Dutch Bread and Grain Prices, 1594-1855:

Measuring Grain Market Integration

Jan de Vries
University of California at Berkeley

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Methodology

　　We can assess market integration quantitatively in three ways, by measuring the absolute differences in price level among markets, by calculating the coefficients of correlation between price changes in market pairs, and by calculating the coefficients of variation that characterize the prices in given markets over time. The first offers information on price convergence or its absence. The price gap between markets is usually thought to reveal the transaction costs that prevent prices from fully equalizing across space. The lower these costs, the more prices converge. The second measures the degree of co-movement between pairs of price series. It reveals how sensitively the markets respond to each other. Both information about other markets and low transaction costs that allow market participants to act on this information will result in highly correlated price movements (even when the absolute price differences might remain substantial). Finally, the coefficient of variation offers a measure of the volatility of prices in a given market. The more markets are

integrated (linking multiple sources of supply) and the more buffer stocks are available to smooth short-term shocks in supply and demand, the lower the variance of prices – in this case, average annual prices – around their long run trend.

Rye

Differences in absolute price level among Dutch domestic markets were rarely large by the late sixteenth century and price shocks were dissipated fairly quickly, restoring via arbitrage a stable long-term relationship. Thus, the average price of rye in eastern markets (the unweighted mean annual price for Utrecht, Zaltbommel, Kampen, Deventer, Zwolle, Arnhem, and Groningen) was less than one percent above that prevailing in the Amsterdam market over the very long period 1596-1855. There were, however, years, and occasionally multi-year periods, with larger price differentials, as displayed in Figure 1. Overall, rye was slightly costlier in the east, where it was locally produced, than in Holland, where most supplies came from distant, East-Elbian production zones. This western advantage disappeared in the period 1648-67, and again in1689-1717 – both periods of frequent warfare – and yielded to a period of great volatility after 1795 – another period of frequent warfare. But underlying these disruptions was a persisting, small absolute price differential in favor of the western provinces.

