Market Integration and Disintegration of Poland and Germany in the 18th Century

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Abstract

Was the 18th century a time period of gradual market integration? Or did the wars, famines, and criminality drive central European markets away from each other? We perform cointegration tests between four German and three Polish cities for rye markets in the 18th century, plus selected tests with other grains. We confirm earlier findings that Gdańsk was very well-connected. In a dynamic analysis between the early and the late 18th century we find that integration decreased considerably between German and Polish cities. At the same time Polish grain markets appear to disintegrate as well.

Main questions

The integration and disintegration process between regionally and culturally remote markets is one of the most interesting phenomena in economic history. Can we find out which factors lead to integration and disintegration? Do wars, plagues, hunger, terrorism or criminality along the trading routes have a serious effect? And if disintegration movements took place in economic history, how many adverse events of which intensity are necessary to lead to long-lasting disintegration?

With this study, we will enlarge the database of the integration/disintegration record by focusing on cities in 18th century Poland (which covered a large part of Central-Eastern Europe, including parts of today's Ukraine, Lithuania and Belarus) and German cities. In 1772 and 1795, the Polish territories were occupied and subsequently annexed by Prussia, Russia and the Habsburg Empire, but we will still call them „Polish" cities for the sake of simplicity (and their ethnic and cultural homogeneity).[1]

This area is also very interesting, because an influential group in Polish economic history argued that a „re-feudalisation" took place in the 18th century (e.g. Topolski 1979, 1994).[2] Inspired by the political decline of Poland in the late 18th century, the question whether there was also an (perhaps preceding) economic decline stimulated Topolski studies. As in most regions of Europe, the bulk of grain was traded and consumed within the country. Only a small part was exported to Western Europe (especially to the Netherlands, and later England). Market integration within Poland might have declined, because the land-owning nobility could have felt threatened to lose their rents to merchants and small farmers, therefore they could

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[1] We will use the term „East-Central European" cities synonymously (well aware that „East-Central Europe" also stretches further to the South).

[2] Topolski (1979) also argued that this phenomenon could be observed in some regions in Western Europe).

have returned to or stuck to neo-feudalistic attitudes. This did not necessarily mean that there should be no integration at all between German and Polish cities. One could imagine different developments at the international and intraregional level, as Li (2000) found for Chinese grain markets in the 18th century.

Research on market integration in the 18th century is particularly interesting, because the literature found contradictory evidence for different sorts of trade and distances. For example, long distance trade in non-competing goods with East Asia has been characterised by market integration tendencies (O'Rourke and Williamson 2002). For grain markets, Kopsidis (1998) looked at the integration at the end of the 18th century in some regions of Western Germany and found less integration than in the 19th century. Granger and Eliot (1967) noted even a higher integration in English regional grain markets in the early 18th century as opposed to the later 18th century. Finally, Gibson and Smout (1995) presented evidence for integration in Scotland only during the 17th century and 1700-1720.

On the other hand, capital market integration during the 18th century proceeded with great force (Neal 1987). Even for grain markets, Persson attributes a crucial role to the development of markets in the 18th century: For the first time, markets became developed enough to take over the role of mitigating local grain shortages (that was previously attempted to achieve with community government interventions).

Which concept of integration, and how to measure it?

In two markets that become more and more integrated over time, we should expect at least two phenomena: If they become integrated because transport costs or tariff protection decreases (or related phenomena), the price levels should converge. If information spreads more easily and the trade share increases significantly, the correlation between price movements should become closer. Declining transport costs and protection (the „transport-tariff wedge“) can also lead to increasing price correlation. But one could also imagine increasingly correlated prices without declining transport costs, if for example the transmission of price information is organized more efficiently.

Granger and Elliot (1967) argued that the correlation of prices is an even better yard-stick than the convergence of price levels. The correlation (or rather, cointegration, to avoid spurious relationships) method has the additional advantage that many of the methodological problems of 18th century price data (volume units, relative demand of silver) are less crucial. We will therefore focus on the cointegration of prices between Polish and German cities, using pairs of cities. Moreover, we will also look at the relations between cities within Poland. The integration during the whole 18th century will interest us, as well as the increasing or decreasing integration during the century. Persson (2000) suggested that there was a strong difference between the integration of the 16th and the 19th centuries in Italian cities. For the period in between, he finds a relatively relatively continuous integration tendency since the 16th centuries in many European countries.

Grain prices played the most important role in early modern European cities. Especially the standard of living of the urban lower classes was overwhelmingly determined by the price of this food category, because its share of expenditures was extremely high. Most other food items (meat, fats, beer, vegetables) were to a certain extent correlated with grain prices, due to substitution processes in both consumption and production. But the correlation was certainly never perfect, due to regional supply and demand shocks. The prices of perishable goods such as milk (and offals as well as other non-traded foods) that played a major role for the rural majority of the European population were even less correlated (see Baten 1999, Baten and Murray 2000). But as we focus on urban markets, grain prices are clearly the most decisive goods. In Northern Europe, rye was more important than the other grains for the nutrition of the majority of the population, whereas wheat ranked second in most places (it was slightly more important for the richer parts of the population). Due to its higher price per weight unit, wheat tended to display higher integration levels between distant markets. In order to test whether the grain markets were really integrated in depth, we will mainly focus on rye prices (but note that rye and wheat were also highly correlated). Other grains were of somewhat smaller importance. Barley did constantly lose its importance since the middle ages, but was still widely consumed in Scandinavia. Oats were mainly used as intermediary for cattle feeding. We will use those other grains for supplementary tests, as we have to be aware of possible measurement errors and missing values.

Selection of cities

We selected the cities under study by a number of criteria. One important aspect was data availability. For the Polish region, we were able to obtain data on Kraków, Lviv, Warszawa (only oat prices), and Gdańsk (see Table 1a and 1b). The latter had a mixed population, which spoke mostly German, but the city's merchants traded Polish grain and it was a part of the Polish kingdom until 1792). We therefore have one major port city, Gdańsk, and two of the largest cities in the interior, Kraków and Warsaw, that were situated on large navigable river. Kraków was situated slightly more remote, as seen from the perspective of the Baltic trade routes. For Warszawa, rye prices were not available, so we looked at oat prices. Finally, Lviv represents a grain market that was relatively far in economic terms – "land-locked" -, as grain from those areas had to be transported a certain distance on the (costly) land way, before a river could be used for transport. The main grain producing areas that influenced Lviv's grain market stretched dozens of kilometers to the Southeast. Thus we have cities with very different transport costs to the coast, this criterion allows to check a potential influence of bein land-locked.

[Tables 1a and 1b about here]

We included the following German towns in our data set. (1) Bremen that has almost direct access to the North Sea, and (2) Braunschweig that is separated by some kilometers of land transport from the nearest navigable water-way. In addition to these two North German towns, we considered (3) Wuerzburg on the Main river (its surroundings delivered grain along the Rhine itself), and (4) Augsburg. The latter city lies in a grain deficit area and it is separated from the North Sea/Baltic Sea area, as its closest navigable waterway is the Danube river that is only good for trading with regions to the East (Bavaria, Austria, Hungary...).

Another issue is the decision between monthly, quarterly and annual data. For most of our cities during the 18th century monthly data were not available. However, annual data has also the advantage that with monthly data we might not find relationships, because grain and even information travelled too slow to display a short-run effect on a remote market.

Methods

The problem of our particular interest was the *long-run equilibrium* relationship between price series for selected cities. We assumed initially that the results should be invariant to some random, short-run local phenomena like e.g. changing weather conditions in different regions, wars etc., and should present a general tendency displayed by the series. As a natural consequence of this choice we applied the cointegration-based vector error-correction models (VECM).[3] Since VECM investigate the long-run relationships, this method seems to neutralize a short-run influence of incidents underlined above, and then the results became more 'endogenous'. Consider a random short-run deviation that took place in a local market (e.g. hail). If this phenomenon has not occurred cyclically, a general tendency should not be broken. Looking at the plotted series and analyzing their properties, the *near-unit-root*-like behavior of prices is of the special importance. Pre-industrial prices were often more volatile than the recent ones. This finding determines the method of estimation – VEC-modelling applied to the logged, original series might not be a proper way of investigating the long-run integration[4].

