

Border Changes and Price Adjustment: Evidence from Interwar Poland, 1918-1939

by
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Abstract: In this essay, the impact of changing political borders on market integration in inter-war Poland, specifically in the years between 1921 and 1937, is analysed. Since the late eighteenth century, Poland had been divided between Russia, the Habsburg Empire, and the emergent Prussia, reappearing on the political map of Europe only after the First World War. Here, it is examined how Polish markets responded, among other things, to changes in tariff barriers. Methods from quantitative economics are employed to study a set of monthly price series which cover the largest cities of the former partition areas. The evidence points to a surprisingly fast and complete adjustment of commodity prices to the new institutional framework. It suggests that from the mid 1920s onwards, Poland was a well integrated economy, reaching a degree of integration comparable to that of France at the end of the nineteenth century.

1. Introduction

What happens to an economy if we change its borders? Since administrative and political borders used to come along with massive barriers to trade, information, and mobility, the removal of such borders should lead to better “economic integration” across locations. However, the literature on economic integration in the wake of changing borders remains inconclusive on these issues. Some authors find borders to remain massive barriers to integration even after they have been formally removed (e.g. McCallum, 1995, Engel and Rogers, 1996), others measure a high degree of economic integration across borders already before their actual removal (e.g. Moodley, Kerr and Gordon, 2000).

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In this paper, I investigate in some detail how commodity markets integrated across removed borders in a possibly unique historical setting: the “reunification” of Poland after the First World War. Already at the end of the eighteenth century, Poland had been partitioned between tsarist Russia, the Habsburg monarchy, and the emerging Prussia. When Poland returned to the map of Europe about 1919, it consisted of several parts that differed dramatically with respect to their institutional framework (currencies, tax system, administrative structures etc.), and were divided by high costs of transportation and communication. Accordingly, all Polish governments attempted to unify and integrate the country. The Polish Statistical Office (GUS) that was set up in 1918 monitored these efforts from 1921 until the end of 1937 with respect to price movements of several basic commodities, publishing monthly prices for all parts of the new state. Since that data is given in a single currency and originates from one single source, one can exclude “noise” from volatile exchange rates or different data definitions that use to plague the data of international cross-border studies.

Hence, it should be possible to evaluate the process of “formal integration” across the former borders on economic integration of certain markets, i.e. to estimate the impact of unifying the different currencies etc. on the performance of certain commodity markets at different locations. The most direct - and most common - way to do so is to compare the outcome of markets at different locations with a theoretical counterfactual, namely market prices at different locations in absence of any barriers to trade, mobility, or communication. This counterfactual is known as the “Law of One Price” (LOP) which simply states that in one market there is one price. Any price differential between two locations gives rise to arbitrage that in turn makes the differential disappear. If arbitrage involves a cost (such as tariffs, taxes, transaction or transportation cost) - which is usually the case in the real world - then arbitrage prevents the price differentials from exceeding that cost. Then, a simple way to assess the degree of economic integration between locations is to calculate some metric of “distance” between observed relative prices and counterfactual relative prices as implied by the LOP. There are several strands in the literature on how to find such a metric. In the following, I will use the time series dynamics of relative prices between locations to estimate the half-life of a deviation from the LOP (e.g. Parsley and Wie, 1996). A shorter half-life of a deviation corresponds to better economic integration. Some recent contributions to the literature apply non-linear econometric models to the data that allow to take the presence of arbitrage costs explicitly into account (e.g. Obstfeld and Taylor, 1997; Erjnaes and Persson, 2000). However, since this usually reduces the estimated half-lives considerably, a simple linear estimation will produce a more conservative estimation of the state of economic integration. Therefore, in order to give a lower bound estimate of economic integration across the former partition borders in Poland I will use a linear model. For the (quite similar) results from applying a non-linear model to

the data see Trenkler and Wolf (2003). The paper comes in 6 sections. Section 2 sketches out some historical background to the reunification of Poland after World War One. Section 3 gives details on the data, while section 4 explains the econometric techniques and contains results of some preliminary tests. The key results are presented and discussed in section 5, and section 6 concludes.

2. Historical background to the economic integration of Poland (1918-1939)

Between 1772 and 1795, the noblemen's republic of Poland (*Rzeczpospolita Polska*) was divided into three parts between the empires of tsarist Russia, the Habsburg monarchy and the emergent Prussia. As a consequence of the partitions - "the first very great breach in the modern political system of Europe" (Edmund Burke) - Poland disappeared from the map. Only the specific constellation at the end of the First World War, where all three partition powers were severely weakened through war and revolution, opened the way for its restoration. The area of Poland in mid-1918 can be described as a power vacuum in central Europe, with several political and military authorities struggling for influence over a territory without clearly shaped borders. Map 1 (see appendix) shows the borders of Poland as in 1921, and indicates the former partition borders.

The devastation of the First World War affected 90% of this area, destroyed the harvest and the livestock, buildings and machines, bridges and railways. Even more damage was done by the exploitation through the German and Russian occupants during the war and sabotage during their retreat (Duda and Orlowski, 1999, p. 231). But the major challenge to building up a Polish state was to unify its different parts. Owing to the long period of partition, different institutions applied to about virtually all aspects of social, political and economic life. Tariffs, regulations, and a lack of transport and communication facilities prevented people from reacting to those different institutions. So presumably the Polish economy was not only devastated by a war, but it was also quite inefficient across the four parts of Poland already before the war. From an economic point of view, the task was to unify the institutional framework and to improve the facilities for transport and communication. It seems that the majority of Polish politicians understood that task when the situation gradually stabilized in November 1918. The government could actually rely on extensive programs for legal, administrative and economic unification that had been prepared since 1907 for a future Polish state. However, the agenda was not set by any political or economic "master plan", but rather by the ongoing war which Polish troops fought with the Soviet army in the east (for the following see Landau, 1992, and Roszkowski, 1992).

