COMMODITY PRICE VOLATILITY AND WORLD MARKET INTEGRATION SINCE 1700

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Abstract—Poor countries are more volatile than rich countries, and this volatility impedes their growth. Furthermore, commodity prices are a key source of that volatility. This paper explores price volatility since 1700 to offer three stylized facts: commodity price volatility has not increased over time, commodities have always shown greater price volatility than manufactures, and world market integration breeds less commodity price volatility. Thus, economic isolation is associated with much greater commodity price volatility, while world market integration is associated with less.

I. Commodity Price Volatility and Development

POOR countries are more volatile than rich countries, and an extensive literature suggests that this is bad for growth. Ramey and Ramey (1995) and Deaton (1999; Deaton & Miller, 1996) were among the first to find evidence that countries with higher volatility had lower mean growth. Their results have since been confirmed: more recent and detailed evidence (Acemoglu et al., 2003; Hnatkovska & Loayza, 2005; Fatás & Mivhov, 2006; Loayza et al., 2007) also shows that the high volatility and slow growth connection seems to be especially pronounced in poor countries. Indeed, in an impressive analysis of more than sixty countries between 1970 and 2003, Poelhekke and van der Ploeg (2007) find strong support for the core-periphery asymmetry hypothesis regarding volatility: that is, the volatility influence is far greater in the poor periphery. Furthermore, while capricious policy and political violence can add to volatility in poor countries, extremely volatile commodity prices "are the main reason why natural resources export revenues are so volatile" (Poelhekke & van der Ploeg 2007, p. 3), and thus why those economies are themselves so volatile.[1]

One reason for this higher volatility is that poor countries specialize in agricultural and mineral production. Primary products, or export commodities as they are often called, experience far greater price volatility than do manufactures or services, although this is more often assumed than demonstrated in the literature.[2] One exception to the "no evidence" attribute of the literature is UNCTAD (2008), which provides graphical evidence of higher price volatility for nonfuel commodities and petroleum than for manufactures between 1970 and 2008. Another is Mintz (1967), who, more than forty years ago, documented lower U.S. export price volatility for finished manufactures than for semimanufactures, crude materials, or food between 1880 and 1963. In any case, the higher volatility of commodity prices has left its mark on relative terms-of-trade experience: since 1960, Latin America, South Asia, and Africa have had far higher terms-of-trade volatility than have the manufactures-exporting industrial economies—indeed, more than three times higher (table 1).

Three questions motivate this paper. First, have primary product commodities always had more volatile prices than manufactured goods, or did this difference arise only with modern capitalism and the price stickiness associated with less competitive industrial organizations in manufacturing compared with the primary sector? This view was championed by Prebisch (1950) more than fifty years ago.[3] Second, has there been any secular trend in commodity price volatility since 1700, or has it been a constant fact of economic life? Finally, and most important, what is the relationship between globalization and commodity price volatility? Does world market integration create more or less price volatility for poor commodity exporters?

International trade might be thought to encourage terms-of-trade volatility since it leads to greater specialization. If the specialization is in commodities rather than manufactures or services, then trade will increase terms-of-trade volatility even more. This argument holds if we make the restrictive assumption that the price volatility is the same across individual commodities and over time. This paper tests this assumption: it explores long-run trends in the price

Received for publication February 12, 2009. Revision accepted for publication January 28, 2010.

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We acknowledge with thanks help rendered by Sambit Bhattacharyya, Chris Blattman, George Boyer, Luis Catão, Bob Gregory, Jason Hwang, Norman Loayza, Alan Matthews, Steve Poelhekke, and referees of this REVIEW, although they are not responsible for any flaws that may remain. D.J. gratefully acknowledges the Social Sciences and Humanities Research Council of Canada for research support. K.O. thanks the Irish Research Council for the Humanities and Social Sciences and the European Commission's Seventh Research Framework Programme (contract number 225342) for their generous support. J.W. does the same for the Harvard Faculty of Arts and Science.

