Crucini, Mario J.; Smith, Gregor W.

Article

Early globaliaztion and the law of one price : evidence from Sweden, 1732-1914

Reference: Crucini, Mario J./Smith, Gregor W. (2016). Early globaliaztion and the law of one price : evidence from Sweden, 1732-1914. In: East Asian economic review 20 (4), S. 427 - 445.
doi:10.11644/KIEP.EAER.2016.20.4.316.

PISSN 2508-1640 EISSN 2508-1667 an open access journal
East Asian Economic Review vol. 20, no. 4 (December) 427-445
http://dx.doi.org/10.11644/KIEP.EAER.2016.20.4.316

Early Globalization and the Law of One Price: Evidence from Sweden, 1732-1914*

Mario J. Crucini†
Vanderbilt University
mario.j.crucini@vanderbilt.edu

Gregor W. Smith††
Queen's University
smithgw@econ.queensu.ca

We review research using departures from the law of one price to measure the advent of globalization in Europe and Asia. In an application, we then study the role of distance and time in statistically explaining price dispersion across 32 Swedish towns for 19 commodities from 1732 to 1914. The resulting large number of relative prices (502,689) allows precise estimation of distance and time effects, and their interaction. We find an effect of distance that declines significantly over time, beginning in the 18th century, well before the arrival of canals, the telegraph, or the railway.

Keywords: Distance Effect, Law of One Price, Globalization, Historical Price Convergence, Market Integration in Sweden
JEL classification: N70, F61, E37

I. INTRODUCTION

When you think globalization began depends on how you define it. Ancient civilizations and medieval cities of course exchanged tools, plants, diseases, and

* We thank several discussants and referees for comments on an earlier, related working paper: Crucini and Smith (2014). We thank Dörte Heger and Margaux MacDonald for skilled research assistance and Rokon Bhuiyan, Monica Jain, and Nicolas-Guillaume Martineau for assistance with data collection. We thank Byron Lew, participants at the 2016 Canadian Economics Association meetings, and three referees of this journal for helpful comments. Crucini gratefully acknowledges the financial support of the National Science Foundation (SES- 0524868). Smith thanks the Social Sciences and Humanities Research Council of Canada and the Bank of Canada research fellowship programme for support of this research. The opinions are the authors alone and are not those of the Bank of Canada.

† Crucini: Department of Economics, Vanderbilt University, Box 1819, Station B, 415 Calhoun Hall, Nashville, TN 37235; mario.j.crucini@vanderbilt.edu.

†† Department of Economics, Queens University, Canada; smithgw@econ.queensu.ca.

ideas. But most recent studies of early globalization define it as integration of a market across regions or countries, as measured by the convergence of commodity prices. These studies focus on prices partly of necessity. We often do not know the shipping costs or travel times, and how they evolved over time, that would help us track integration with those measures. But prices also have distinct advantages. First, they allow studies to tie in directly to research on the modern law of one price, by using exactly the same statistical methods as are applied to today's data. Second, reliable statistical inference is possible because there are many observations.

O'Rourke and Williamson (2002) note the international trade in luxury goods-such as spices, silk, furs, and gold-from 1500 to 1800. But they suggest that falling transport costs led to a globalization big bang in the 1820s marked by the integration of markets for necessities like grains and textiles. For the first time, this international integration began to affect how capital and labour were used within domestic economies and thus also to be the subject of political debates. Some recent research has suggested that market integration occurred even earlier, in the late 18th century in northern Europe and in Asia, particularly as measured by the convergence of prices within countries or regions.

In this paper we briefly review the research on historical price convergence, both international and intranational. We then seek to contribute to research in price history with a study of Sweden, with data drawn from the work of Lennart Jörberg (1972) who led a team of researchers. This research choice has three appealing features. First, it allows a long span of data, from 1732 to 1914. Studying data back to the 18th century is not always possible in the related research, as noted by Jacks, O'Rourke, and Williamson (2011). Second, there is a large number of locations, with prices collected at up to 32 market towns. This geographical richness proves useful in studying the effect of distance on relative prices and how that effect evolved over time. Third, we also study 19 commodities, including a range of foodstuffs and manufactured goods. The list includes: Baltic herring, bar iron, beef, butter, charcoal, hay, hops, log timber, oxen, pork, sawn batten, sheep, straw, tallow, tallow candles, tar, wax candles, wheat, and wool. Thus we can see whether price dispersion reflected the perishability or weight-to-value ratio of a specific commodity, for example.

The large span of years, commodities, and locations provides a great deal of statistical precision. We find an effect of distance on price dispersion, for almost all commodities. Pooling across the commodities, we find that the distance effect declines over time. This decline shows considerable variation from year to year.

For example, it was interrupted during the early 19th century. Most notably, the process of convergence began in the 18th century, and specifically after 1760. This finding of early convergence mirrors results from recent studies of international and intranational grain markets.

II. THE LAW OF ONE PRICE IN HISTORICAL DATA

A wealth of recent research looks at the extent of price convergence between locations, its evolution over time, and the causes of and obstacles to that convergence. First, several studies assess the law of one price (LOP) internationally. For example, Rogoff, Froot and Kim (2001) describe the price differences between London and Amsterdam for 7 commodities over many centuries. O'Rourke and Williamson (1994) study 13 commodities traded between the US and UK from 1870 to 1913, and report a convergence trend. Klovland (2005) studies 39 commodities in Britain and Germany for a similar period, from 1850 to 1913, and again studies the persistence of LOP deviations. Chilosi and Federico (2015) study the integration of Asia in the world economy after 1800 by tracking price differences for commodities such as silk, tea, cotton, and rice between cities in India, Indonesia, Japan, and China and those in the United Kingdom, the Netherlands, and France. They find that most convergence occurred early in the 19th century, which they attribute to the decline of European trading monopolies with Asia.