The war required massive outlays and some mechanism to finance them. Since international credit was not available - the Paris peace conference did not begin before January 1919, and Poland was yet to be formally recognised as a state -, the government had to choose between the expropriation (“nationalisation”) of domestic private capital and some mechanism to tax it (Landau and Tomaszewski, 1999). The political compromise in 1919 relied on early concessions to the socialists on the one hand (the eight-hour working day was introduced already in November 1918, see Landau, 1992) and on respecting private property rights on the other. As a consequence, the next step was to create the institutional framework necessary to tax capital and labour: a common currency and a working fiscal administration. The unification of the fiscal administration was among the very first institutional changes. While for the southern and central vojvodships, this was formally reached already in April 1919, the former German parts remained separated until January 1922, (Upper) Silesia even until June 1922 (Markowski, 1927; Bielak 1931). A common income tax was decreed in July 1920, but, because of administrative difficulties, it took several years to implement it on the former Russian territories. Business taxes in turn were introduced and unified on the whole territory until July 1925, following the Russian system of business certifications. However, some differences of the tax system - e.g. the real estate tax - remained persistent until 1936 (for details cf. Weinfeld, 1935).

The precondition for any tax system to work was the creation of a common currency area, namely the unification of the five (!) currencies that were in circulation on the Polish territory: the German Mark, the Austrian Crown, and the Russian Rouble, as well as the Polish Mark in the Kingdom of Poland and the “Ost-Rubel” on the territory of “Ober Ost”¹ - two currencies that the Germans introduced on former Russian territories after their occupation during World War I. Since the Warsaw government only controlled the Polish Mark, it adopted a stepwise strategy to get rid of the competing banknotes (Landau, 1992). Some months after the introduction of the Polish Mark as a parallel currency in the different areas, the other currencies were withdrawn. For the central, southern and western vojvodships, this was realised already in April 1920, with the exception of Upper Silesia (Nov. 1923) (Zbijewski, 1931). While such a quick institutional change was an indisputable success, it could not create the necessary revenues to win a war. But it opened the way for the Polish government to effectively tax money holders by inflation. As estimated by Zdziechowski (1925), between 1918 and 1919 the money supply increased by 519%, in the following year by another 929%, to reach in 1923 more than

¹“Ober Ost” was a German military state, founded in 1915 by the General Ludendorff, on the territory of the former Grand Duchy of Lithuania (Liulevicius, 2000).

12.000.000% (!) of the level in 1918 (Zdziechowski, 1925). Obviously, the temporal gains from seigniorage and the devaluation of the budget deficit were quickly wiped out by the costs of hyperinflation, namely the loss of access to foreign capital. When Prime Minister Władysław Grabski tried to stabilise the currency in 1924, his definite aim was to link the Polish currency with some foreign currency which had successfully restored the gold standard in order to get access to the international capital market. Indeed, Grabski was able to realise this task with the help of a temporary property tax - fixed in Swiss gold francs - and several international loans. Already in mid January 1924, the nominal exchange rate was stabilised and a new currency, the Złoty, was fixed par with the Swiss gold franc, i.e. 1 Złoty = 9/31 gram of pure gold. A new organisation, the Bank Polski S.A., was established with the exclusive right to issue banknotes, while the government kept the right to issue coins (Zbijewski, 1931). The fixed parity turned out to be an overvaluation, which had to be corrected in several devaluations of the Złoty from July 1925 on, but it nevertheless prepared the ground for a stable currency. The exchange rate stabilised at a sustainable level around May 1926, while formally the new parity was fixed only in October 1927 at 1 Złoty = 1000/5924.44 gram of pure gold.² From now on, the government began to defend the parity at any cost.

The war in the east also had an impact on the transport system, since it required a network to transport men and material. After rather spontaneous take-overs of the railway networks in the different areas during the last months of the First World War, already in October 1918 a railway ministry began to work, developing a 10-years plan for the completion and extension of the Polish railway network. At the same time, the heritage of 129 types of cars and 165 types of engines had to be overcome, new kinds of freight cars had to be developed (e.g. refrigerator wagons), the different densities of the network adjusted and the main economic centres of the former partition areas connected (Hummel, 1939, p. 146). The speed of the network and its capacity to transport goods was not only a function of the existence of railway connections themselves, but also crucially depended on the material used. Table 1 gives an overview for the development of important newly built railway lines and the changes in speed. Since nearly all freight transport took place on railways with normal gauge (97.6% in 1925 and 98.7% in 1938) (Brzosko, 1982, p. 358),³ this development of the rail-

²See Dziennik Ustaw RP, Nr. 88, poz. 790, Warsaw, 1927.

³This information obviously refers only to that part of transportation that was comprised in some kind of official statistics, i.e. transport over longer distances. Buczyński (1939, pp. 91ff) estimated that during the period 1934-1936 just 39% of the total Polish wheat surplus (production not consumed by producers themselves) was transported on railways. The rest was mainly shipped on horse-

way network can be expected to have had a strong integrating impact on the economy.