[1] There are many reasons that poor countries face higher volatility and that higher volatility costs them so much more in diminished growth rates. Philippe Aghion and his collaborators (2005, 2006) offer one: macroeconomic volatility driven by either nominal exchange rate or commodity price movements will depress growth in poor economies with weak financial institutions and rigid nominal wages, both of which characterized all poor economies in the past even more than today. See also Aizenman and Marion (1999), Flug, Spilimbergo, and Wachtenheim (1999), Elbers, Gunning, and Kinsey (2007), and Koren and Tenreyro (2007).

[2] Here are two examples. Radetzki (2008, pp. 64–66) discusses the "well-known and oft-repeated" observation that commodity prices are extremely volatile and that "the prices of manufactures tend to be more stable." He provides evidence of volatile commodity prices and discusses why these might be expected to be more volatile than manufactured prices. However, he does not provide or cite empirical evidence regarding the relative volatility of the two types of prices. Szirmai (2005, p. 543) takes the view that "prices of primary exports turn out to be no more unstable than those of manufactured goods or capital goods," again without providing evidence.

[3] See the excellent survey in Cuddington, Ludema, and Jayasuriya (2007).

The Review of Economics and Statistics, August 2011, 93(3): 800–813

TABLE 1.—COMPARATIVE TERMS-OF-TRADE VOLATILITY BY REGION

	Industrialized Economies	East Asia and the Pacific	Latin America and the Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa
1960s	1.8	5.2	7.2	4.8	12.8	7.2
1970s	5.2	8.2	13.0	11.5	18.0	18.2
1980s	3.5	6.1	11.0	9.0	10.2	12.2
1990s	2.1	1.9	8.1	7.8	7.8	10.8
Average	3.2 (100)	5.4 (169)	9.8 (306)	8.3 (259)	12.2 (381)	12.1 (378)

These figures are taken from Loayza et al. (2007, p. 346). Terms-of-trade volatility is calculated as the standard deviation of the logarithmic change in terms of trade over each of the four decades 1960–2000.

volatility of individual goods rather than in the volatility of aggregate commodity price indices, as is typical in the literature.[4] If international trade lowers the price volatility of individual commodities, then it might on balance lead to a more stable price environment overall, even for countries with a comparative advantage in primary products. Thus, it is strictly an empirical matter as to whether the price stabilization effect or the specialization effect dominates.

Why might trade lower the volatility of individual commodity prices? The idea, of course, is that local shocks to supply and demand are stabilized when a small domestic economy trades with a large world economy. Thus, when the world went global in the early nineteenth century (O'Rourke & Williamson, 2002), did commodity prices become less volatile as small local economies became integrated with large world markets? When the world went autarkic between the world wars, did commodity prices become more volatile, for symmetric reasons? What about episodes of war and peace? Were commodity prices more volatile during the French wars of the late eighteenth and early nineteenth centuries, during World War I, and during World War II, than during the pro-global nineteenth century under pax Britannica or the pro-global decades since 1970? What does history tell us about the commodity price volatility and world market integration connection?

This is hardly the first time that these questions have been raised, although this paper is the first time, to our knowledge, that these questions have been confronted with extensive long-run price evidence. Persson, a scholar of medieval and early modern European grain markets, tells us how central these questions were to the eighteenth-century physiocrats, or what Persson calls *les économistes*. As far as *les économistes* were concerned, he wrote, "the best and favoured remedy against price fluctuations was market integration, and its prerequisite was free trade in grain" (1999, p. 7). Furthermore, it appears that *les économistes* anticipated the modern development economist's conclusion that volatility is bad for growth by more than 300 years: "One of the accomplishments of [*les économistes*] was the claim that price volatility . . . had disincentive effects on investment and effort in agriculture . . . and that [it was] a prime cause for the distressed state of agriculture" (Persson, 1999, p. 7). One of the earliest of *les économistes*, the Englishman Charles Davenant, asserted in 1699 that "a stable price would reign if [national grain] markets were permitted to trade since price differences would make traders move grain from surplus to deficit regions or nations" (Persson, 1999, pp. 8–9, citing Davenant, 1699, p. 82).

So, were *les économistes* right?