Second, several studies examine LOP deviations intranationally. For example, Shiue (2002) studies grain prices across 121 prefectures in China during the 18th century. She reports effects of distance and access to water transport on price differences but shows that overall grain markets appeared to be integrated across regions. This finding challenges the view that such integration (via a transport revolution) is a precursor to economic growth, for such growth was quite limited in China during this period. Cheung (2008) describes the rice market within China in the 18th century and the extent of its integration, using both statistical methods and a history of Qing policy. Dobado-González and Marrero (2005) document how corn prices converged across 32 Mexican states from 1885 to 1908. Trenkler and Wolf (2005) study wheat flour prices across Polish cities in the interwar period. Slaughter (1995) studies the prices of 10 goods in US cities during 1820-1860 and describes how they tended to converge across cities over time. These studies of intranational prices draw one's attention to mechanisms such as improved transport and communication, which have been documented within a number of countries. For example, Slaughter describes the roles of canals, steamboats, and railroads in price convergence.

Third, a number of studies compare international and intranational price dispersion for two key commodities: rice and wheat. Studying these goods has four distinct advantages: (a) they are storable; (b) they are internationally traded; (c) in some cases their prices are recorded according to standardized varieties; and (d) in some cases shipping costs can be collected. These features suggest that arbitrage could operate, with the passage of time, as emphasized by Pippenger and Phillips (2008) in their study of wheat prices in the late 20th century. Shiue (2005) describes the differences in grain prices across cities in Germany and its neighbors as the zollverien customs union spread between 1815 and 1855. She compares these differences with those between German and non-German cities and finds a small border effect. Jacks (2005) studies the period 1800-1913 for up to 100 cities in 10 countries. He documents wheat price convergence using several different statistics and finds a decline in the effect of distance over time. Shiue and Keller (2007) show integration of rice markets in the Yangzi Delta in the 18th century and a similar pattern in grain markets in Britain. Dobado-Gonzlez, Garca-Hiernaux, and Guerrero (2015) confirm intranational integration of rice markets within parts of China and Japan in the 18th century (as in Europe) though not international integration in the Far East.

Several studies also document interruptions in the process of convergence. Jacks, O'Rourke, and Williamson (2011) study historical and contemporary data sources since 1700. They document the increases in price volatility during 1776-1819 when trade in the Atlantic economies was disrupted by the Revolutionary War and the French Wars. Dobado-González, García-Hiernaux, and Guerrero (2012) comprehensively review debates on the timing of price convergence, and trace it back to the 18th century by studying wheat prices internationally. Kaukiainen (2001) provides some concrete examples of the mechanisms at work. He studies the inter-city times for the transmission of Lloyds's List (a shipping newsletter) and the private correspondence of a Finnish merchant. These data show that steamships, improved mail-coach times, and faster packet ships led to declines in mail dispatch times that helped integrate markets even if goods shipped no faster. Notably, these improvements occurred early in the 19th century, before the telegraph and the railway.

III. SWEDISH COMMODITY PRICE DATA AND CURRENCY HISTORY

Our goal is to study intranational price dispersion in Sweden back to the 18th century and using a range of commodities. Jörberg (1972) describes the Swedish price data, which apply to 32 towns or regions at various times and to many commodities. Scholars have used them to study the cost of living and real wages, but apparently not LOP deviations. Lagerlöf (2015) studies grain prices from this source for 1816-1870, within a broader study of Malthusian checks. He finds that local grain prices were correlated with local harvests, suggesting that grain markets were not fully integrated.

The numbers come from market price scales that were used for taxes, tithes, and other payments. The prices were averages of current annual prices in market towns within each region. Prices were recorded at Thomasmäss (December 21) each year until 1803, and in November thereafter.

Table 1 lists the location codes and districts studied by Jörberg. It then lists the largest market town in each district, along with its latitude and longitude. We measure the great circle distance between towns in kilometres. Of course the actual travel distance may have differed from this, but we have not found data on actual travel methods or times. Thus there may be some attenuation bias in distance effects due to measurement error.

The commodity list includes nine agricultural commodities (beef, butter, hay, hops, pork, straw, tallow, wheat and wool), two animals (oxen and sheep), one fish (Baltic herring), four non-agricultural commodities (bar iron, log timber, sawn batten, and tar) and three sources of light or heat (charcoal, tallow candles, and wax candles). This mix of goods is typical of price history datasets. Since the number of towns in the study is 32, the number of possible pairs is 496 but the number of available location pairs differs substantially by commodity.