Table 1. Important railway-connections between main cities and average length of the trip

Date of opening	Connection	Distance	Av. length of the trip (as in 1937)
1861	Kraków-Lwów	ca. 341 km	5.00 hrs
1917	Warsaw-Lwów via Lublin	ca. 500 km	8.30 hrs
1872	Warsaw-Poznań via Toruń	ca. 376 km	7.0 hrs
Nov. 1921	Warsaw-Poznań via Września	ca. 304 km	4.45 hrs
1857	Poznań-Kraków via Wrocław	ca. 380 km	n.a.
Nov. 1926	Poznań-Kraków via Wieluń	ca. 330 km	n.a.
1848	Warsaw-Kraków via Częstochowa	ca. 364 km	8.00 hrs
Nov. 1934	Warsaw-Kraków via Radom	ca. 320 km	5.20 hrs

Sources. Pisarski (1974), p. 58; Olszewicz (1938), p. 223.

Hence, the most obvious *non-tariff* barriers to trade and mobility within the new Polish state such as different currencies, different tax systems, and shortage of transport facilities were considerably reduced if not completely removed until 1926. The *tariff* barriers were removed already until mid-1921. One of the first steps to unify the new economy was the introduction of a common external tariff in November 1919. But it took some more time to get rid of internal tariffs and a system of widespread regulations of commodity and factor markets. Again, in part this system was motivated by the need to furnish the Polish troops, fighting with the Soviet army in the east, but it had also aspects of political logrolling between different groups. Especially the markets for agricultural products (e.g. bread, grain, potato, sugar) and basic commodities (e.g. coal, soap, matches) were affected by a variety of measures that discriminated between regions and social groups. For example, there remained a customs frontier between the former Prussian partition area and the rest. This kept grain prices in that area at an artificially low level, thereby providing cheap supply for the fighting troops (Kozłowski, 1989, p. 157; Landau and Tomaszewski, 1999, p. 69). After the

drawn vehicles within a 50km radius, which we can drop for the purpose of our investigation on a national scale.

armistice between Poland and Soviet Russia, the Polish government launched a program to liquidate the whole system of regulations. The internal customs frontier was removed in mid-1921, and until the end of 1921, most other regulations on the commodity markets had disappeared (Tomaszewski, 1966, p. 158). In the following sections, we analyse how the described efforts to unify Poland and to make the former partition borders disappear - that is, institutional change - affected the economy. Do we find evidence that the degree of economic integration increased? Did prices across the different parts of Poland adjust in line with the counterfactual Law of One Price?

3. The data

The data originates from several publications of the Polish Statistical Office (GUS)⁴ in Warsaw which cover the period from January 1921 to December 1937. They provide a series of monthly retail prices of several basic commodities, including coal, soap, vegetables, and four kinds of grain. However, some of these markets were at least temporally subject to high levels of concentration, with prices set by interregional cartels rather than by competitive arbitrage traders as suggested by the theoretical LOP. Therefore, I chose to focus on the market of wheat flour (milled at the same grade) in different cities, where the historical records do not show any major market concentration. Since most of the grinding had been done in small mills that were evenly spread over the whole country, one can speak of a dense, decentralised network of mills from which the flour was shipped into the cities. Therefore, it makes sense to assume that the observed prices of wheat flour in cities were the outcome of a competitive market, with arbitrage adjusting for large differentials between different locations.

The prices of wheat flour were reported to the GUS by the city administrations, for 1921-1925 as monthly averages, for 1926-1937 as prices of the last week in a month. While the number of cities included in the sample increased over time, we have evidence over the complete period for the cities of Warsaw, Kraków, Lwów, and Poznań. This gives us 6 city-pairs and allows us to distinguish between the formerly Russian Kingdom of Poland (Warsaw), the former Austrian area (Kraków and Lwów) and the former German area (Poznań). We split that sample due to the currency reform in 1924 that followed the period of

⁴The Główny Urząd Statystyczny [Main Statistical Office] published that price series for 1921-1928 in its *Rocznik Statystyczny* [Statistical Yearbook], Warsaw (1923-1929); the series for 1929-1937 are contained in a publication *Statystyka Cen* [Price Statistics], published monthly for 1929 (1930), and quarterly for 1930 - 1937 (1931-1938).