II. Commodity Price Volatility since 1700: Data and Measurement

The most recent and comprehensive paper on modern commodity price behavior is by Poelhekke and van der Ploeg (2007). The price data they used are "monthly averages of free-market price indices for all food, agricultural raw materials, minerals, ores & metals, crude petroleum (average of Dubai/Brent/Texas equally weighted). Base year 2000 = 100." The source of these data is UNCTAD (2007). We use similar free market price statistics, except that we quote them in local markets, so that they reflect the impact of tariffs and embargoes. Our data are price quotes for various items that are allocated, following UNCTAD classifications, to three groups: all food (AF), agricultural raw materials (ARM), and minerals, ores, and metals (MOM). We add a fourth group for manufactures or final goods (FG). These are further aggregated into all items (ALL) and all commodities (COM).

Table 2 describes the data in greater detail. Nine sources providing monthly data are listed in panel A. The famous Philadelphia database collected by Anne Bezanson and her collaborators (Bezanson, 1951; Bezanson, Gray, & Hussey, 1935, 1936; Bezanson et al., 1954) is in four parts: 1720–1775 (19 items), 1770–1790 (25 items), 1784–1861 (133 items), and 1852–1896 (100 items). The Dutch data collected by Posthumus (1946) and the Danish data collected by Friis and Glamann (1958) are both much shorter (1750–1800) and smaller (49 and 29 items, respectively). The data underlying the Gayer, Rostow, and Schwartz (1953) British commodity price index for 1790 to 1850 contain 69 items. Our historical price database is augmented with the monthly commodity price series published by the IMF (45 series)

[4] For example, Cashin and McDermott (2002) look at the behavior of a broad-based annual aggregate price index (the *Economist*'s industrial commodities price index). This index is heavily weighted toward commodities, although it also includes some basic manufactured goods. In contrast to Cashin and McDermott, we use higher-frequency (monthly or quarterly) data where possible, use price evidence for a longer time period and are interested not just in aggregate price volatility but in the relative price volatility of commodities and manufactured goods. Note, however, that later in the paper, when using the GARCH framework to model price volatility, we switch to using average price indices rather than individual commodity prices.

TABLE 2.—COMMODITY PRICE DATA SOURCES, 1700–1950

Market and Commodity	Source	Time Period	Number of Commodities
	A: Monthly Data		
Philadelphia	Bezanson, Gray, and Hussey (1936)	1720–1775	19
AF			11
ARM			5
MOM			0
FG			3
Philadelphia	Bezanson et al. (1936)	1770–1790	25
AF			16
ARM			5
MOM			0
FG			4
Philadelphia	Bezanson et al. (1936)	1784–1861	133
AF			51
ARM			31
MOM			12
FG			39
Philadelphia	Bezanson et al. (1954)	1852–1896	100
AF			37
ARM			25
MOM			12
FG			26
Denmark	Friis-Glamann (1958)	1750–1800	29
AF			18
ARM			7
MOM			0
FG			4
The Netherlands	Posthumus (1946)	1750–1800	49
AF			18
ARM			18
MOM			5
FG			8
Britain	Gayer, Rostow, and Schwartz (1953)	1790–1850	69
AF			14
ARM			35
MOM			9
FG			11
World	UNCTAD (2007)	1960–2007	52
AF			23
ARM			12
MOM			17
FG			0
World	International Monetary Fund (2008)	1980–2008	45
AF			27
ARM			10
MOM			8
FG			0
	B: Annual Data		
England	Clark (2005)	1700–1869	36
AF			19
ARM			7
MOM			3
FG			7
Britain	Sauerbeck-Statist (1886–1930)	1850–1950	41
AF			18
ARM			18
MOM			5
FG			0

for 1980 to 2008 and UNCTAD (52 series) for 1960 to 2007. As we shall see in table 6, we also have quarterly data for U.S. export prices for 1880 to 1963.