Consider that the relationship between prices π in cities (or regions) 1 and 2 at time t is described by a two-dimensional vector autoregressive model of order *k-th*

$$\begin{bmatrix} \pi_t^1 \\ \pi_t^2 \end{bmatrix} = \begin{bmatrix} p_1^{1,1} & p_1^{1,2} \\ p_1^{2,1} & p_1^{2,2} \end{bmatrix} \begin{bmatrix} \pi_{t-1}^1 \\ \pi_{t-1}^2 \end{bmatrix} + \ldots + \begin{bmatrix} p_k^{1,1} & p_k^{1,2} \\ p_k^{2,1} & p_k^{2,2} \end{bmatrix} \begin{bmatrix} \pi_{t-k}^1 \\ \pi_{t-k}^2 \end{bmatrix} + \Theta \mathbf{A}_t + \begin{bmatrix} u_t^1 \\ u_t^2 \end{bmatrix}.$$

where p's represent the coefficients, and matrix **A** contains deterministic terms (intercept, linear time trend), but we do not assume *a priori* which terms are represented by **A**. The above model is presented in an error-correction form:

$$(1) \qquad \Delta \mathbf{X}_t = \mathbf{P}\mathbf{X}_{t-1} + \sum_{i=1}^{k} \mathbf{G}_i \Delta \mathbf{X}_{t-i} + \Theta \mathbf{A}_t + \mathbf{u}_t .$$

If the rank of **P** is r = 1 it is then reasonable to decompose **P** into two matrices $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ and re-write (1) as follows:

$$(2) \qquad \Delta \mathbf{X}_t = \alpha \beta ' \mathbf{X}_{t-1} + \sum_{i=1}^{k} \mathbf{G}_i \Delta \mathbf{X}_{t-i} + \boldsymbol{\Theta} \mathbf{A}_t + \mathbf{u}_t .$$

[3] The main ideas behind the VEC-modeling are presented by, e.g. Johansen and Juselius (1990).
[4] One could apply the cointegration analyzis using the non-linear trends, e.g. Hodric-Prescott, and then obviously avoid the near-unit-root problem.

Obviously, the matrix $\boldsymbol{\beta}$ contains the elements of the cointegrating vectors, while $\boldsymbol{\alpha}$ the so-called speed-of-adjustment coefficients.

The market integration, or at least price co-movement, requires a stable long-run equilibrium, which might be traced out using the cointegration procedure. The parameters of particular interest are $\boldsymbol{\beta} = [\beta_1, -\beta_2]'$. The normalizing cointegrating vector for a perfect co-movement should be close, as straightforward algebra suggests, to $\boldsymbol{\beta} = [1,-1]'$, which implies that a deviation from the equilibrium in market *1* is compensated by a very similar move observed in market *2* (only distorted by the error term).

In other words, if there is one cointegrating relationship between grain price series in two cities, the two cities' grain markets were probably integrated (but notice that they might have also been subject to common shocks, such as climatic ones). The closer the condition $\boldsymbol{\beta} = [1,-1]'$ is met, the smaller and less important are temporary deviations from the common market price.

Lag Length and Model Selection

As mentioned above, the optimal lag length selection is of special significance for our analysis. The lag length is selected on the basis of information criteria, which are usually employed for the selection of lag length in VECMs and cointegration tests (Lütkepohl and Saikkonen 1999). More recently, however, Aznar and Salvador (2002) have shown that some criteria do not optimally solve the selection problems for the models with non-stationary variables. Following their results we apply the minimization of the Schwarz (SC) criterion for the augmented Dickey-Fuller tests (ADF). We choose the version of VECM using the same method. Since the other unit-root tests employ a Newey-West type variance estimator, the truncation lag length in

Phillips tests (PT), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin tests (KPSS) is selected in accordance to the Newey-West 'automatic' procedure (Newey and West 1994).

Unit root tests.

There is little doubt that none of the unit root tests gives certainty about the question of stationarity. Since the KPSSs are likely to have the best properties among the widely applied tests, we concentrate on the outcomes obtained using this procedure. As an additional verification we conduct the ADFs and PPs tests. All tests are carried out with the different assumptions about the deterministic variables[5] in the auxiliary models:

KPSS: (1) H_0: $X_t = \gamma_1 + u_{1,t}$; H_1: $X_t = X_{t-1} + u_{1,1,t}$;

(2) H_0: $X_t = \gamma_2 + \mu_2 t + u_{2,t}$; H_1: $X_t = \gamma_{2,1} + X_{t-1} + u_{2,1,t}$;

ADF: (1) $\Delta X_t = \sum_{i=1}^{p} a_{3,i}\Delta X_t + \varphi_3 X_{t-1} + u_{3,t}$; (2)

$$\Delta X_t = \alpha_4 + \sum_{i=1}^{p} a_{4,i}\Delta X_t + \varphi_4 X_{t-1} + u_{4,t};$$

(3) $\Delta X_t = \alpha_5 + \sum_{i=1}^{p} a_{5,i}\Delta X_t + \varphi_5 X_{t-1} + \mu_5 t + u_{45,t}$;

PT: $X_t = b_1 X_{t-1} + u_{6,t}$;

PP: (1) $X_t = \beta_2 + b_2 X_{t-1} + u_{7,t}$; (2) $X_t = \beta_3 + b_3 X_{t-1} + \mu_8 t + u_{8,t}$,

where: γ, α, β – intercept, Δ - difference operator, a, b, φ, μ – OLS parameters, $u_{j,t}$ – error term. We obtained rather standard and expected outcomes. The conclusions for

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[5] Note that the vector of deterministic variables is pre-selected subject to the plots. Although the plots strongly suggest that there is no linear trend in the data generating process we conduct the tests using all auxiliary models. We follow the same strategy choosing VEC model versions in the next sections.

different tests differ slightly, but in general we might accept the hypothesis that all series are integrated of order 1.

[Tables 2a and 2b about here]

Cointegration analysis of the whole 18th century

After obtaining the unit root test results we conducted the Johansen cointegation test (trace). As in the ADF case we used the Schwarz criterion for selecting lag length and model version. Again, we did not pre-specified *a priori* the deterministic variables in **β** and **Θ**. Five versions of the auxiliary models were tested: (I) without any deterministic variable in both cointegrating equation and in VAR, (II) with intercept in cointegrating equation, (III) intercept in both cointegrating equation and in VAR, (IV) intercept and linear trend in cointegrating equation and intercept in VAR, (V) intercept and linear trend in both cointegrating equation and in VAR. What could be an economic interpretation of these different models? An appearance of a deterministic variable in cointegrating vector might suggest, in our case, that there was a common factor affecting both markets. However, a strictly economic explanation of the intercept or linear trend is rather impossible[6]. Table 3 reports the outcomes.

[Table 3 about here]

Again, the results were sensitive to the chosen lag length and model version. We found that the rye markets in the northern part of Germany and the south-eastern part of Poland (Kraków, Lviv, and Bremen) were not integrated. Interestingly, rye markets of all Polish cities were not integrated, either. The frictions between the

[6] In some cases SC suggested that we should perform two of those five models. However, we decided to use a model with less deterministic variables.

markets within Poland seem to have been at least as large – in some cases – as between Poland and Germany.

The β_2-parameter informs us whether the integrated series moves together very closely (then β_2 is close to –1). Although we noticed one case, which did not confirm our expectations (positive value of β_2 for Kraków-Braunschweig), the obtained values of β_2-parameters were indeed close to –1 (Table 4). Enormously high values obtained for rye markets in Lviv and Augsburg, Braunschweig, and Würzburg were related to the selected model version. After obtaining those results we had conducted an experiment for unchanged lag length and for the model I, which produced the values of -1.077, -1.322 and -1.071, respectively.

[Table 4 about here]

Since we had decided to select the lag length and model version using the minimization of SC, we did not mine the data until we achieved easily interpretable results.[7] In general, we can summarize the results about rye market integration as we did in Figure 1. We will focus in the following discussion on regional patterns: which cities were well and which cities were less integrated? It became particularly evident how well-connected Gdańsk was in the 18th century. Its rye market was cointegrated with all other markets. This high rye market integration of Gdańsk is confirmed when we tested other grains: Its barley price series was cointegrated with Kraków and Lviv, wheat also with Kraków. The Polish cities of the interior were cointegrated with three of the four German cities' rye markets. Overall, the 18th century appears as a time

[7] Wallusch (2002) reported a problem concerning the small lag length in VAR- and VEC-modeling of the pre-industrial price series, and then the careful usage of autoregressive models in pre-industrial cliometrics. Our analysis extended his observations on the role of deterministic variable. Here we just faced a standard problem of model and lag selection, but the 'technical' background of the pre-industrial time series analysis is more complicated and deserves more attention than cliometricians have paid yet

period of strongly integrated grain markets between Germany and Poland, whereas the markets within Poland were interestingly not very integrated.