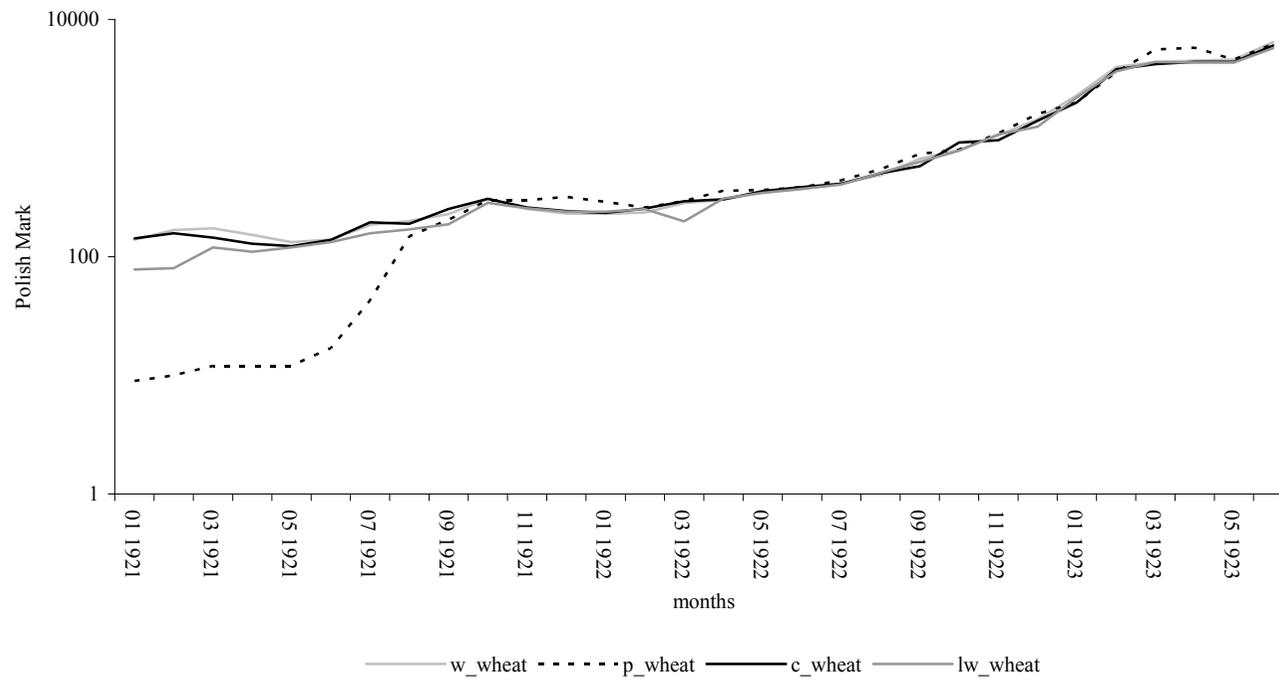


Figure 1. Price of 1 kg of wheat flour in Warsaw (W), Poznań (P), Kraków (C) and Lwów (Lw), 1921-1923 [semi-logarithmic scale]

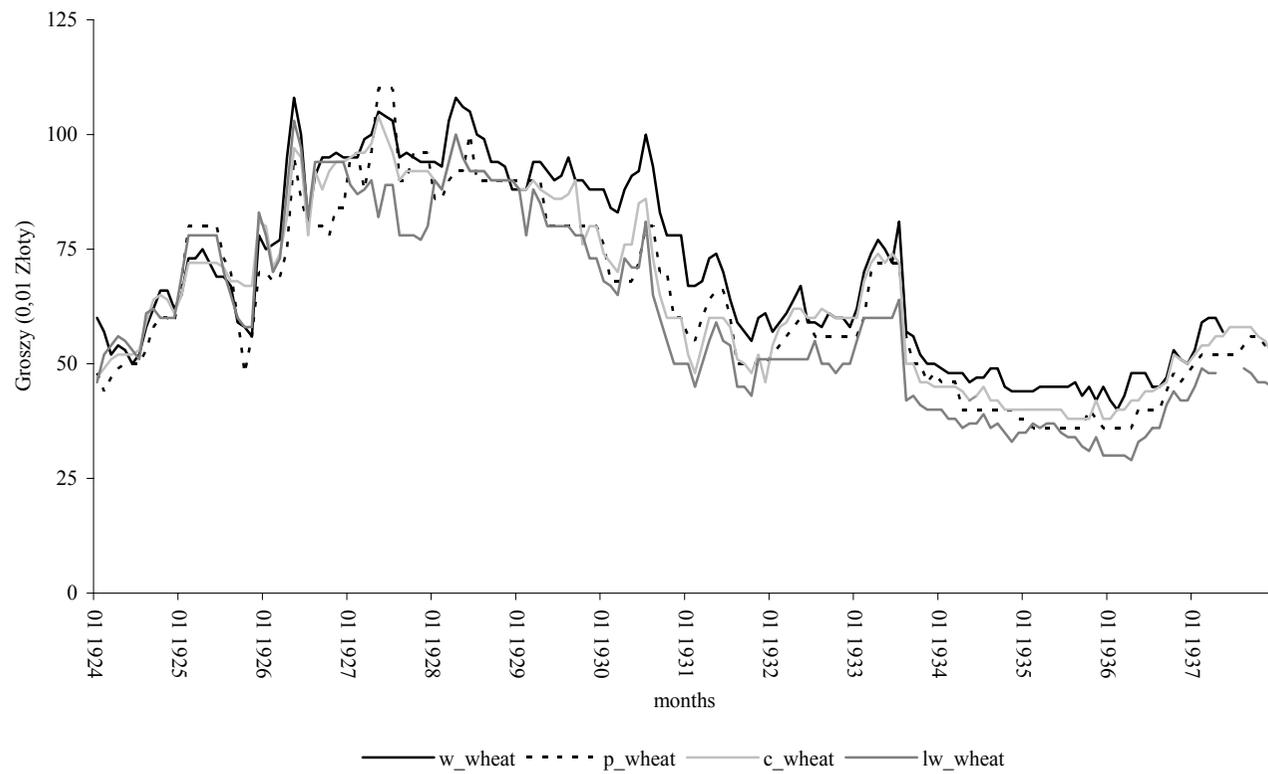


Figure 2. Price of 1 kg of wheat flour in Warsaw (W), Poznań (P), Kraków (C) and Lwów (Lw), 1924-1937

hyperinflation. The GUS published all price series until June 1923 in Polish Mark and, beginning January 1924, in the new currency, the Złoty. Therefore, we get a first sample including 30 observations (Jan. 1921-June 1923) for each city, and a second sample including 168 observations (Jan. 1924-December 1937) for each city.

In order to get a general idea of the price movements between the cities, Figs. 1 and 2 plot the prices for wheat flour for the two sample periods. Due to the hyperinflation from mid-1922 onwards, the first graph is given on a semi-logarithmic scale. Fig. 1 shows the strong effect of the removal of the domestic trade barriers after the end of the Polish-Russian war which has already been mentioned. Until then, the prices in the former Prussian partition area were kept at an artificially low level in order to provide cheap grain for the fighting troops in the east (see section 2). This, together with the fact that the administrated railway tariffs had not been raised before July 1923, while grain prices were blown up by hyperinflation,⁵ gives us a picture of an apparently well integrated market already in 1922/1923. Similar developments can be found for other commodities. Fig. 2 shows the price developments for the sample period 1924-1937. The graph seems to indicate that the high degree of integration, which had been reached until 1924, started to decrease somewhat around 1928, i.e. already before the onset of the great depression. While for most Polish cities grain prices followed the world-wide downward trend from 1928 onwards,⁶ the prices in Warsaw apparently remained at a slightly higher level until the end of the great depression. In addition, we see that something changed around mid-1932 and late 1933.