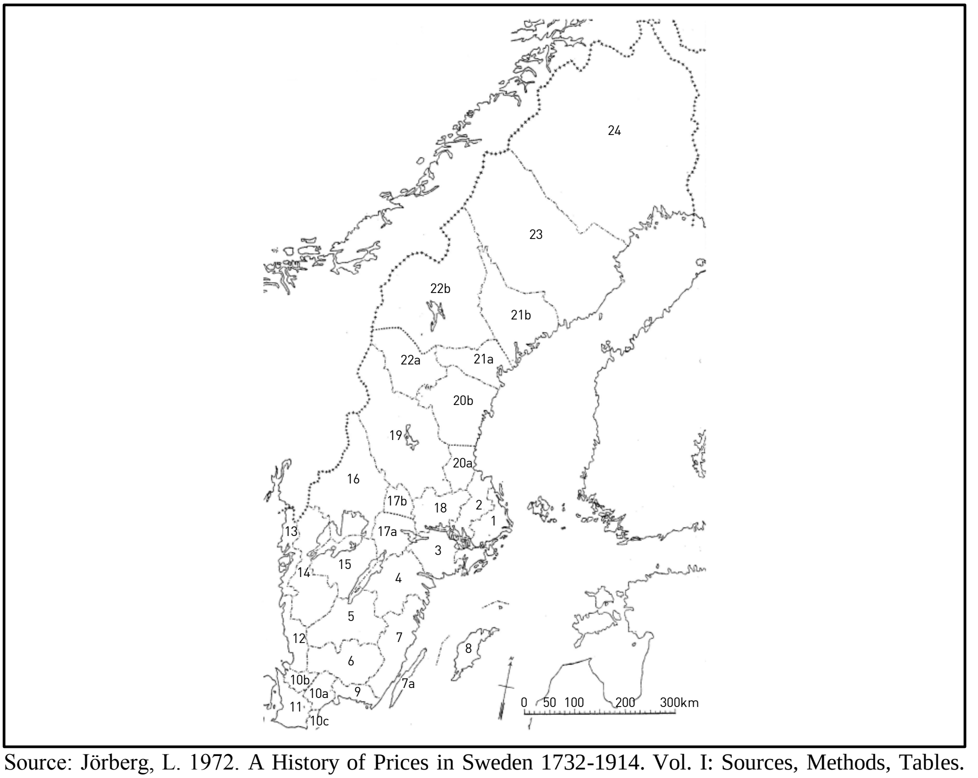
Sweden adopted a series of unusual monetary arrangements during the 18th century. From 1732 to 1775 prices are quoted in silver *dalers* (*daler silvermynt*) (with unit öre, with 32 per *daler*). From 1776 to 1802 they are quoted in *riksdaler* specie (with units shilling, with 48 per *riskdaler*). During this period there were two internal units of account: *riksdaler banco* and *riksdaler riksgälds*, that had a varying relative value. Jörberg (1972, p. 79) notes that market price scales were quoted in *riksdaler riksgälds*. After 1803 all prices are in *kronor* (singular: *krona*) per metric unit. Weights and measures also varied over time.

Table 1. Swedish Towns

Code	District	Town	Latitude	Longtitude
1	Stockholm county	Stockholm	59.326	18.058
2	Uppsala county	Uppsala	59.857	17.639
3	Södermanland county	Nyköping	58.753	17.010
4	Östergötland county	Linköping	58.416	15.624
5	Jönköping county	Jönköping	57.782	14.159
6	Kronoberg county	Växjö	56.877	14.809
7	Kalmar county	Kalmar	56.661	16.363
7a	Isle of Öland	Borgholm	56.879	16.656
8	Isle of Gotland	Visby	57.641	18.296
9	Blekinge county	Karlskrona	56.160	15.586
10	Kristianstad county	Kristianstad	56.031	14.155
10a	Kristianstad	Kristianstad	56.031	14.155
10b	Ängelholm	Ängelholm	56.243	12.862
10c	Simrishamn	Simrishamn	55.556	14.350
11	Malmöhus county	Malmö	55.603	13.001
12	Halland county	Halmstad	56.674	12.857
13	Göteborg and Bohus	Gothenburg	57.697	11.987
14	Älvsborg county	Vanersborg	58.381	12.323
15	Skaraborg county	Skara	58.386	13.438
16	Värmland county	Karlstad	59.378	13.504
17	Örebro county	Örebro	59.274	15.208
17a	Närke	Örebro	59.274	15.208
17b	Nora, Linde, Karlskoga	Nora	59.519	15.040
18	Västmanland county	Västeras	59.616	16.552
19	Kopparberg county	Falun	60.602	15.633
20	Gävleborg county	Gävle	60.675	17.142
20a	Gästrikland	Gävle	60.675	17.142
20b	Hälsingland	Hudiksvall/Soderhamn	61.489	17.062
21	Västernorrland county	Härnosand	62.632	17.938
21a	Medelpad	Sundsvall	62.391	17.307
21b	Angermanland	Härnosand	62.632	17.938
22	Jämtland county	Östersund	63.222	14.602
22a	Härjedalen	Harjedalen	62.250	13.950
22b	Jämtland	Östersund	63.222	14.602
23	Västerbotten county	Umea	63.838	20.248
24	Norrbotten county	Lulea	65.584	22.155

Notes: Codes and districts are from Jörberg (1972). Town denotes the largest market town in each district, or the midpoint if two towns are listed. Latitude and longitude are in degrees.

Figure 1. Regions of Sweden



Source: Jörberg, L. 1972. A History of Prices in Sweden 1732-1914. Vol. I: Sources, Methods, Tables. Lund: CWK Gleerup.

Jörberg (pp 81-83) discussed at length the pitfalls in trying to convert prices into comparable, common currency units over time. Given those pitfalls, he advised against an attempt to convert all prices into, say, kronor for the entire period. We focus on relative prices across locations and how their dispersion varied over time-rather than on relative prices over time-and so automatically follow this advice. Thus the prices are in a common currency for a specific year but the currency units vary over time. The currency changes do not affect our calculations. However, they would preclude the use of some other methods, such as the time-series modelling adopted by Jacks (2005) or that of Dobado-González, García-Hiernaux, and Guerrero (2012) that measures mean-reversion.

Although we have found no data on travel times or shipping costs, outlines of Swedish history by Weibull (1993) and Kent (2008) document some of the milestones in transportation and communications during this period. The early 19th century saw the introduction of canals, including the Trollhätte canal in 1800 and the Göta canal in 1832. Even then, a trip from Stockholm to Gothenburg could take a week. Railways (which reduced these travel times) and the telegraph followed during the 1850s and 1860s. Sweden was not an early industrializer, though. In 1900 half of employment remained in agriculture.