What could have been the reason for this non-integration of rye markets between the Polish cities? It is interesting to observe that while rye markets were not integrated, barley and oats markets were. Barley and oats were overwhelmingly consumed within Poland, whereas rye (and wheat) were to a higher percentage exported. Therefore, we interpret this non-integration in the rye markets as follows. Information about rye flowed between the traders in the Polish cities and their respective trading partners in Germany and Western Europe. Information on oats and barley in contrasts also flowed intensively between Polish cities, reinforced by the re-feudalisation process (Bogucka and Samsonowicz 1986) that also had the consequence that city dwellers did not buy as much food on the market, but rather were involved themselves in food production.

Hypotheses about the development of market integration between 1700-1750 and 1750-1800

The final step of our analysis is to answer the question: did integration increase or decrease over the 18th century? Which factors could have played a role? We know from anthropometric research that the quality of nutrition was better in the early and mid-18th century (albeit not in the very first decades), whereas it deteriorated in the late 18th century (Komlos 1989, Baten 1999, 2001). Dramatic declines in nutritional status often coincide with social unrest and conflict. In the years around 1800 the number of violent conflicts was particularly high, not only in terms of „normal“ wars, but the French revolution led to a new dimension of political and social conflict. In our region under study, Poland was repeatedly occupied and divided among its neighbours. The German principalities were involved in a particular large number of conflicts, and in the most densely populated areas (such as the Palatinate and other parts of the Rhineland), social conflicts were particularly visible. Around 1800, the activities in armed robbery reached a climax. Which impact could the large uncertainties of this situation in the late 18th century have on economic integration between mid-western and mid-eastern Europe?

Hypothesis 1: the situation in the later 18th century meant greater risks for long-distance trade, given the number of violent conflicts and the higher returns to pirate and robbery activities.

Therefore, market integration should have been higher in the first half of the 18th century, the more peaceful Baroque period. Granger and Eliot's (1967) finding that regional market integration was higher in early 18th than in the late 18th century makes this hypothesis plausible (especially as Granger expected the contrary, assuming that market integration is a process that took place steadily over time). However, Li (2000) found for China in the 18th that regional disintegration occurred simultaneously with long-distance integration. The grain markets of Bejing and Shanghai integrated, while the local markets in the Hebei province (in terms of size not unsimilar to England, its older name was Zhili) disintegrated. The same could have happened to the 18th century Northern Europe.

Hypothesis 2: Climatic conditions in the late 18th century were less favorable for agricultural production, and population density increased, so that real grain prices increased significantly. Higher prices made the trade with relatively remote production areas more profitable. Therefore grain was also transported from the Polish (including Ukrainian) regions that were formerly separated from West European markets by high transport costs. The higher quantity of traded grain also led to a greater quantity of information that moved between mideastern and midwestern Europe. In addition, the Prussian occupation of a large part of Poland might have led to economic integration with German markets (but Kraków and Lviv would be counter-examples here). According to this second hypothesis, we would expect a higher market integration in the second half of the 18^{th} century than in the earlier period.

Integration between the early and late 18^{th} century: methods and results

We divided the whole period into two sub-samples of 50 years each. The method of analysis differs slightly from the one that we had used for the whole period. The 'technical' differences concern unit root tests, which have not been conducted for the small samples, and the modified Johansen test.

Cointegration analysis of recent phenomena is often applied to the monthly or quarterly data, yielding a large number of observations even for relatively small time periods. Despite a very long time horizon, we focus in this section on only 50 (yearly) observations. Though this number satisfies the definition of a "long period", it does not provide a sufficient number of observations. To avoid this problem we followed the methods that had been presented by Reimers (1991) and Cheung and Lai (1993).

Both procedures use the Reinsel and Ahn (1992, see also Reinsel 1997, especially page 201) suggestions and employ a scaling factor represented as a function of sample size (n), lag length (k) and number of estimated coefficients (z). Reimers (1991, page 89) adjusted[8] the trace test statistics proposed by Johansen and Johansen and Juselius in their seminal papers by a factor $(n-kz)/n$ and obtained

[8] More recently Johansen (2002) stressed out, however, that the 'degrees of freedom' corrections do not capture the dependence on the number of estimated parameters.

$-(n-kz)\sum_{i=r+1}^{p}\ln\left(1-\hat{\lambda}_i\right)$. On the other hand, Cheung and Lai showed that an alternative way is to adjust the critical values (C^V) by a similar factor. However, noting that $C^V(n)/C^V(\infty)=n/(n-kz)$, it is immediately visible that the correction increases together with the lag length and/or number of estimated coefficients. Tables 5 and 6 report the test results and values of β_2-coefficients.

[Tables 5 and 6 about here]

Similar power of these corrections does not allow to select the better one. Obviously, if the two tests give different results, then the conclusion is partially ambivalent. However, all tests yielded similar outcomes.

How did grain market integration develop between the early and the late 18th century? We summarize the results of table 5 for the rye markets in Figure 2 and 3. A line indicates cointegration. In general, there was a tendency towards desintegration between the German and Polish rye markets of our sample. The number of integrated markets between east and west declined from eight in the earlier to four in the later period. Therefore, our findings do not support hypothesis 2 that the overall price increase made long distance trade more interesting in the late 18th century. The desintegration movement was caused by the Baltic trading centre of Gdańsk, and not by Kraków and Lviv.

Interestingly, market integration within Poland might have decreased at the same time. The rye market integration that we found for Gdańsk and Kraków for the early 18th century disappeared later-on (this was also the case of barley and wheat). For the barley markets, we find a similar disintegration movement within Poland between Gdańsk and Lviv (Table 5). Small-distance oat trade between Kraków and

Warszawa was cointegrated, but we can safely conclude that Lviv was particularly isolated in the later 18th century from other Polish markets.

Impulse response analysis: the spread of price shocks

Then we conducted the impulse response analysis, which provides some additional information about the cointegrated system. Lütkepohl and Reimers (1993) argued that impulse response analysis for the non-stationary time series is a more appropriate way to interpret the long-run relationship than the cointegrating vector. Their suggestions, however, are of particular importance for the VECM with more than 2 variables. In our case impulse respose analysis would be rather a tool, which helps to trace out an impact of the price shocks: we compared the magnitude[9] and focused on the 'sign' of response.

First, we conducted the Granger-causality test to choose the proper data ordering. There are three sources of causality in the VECM. We decided to test the zero restrictions imposed on the speed-of-adjustment coefficients. Consider the case of Gdańsk and Augsburg. The VECM is of the following form:

$$\begin{bmatrix} \Delta p_t^{GD} \\ \Delta p_t^{WÜR} \end{bmatrix} = \begin{bmatrix} \alpha^{GD} \\ \alpha^{WÜR} \end{bmatrix} \begin{bmatrix} \beta^{GD} & \beta^{WÜE} \end{bmatrix} \begin{bmatrix} p_{t-1}^{GD} \\ p_{t-1}^{WÜR} \end{bmatrix} + \begin{bmatrix} \pi_{11,1} & \pi_{12,1} \\ \pi_{21,1} & \pi_{22,1} \end{bmatrix} \begin{bmatrix} \Delta p_{t-1}^{GD} \\ \Delta p_{t-1}^{WÜR} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^{GD} \\ \varepsilon_t^{WÜR} \end{bmatrix} \quad (3)$$

The null hypotheses are:

H_0^1: changes in prices in Würzburg do not Granger-cause

changes in prices in Gdańsk, i.e. $\alpha^{GD} = 0$

H_0^2: changes in prices in Gdańsk do not Granger-cause

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[9] Notice that we used the Choleski factorisation to avoid the correlation effect in residuals. The orthogonalised innovation do not have an economic interpretation and thus the values of the response function should not be interpreted in the elasticity terms. For instance, if the stabilised value of the response of prices in Würzburg is 0.142, while for Augsburg 0.136 is obtained, it does not mean that

changes in prices in Würzburg, i.e. $\alpha^{WÜR} = 0$.

We tested the hypotheses employing the standard likelihood ratio test. The results are presented in Table 7.

[Table 7 about here]

The results might be interpreted in the same way as Persson (2000) did. Persson, who exluded Germany and Poland from his studies on European grain markets, wrote: *"If one market systematically gets new information before the other it will turn up as a market leader without actually dominating the other market in the literal sense of the word".* (Persson 2000, p. 98). This market leadership can either be typical of important trading cities that attract information more strongly than cities less involved in trade. In addition, Persson argued that places that are geographically closer to the Baltic centres of grain production are sometimes "leaders", because they obtain information about grain production shocks earlier. (We think that the "measurement without theory" criticism does not apply to our VECM analyses, because it is theoretically clear that the grain price in one city influences grain prices in other cities.)