4. Error correction analysis

4.1 Preliminary tests

Was the market for wheat flour integrated across the different parts of Poland? We can answer this question by estimating an error correction model of the behaviour of prices between the four cities in our sample. An error correction model can be seen as the econometric model equivalent to the LOP. The idea behind error correction models is that - while the variables themselves might

⁵See Ministerstwo Komunikacji [Ministry of Communication]: *Dziesięciolecie Polskich Kolei Państwowych 1918-1928* [Ten Years Of Polish State Railways 1918-1928], Warsaw (1928), p. 180.

⁶World grain prices declined during the 1920s due to a continuous expansion of world acreage, which was only interrupted by crop failures in the mid 1920s (Feinstein et al., 1997, pp.71 ff).

show marked trends (or non-stationarity) - there exists an “equilibrium” relationship between certain variables. If at a certain point in time the variables are out of equilibrium, economic forces exist which make them adjust back to the equilibrium relationship with a certain time lag. Consequently, as a first step of error correction modelling, one should perform appropriate tests for that assumed relationship. By simple inspection of our graphs we see that the individual price series are non-stationary. What about the series of relative prices? Following Froot, Kim and Rogoff (1995) we can construct for each pair of locations a time series of relative prices,

$$(1) \quad d_{ij,t} = \log\left(\frac{P_{i,t}}{P_{j,t}}\right) .$$

We performed a Dickey-Fuller-test of stationarity for each sample period (Greene, 1993, pp. 48f). The test is carried out on the following simple AR(1) specification:

$$(2) \quad \Delta d_{ij,t} = \mu_{ij} + \gamma_{ij} d_{ij,t-1} + \varepsilon_{ij,t}$$

where $\varepsilon_{ij,t}$ is assumed to be white noise. The series d_{ij} is stationary if $\gamma_{ij} < 0$, so we perform a one sided test on a null hypothesis $H_0 : \gamma = 0$ against $H_1 : \gamma < 0$. While it may appear that the test can be carried out by performing a t -test on the estimated γ , the t -statistic under the null hypothesis of a unit root does not have the conventional t -distribution. Dickey and Fuller (1979), and more recently McKinnon (1991), showed that the distribution under the null hypothesis is non-standard, and simulated the critical values for selected sample sizes. As the graphs suggest, we allowed for an intercept and a deter-

Table 2. t -statistics of DF-test on relative wheat prices for different market-relations (1921-23, 1924-37)

	Warsaw-Kraków	Warsaw-Poznań	Poznań-Kraków	Poznań-Lwów	Lwów-Kraków	Lwów-Warsaw	5% critical values	1% critical values
01 1921-06 1923	-4.3765	-0.9683	-1.2020	-1.223	-4.6408	-3.1684	-3.5731	-4.3082
01 1924-12 1937	-4.7836	-4.9997	-5.8890	-4.498	-3.6525	-3.1292	-2.8799	-3.4730

ministic trend in the first sample, and for an intercept in the second. Table 2 gives the results for relative wheat prices between pairs of cities for the two sample-periods.

The hypothesis of a unit root in the relative prices of wheat flour between pairs of cities is rejected at a 5% level for all cases in the *second* period, indicating a stationarity of these price-relations. For the Lwów-Kraków relation this is true even for the first period, probably due to the fact that both cities formerly belonged to the same Austrian partition area. Interestingly, for the first period stationarity also seems to hold for the price relation between Warsaw and Kraków. This might be related to the very early railway connection between these two cities (see table 1). Apart from that, the series of relative prices for the first period are non-stationary, as the hypothesis of a unit root cannot be rejected at a 5% level. Obviously, this “non-stationarity” in the data is a consequence of the manifold structural changes at the very beginning of that period. As expected, the gradual removal of political discriminations between all three partition areas until 1923 is mirrored in the non-stationarity of relative prices in that period.

As a next step, let us check whether the tested stationary relations for 1924-1937 can be assumed to be structurally stable over the whole period. In fact, Fig. 2 suggests that there were some “equilibrium relationships” between locations, but that they might have been broken at several points in time. As a simple way to test for that, we performed Chow breakpoint tests on the specification (2), which is implied by our Dickey-Fuller test. The test statistic λ has an asymptotic χ^2 distribution with degrees of freedom J equal to $(m-1)k$ under the null hypothesis of no structural change (where m is the number of sub-samples, and k the number of estimated coefficients). The tests were performed by moving a “data window” of length $T = T_1 + T_2$ around the area of a possible breakpoint, using 90% of the data for estimation (T_1) and the remainder for testing (T_2). Table 3 gives the resulting likelihood-ratio (*LR*)-statistics of that procedure, including all cases where H_0 had to be rejected on a 1% significance level.