For other European countries, some comparable sources of price data exist because of the work of the International Scientific Committee on Price History in the 1930s and 1940s, described by Cole and Crandall (1964). These sources include the monographs by Posthumus (1946) on Holland, Elsas (1936, 1949) on Germany, Hauser (1936) on France, Hamilton (1947) on Spain, and Pribram (1938) on Austria. The Danish price history project begun by Friis and Glamann (1958) is another rich source. Data from these and other studies can be found at the Global Price and Income History Group (www.gpih.ucdavis.edu), the IISH List of Datafiles of Historical Prices and Wages (www.iisg.nl/hpw/), or at eh.net. But data for these countries involve significantly fewer intranational locations. Historical data on grain prices can be found at Corn Returns Online (cornreturnsonline.org) while modern data are available at the Center for International Price Research (centerforinternationalprices.org).

IV. PATTERNS IN COMMODITY PRICE INTEGRATION

We next consider departures from the law of one price both by commodity and pooled over commodities, measured with a median over time and also year by year. Our analysis proceeds in two stages. First we consider time-invariant barriers, represented by the distance between towns. Second, we consider the possibility that the economic impact of distance changed over time. Obvious candidates are improvements in transportation that reduced the cost per kilometre of shipments. Less obvious, but also plausible, is the notion that expansions of the transportation network gave rise to new trading linkages where trade costs were initially prohibitive.

Consider a commodity $\boldsymbol{i}$ in year t that is priced in towns j and k: its price is denoted p. Begin with the log relative price:

$$q_{i,jk,t} = lnp_{i,j,t} - lnp_{i,k,t} \tag{1}$$

The time-varying measure of dispersion then is defined as:

$$aq_{i,jk,t} = 100 * |q_{i,jk,t}| \tag{2}$$

When the focus is time-invariant barriers, we work with the median of the absolute value of LOP deviations, where the median is taken over all time periods for which the bilateral relative price observations are available:

$$madaq_{i,jk} = median_t(aq_{i,jk,t}) \tag{3}$$

We study the median absolute deviation to mitigate sensitivity to outliers as may arise due to measurement error.

In each sub-section of our analysis we present both pooled and good-specific results. This is important for three reasons. First, much research focuses on grain prices and because wheat is one of our commodities the disaggregated analysis provides a point of contact with this work. Second, since the question of interest is market integration broadly defined, it is important to know if results for wheat hold for other commodities in the cross-section. Third, pooling enables us to stimate parameters more precisely.

All standard errors are cluster-robust, so that they are not understated due to correlation across towns or years. We thus follow Cameron and Miller's (2015) guidelines for inference. In time-invariant statistical models we cluster over town pairs jk. In time-varying regressions we cluster over both town pairs jk and years t, using the multiway clustering of Cameron, Gelbach, and Miller (2011). (Cameron and Miller suggest that I = 19 is not a large enough number of commodities to cluster in that dimension.) In practice these standard errors are considerably larger than the traditional heteroskedasticity-robust ones, so the resulting inferences are conservative.

4.1 Time-Invariant Distance Effects

Denoting distance by d_{jk}, the statistical specification is:

$$madq_{i,jk} = \alpha_i + \beta lnd_{jk} + \varepsilon_{i,jk} \tag{4}$$

which includes fixed effects for commodities, labelled α_i. Fixed effects for town pairs jk are not included because they are very highly collinear with log distance.

Table 2. Commodity-by-Commodity Estimation 1732-1914

$$madq_{i,jk} = \alpha_i + \beta_i lnd_{jk} + \varepsilon_{i,jk}$$

Commodity	$\hat{\beta}_i$ (se)	R^2	N
Baltic Herring	7.58*** (1.06)	0.27	87
Bar Iron	8.78*** (2.04)	0.17	70
Beef	0.62 (1.09)	0.00	227
Butter	5.53*** (0.52)	0.15	531
Charcoal	23.44*** (5.80)	0.20	55
Hay	3.97*** (0.61)	0.07	527
Hops	12.48*** (1.56)	0.22	261
Log Timber	20.82*** (3.26)	0.13	249
Oxen	18.39*** (1.70)	0.24	237
Pork	8.58*** (1.07)	0.26	249
Sawn Batten	9.47*** (1.73)	0.08	429
Sheep	8.44*** (1.08)	0.12	292
Straw	10.01*** (1.29)	0.09	489
Tallow	4.96*** (0.63)	0.13	310
Tallow Candles	1.66*** (0.29)	0.08	432
Tar	8.46*** (1.44)	0.33	51
Wax Candles	4.05*** (0.93)	0.04	431
Wheat	2.94*** (0.50)	0.13	332
Wool	3.76 (9.26)	0.01	10

Notes: Distance is in kilometres. Standard errors in parentheses are robust to heteroskedasticity with *p<0.1, **p<0.05, ***p<0.01.

Table 2 reports the results of estimating this statistical model (4) for each commodity. Commodity-specific intercepts are not shown. For 17 commodities the distance effect, as measured by β, is significant at the 1% level; for 2 commodities (beef and wool) it is positive but statistically insignificant. The largest values are for charcoal, log timber, oxen, and hops. This heterogeneity in β_i could arise due to differences in value-to-weight ratios.

Table 3 reports the pooled regression results with coefficients on distance constrained to be the same across commodities. This involves 5268 observations on the 19 commodities in 32 Swedish towns. The row of results labelled α_i allows each commodity to have a different constant term in the regression (not reported) whereas the row labelled α forces all regressions to have the same constant term. The restriction on the constant has some effect on the value $\hat{\beta}$ of and these intercepts are clearly important since the fraction of variance explained drops from 76% to 6% when a common intercept is imposed. In either case the distance effect is statistically significant at the 1% level. The fact that price dispersion is rising in distance of course is consistent with research studies that use modern data and with previous studies of historical prices reviewed in section 2.

In summary, we have found evidence of a positive role of distance in accounting for price dispersion, both in the pooled estimation and in most commodity-level results. We next explore how this dispersion, and its correlation with distance, changed over time.