Hence, if changes in prices in Gdańsk Granger-cause (in other words are weakly exogenous) changes in prices in Würzburg – if $\alpha^{WÜR} \neq 0$ – Gdańsk is a 'better (or earlier) informed' market. We expected that the null would not be rejected. Figures 4-6 depicts the results of the impulse response analysis.

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the elasticities are equal to the presented numbers, but that the changes in Gdańsk had slightly greater impact on prices in Würzburg than in Augsburg.

Following Lütkepohl and Reimers we focused only on the stabilised values of the response functions. A shock in German prices produced an increase in prices in Gdańsk. The prices in Bremen had the largest impact. Surprisingly, the value of the response to a shock in Würzburg was relatively close to the one obtained for Bremen (compared with Augsburg and Braunschweig). A different situation was observed for the response to a shock in Gdańsk. An increase in rye price in Gdańsk affected the prices in Augsburg, Braunschweig, and Würzburg in the same direction, while it produced a decreasing tendency in Bremen. The last effect might be connected to the competition between these markets, or substitution effects with other agricultural products.

In the case of Kraków and Lviv both cities were not cointegrated with the harbour cities. Hence, we expected that the relationship between cities located far from the coast would be mostly characterised by the two-directional causality: A price shock in one city (or its region) caused slightly later a price shock in another city, but the same is just as likely in the other direction. The results confirmed our intuition only partially. We detected the bi-directional causality for the German cities and Kraków, while for Lviv the null hypothesis of causality from German cities to Lviv has been rejected. This result is puzzling, since above no cointegration between Lviv and Bremen or Gdańsk was found. If there was a long-run relationship between those cities, the interpretation would be straightforward: Lviv was placed close to the producers. Although this interpretation seems to offer the only possible way of explanation, it must be treated with caution. The figures 5 and 6 present the impulse response analysis for Kraków and Lviv. Notice again that the variables were ordered subject to the causality tests.

With one exception we found a positive reaction to the price shock. The magnitude of the response was much greater when shock in Kraków was considered. In both cases the ‘largest co-movement’ was found for Augsburg. Interestingly, we detected a negative reaction of the rye prices in Kraków (Braunschweig) to the one standard deviation shock in Braunschweig (Kraków).

Conclusion

We performed cointegration tests between four German and three Polish cities for rye markets, plus selected tests with other grains. We confirmed earlier findings that Gdańsk was very well-connected. Cities of the interior were slightly less integrated, both in Germany and Poland, but still the degree of grain market integration was considerable in the 18th century. In a dynamic analysis between the early and the late 18th century we find that integration decreased considerably between German and Polish cities. At the same time Polish grain markets appear to disintegrate as well. These findings are compatible with Kopsidis (1998) that grain markets at the very end of the 18th century were not very integrated. We also confirm the Granger and Eliot (1967) view that early 18th integration in England was higher than in the late 18th century. The much more unstable situation in the later 18th century meant greater risks for long-distance trade, given the number of violent conflicts and the higher returns to criminal activities. The integration of the more peaceful late Baroque period might have only been regained during later in the 19th century.

References

Aznar, A., Salvador, M., 2002. Selecting the Rank of the Cointegration Space and the Form of the Intercept Using an Information Criterion. Econometric Theory 18, 926-947.

Baten, J., 1999. Ernaehrung und wirtschaftliche Entwicklung in Bayern, 1730-1880. Steiner Verlag, Stuttgart.

Baten, J., Murray, J., 2000. Heights of Men and Women in Nineteenth Century Bavaria: Economic, Nutritional, and Disease Influences. Explorations in Economic History 37, 351-369.

Bogucka M., Samsonowicz H., 1986. Dzieje miast i mieszczañstwa w Polsce przedrozbiorowej. Wroclaw PWN.

Cheung, Y.-W., Lai, K. S., 1993. Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration. Oxford Bulletin of Economics and Statistics 55, 313-328.

Gibson, A.J.S., Smout, T.C., 1995. Regional Prices and Market Regions: the Evolution of the Early Modern Scottish Grain Market. Economic History Review 47, 258-282.

Granger, C. W. J., Elliot, C. M., 1967. A Fresh Look at Wheat Prices and Markets in the Eighteenth Century. Economic History Review 20, 257-265.

Johansen, S., Juselius, K., 1990. Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money. Oxford Bulletin of Economic and Statistics 52, 169-210.

Johansen, S., 2002. A Small Sample Correction for the Test of Cointegrating Rank in the Vector Autoregressive Model. Econometrica 70, 1929-1961.

Komlos, J., 1989. Nutrition and Economic Development in the Eighteenth-Century Habsburg Monarchy: An Anthropometric History. Princeton, Princeton University Press.

Kopsidis, M., 1998. Der westfaelische Agrarmarkt im Integrationsprozess 1780-1880. Phasen und Einflussfaktoren der Marktentwicklung in historischen Transformationsprozessen. Jahrbuch fuer Wirtschaftsgeschichte, 169-198.

Kopsidis, M., 2002. The Creation of a Westphalian Rye Market 1820-1870: Leading and Following Regions. A Co-integration Analysis. Jahrbuch für Wirtschaftsgeschichte, 85-112.

Lütkepohl, H., Saikkonen P., 1999. Order Selection in Testing for the Cointegrating Rank Rank of a VAR Process. In: Engle, R. F., White, H. (Eds.), Cointegration, Causality, and Forecasting. A Festschrift in Honour of Clive W. J. Granger. Oxford University Press. pp. 168-199.

Lütkepohl, H., H.-E. Reimers., 1993. Impulse Response analysis of Cointegrated Systems. Journal of Economic Dynamics and Controle 16, 53-78.

Neal, L., 1987. The Integration and Efficiency of the London and Amsterdam Stock Markets in the Eighteenth Century. Journal of Economic History 47, 97-1.

Newey, W., West, K., 1994. Automatic Lag Selection in Covariance Matrix Estimation. Review of Economic Studies 61, 631-653.

O'Rourke, K., Williamson, J., 2002. When did globalization begin?. European Review of Economic History 6, 23-50.

Persson, K. G., 2000. Grain Markets in Europe, 1500-1900: Integration and Deregulation. Cambridge University Press, Cambridge.

Reimers, H.-E., 1991. Analyse kointegrierter Variablen mittels vektorautoregressiver Modelle. Heidelberg: Physica-Pherlag.

Reinsel, G. C., 1997. Elements of Multivariate Time Series Analysis. 2nd ed., Springer-Verlag, New York.

Reinsel, G. C., Ahn, S. K., 1992. Vector Autoregressive Models with Unit Roots and Reduced Rank Structure: Estimation, Likelihood Ratio Tests, and Forecasting. Journal of Time Series Analysis 13, 353-375.

Topolski, J., 1994. The manorial economy in early-modern east-central Europe. origins, development and consequences. Variorum, Aldershot.

Topolski, J. 1979. La nascita del capitalismo in Europa : crisi economica e accumulazione originaria fra XIV e XVII secolo. Einaudi, Torino.

Wallusch, J., 2002. Prices and Export. On the Grain Export and its Influence on the Prices in Poland. Paper presented at the International Seminar in Pre-Industrial Cliometric History, University of Burgos, Peñaranda del Duero, Burgos, 25-27 March 2002, mimeo.

Table 1a. Data Sources.