In panel B, in table 2, two annual series are listed. The English series collected by Gregory Clark (2005) covers 1700 to 1869, and contains 36 items. The Sauerbeck (1886–1917) and Statist (1930) annual British price series cover 1850 to 1950 and contain 41 items. The annual series have, of course, lower frequency, and thus are not exactly comparable to the monthly series, but they do offer the advantage of more observations from the world's most important nineteenth-century market, Great Britain, and, perhaps more important, coverage of the first half of the twentieth-century. Appendix A provides full details for the commodities and classifications employed for the historical price data, and Appendix B repeats the exercise for the IMF and UNCTAD data. Finally, note that a large number of individual commodity price series have been excluded from our data set. In order to ensure comparable results, only goods that span entire sub–periods (for example, wheat in Philadelphia from 1720 to 1775) have been incorporated into our final data set.

Figures 1 through 5 give some visual evidence on the evolution of average commodity price volatility over the period from 1700 to 2008. For all goods prices—whether annual, quarterly, or monthly—a common methodology is followed. First, the price series for individual goods are transformed into index form. For example, in the case of wheat in Philadelphia for 1720 to 1775, the average of prices for 1746 to 1750 is set equal to 100, and an index for the price of wheat for all other years is calculated accordingly. The average value of the price indices across commodities is then computed for each period. Figures 1 through 5 plot the period-over-period difference in the logged commodity price index, or $\ln(P_t/P_{t-1})$. For the longest-running series, that for Philadelphia between 1720 and 1896, sizable month-over-month percentage changes in commodity prices are evident, especially in times of war. However, there appears to be very little long-run trend in the series. This is also true for the monthly commodity price series for the Netherlands, Denmark, and Britain in figure 2. Augmented Dickey-Fuller and Phillips-Perron tests for the presence of unit roots were carried out for each of these monthly differenced commodity price index series. The null of a unit root for all price series was rejected at the 1% significance level under both tests. Further long-run evidence is provided by figure 3, which charts the year-over-year percentage change in commodity prices for England from 1700 to 1950. Again, periods of war and autarky seem broadly correlated with greater commodity price volatility, a theme to which we return below. Figures 4 and 5 provide monthly and quarterly evidence, respectively, for the late nineteenth and twentieth centuries. In both cases, the 1950s and 1960s appear as a period of relatively low volatility, compared with what went before and after. This exception apart, there is no significant evidence of trends in the data here either.

III. Commodity Price Volatility since 1700: Analysis

A. *Have Commodity Prices Always Been More Volatile?*

Have commodities always exhibited greater volatility than manufactures? The answer is unambiguous: yes. Table 3

