0.56]	0.65 [0.59, 0.72]
Lübeck	1876M2 to 1888M12	0.14 [0.00, 0.55]	0.44 [0.15, 0.64]	0.52 [0.34, 0.68]	0.81 [0.52, 0.86]	0.75 [0.41, 0.90]	0.86 [0.82, 0.89]
St. Petersburg	1876M2 to 1888M12	0.39 [0.00, 0.79]	0.16 [0.01, 0.59]	0.19 [0.00, 0.42]	0.07 [0.00, 0.49]	0.08 [0.00, 0.33]	0.20 [0.10, 0.33]
Riga	1876M2 to 1888M12	0.35 [0.00, 0.59]	0.54 [0.22, 0.71]	0.39 [0.10, 0.60]	0.09 [0.00, 0.36]	0.04 [0.00, 0.15]	0.51 [0.34, 0.63]
Rostock	1876M2 to 1888M12	0.10 [0.00, 0.62]	0.28 [0.01, 0.54]	0.57 [0.42, 0.66]	0.61 [0.32, 0.72]	0.63 [0.40, 0.79]	0.88 [0.81, 0.92]
Stettin	1876M2 to 1888M12	0.34 [0.00, 0.75]	0.12 [0.01, 0.53]	0.33 [0.17, 0.48]	0.22 [0.05, 0.43]	0.35 [0.21, 0.46]	0.84 [0.76, 0.88]
Wismar	1876M2 to 1888M12	0.07 [0.00, 0.89]	0.49 [0.06, 0.69]	0.63 [0.31, 0.77]	0.82 [0.40, 0.91]	0.81 [0.59, 0.93]	0.85 [0.77, 0.89]
London	1876M2 to 1888M12	---	---	---	---	---	---
Median	1876M2 to 1888M12	0.17 [0.02, 0.29]	0.28 [0.13, 0.43]	0.39 [0.27, 0.49]	0.22 [0.16, 0.44]	0.35 [0.24, 0.50]	0.84 [0.76, 0.87]
Average	1876M2 to 1888M12	0.22 [0.07, 0.26]	0.30 [0.24, 0.35]	0.40 [0.34, 0.44]	0.40 [0.35, 0.44]	0.42 [0.37, 0.46]	0.68 [0.64, 0.72]

Note: A 95% percent confidence interval is presented in brackets below the market integration estimates.

Table 11: Regression Results Wheat and Rye

	Wheat				Rye			
	Sample 1 Full Sample	Full sample	Sample 2 Sub- sample 1	Sub- sample 2	Sample 1 Full sample	Full Sample	Sample 2 Sub- sample 1	Sub- sample 2
	1843M7 to 1862M3	1850M3 to 1888M6	1850M3 to 1869M12	1870M1 to 1888M6	1843M7 to 1862M3	1850M1 to 1886M2	1850M1 to 1869M12	1870M1 to 1886M2
Distance	-0.91*** (0.10)	-0.53*** (0.13)	-0.73*** (0.14)	-0.11 (0.19)	-0.61*** (0.14)	-0.36*** (0.11)	-0.43*** (0.12)	-0.16 (0.15)
d1×distance	0.67*** (0.15)	0.33* (0.19)	0.48** (0.19)	-0.06 (0.27)	0.39* (0.20)	0.27* (0.15)	0.34* (0.17)	0.23 (0.21)
d2×distance	0.19 (0.15)	0.07 (0.19)	0.24 (0.19)	-0.24 (0.27)	0.37* (0.20)	0.02 (0.15)	0.15 (0.17)	-0.35 (0.21)
d3×distance	0.19 (0.15)	-0.07 (0.19)	0.10 (0.19)	-0.41 (0.27)	0.01 (0.20)	-0.15 (0.15)	-0.10 (0.17)	-0.24 (0.21)
d4×distance	0.18 (0.18)	-0.06 (0.19)	0.16 (0.19)	-0.53* (0.27)	0.15 (0.20)	-0.18 (0.15)	-0.01 (0.17)	-0.60*** (0.21)
d5×distance	0.28* (0.15)	0.03 (0.19)	0.21 (0.19)	-0.30 (0.27)	0.29 (0.20)	0.06 (0.15)	0.19 (0.17)	-0.36* (0.21)
d1	-0.65*** (0.06)	-0.60*** (0.09)	-0.59*** (0.09)	-0.57*** (0.13)	-0.63*** (0.06)	-0.58*** (0.06)	-0.56*** (0.06)	-0.62*** (0.08)
d2	-0.37*** (0.06)	-0.32*** (0.09)	-0.35*** (0.09)	-0.28** (0.13)	-0.37*** (0.06)	-0.32*** (0.06)	-0.30*** (0.06)	-0.39*** (0.08)
d3	-0.14** (0.06)	-0.06 (0.09)	-0.09 (0.09)	-0.02 (0.13)	-0.14** (0.06)	-0.15** (0.06)	-0.15** (0.06)	-0.18** (0.08)
d4	-0.11* (0.06)	-0.05 (0.09)	-0.11 (0.09)	0.06 (0.13)	-0.17** (0.06)	-0.12** (0.06)	-0.12* (0.06)	-0.15** (0.08)
d5	-0.04 (0.56)	-0.14 (0.09)	-0.18* (0.09)	-0.08 (0.13)	-0.07 (0.06)	-0.12** (0.06)	-0.14** (0.06)	-0.09 (0.08)
Constant	0.99*** (0.05)	0.93*** (0.06)	0.97*** (0.06)	0.87*** (0.09)	0.99*** (0.04)	0.94*** (0.04)	0.95*** (0.05)	0.90*** (0.06)