City	Grain	Period	Source
Augsburg	rye	1700-99	Moritz John Elsas, Umriss einer Geschichte der Preise und Löhne in Deutschland: vom ausgehenden Mittelalter bis zum Beginn des neunzehnten Jahrhunderts
Braunschweig	rye	1700-00	Elsas
Bremen	rye	1705-00	Elsas
Gdańsk	barley	1701-00	Tadeusz Furtak, Ceny w Gdańsku w latach 1701-1815, Lviv 1935.
	rye	1701-00	
	wheat	1703-00	
Kraków	rye	1700-95	Edward Tomaszewski, Ceny w Krakowie w latach 1601-1795, Lviv 1934.
	oat	1750-95	
	barley	1700-95	
	wheat	1700-95	
Lviv	barley	1700-98	Stanisław Hoszowski, Ceny we Lwowie w latach 1701-1914, Lviv 1934.
	oat	1700-98	
	rye	1700-98	
Warszawa	oat	1700-99	Stanisław Siegel, Ceny w Warszawie, Lviv 1932.
Würzburg	rye	1700-99	Elsas

Table 1b. Missing Observations

City	Grain	Period
Kraków:	barley	1700-03, 1706-1709, 1711-12, 1723, 1726-27, 1729, 1732-35, 1737, 1757
	oat	1754
	rye	1700-03, 1704-06, 1708, 1710, 1723-35
	wheat	1700-04, 1706-1708, 1712, 1720, 1723, 1725, 1729, 1732-35, 1737, 1744, 1746-1748, 1754-1757, 1760-61, 1764, 1771, 1787
Lviv	oat	1700-01, 1703, 1708, 1715, 1721-22, 1727-29, 1741-42,1744, 1748, 1755-56, 1760-66, 1773-85, 1787-89, 1793, 1796-97
	barley	1700-04, 1708, 1721-24, 1729, 1731, 1733, 1735-41, 1744-46, 1749-50, 1752-58, 1760, 1762, 1771-85, 1787-93, 1795-97
	rye	1700-01,1704-05,1712-13, 1721-24, 1728, 1730, 1732-33, 1737, 1739, 1741-42, 1744-45, 1750-1753, 1755-1760, 1762, 1767, 1771, 1774-85, 1787-97
Warszawa	oat	1701, 1713, 1718-19, 1723, 1727, 1743, 1745, 1747-48, 1754-55, 1758, 1762-64

Table 2a. Unit root test results (variables in levels).

Variable	KPSS		ADF			PT	
	Test value	Conclusion	Lag length	Test value	Conclusion	Test value	Conclusion
rye							
Augsburg	0.513	rejected	1	-0.135	not rejected	-0.007	not rejected
Braunschweig	0.785	rejected	1	-0.40	not rejected	-0.165	not rejected
Bremen	1.785	rejected	2	0.769	not rejected	0.657	not rejected
Gdańsk	1.182	rejected	2	0.468	not rejected	0.377	not rejected
Kraków	0.408	I(0)	1	0.051	not rejected	0.065	not rejected
Lviv	1.953	rejected	1	0.094	not rejected	0.237	not rejected
Würzburg	0.520	rejected	1	0.018	not rejected	0.061	not rejected
barley							
Gdańsk	1.363	rejected	2	0.477	not rejected	0.427	not rejected
Kraków	0.910	rejected	1	0.196	not rejected	0.276	not rejected
Lviv	1.256	rejected	1	-0.132	not rejected	-0.123	not rejected
oat							
Kraków	0.581	rejected	1	0.347	not rejected	0.569	not rejected
Lviv	1.474	rejected	1	-0.157	not rejected	-0.016	not rejected
Warszawa	0.922	rejected	1	-0.451	not rejected	-0.486	not rejected
wheat							
Gdańsk	1.153	rejected	2	0.642	not rejected	0.616	not rejected
Kraków	0.745	rejected	1	0.142	not rejected	0.209	not rejected

Critical values for KPSS: 0.463, ADF: -1.93, PP: -1.94

Table 2b. Unit root test results (variables in 1st . differences).

Variable	KPSS		ADF			PT	
	Test value	Conclusion	Lag length	Test value	Conclusion	Test value	Conclusion
				rye			
Augsburg	0.063	I(1)	2	-7.380	I(1)	-9.691	I(1)
Braunschweig	0.073	I(1)	2	-7.833	I(1)	-9.305	I(1)
Bremen	0.060	I(1)	3	-6.755	I(1)	-9.721	I(1)
Gdańsk	0.131	I(1)	4	-5.484	I(1)	-8.318	I(1)
Kraków	.	.	2	-4.957	I(1)	-9.546	I(1)
Lviv	0.057	I(1)	3	-5.891	I(1)	-8.494	I(1)
Würzburg	0.025	I(1)	2	-7.217	I(1)	-11.028	I(1)
				barley			
Gdańsk	0.124	I(1)	4	-5.656	I(1)	-8.922	I(1)
Kraków	0.040	I(1)	3	-5.468	I(1)	-9.855	I(1)
Lviv	0.060	I(1)	2	-6.800	I(1)	-11.062	I(1)
				oat			
Kraków	0.061	I(1)	1	-5.86	I(1)	-7.147	I(1)
Lviv	0.057	I(1)	2	-6.677	I(1)	-8.552	I(1)
Warszawa	0.051	I(1)	1	-8.254	I(1)	-9.463	I(1)
				wheat			
Gdańsk	0.101	I(1)	5	-5.047	I(1)	-8.124	I(1)
Kraków	0.034	I(1)	1	-7.124	I(1)	-8.501	I(1)

Critical values: see Table 2a.

Table 3. Cointegration test results – full sample.

Cities	Grain	Model, lags	H_0	Johansen tests t.v.	Johansen tests C^V
Gdańsk-Augsburg	rye	I(2)	r = 0	17.925	12.53
			r = 1	0.117	3.84*
Gdańsk-Braunschweig	rye	I(2)	r = 0	18.506	12.53
			r = 1	0.266	3.84*
Gdańsk-Bremen	rye	I(1)	r = 0	35.62	12.53
			r = 1	0.252	3.84*
Gdańsk-Kraków	rye	II(2)	r = 0	19.303	19.96
			r = 1	6.581	9.24^{0}
Gdańsk-Lviv	rye	I(2)	r = 0	9.586	12.53
			r = 1	0.358	3.84^{0}
Gdańsk-Würzburg	rye	I(1)	r = 0	27.164	12.53
			r = 1	0.042	3.84*
Kraków-Augsburg	rye	I(1)	r = 0	18.444	12.53
			r = 1	0.014	3.84*
Kraków-Braunschweig	rye	IV(1)	r = 0	40.697	25.32
			r = 1	12.026	12.25*
Kraków-Bremen	rye	I(1)	r = 0	10.116	12.53
			r = 1	0.426	3.84^{0}
Kraków-Lviv	rye	I(1)	r = 0	12.183	12.53
			r = 1	0.113	3.84^{0}
		II(1)	r = 0	19.795	19.96
			r = 1	3.98	9.24^{0}

Cities	Grain	Model, lags	H_0	Johansen tests t.v.	Johansen tests C^V
Kraków- Würzburg	rye	I(1)	r = 0	17.819	12.53
			r = 1	0.089	3.84*
Lviv-Augsburg	rye	II(1)	r = 0	27.533	19.96
			r = 1	4.361	9.24*
Lviv-Braunschweig	rye	II(1)	r = 0	28.152	19.96
			r = 1	4.388	9.24*
Lviv-Bremen	rye	I(2)	r = 0	6.818	12.53
			r = 1	0.589	3.84^{0}
Lviv- Würzburg	rye	II(1)	r = 0	28.296	19.96
			r = 1	4.433	9.24*
Gdańsk-Kraków	barley	I(2)	r = 0	17.654	12.53
			r = 1	0.153	3.84*
Gdańsk-Lviv	barley	IV(1)	r = 0	51.886	25.32
			r = 1	10.692	12.25*
Kraków-Lviv	barley	II(1)	r = 0	18.4386	19.96
			r = 1	4.9398	9.24^{0}
Lviv-Warszawa	oat	I(1)	r = 0	21.420	12.53
			r = 1	0.04	3.84*
Gdańsk-Kraków	wheat	I(2)	r = 0	18.621	12.53
			r = 1	0.478	3.84*

Table 4. β_2 parameter values – full sample.

Cities	Grain	Model and lags	β_2	Cities	Grain	Model and lags	β_2
Gdańsk-Augsburg	rye	I(2)	-1.071	Kraków-Würzburg	rye	I(1)	-1.050
Gdańsk-Braunschweig	rye	I(2)	-1.320	Lviv-Augsburg	rye	II(1)	-3.873
Gdańsk-Bremen	rye	I(1)	-1.035	Lviv-Braunschweig	rye	II(1)	-5.020
Gdańsk-Kraków	rye	I(2)	-1.027	Lviv-Bremen	rye	-	-
Gdańsk-Lviv	rye	-	-	Lviv-Würzburg	rye	II(1)	-5.546
Gdańsk-Würzburg	rye	I(1)	-1.074	Lviv-Warszawa	oat	I(1)	-1.119
Kraków-Augsburg	rye	I(1)	-1.047	Gdańsk-Kraków	barley	I(2)	-0.978
Kraków-Braunschweig	rye	IV(1)	2.947	Gdańsk-Lviv	barley	IV(1)	-0.084
Kraków-Bremen	rye	-	-	Kraków-Lviv	barley	-	-
Kraków-Lviv	rye	-	-	Gdańsk-Kraków	wheat	I(2)	-1.025

Table 5. Cointegration test results – sub-samples.