Table 3. Pooled Estimation 1732-1914

$$madq_{i,jk} = \alpha_i + \beta lnd_{jk} + \varepsilon_{i,jk}$$

Intercept	$\hat{\beta}$	R^2	N
	(*se*)		
α	7.44*** (0.50)	0.06	5268
α_i	5.60*** (0.33)	0.76	5268

Notes: Distance is in kilometres. Standard errors in parentheses are clustered by town pair *jk* where *p<0.1, **p<0.05,***p<0.01. If *jk* dummy variables are included in these specifications the ln(d_{jk}) variable is dropped due to multi-collinearity. Intercept *i* is for a specific commodity.

4.2 Time Variation

We report statistics that measure whether price dispersion varied over time and specifically whether we can attribute that variation to an evolving effect of distance. In a historical study spanning 182 years, it seems reasonable to expect improvements in transportation technology and infrastructure to alter price dispersion over time. We use year-specific effects to allow flexibility in measuring the rate of change of market integration.

The only new variable introduced is time itself. This can be thought of as exploratory data analysis, but an obvious advantage is that this covariate, time, is exogenous. The disadvantage of simply using time as a regressor is a loss of test power in assessing the effect of a specific event, such as a particular technological change such as the expansion of roads or railroads. But we have a lot of data, so this agnostic approach should detect both a trend to integration of commodity markets and interruptions to that trend, whatever their causes.

Given our earlier findings we begin by controlling for distance in the same way, but now we do not use the median across time of the absolute deviations. Thus the specification is:

$$adq_{i,jk,t} = \alpha_i + \alpha_t + \beta_t lnd_{jk} + \varepsilon_{i,jk} \tag{5}$$

The variable α_t is a year-specific fixed effect: α_t=1 in a specific year and 0 otherwise. The coefficient β_t also is year-specific. Measuring the time-varying effects in this way allows for dispersion to increase or decrease with a wide range of patterns over time. There are 502,689 observations.

Table 4 gives the results, pooled across commodities. The first row allows for no time variation, but only commodity-specific intercepts, α_i, and a constant effect of distance, measured by β. We now study a time-varying measure of dispersion, $adq_{i,jk,t}$, yet it is striking that distance and commodity-specific fixed effects (which of course do not vary over time) still have a great deal of explanatory power. The R^2 statistic is 0.5990.

However, it also is easy to detect time variation. In the second row there are intercept time effects; in the third row there are only slope time effects; in the fourth row both are present. The changes in the R^2 are small numerically but statistically significant, given the large number of observations. Thus we cannot reject the hypothesis that both the slope and intercept changed over time.

Table 4. Pooled Estimation with Time Effects 1732-1914

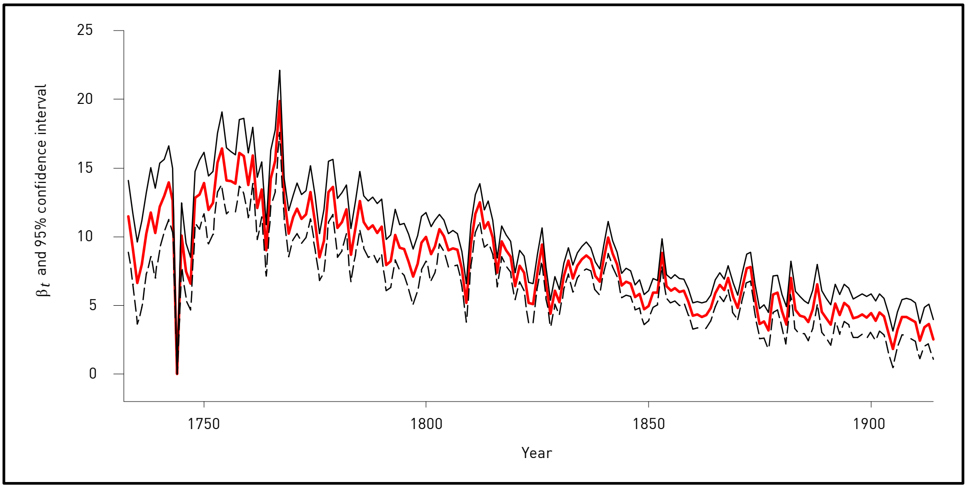
$$adq_{i,jk,t} = \alpha_i + \alpha_t + \beta_t lnd_{jk} + \varepsilon_{i,jk}$$

Parameters	$\hat{\beta}$	R^2	N
α_i, β	5.37*** (0.33)	0.5990	502,689
α_i, α_t, β	7.35*** (0.46)	0.6228	502,689
α_i, β_t		0.6200	502,689
α_i, α_t, β_t		0.6246	502,689

Notes: Distance is in kilometres. Standard errors in parentheses are clustered by town pair and year using the method of Cameron, Gelbach and Miller (2011) where *p<0.1, **p<0.05, ***p<0.01. The dummy variables α_i and α_t apply to goods and years respectively.