Note: Standard errors in parentheses; asterisks denote statistical significance at levels of 10%, 5% and 1% respectively.

Table 12: Regression Results Oats and Barley

	Oats				Barley		
	Sample 1 Full Sample	Full Sample	Sample 2 Sub-sample 1	Sub- sample 2	Sample 1 Full Sample	Sample 2 Full Sample	Sample 3 Full Sample
	1843M3 to 1852M5	1853M1 to 1888M2	1853M1 to 1869M12	1870M1 to 1888M2	1843M7 to 1855M12	1856M5 to 1870M11	1876M2 to 1888M12
Distance	-0.65*** (0.21)	-0.71*** (0.15)	-0.75*** (0.19)	-0.61*** (0.19)	-0.60*** (0.17)	-0.60*** (0.13)	-0.83*** (0.19)
d1×distance	0.45 (0.29)	0.33 (0.21)	0.38 (0.27)	0.17 (0.27)	0.672 (0.48)	0.67 (0.48)	1.23 (0.27)
d2×distance	0.173 (0.29)	0.45** (0.21)	0.63** (0.27)	0.01 (0.27)	0.50 (0.48)	0.50 (0.48)	0.73 (0.27)
d3×distance	-0.07 (0.29)	0.33 (0.21)	0.46* (0.26)	0.10 (0.27)	-0.39 (0.48)	-0.39 (0.48)	0.42 (0.27)
d4×distance	-0.45 (0.29)	-0.25 (0.21)	-0.33 (0.26)	-0.04 (0.27)	-0.01 (0.49)	-0.01 (0.48)	-0.11 (0.27)
d5×distance	0.67** (0.29)	0.12 (0.21)	0.17 (0.26)	0.19 (0.27)	0.12 (0.49)	0.12 (0.48)	-0.12 (0.27)
d1	-0.64*** (0.10)	-0.53*** (0.08)	-0.51*** (0.10)	-0.53*** (0.10)	-0.81*** (0.11)	-0.81*** (0.11)	-0.78*** (0.10)
d2	-0.48*** (0.10)	-0.48*** (0.08)	-0.52*** (0.10)	-0.34*** (0.10)	-0.58*** (0.11)	-0.58*** (0.11)	-0.57*** (0.10)
d3	-0.26*** (0.10)	-0.21*** (0.08)	-0.29*** (0.10)	-0.06 (0.10)	-0.22** (0.11)	-0.22* (0.11)	-0.39*** (0.10)
d4	-0.02 (0.10)	-0.07 (0.08)	-0.07 (0.10)	-0.05 (0.10)	-0.16 (0.11)	-0.16 (0.11)	-0.26*** (0.10)
d5	-0.23*** (0.10)	-0.31*** (0.08)	-0.31*** (0.10)	-0.31*** (0.10)	-0.04 (0.11)	-0.04 (0.11)	-0.26*** (0.10)
constant	0.86*** (0.07)	0.88*** (0.06)	0.90*** (0.07)	0.85*** (0.07)	0.98*** (0.08)	0.94*** (0.08)	0.90*** (0.07)

Note: Standard errors in parentheses; asterisks denote statistical significance at levels of 10%, 5% and 1% respectively.