Cities and grain	H_0	Model and lag length	1700-1750				Model and lag length	1751-1800			
			Reimers test		Cheung-Lui test			Reimers test		Cheung-Lui test	
			t.v.	C^V	t.v.	C^V		t.v.	C^V	t.v.	C^V
Gdańsk-Augsburg	r =0	IV(1)	38.302	25.32	51.069	33.76	I(2)	3.934	12.53^{0}	8.226	26.199^{0}
rye	r = 1		8.889	12.25*	11.852	16.333*		0.264	3.84	0.552	8.029
Gdańsk-Braunschweig	r =0	II(1)	26.690	19.96	32.850	54.566	I(1)	8.262	12.53^{0}	9.915	15.036^{0}
rye	r = 1		6.870	9.24*	8.456	11.372*		0.274	3.84	0.329	4.608
Gdańsk-Bremen	r =0	I(1)	20.626	12.53	25.21	15.314	I(1)	13.638	12.53	16.366	15.036
rye	r = 1		0.000	3.84*	0.000	4.693*		0.260	3.84*	0.311	4.608*
Gdańsk-Kraków	r =0	II(1)	24.828	19.96	30.558	24.566	I(2)	4.527	12.53^{0}	10.563	29.237^{0}
rye	r = 1		4.578	9.24*	5.634	11.372*		0.237	3.84	0.553	8.96
Gdańsk-Lviv	r =0	I(2)	3.315	12.53^{0}	6.775	25.605^{0}	I(1)	6.625	12.53	8.020	15.168
rye	r = 1		0.158	3.84	0.323	7.847		0.076	3.84^{0}	0.092	4.648^{0}
Gdańsk-Würzburg	r =0	I(1)	15.846	12.53	19.015	15.036	I(2)	10.94	12.53^{0}	22.875	26.199^{0}
rye	r = 1		0.007	3.84*	0.008	4.608*		0.154	3.84	0.322	8.029
Kraków-Augsburg	r =0	I(1)	8.501	12.53^{0}	10.160	14.975^{0}	I(1)	10.914	12.53^{0}	13.409	15.394^{0}
rye	r = 1		0.087	3.84	0.105	4.589		0.199	3.84	0.244	4.718
Kraków-Braunschweig	r =0	II(1)	23.271	19.96	28.507	24.451	I(1)	9.162	12.53^{0}	11.257	15.394^{0}
rye	r = 1		6.003	9.24*	7.354	11.319*		0.211	3.84	0.259	4.718
Kraków-Bremen	r =0	II(1)	23.571	19.96	29.631	25.093	I(1)	13.223	12.53	16.246	15.394
rye	r = 1		4.751	9.24*	5.973	11.616*		0.398	3.84*	0.489	4.718*
Kraków-Lviv	r =0	I(1)	10.069	12.53^{0}	12.033	14.975^{0}	I(1)	5.041	12.53^{0}	6.193	15.394^{0}
rye	r = 1		0.012	3.84	0.014	4.589		0.280	3.84	0.344	4.718
Kraków- Würzburg	r =0	I(1)	6.343	12.53^{0}	7.581	14.975^{0}	I(1)	14.116	12.53	17.342	15.394
rye	r = 1		0.008	3.84	0.01	4.589		0.180	3.84*	0.221	4.718*
Lviv-Augsburg	r =0	I(1)	17.749	12.53	21.212	14.975	I(1)	5.814	12.53^{0}	7.038	15.168^{0}
rye	r = 1		0.000	3.84*	0.000	4.589*		0.137	3.84	0.166	4.648
Lviv-Braunschweig	r =0	I(2)	3.539	12.53^{0}	6.067	21.48^{0}	II(1)	21.38	19.96	26.581	24.815
rye	r = 1		0.179	3.84	0.307	6.583		4.351	9.24*	5.410	11.488*
Lviv-Bremen	r =0	I(2)	2.099	12.53^{0}	4.751	28.357^{0}	I(1)	4.971	12.53^{0}	6.017	15.168^{0}
rye	r = 1		0.264	3.84	0.597	8.691		0.064	3.84	0.078	4.648
Lviv- Würzburg	r =0	I(1)	10.191	12.53^{0}	12.178	14.975^{0}	I(1)	5.845	12.53^{0}	7.075	15.168^{0}
rye	r = 1		0.022	3.84	0.027	4.589		0.197	3.84	0.238	4.648
Kraków-Lviv	r =0	-	-	-	-	-	I(1)	8.5	12.53^{0}	10.443	15.394^{0}
oat	r = 1		-	-	-	-		0.599	3.84	0.756	4.718
Kraków-Warszawa	r =0	-	-	-	-	-	I(1)	11.738	12.53^{0}	14.421	15.394^{0}

oat	r = 1		-	-	-	-		0.321	3.84	0.394	4.718
Lviv-Warszawa	r =0	I(1)	16.755	12.53	20.024	14.975	I(1)	4.436	12.53^{0}	5.369	15.168^{0}
oat	r = 1		0.031	3.84*	0.037	4.589*		0.011	3.84	0.013	4.648
Gdańsk-Kraków	r =0	II(1)	25.699	19.96	31.630	24.566	I(1)	10.166	12.53^{0}	12.489	15.394^{0}
barley	r = 1		4.347	9.24*	5.351	11.372*		0.163	3.84	0.201	4.718
Gdańsk-Lviv	r =0	II(1)	28.614	19.96	35.217	24.566	I(2)	5.828	12.53^{0}	12.489	26.85^{0}
barley	r = 1		6.131	9.24*	7.564	11.372*		0.094	3.84	0.201	8.229
Kraków-Lviv	r =0	I(1)	6.433	12.53^{0}	7.687	14.975^{0}	I(1)	6.166	12.53^{0}	7.576	15.394^{0}
barley	r = 1		0.119	3.84	0.142	4.589		0.252	3.84	0.31	4.718
Gdańsk-Kraków	r =0	I(1)	6.117	12.53^{0}	7.404	15.168^{0}	II(1)	14.663	19.96^{0}	18.545	25.244^{0}
wheat	r = 1		0.045	3.84	0.054	4.648		3.423	9.24	4.329	11.686

Notes: t.v. is a t-Test of the null hypothesis, and C^V means critical values, * – one cointegrating vector detected, ** – two cointegrating vectors detected, ^{0} – zero cointegrating vectors detected..

Table 6. β_2 parameter values – sub-sample.