Table 3. LR-statistics ($J = 2$) for Chow breakpoint tests on several market relations

Estimated breakpoint	Warsaw-Kraków	Warsaw-Poznań	Poznań-Kraków	Poznań-Lwów	Lwów-Kraków	Lwów-Warsaw	λ ($\alpha : 0,01$)
05 1929	14.043	9.304	0.947	8.228	9.547	11.291	
11 1929	6.636	7.324	0.018	10.571	9.600	2.124	
01 1932	18.250	8.239	1.573	7.055	12.128	1.062	9.210
06 1932	6.873	11.132	1.505	7.055	12.127	1.062	
07 1933	26.593	5.520	2.221	3.759	7.975	8.583	
11 1933	3.947	12.983	0.278	2.082	2.472	4.557	
06 1936	12.014	4.091	0.448	0.446	1.686	3.833	

Apart from the case of Poznań-Kraków, we find clear evidence for structural instability in the market relations, which has to be incorporated in our empirical approach. Since the work of Perron (1989) it is well known that there are pitfalls in dealing with non-stationary time series in the presence of structural breaks. There are several ways to tackle the problem. First, one could apply Bayesian estimation techniques, which incorporate structural changes in the estimation process by an updating procedure (see Stark, 1998, for an Bayesian error correction model). Second, one could endogenise the structural changes by an appropriate transformation of the data. This is not trivial, since it requires an identification of the relevant shift parameters, and possibly introduces complicated dynamics into the series. I propose a third and simpler way, which is widespread in the macroeconomic literature. Let us derive a structural error correction model from theoretical reasoning. If we split the sample according to the detected breakpoints, we can try to estimate the parameters of our theoretical model for the different sub-periods. At the cost that there will not be a perfect fit of that model with the underlying data generation process, this approach allows to produce estimates with a straightforward interpretation that are comparable across different relations and sub-samples.

4.2 A simple structural model of error correction⁷

Assume several locations ($i = 1, \dots, I$) that are linked through regional trade. Similar to international relations “inter-regional commodity trade” between locations is driven by “domestic exchange rates”, i.e. the price differentials, which are corrected for spatial transaction costs. Demand and supply at locations $i = (1, \dots, L)$ are described by:

$$(3) \quad q_{i,t} = p_{i,t}^{\alpha_i} D_{i,t}$$

$$(4) \quad Y_{i,t} = (C + I + G)_{i,t} + NX_{i,t} = A_{i,t} + NX_{i,t}$$

$$(5) \quad n_{xi,t} = \Delta \log(NX_{i,t}); y_{i,t} \equiv \Delta \log(Y_{i,t}),$$

where $q_{i,t}$ is the quantity of the good demanded at location i at time t , and $p_{i,t}$ is its price. The price elasticity of demand α_i is allowed to differ across locations and is assumed to be negative. $D_{i,t}$ captures all kinds of idiosyncratic fac-

⁷In a slightly different version, this model was first used in a labour market context by Boyer and Hatton (1994), pp. 84-106.

tors that shift demand at location i . Supply is described by location-specific absorption A_i , and the amount of domestic net-exports NX_i . Trade is assumed to be multilateral, where we denote a location i 's share of net-exports to location j by (s_i) and to all remaining locations by $(1 - s_i)$. In analogy to simple models of international trade, domestic trade between locations is driven by "domestic real exchange rates" λ_{it} , where location i 's trading partner j is weighted by its share in total exports, (s_j) . Finally, spatial transaction costs tc are captured by an elasticity to trade β . This is somewhat ad hoc, but makes the analysis more tractable. The model is therefore completed by the following equations:

$$(6.1) \text{ and } (6.2) \quad \lambda_{i,t} = \frac{p_{i,t} p_{z,t}^{1-s_i}}{p_{j,t} s_i}; \beta \equiv tc^{-1}; s_i \in [0, 1];$$

$$(7) \quad NX_{i,t} = f(\lambda_{i,t}, \beta_{i,t}) = \left(\frac{p_{j,t} s_i}{p_{i,t} p_{z,t}^{1-s_i}} \right)^{\beta_{i,t}}; \text{ with } \frac{\partial NX}{\partial \lambda} \leq 0; \frac{\partial NX}{\partial tc} \leq 0$$

$$(8) \quad nxi,t = \beta_{i,t} [s_i \log(p_{j,t-1}) - (1 - s_i) \log(p_{z,t-1}) - \log(p_{i,t-1})].$$

We can solve the model by imposing a market clearing condition and using each markets relation to z , i.e. to the relation the rest of the world. Hence, solving for $\Delta \log p_{i,t}$ and $\Delta \log p_{j,t}$ gives:

$$(9) \quad \Delta \log p_{i,t} = \frac{1}{\alpha_i} \{ y_{i,t} - \Delta \log D_{i,t} - \beta_{i,t} [s_i \log(p_{j,t-1}) - (1 - s_i) \log(p_{z,t-1}) - \log(p_{i,t-1})] \},$$

$$(10) \quad \Delta \log p_{j,t} = \frac{1}{\alpha_j} \{ y_{j,t} - \Delta \log D_{j,t} - \beta_{j,t} [s_j \log(p_{i,t-1}) - (1 - s_j) \log(p_{z,t-1}) - \log(p_{j,t-1})] \}.$$

If we eliminate now $\log(p_{z,t-1})$, we can express (10) in (9):

$$(11) \quad \Delta \log p_{i,t} = \frac{y_{i,t} - \Delta \log D_{i,t}}{\alpha_i} - \left[\frac{\beta_{i,t}(1-s_i)}{\beta_{j,t}(1-s_j)} \right] \frac{y_{j,t} - \Delta \log D_{j,t}}{\alpha_j} + \left[\frac{\beta_{i,t}\alpha_i(1-s_i)}{\beta_{j,t}\alpha_j(1-s_j)} \right] \Delta \log p_{j,t} + \left[\frac{\beta_{i,t}(1-s_j s_i)}{\alpha_i(1-s_j)} \right] \log \left(\frac{p_i}{p_j} \right)_{t-1}.$$

For each location we get:

$$(12) \quad \Delta \log p_{it} = C_{0t}(y_i, y_j, \Delta D_i, \Delta D_j) + C_{1t} \Delta \log p_{jt} + C_{2t} \log \left(\frac{p_i}{p_j} \right)_{t-1} + \varepsilon_t.$$

If one assumes that the variables driving local demand on commodity markets (D) are integrated of order 1 (as frequently found with log income series), then ΔD will be of order 0 and form a random disturbance (Banerjee et al., 1993, p. 29). The coefficients C_0, C_1, C_2 will be treated as constant over the sub-samples, which implies among other things that the ratio of bilateral net-export shares does not change over time.