Figure 1. East/West rye price ratios, 1600-1854
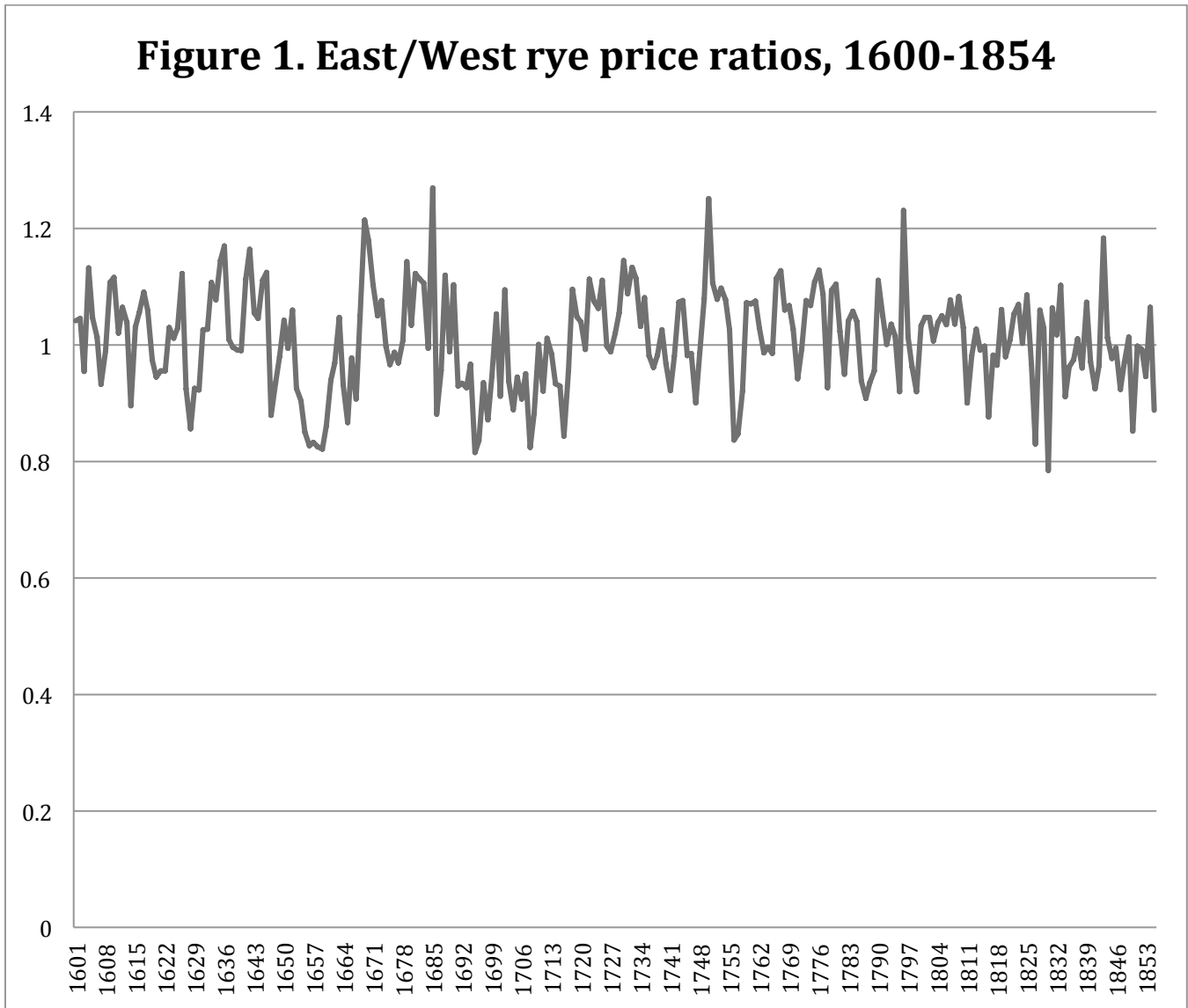
These small absolute price differentials did not provide an opportunity for large or persisting rye shipments from the eastern production regions to Holland's cities. Yet the eastern markets show a high degree of price integration with Amsterdam, as revealed by the coefficients of correlation. Table 1 displays these coefficients for as many

city pairs as the assembled data allow, at fifty-year intervals from 1596 to

1849. From beginning to end, the coefficients are high. They illustrate

nicely the cautionary stricture that "correlation is not causation." The

integration of Dutch rye prices existed more because of the potential of

low-cost distribution than because of the actual ongoing movement of large

volumes of rye throughout the Netherlands.

Table 1. A. Coefficients of correlation of annual average rye prices between city pairs in the Netherlands, detrended, 1596-1799.

1596-1649	A'dam	Utrecht	Z'bml	Deventer	Arnhem	Groningen
Utrecht	.970					
Z'bml	.929	.938				
Deventer	.940	.965	.961			
Arnhem	.717	.711	.744	.780		
Groningen	.948	.955	.963	.927	.809	
Orphanages	.883	.853	.848	.842	.695	.843

1650-99	A'dam	Utrecht	Z'bml	Kampen	Deventer	Arnhem	Gron.
Utrecht	.930						
Z'bml	.883	.932					
Kampen	.931	.942	.889				
Deventer	.972	.983	.959	.964			
Arnhem	.725	.820	.789	.859	.865		
Groningen	.908	.902	.862	.918	.958	.730	
Orphanages	.723	.744	.617	.603	.826	.486	.686

1700-49	A'dam	Utrecht	Z'bml	Kampen	Deventer	Arnhem	Gron.
Utrecht	.966						
Z'bml	.910	.914					
Kampen	.947	.965	.906				
Deventer	.891	.911	.839	.929			
Arnhem	.702	.690	.695	.750	.776		
Groningen	.887	.896	.857	.919	.852	.747	
Orphanages	.942	.921	.877	.901	.881	.827	.844

1750-99	A'dam	Utrecht	Z'bml	Kampen	Deventer	Arnhem
Utrecht	.908					
Z'bml	.909	.938				
Kampen	.943	.951	.899			
Deventer	.851	.820	.816	.914		
Arnhem	.368	.613	.756	.568	.763	
Orphanages	.957	.948	.823	.932	.839	.375