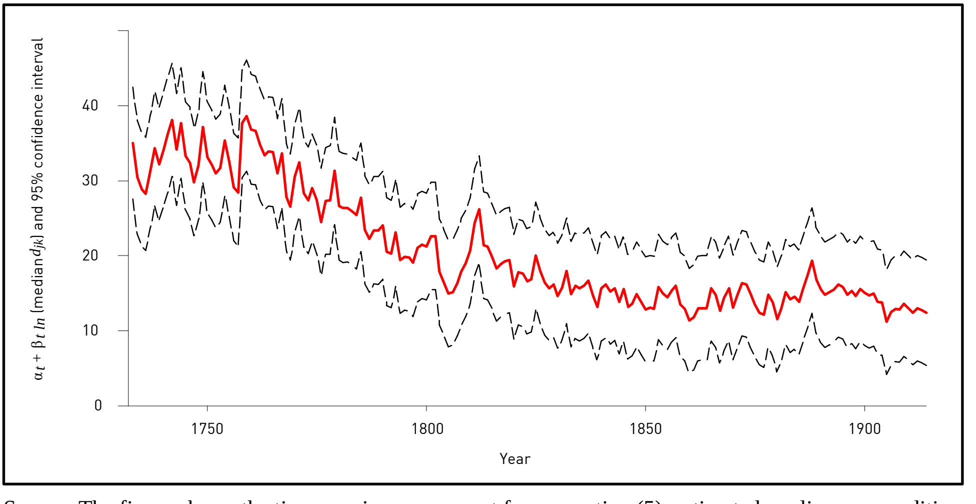
Figure 2 graphs the estimated slope β_t, along with 95% confidence intervals, for each year from 1732 to 1914. Early in the period this slope is quite variable, but a downward trend is evident after about 1775. However, given that variations in both the slope and intercept coefficients are significant, it is possible that one could find β_t falling from one year to another yet $\hat{\alpha}_t$ rising so that predicted price dispersion rose at many distances in the sample. Thus β_t may not be a good measure of the distance effect's variation over time. It falls fastest in the remainder of the 18th century, then continues a more gradual decline-with some volatility-until 1914. We note that there is indeed a mild upward drift in α_t. Combined with figure 2 this shows that the distance function became flatter over time. These year-specific intercepts and slopes are estimated quite precisely for each year, because of the large number of locations and commodities. One thus can measure the overall effect of time (at a given distance d_{jk}) with the statistic $\alpha_t + \beta_t \ln(d_{jk})$. Figure 3 graphs this statistic against time, along with 95% confidence intervals, for each year and at the median distance. This overall time effect is volatile at the beginning of the sample, but then begins a marked decline after 1760.

Figure 2. Distance Function Slope $\boldsymbol{\beta_t}$, 1732-1914



Source: The figure shows the time-varying slope from equation (5), estimated pooling commodities. Dashed lines give the 95% confidence intervals based on double-clustered standard errors.

Figure 3. Median Distance Function, 1732–1914

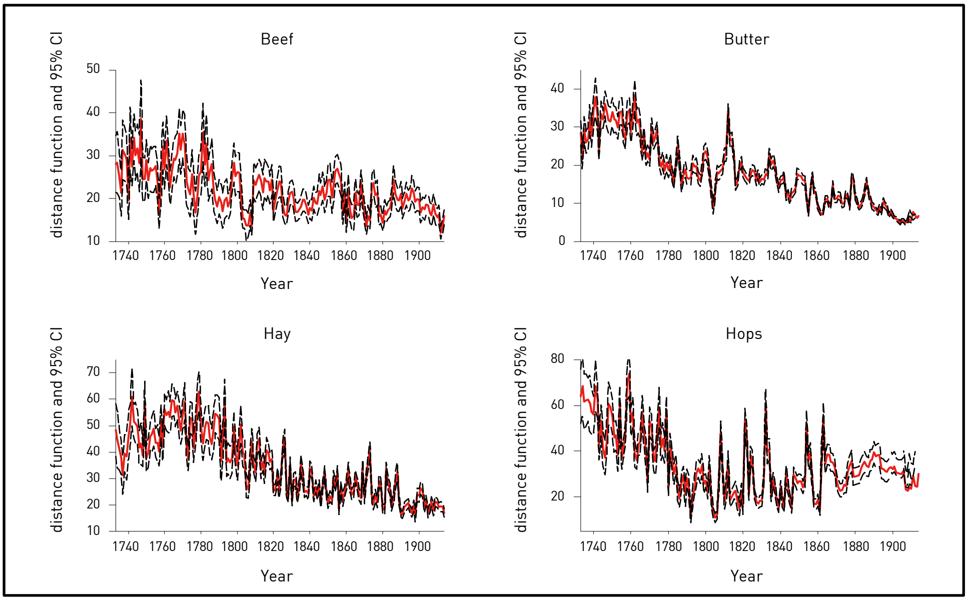


Source: The figure shows the time-varying component from equation (5), estimated pooling commodities, and evaluated at the median distance: $\alpha_t + \beta_t \ln[\text{median}(d_{jk})]$. Dashed lines give the 95% confidence intervals based on double-clustered standard errors.

It is interesting to explore whether this pattern holds true for each commodity. Again we take advantage of the many locations to explore the time path non-parametrically, without imposing a functional form on the trend. We estimate equation (5) but with commodity-specific, time-varying parameters $\alpha_{i,t}$ and $\beta_{i,t}$. The fit varies across commodities, with R^2 ranging from 0.06 for wax candles or 0.10 for beef to 0.34 for Baltic herring or 0.44 for bar iron. The explanatory power for wheat, where $R^2 = 0.22$, is typical.