FIGURE 1.—MONTHLY CHANGES IN COMMODITY PRICES, PHILADELPHIA, 1720–1896

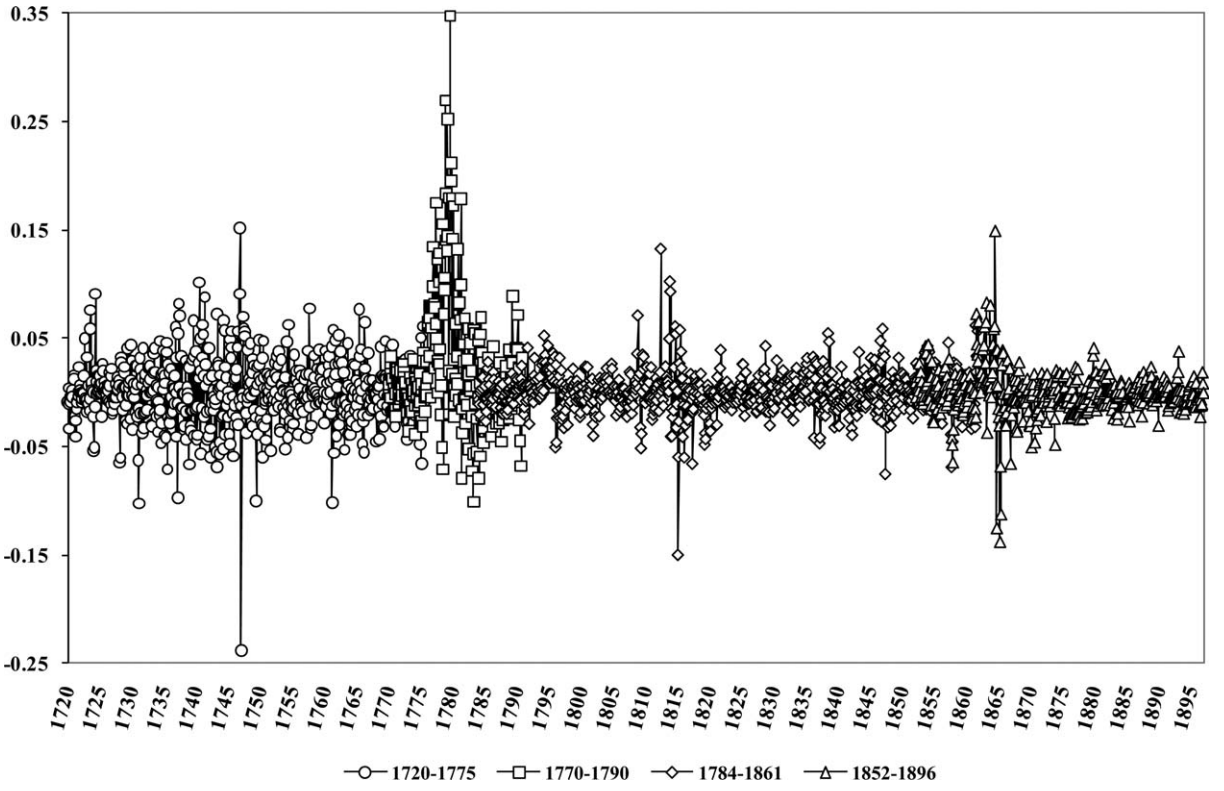