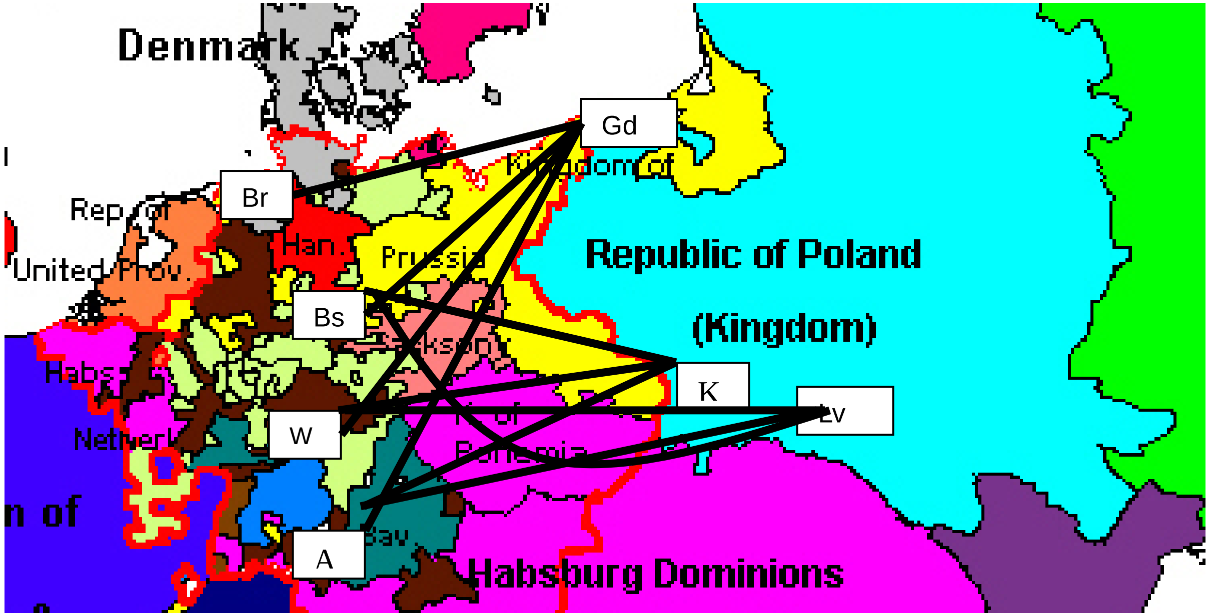
Cities	Grain	Model and lags	β_2 1700-50	Model and lags	β_2 1751-00	Cities	Grain	Model and lags	β_2 1700-50	Model and lags	β_2 1751-00
Gdańsk-Augsburg	rye	IV(1)	-0.515	I(2)	-	Lviv-Augsburg	rye	I(1)	-1.012	I(1)	-
Gdańsk-Braunschweig	rye	II(1)	0.225	II(1)	-	Lviv-Braunschweig	rye	I(1)	-	II(1)	2.996
Gdańsk-Bremen	rye	I(1)	-1.050	I(2)	-1.023	Lviv-Bremen	rye	I(2)	-	I(1)	-
Gdańsk-Kraków	rye	II(1)	0.068	I(1)	-	Lviv-Würzburg	rye	II(1)	-2.152	I(1)	-
Gdańsk-Lviv	rye	I(2)	-	I(1)	-	Kraków-Lviv	oat	-	-	I(1)	-
Gdańsk- Würzburg	rye	I(1)	-1.054	I(2)	-	Kraków-Warszawa	oat	-	-	I(1)	-
Kraków-Augsburg	rye	II(1)	-	I(1)	-	Lviv-Warszawa	oat	I(1)	-1.113	I(1)	-
Kraków-Braunschweig	rye	II(1)	5.516	I(1)	-	Gdańsk-Kraków	barley	II(1)	-0.031	I(1)	-
Kraków-Bremen	rye	II(1)	7.907	I(1)	-0.9888	Gdańsk-Lviv	barley	II(1)	-0.016	I(2)	-
Kraków-Lviv	rye	I(1)	-	I(1)	-	Kraków-Lviv	barley	I(1)	-	I(1)	-
Kraków-Würzburg	rye	I(1)	-	I(1)	-1.06	Gdańsk-Kraków	wheat	II(1)	-	II(1)	-

Table 7. Granger Causality Test Results

Null Hypothesis	Test Statatistics	Conclusion	Null Hypothesis	Test Statatistics	Conclusion
Gdańsk $\nrightarrow$ Augsburg	11.520	H_0 rejected	Augsburg $\nrightarrow$ Gdańsk	1.936	H_0 not rejected
Gdańsk $\nrightarrow$ Braunschweig	7.551	H_0 rejected	Braunschweig $\nrightarrow$ Gdańsk	1.832	H_0 not rejected
Gdańsk $\nrightarrow$ Bremen	0.038	H_0 not rejected	Bremen $\nrightarrow$ Gdańsk	16.950	H_0 rejected
Gdańsk $\nrightarrow$ Würzburg	6.829	H_0 rejected	Würzburg $\nrightarrow$ Gdańsk	11.538	H_0 rejected
Kraków $\nrightarrow$ Augsburg	6.290	H_0 rejected	Augsburg $\nrightarrow$ Kraków	6.886	H_0 rejected
Kraków $\nrightarrow$ Braunschweig	26.421	H_0 rejected	Braunschweig $\nrightarrow$ Kraków	4.102	H_0 rejected
Kraków $\nrightarrow$ Würzburg	6.333	H_0 rejected	Würzburg $\nrightarrow$ Kraków	12.331	H_0 rejected
Lviv $\nrightarrow$ Augsburg	21.868	H_0 rejected	Augsburg $\nrightarrow$ Lviv	0.808	H_0 not rejected
Lviv $\nrightarrow$ Braunschweig	22.866	H_0 rejected	Braunschweig $\nrightarrow$ Lviv	0.302	H_0 not rejected
Lviv $\nrightarrow$ Würzburg	23.833	H_0 rejected	Würzburg $\nrightarrow$ Lviv	0.144	H_0 not rejected

Critical value $\chi^2(1) = 3.841$.

Figure 1: Integration of Rye Prices: the whole 18th C



Abbreviations
K = Kraków
LV = Lviv
Gd = Gdańsk
Br = Bremen
Bs = Braunschweig
W = Wuerzburg
A = Augsburg

Figure 2: Integration of Rye Prices 1700-1750

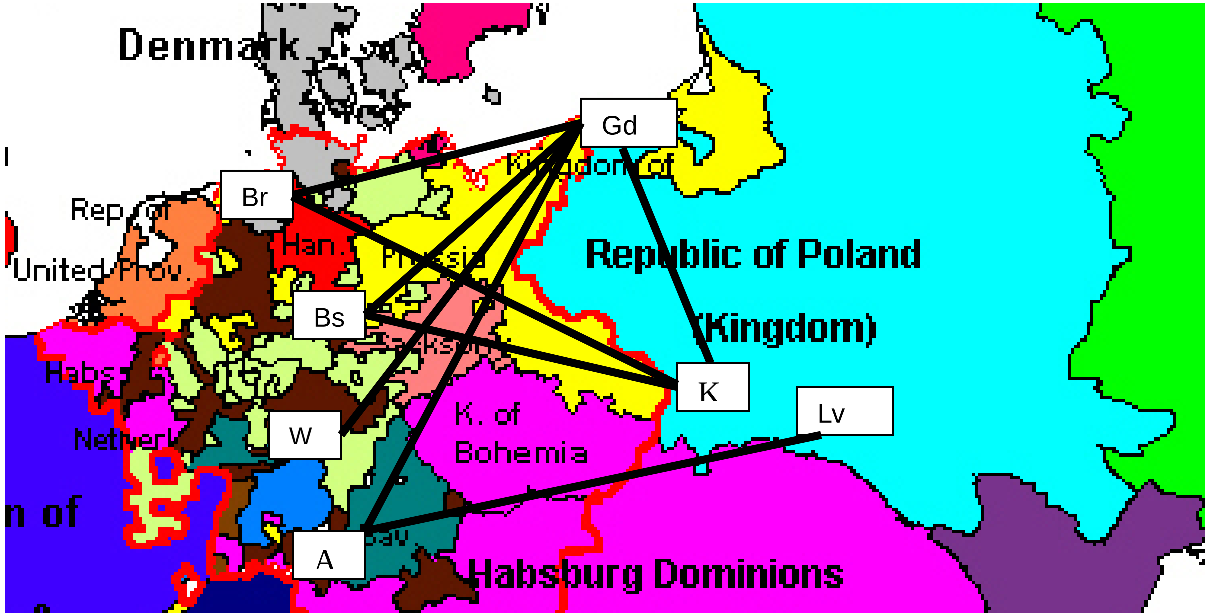


Figure 3: Integration of Rye Prices 1750-1800

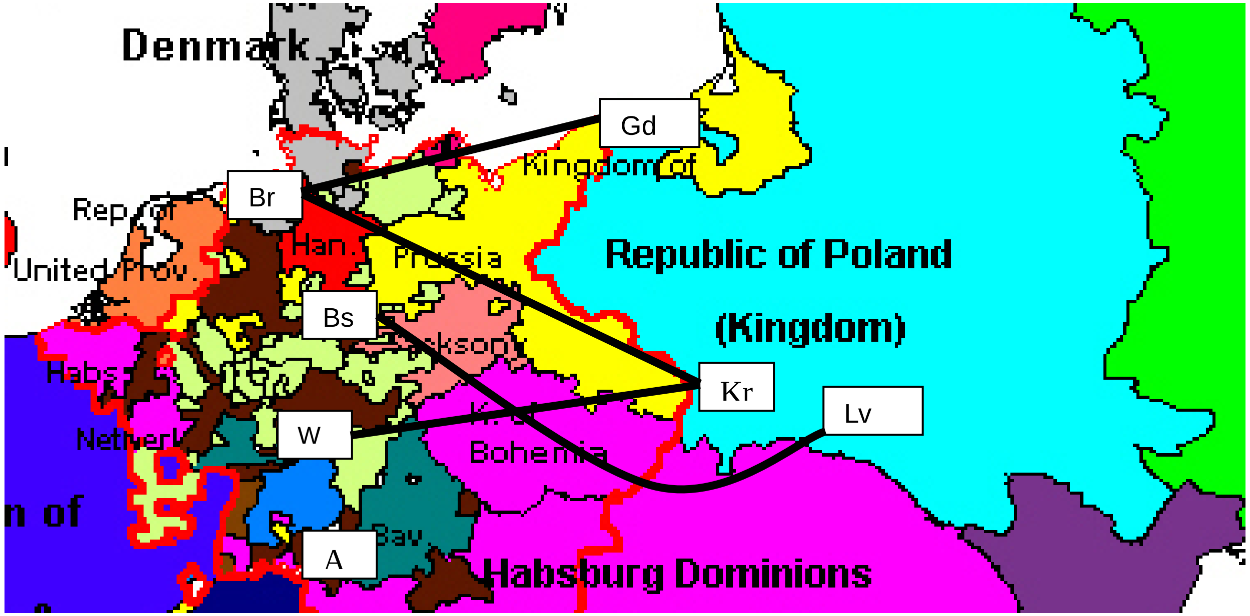


Figure 4. Response of Prices in Gdańsk to One-Standard Deviation Shock in Prices in German Cities (upper panel) and Response of Prices in German Cities to One-Standard Deviation Shock in Prices in Gdańsk (bottom panel)