The coefficients C_1 are expected to be positive and equal to one for two perfectly symmetric locations, the coefficients C_2 will be negative, since they contain the price elasticity of demand, which is assumed to be negative. Then, for every pair of locations our model yields the following system of equations:

$$(12.1) \quad \Delta \log p_{i,t} = C_{0,t} + C_{1i,t} \Delta \log p_{j,t} + C_{2i,t} \log \left(\frac{p_i}{p_j} \right)_{t-1} + \varepsilon_{i,t},$$

$$(12.2) \quad \Delta \log p_{j,t} = C_{0,t} + C_{1j,t} \Delta \log p_{i,t} + C_{2j,t} \log \left(\frac{p_j}{p_i} \right)_{t-1} + \varepsilon_{j,t}.$$

Substitution and rearranging gives as the reduced form of that model an implied error correction model, that can be easily estimated. Outside of a stable equilibrium price ratio, the adjustment-process of price differentials is supposed to be of the following form:

$$(13) \quad \Delta \log p_t = \Omega + H \Pi \log \left(\frac{p_j}{p_i} \right)_{t-1} + \varepsilon_t$$

with

$$\Delta \log p_t = \begin{bmatrix} \Delta \log p_{i,t} \\ \Delta \log p_{j,t} \end{bmatrix}, \quad \Omega = \begin{bmatrix} \delta_i \\ \delta_j \end{bmatrix}, \quad H = \begin{bmatrix} \gamma_i \\ \gamma_j \end{bmatrix}, \quad \Pi = (1, 0), \quad \varepsilon_t = \begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \end{bmatrix},$$

and

$$\delta_i = \left(\frac{C_0 + C_{1i}C_0}{1 - C_{1i}C_{1j}} \right), \delta_j = \left(\frac{C_0 + C_{1j}C_0}{1 - C_{1i}C_{1j}} \right), \gamma_i = \left(\frac{C_{2i} - C_{1i}C_{2j}}{1 - C_{1i}C_{1j}} \right),$$

$$\gamma'_j = \left(\frac{C_{1i}C_{2i} - C_{2j}}{1 - C_{1i}C_{1j}} \right), \gamma_j \equiv -\gamma'_j$$

An equilibrium is characterised by $\Delta \log(p_t) = \varepsilon_t = 0$, thus $|\delta_i / \gamma_i|$ and $|\delta_j / \gamma_j|$ give an estimate of some equilibrium parameters “ k_{ij}, k_{ji} ”. Out of such a state of equilibrium, the γ -parameters measure the speed of adjustment back to the equilibrium. An increase in economic integration should be reflected in both, a higher speed of adjustment γ and a lower constant δ . Hence, the lower the estimated k , the higher the degree of integration between two locations.

5. Results and discussion

Table 4 reports the results of estimating the described structural error correction model (13) for the Polish wheat market over different periods, where we split the sample according to the estimated breakpoints. In 13 of the 36 cases the estimated adjustment parameters γ of the city-pairs are significantly different from zero and if so, they always have the expected negative sign. But how shall we interpret these results? The estimates for Kraków-Lwów can serve as a benchmark relative to the corresponding estimates for other relations, since both cities were formerly part of the same (Austrian) partition area and therefore are supposed to be well integrated. Compared to that case, the overall results for the long-run k -parameter indicate that the degree of integration increased, since both the estimated constants decrease and the adjustment parameters increase over time. We find the highest degree of integration (the lowest k) for the pair Poznań-Kraków, similar to the degree of integration between Kraków and Lwów at the end of the period.

Based on our estimates, we can now calculate the speed of adjustment - the time it takes for a local disturbance to be absorbed by the system. However note that a precondition for this is to find asymmetric relationships between locations in the sense of weak exogeneity. Weak exogeneity at one location implies that its price has an impact on the price at another location without itself being affected by the price at that location (Persson, 1999, p. 98). Therefore, the estimated adjustment parameter of such an exogenous location must be insignificant, whereas the adjustment parameter of the second market must be negative and significant. For a significant adjustment parameter γ (and only for these) our

Table 4. Error correction model of the Polish wheat market (standard deviations in brackets, bold letters indicate significance at 10% level)