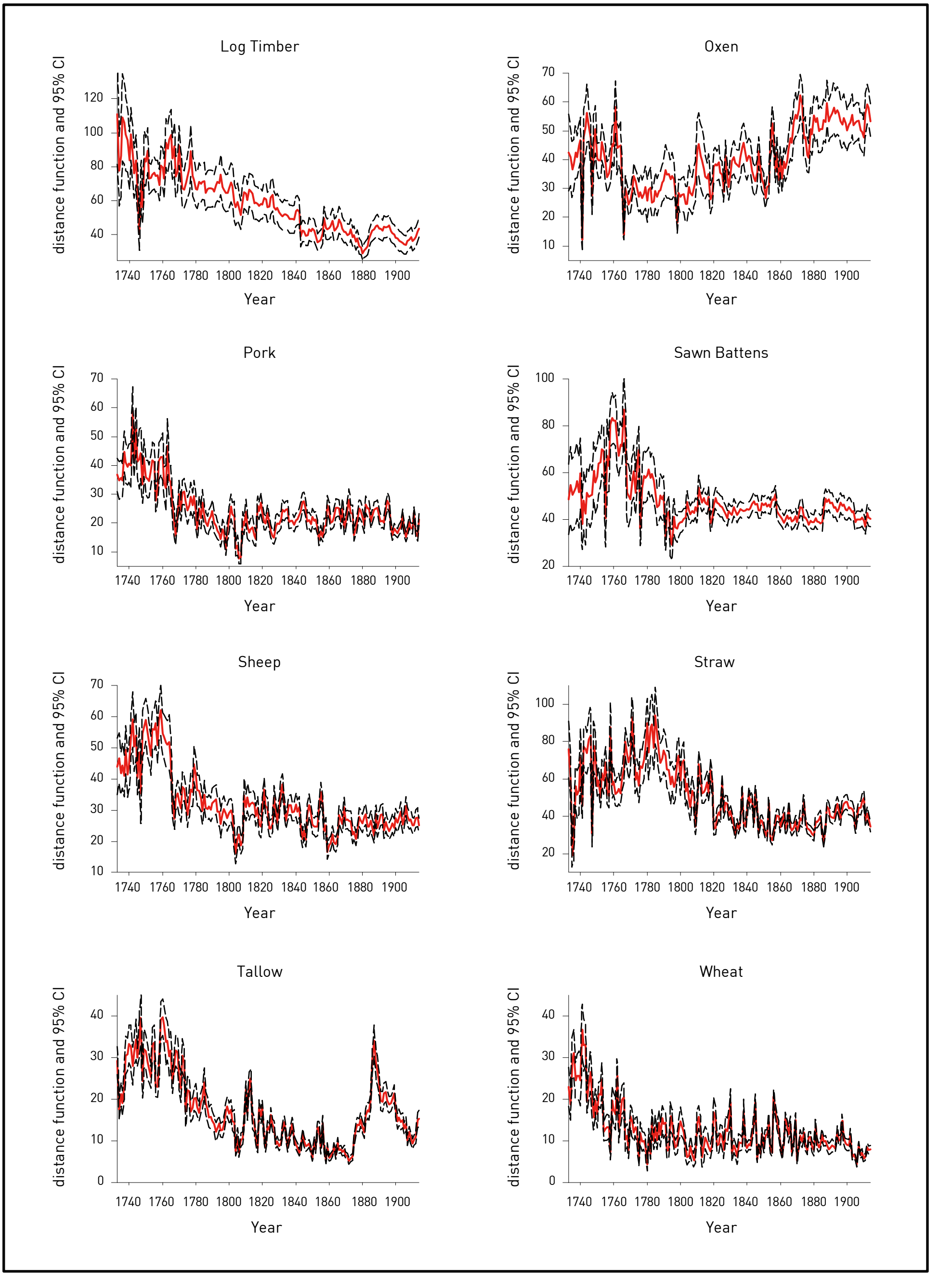
Figure 4 shows the commodity-specific distance function evaluated at the median distance: $\alpha_{i,t} + \beta_{i,t}\ln[\text{median}(d_{jk})]$. The 12 commodities shown are those with (i) more than 20,000 observations and (ii) observations spanning the entire period. This set includes 420,289 observations: 84% of the total used in table 4 and figure 2. The distance function becomes flatter over the entire time period for each commodity, except oxen. Moreover, this pattern clearly began in the 18th century for each commodity except oxen and straw. The disaggregated data thus show that figure 2 provides a good summary of the overall pattern of price convergence.

Figure 4. Median Distance Function by Commodity, 1732–1914



Source: The figures show the commodity-specific distance function evaluated at the median distance: $\alpha_{it} + \beta_{it}\ln[\text{median}(d_{jk})]$. for each year, and its 95% confidence interval. The 12 commodities are those with (i) more than 20,000 observations and (ii) observations spanning the entire period.

Figure 4. Continued



The last panel of figure 4 plots the distance function for wheat, and so allows comparison with other studies that focus on that commodity. As we noted in section 2, some studies find wheat prices converging over the 1800s but with an interruption early in that century. We do not find these same patterns within Swedish wheat prices, where figure 4 shows that the distance function does not have a trend after 1800 and does not appear to tilt up during the Napoleonic Wars. Instead, we find most of the decline in wheat-price dispersion within Sweden occurred before 1800. However, the results pooled across commodities in figure 2 *do* show both a continuing decline in dispersion from 1800 to 1850 and some interruption in intranational convergence during the early nineteenth century.

V. CONCLUSION

This paper aims to contribute to research on price history by studying prices for 19 commodities in 32 Swedish towns from 1732 to 1914. These large ranges of commodities, intranational locations, and years are made possible due to the work of Jörberg (1972) and his colleagues. The large number of observations enhances precision in each statistical model and allows us to study time effects non-parametrically. The statistical model also allows for changes over time in the currency units that preclude construction of a continuous price series. We cluster standard errors so as not to overstate precision due to error correlation across towns or years.

We find a resilient effect of distance on price dispersion, for almost all commodities. Pooling across them, we find that the distance function became flatter over time, evidence of advances in communication and transportation. This pattern applied over most commodities. But it was by no means monotonic, with considerable variation from year to year. Notably, this process appears to have begun in the 18th century, before the arrival of canals, the telegraph, or the railway.

Even if we do not know the transport and communication changes that were at work in 18th century Sweden, we know from the other research cited here that a falling distance effect in relative prices historically has been an accurate indicator of such improvements. This is a key lesson from the historical research. Prices continue to be less expensive to collect than many other data. Atkin and Donaldson (2015) find that internal transportation costs (and hence distance effects) on prices in Ethiopia and Nigeria can have a large effect on prices at the port of exit and hence on international trade. Just as in the historical data, intranational price convergence may be a precursor to globalization.

REFERENCES

Atkin, D. and D. Donaldson. 2015. Who's Getting Globalized? The Size and Implications of Intra-national Trade Costs. NBER Working Paper, no. 21439.