B. Coefficients of correlation in annual average rye prices, international city pairs, 1596-1799.

1596-1649	A'dam	Antwerp	Brussels	Cologne
Antwerp	.667			
Brussels	.391	.926		
Cologne	.277	.101	.469	
Danzig	.811	.424	.135	.278

1650-99	A'dam	Antwerp	Brussels	Cologne	Copenhagen
Antwerp	.960				
Brussels	.852	.997			
Cologne	.638	.854	.677		
Copenhagen	.394	----	.787	--.135	
Danzig	.817	.629	.726	.740	.730

1700-49	A'dam	Antwerp	Brussels	Cologne	Copenhagen
Antwerp	.817				
Brussels	.657	---			
Cologne	.408	.726	.367		
Copenhagen	.618	---	.283	.360	
Danzig	.864	.550	.488	.238	.566

1750-99	A'dam	Antwerp	Brussels	Cologne	Copenhagen
Antwerp	.776				
Brussels	.756	.980			
Cologne	.331	.478	.470		
Copenhagen	.630	.583	.650	.376	
Danzig	.858	.515	.636	.271	.847

Panel B of Table 1 displays coefficients of correlation for international locations, from which the strong link with the Baltic, via the port of Danzig, is readily apparent (here, correlation *does* reveal causation!). The Southern Netherlands also remained in close contact with the Amsterdam market, but the integration with Cologne was much weaker.

Dutch domestic rye markets were highly correlated with each other and the absolute differences in their price levels were small throughout the early modern era. This, of course, is no surprise. But these indicators of market efficiency did not shelter the Republic from periodic price shocks. The efficient markets dampened these shocks and reduced their duration, but they could not remove them altogether. Price volatility is measured by the coefficient of variation (CV), which is the standard deviation of a price series divided by the mean of the price observations. In the long run, CV remained fairly steady at approximately 0.25. This is not a particularly low value for early modern price series, but, as Figure 2 shows, CV itself was volatile. Brief periods of crisis pushed it upward, only to be followed by periods of much lower CV, especially in the eighteenth century, when CV averaged approximately 0.20.

Figure 2. Coefficients of variation: rye prices, 1600-1820
11-year moving average
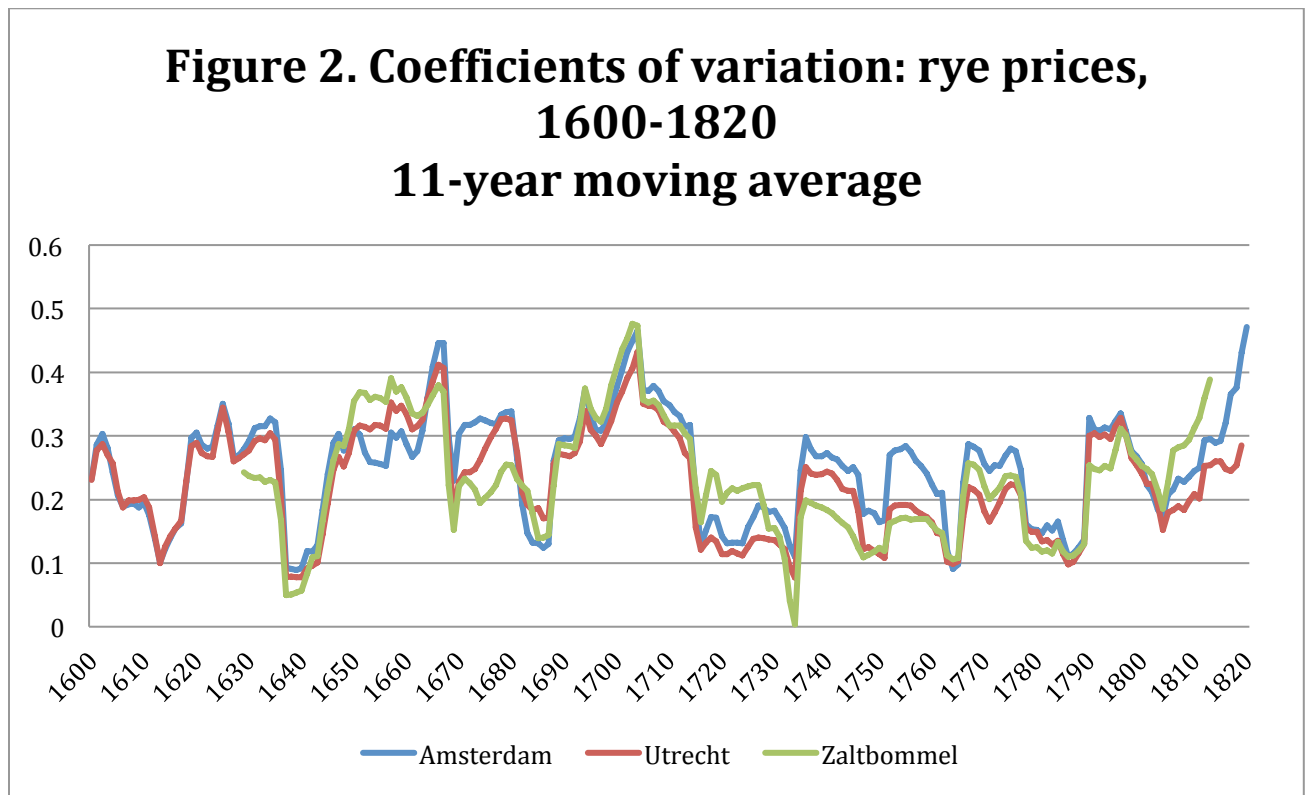
Wheat