Relation		δ_i	δ_j	γ_i	γ_j	$\left \frac{\delta_i}{\gamma_i} \right $	$\left \frac{\delta_j}{\gamma_j} \right $
Kraków-Warsaw	01 1924 - 04 1929	0.0099 (0.0075)	0.0071 (0.0094)	-0.1706 (0.1223)	-0.2479 (0.1526)	0.0586	0.0286
	05 1929 - 12 1931	-0.0203 (0.018)	-0.0135 (0.0095)	-0.1540 (0.1875)	0.1802 (0.1298)	0.1318	0.0749
	01 1932 - 06 1933	0.0264 (0.009)	0.0092 (0.013)	-0.5021 (0.1314)	-0.3251 (0.1867)	0.0526	0.0283
	07 1933 - 12 1937	-0.0059 (0.0093)	-0.005 (0.0079)	-0.3604 (0.1551)	-0.7909 (0.1331)	0.0164	0.0063
Poznań-Warsaw	01 1924 - 04 1929	0.01 (0.01)	0.0071 (0.0096)	-0.3231 (0.114)	-0.0042 (0.109)	0.031	1.6905
	05 1929 - 05 1932	-0.0153 (0.01)	-0.01 (0.0096)	-0.4577 (0.1678)	0.0289 (0.1577)	0.0334	0.346
	06 1932 - 10 1933	-0.011 (0.02)	-0.0015 (0.0248)	-0.3465 (0.4393)	-0.9113 (0.5388)	0.0317	0.0016
	11 1933 - 12 1937	0.0009 (0.0068)	0.0021 (0.0069)	-0.1751 (0.1042)	-0.2561 (0.1058)	0.0051	0.0082
Poznań-Kraków	01 1924 - 12 1937	-0.0002 (0.0049)	-0.0009 (0.0050)	-0.4038 (0.0672)	-0.0292 (0.0682)	0.0005	0.0308
Poznań-Lwów	01 1924 - 10 1929	0.007 (0.008)	0.008 (0.010)	-0.191 (0.083)	0.146 (0.086)	0.0366	0.055
	11 1929 - 12 1937	-0.007 (0.006)	-0.007 (0.008)	-0.266 (0.087)	0.014 (0.118)	0.0263	0.5
Lwów-Warsaw	01 1924 - 04 1929	0.01 (0.01)	0.0071 (0.0096)	-0.3855 (0.1346)	-0.0216 (0.1255)	0.0259	0.3287
	05 1929 - 12 1937	-0.0073 (0.0084)	-0.0047 (0.0065)	-0.0094 (0.1072)	-0.249 (0.0829)	0.7766	0.0189
Kraków-Lwów	01 1924 - 04 1929	0.01 (0.0076)	0.01 (0.01)	-0.0445 (0.0851)	-0.2956 (0.1161)	0.2247	0.0338
	05 1929 - 05 1932	-0.0203 (0.0138)	-0.016 (0.0141)	-0.2583 (0.2884)	-0.5981 (0.2948)	0.0786	0.0268
	06 1932 - 12 1937	-0.00291 (0.008)	-0.0036 (0.0092)	-0.0465 (0.1393)	-0.3956 (0.1604)	0.0626	0.0091
Kraków-Warsaw 01 1921- 06 1923		0.1322 (0.0324)	0.1291 (0.0346)	-0.4416 (0.4216)	-0.4109 (0.4503)	0.2994	0.3142
Kraków-Lwów 01 1921- 06 1923		0.1291 (0.0334)	0.1482 (0.0340)	-0.3547 (0.2081)	-0.3955 (0.2119)	0.3639	0.3747

specification (13) implies that deviations from the equilibrium price ratio will be adjusted with a speed proportional to the deviation from that equilibrium price ratio. This allows to calculate the half-life of the time it takes that a disturbance at a weakly exogenous location is absorbed at the second location simply as $t = \frac{\ln(0,5)}{\gamma}$. For example, during the period 1924-1929, the impact of a disturbance at Warsaw on Poznań had a calculatory half-life of 2.1 months, a shock at Lwów on Poznań in turn had a half-life of 3.6 months. Prices at Lwów adjusted to disturbances at Kraków during the 1920s with a half-life of 2.3, but during the 1930s with a half-life of only 1.75 months.

As the evidence from the equilibrium parameters this indicates that Polish wheat markets were well integrated during the interwar period. Finally, the results are quite close to the speed of adjustment found by other researchers on intranational relations in European wheat markets during the second half of the nineteenth century. Persson (1999) for example analysed French wheat markets and found a half-life of disturbances between Toulouse and Bordeaux of 2.2 months (1855-72), for Toulouse and Rouen of 5.1 (1860-80), and for Rouen-Marseille of 6.1 months (1885-1913) (Persson, 1999, p. 102). Compared to these findings on France, our data for the Polish market of wheat flour suggests that Poland's reunification was a success in terms of economic integration.

6. Conclusion

Overall, the evidence from price data suggests that Poland was a rather well integrated economy already around the mid-1920s. The time series behaviour of wheat prices between pairs of cities indicated that a weak form of the Law of One Price held for that market. Apparently, there existed price ratios between the cities that were stable over at least part of the period 1921-1937. Based on a structural error correction model I estimated that deviations from these price ratios were corrected with a half-life of about 2 to 4 months, similar to the findings of Persson (1999) on the behaviour of wheat prices across French cities during the second half of the nineteenth century. I also found evidence that most of the price ratios were not structurally stable over the whole period but changed towards an even stronger form of the LOP, probably due to decreasing costs of arbitrage across Poland. Hence, the *formal integration* of Poland until the mid-1920s, i.e. the unification of currencies, of taxes, and of the fiscal administration, the removal of tariff-barriers and regulations etc. was successful insofar as it was followed by a process of *economic integration*. Obviously, the method applied allowed to analyse only a very small set of location-pairings and only the market for one single homogeneous good. But with Warsaw, Kraków, Lwów, and

Poznań as four of the five biggest Polish cities⁸ in the sample and a focus on wheat as a widespread kind of grain this result captures with a high probability more general features of the Polish economy. Moreover, the finding that Poland was a well integrated economy from the mid-1920s onwards can be supported by supplementary evidence for other commodity markets and a broad set of domestic trade data across the country (see Wolf 2003).

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⁸We did not include Łódź in our sample, the second biggest Polish city during the period, since this would not add much to answer our question. The available data for Łódź, being located in the former Russian partition area, some 120 km southwest of Warsaw, show that prices and price dynamics were very close to prices at Warsaw.

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Appendix

Map. Poland as in 1921 and the former partition borders



Based on *Rocznik Statystyczny 1928*, Warsaw (1929).