Cameron, A. C. and D. L. Miller. 2015. "A Practitioner's Guide to Cluster-robust Inference," *Journal of Human Resources,* vol. 50, no. 2, pp. 317-372.

Cameron, A. C., Gelbach, J. B. and D. L. Miller. 2011. "Robust Inference with Multiway Clustering," *Journal of Business and Economic Statistics,* vol. 29, no. 2, pp. 238-249.

Cheung, S. W. 2008. *The Price of Rice: Market Integration in Eighteenth-Century China.* Bellingham: Center for East Asian Studies, Western Washington University Press.

Chilosi, D. and G. Federico. 2015. "Early Globalizations: The Integration of Asia in the World Economy, 1800-1938," *Explorations in Economic History,* vol. 57, pp. 1-18.

Cole, A. H. and R. Crandall. 1964. "The International Scientific Committee on Price History," *Journal of Economic History,* vol. 24, no. 3, pp. 381-388.

Crucini, M. J. and G. W. Smith. 2014. Geographic Barriers to Commodity Price Integration: Evidence from US Cities and Swedish Towns, 1732-1860. NBER Working Paper, no. 20247.

Dobado-González, R. and G. A. Marrero. 2005. "Corn Market Integration in Porfirian Mexico," *Journal of Economic History,* vol. 65, no. 1, pp. 103-128.

Dobado-González, R., García-Hiernaux, A. and D. E. Guerrero. 2012. "The Integration of Grain Markets in the Eighteenth Century: Early Rise of Globalization in the West," *Journal of Economic History,* vol. 72, no. 3, pp. 671-707.

______. 2015. "West versus Far East: Early Globalization and the Great Divergence," *Cliometrica,* vol. 9, no. 2, pp. 235-264.

Elsas, M. J. 1936, 1949. *Umriss einer Geschichte der Preise und Löhne in Deutsch-land vom ausgehenden Mittelalter bis zum Beginn des neunzehnten Jahrhunderts.* 2 vols. Leiden: A. W. Sijthoff.

Friis, A. and K. Glamann. 1958. *A History of Prices and Wages in Denmark, 1660-1800.* vol. I. London: Longmans, Green and Co.

Hamilton, E. J. 1947. *War and Prices in Spain, 1651-1800.* Cambridge: Harvard University Press.

Hauser, H. 1936. *Recherches et documents sur l'histoire des prix en France de 1500 à 1800.* Paris: Les Presses Modernes.

Jacks, D. S. 2005. "Intra and International Commodity Market Integration in the Atlantic Economy, 1800-1913," *Explorations in Economic History,* vol. 42, no. 3, pp. 381-413.

Jacks, D. S., O'Rourke, K. H. and J. G. Williamson. 2011. "Commodity Price Volatility and World Market Integration Since 1700," *Review of Economics and Statistics,* vol. 93, no. 3, pp. 800-813.

Jörberg, L. 1972. *A History of Prices in Sweden 1732-1914. Vol. I: Sources, Methods, Tables.* Lund: CWK Gleerup.

Kaukiainen, Y. 2001. "Shrinking the World: Improvements in the Speed of Information Transmission, c. 1820-1870," *European Review of Economic History,* vol. 5, no. 1, pp 1-28.
Kent, N. 2008. *A Concise History of Sweden.* Cambridge: Cambridge University Press.
Klovland, J. T. 2005. "Commodity Market Integration 1850-1913: Evidence from Britain and Germany," *European Review of Economic History,* vol. 9, no. 2, pp. 163-197.
Lagerlöf, N.-P. 2015. "Malthus in Sweden," *Scandinavian Journal of Economics,* vol. 117, no. 4, pp. 1091-1133.
O'Rourke, K. and J. G. Williamson. 1994. "Late Nineteenth-Century Anglo-American factor-Price Convergence: Were Heckscher and Ohlin Right?," *Journal of Economic History,* vol. 54, no. 4, pp. 892-916.
______. 2002. "When Did Globalisation Begin?," *European Review of Economic History,* vol. 6, no. 1, pp. 23-50.
Pippenger, J. and L. Phillips. 2008. "Some Pitfalls in Testing the Law of One Price in Commodity Markets," *Journal of International Money and Finance*, vol. 27, no. 6, pp. 915-925.
Posthumus, N. W. 1946. *Inquiry into the History of Prices in Holland. Vol. I: Wholesale Prices at the Exchange of Amsterdam, 1585-1914. Rates of Exchange at Amsterdam, 1609-1914.* Leiden: E. J. Brill.
Pribram, A. F. 1938. *Materialen zur Geschichte der Preise und Löhne in Osterreich.* Vienna: C. Veberreuters Verlag.
Rogoff, K., Froot, K. A. and M. Kim. 2001. The law of one price over 700 years. IMF Working Paper, 01/174.
Shiue, C. H. 2002. "Transport Costs and the Geography of Arbitrage in Eighteenth-Century China," *American Economic Review,* vol. 92, no. 5, pp. 1406-1419.
______. 2005. "From Political Fragmentation towards a Custom Union: Border Effects of the German Zollverein, 1815 to 1855," *European Review of Economic History,* vol.9, no. 2, pp. 129-162.
Shiue, C. H. and W. Keller. 2007. "Markets in China on the Eve of the Industrial Revolution," *American Economic Review,* vol. 97, no. 4, pp. 1189-1216.
Slaughter, M. J. 1995. The Antebellum Transportation Revolution and Factor Price Convergence. NBER Working Paper, no. 5303.
Trenkler, C. and N. Wolf. 2005. "Economic Integration across Borders: The Polish Interwar Economy," *European Review of Economic History,* vol. 9, no. 2, pp. 199-231.
Weibull, J. 1993. *Swedish History in Outline*. The Swedish Institute.

First version received on 6 October 2016
Peer-reviewed version received on 28 October 2016
Final version accepted on 16 November 2016