Wheat was a far less homogeneous product than rye. Depending on its region of production wheat was associated with distinct qualities and this led to the maintenance of significant price differentials. The bread price commissioners had frequent occasion to discuss these differentials as they pondered which types of wheat to track as they set bread prices. The spread in wheat prices at any given point in time adds an element of complication to the integration of regional grain markets – or, more correctly, to our effort to measure this integration. Moreover, while production areas were associated with enduring quality differences, the

wheat of a given region could also vary considerably in quality from year to year, causing the transactions at a given market to reveal substantial price spreads for what was, ostensibly, the same grain.[1] In general, wheat prices more than rye reflected persisting quality differentials that render the "law of one price" an elusive benchmark for assessments of market integration.[2]

Price correlations between markets were always a notch lower for wheat than for rye. Eighteenth century price notations at the Amsterdam grain exchange (see Table 2) show that the two Baltic grades (Polish and Konigsberg) were well correlated, and two domestic grades (Frisian and Zeeland) were also, but the correlation between imported and domestic grades of wheat on the same market were a bit lower. Moreover, the price differentials between the costliest grades of wheat -- Polish and Zeeland -- and the cheaper Konigsberg and Frisian grades was on the order of 12-13 percent.

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[1] For instance, weekly price notations for Polish wheat at the Amsterdam Grain Exchange in the period 1709-1787 exhibited an average price spread of 24 percent. The spread for Prussian Rye was 14.4 percent.

[2] "In any grain harvest a portion of the crop will be formed by light or broken kernels. These were often retained on the farm for fodder or consumed by the farm household. Likewise, the finest grains were also retained to serve as seed corn for the next planting. Harvest and market conditions could affect retention at both margins, thus altering the overall quality of the marketed grain." Liam Brunt and Edmund Cannon, "Variation in the price and Quality of English Grain, 1750-1914: Quantitative Evidence and Empirical Implications," Explorations in Economic History 58 (2015), 74-92.

Table 2. Coefficients of correlation on first differences of annual average prices on the Amsterdam Grain Exchange, 1733-1779.