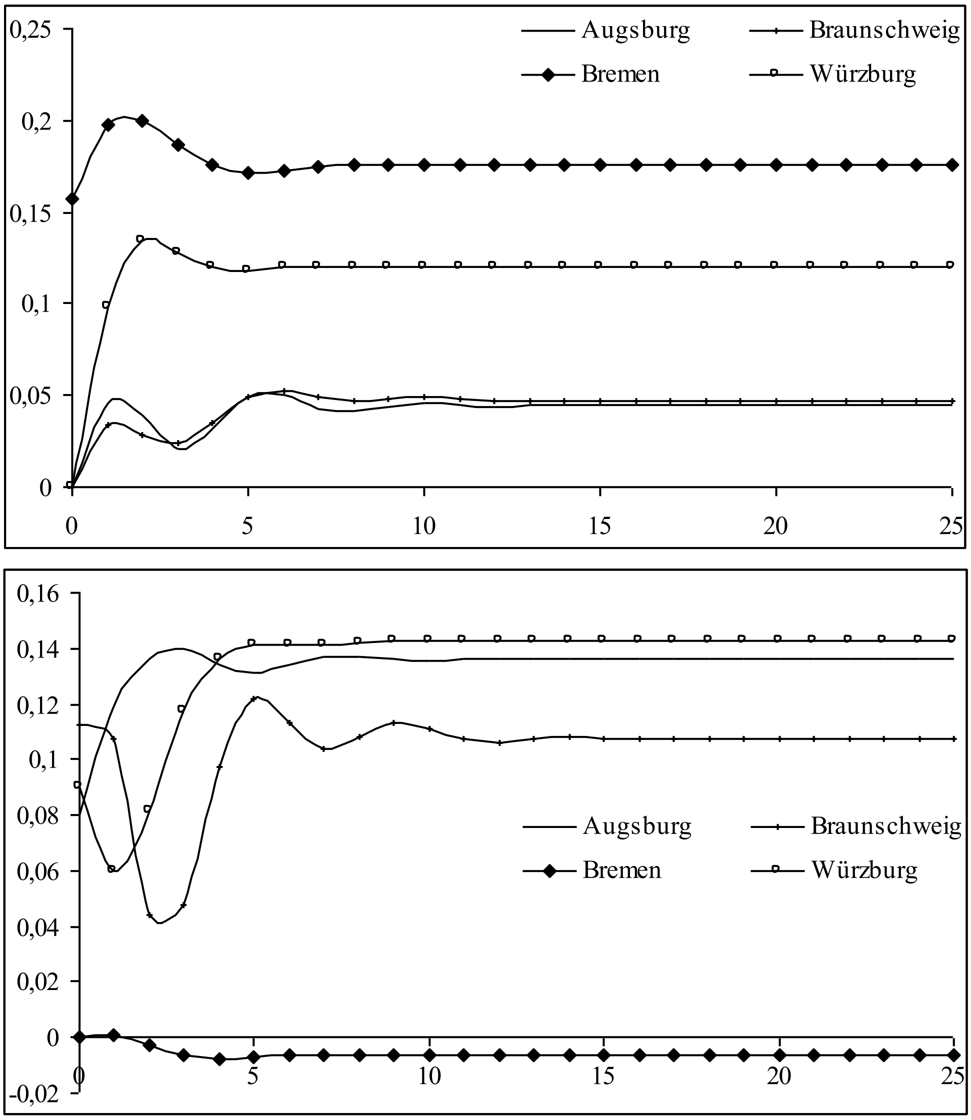


Figure 5. Response of Prices in Kraków to One-Standard Deviation Shock in Prices in German Cities (upper panel) and Response of Prices in German Cities to One-Standard Deviation Shock in Prices in Kraków (bottom panel)

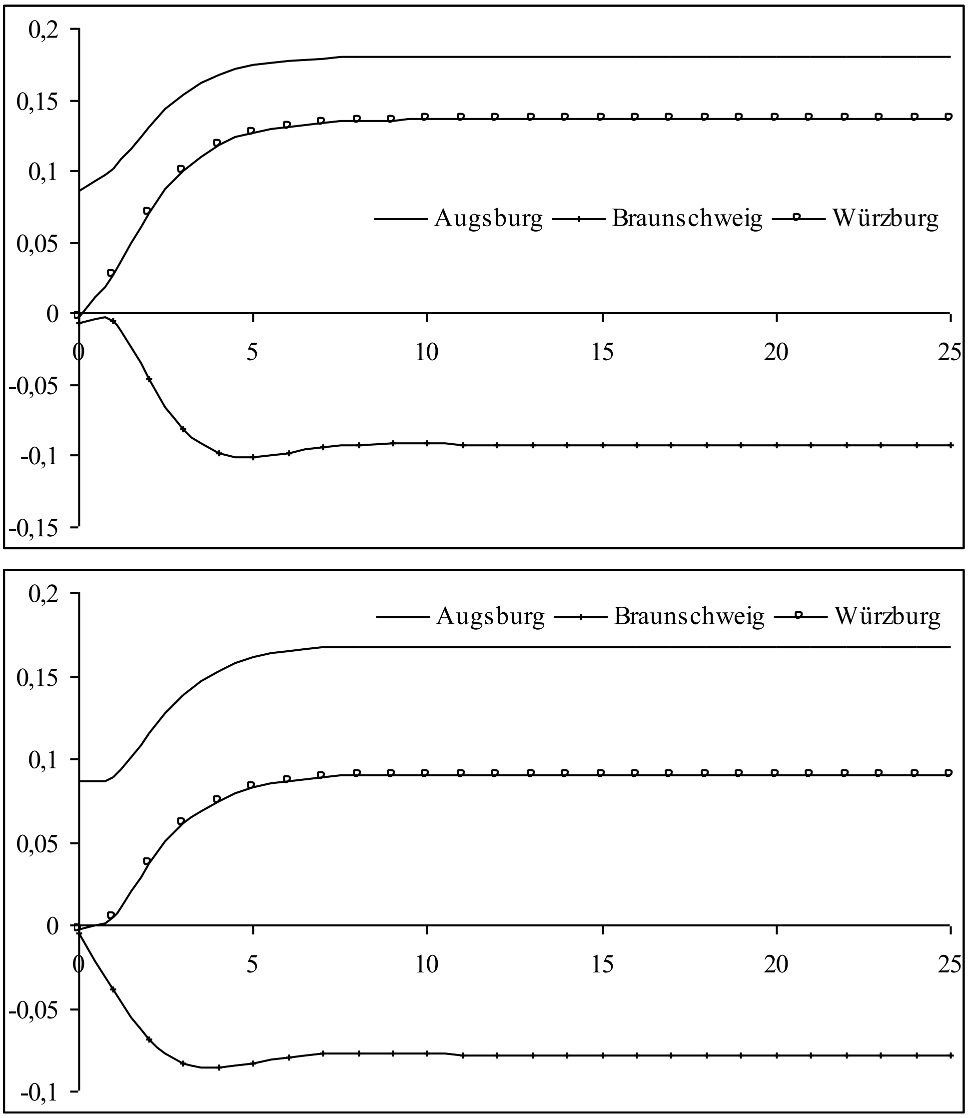


Figure 6. Response of Prices in Lviv to One-Standard Deviation Shock in Prices in German Cities (upper panel) and Response of Prices in German Cities to One-Standard Deviation Shock in Prices in Lviv (bottom panel)