	Polish	Konigsberg	Frisian	Zeeland
Polish	1.000			
Konigsberg	0.969	1.000		
Frisian	0.841	0.887	1.000	
Zeeland	0.854	0.878	0.908	1.000
Mean price:				
guilders per last:	193.36	172.15	177.53	198.29
Coeff. of variation	24.2	24.3	23.3	26.1

Wheat prices beyond the maritime zone reveal somewhat larger market price differentials with Holland's markets than do those for rye. At first glance, this is unexpected since, measure for measure, wheat was usually about 50 percent more expensive than rye, which would cause transport and other transaction costs to weigh less heavily on its final market price in distant markets. As shown in Figure 3, these differentials were not large in the seventeenth century. Utrecht wheat prices were highly correlated with the Amsterdam market while Kampen, across the Zuider Zee from Amsterdam, paid, on average a 5 percent premium on the Amsterdam price. The small market town of Zaltbommel, downstream from a wheat-producing region, paid 6 percent less than Amsterdam. In the eighteenth century, these differentials grow, especially after 1750. Both Utrecht and Kampen then faced prices at least 13 percent above the Amsterdam level, while Zaltbommel continued to pay 6 percent less. After

1800, these patterns changed again and wheat prices in all three provincial markets fell below the Amsterdam market. Of course, the Amsterdam market price for wheat did not dominate national markets as it did for rye. The multiple sources of wheat, their shifting relative importance, and the differing grades of wheat appear to have led to less price integration – or to greater difficulty in measuring it given the available data.

Figure 3. East/West wheat price ratios, 1600-1822
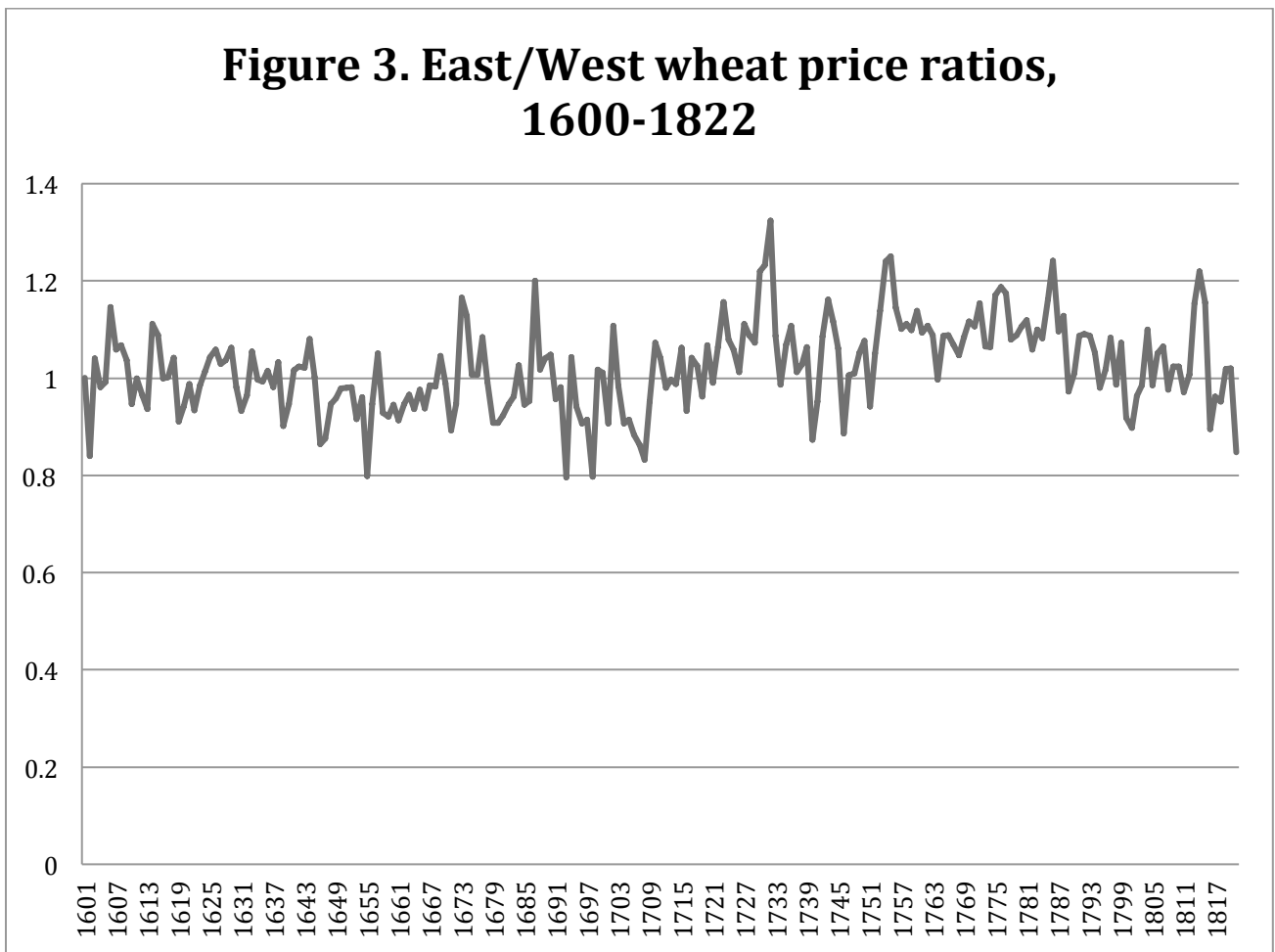
Despite these complications, the domestic wheat markets showed a high degree of co-movement in annual prices, as measured by coefficients of correlation displayed for fifty-year intervals in Table 3, while the volatility of wheat prices, shown in Figure 4, was similar in intensity and timing to that for rye. For both grains, perhaps the most striking feature of these measures of market performance is the combination of high levels of integration and lack of significant change in the degree of integration over the 250 years analyzed here.

Table 3. A. Coefficients of correlation in Annual average wheat prices between city pairs in the Netherlands, detrended, 1596-1799.

1596-1649	Haarlem	Utrecht	Z/bml	Goes
Utrecht	.898			
Z'bml	.823	.941		
Goes	.613	.410	.727	
Orphanages	.527	.454	.476	.246

1650-99	Haarlem	Utrecht	Z'bml	Goes	Kampen
Utrecht	.926				
Z'bml	.921	.978			
Goes	.542	.495	.512		
Kampen	.615	.856	.792	.466	
Orphanages	.787	.736	.727	.438	.487

1700-49	A'dam Polish	Haarlem	Dordt.	Utrecht	Z'bml	Kampen
Haarlem	.875					
Dordrecht	.873	...				
Utrecht	.927	.944	.936			
Z'bml	.918	.804	.925	.976		

Kampen	.804	.898	.848	.942	.937	
Orphanages	.757	...	.832	.799	.834	.680

1750-99	A'dam Polish	Dordt	Utrecht	Z'bml	Kampen
Dordrecht	.895				
Utrecht	.954	.940			
Z'bm	.929	.912	.944		
Kampen	.822	.895	.792	.828	
Orphanages	.895	.826	.863	.683	.669

B. Coefficients of correlation in annual average wheat prices, international city pairs

1596-1649	Haarlem	Utrecht	Antwerp	Brussels
Utrecht	.898			
Antwerp	.741	.783		
Brussels	.592	.605	.903	
London	.034	.173	.168	.103

1650-99	Haarlem	Utrecht	Antwerp	Brussels	Copenhagen
Utrecht	.926				
Antwerp	.923	.943			
Brussels	.931	.929	.982		
Copenhagen	.831	.812	...	.583	
London	.495	.452	...	.511	-- .193

1700-49	A'dam Polish	Utrecht	Antwerp	Brussels	Copenhagen
Utrecht	.927				
Antwerp					
Brussels	.751	.655	...		
Copenhagen	.159	.265	...	.490	
London	.308	.518	...	.692	--.134

1750-99	A'dam Polish	Utrecht	Antwerp	Brussels	Paris	Copenhagen
Utrecht	.954					
Antwerp	.840	.873				
Brussels	.851	.882	.977			
Paris	.737	.722	.745	.902		
Copenhagen	.550	.497	.554	.881	.031	
London	.430	.452	.216	.528	.305	.170

Figure 4. Coefficients of Variation: wheat prices, 1600-1820 in 11-year moving averages