FIGURE 2.—MONTHLY CHANGES IN COMMODITY PRICES, 1750–1850

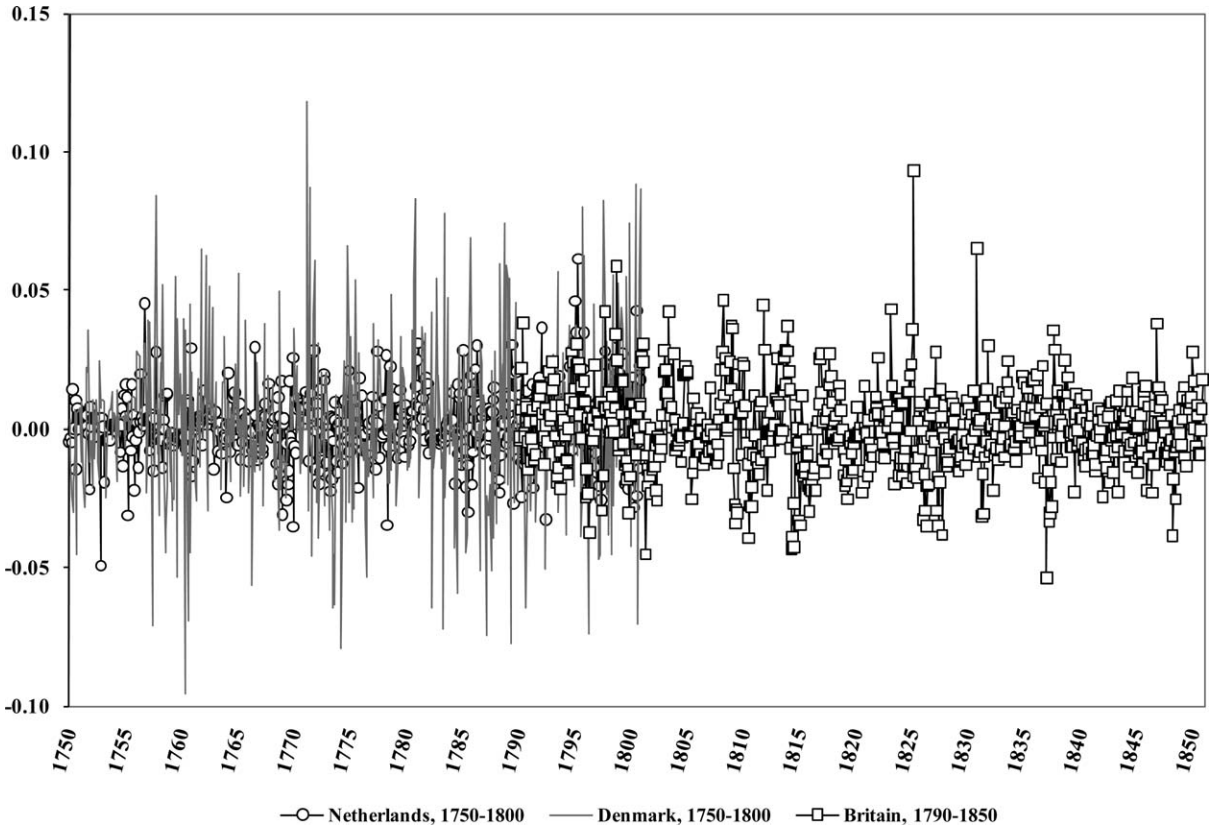
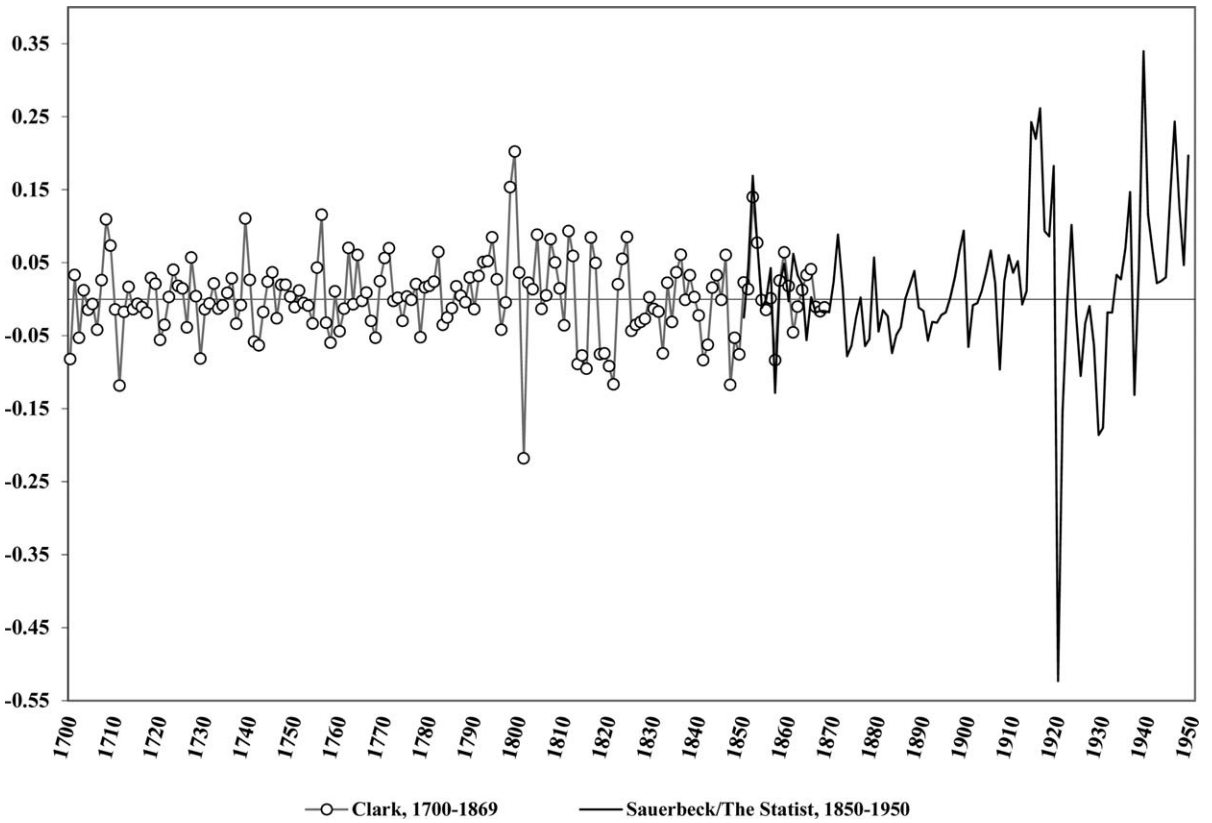
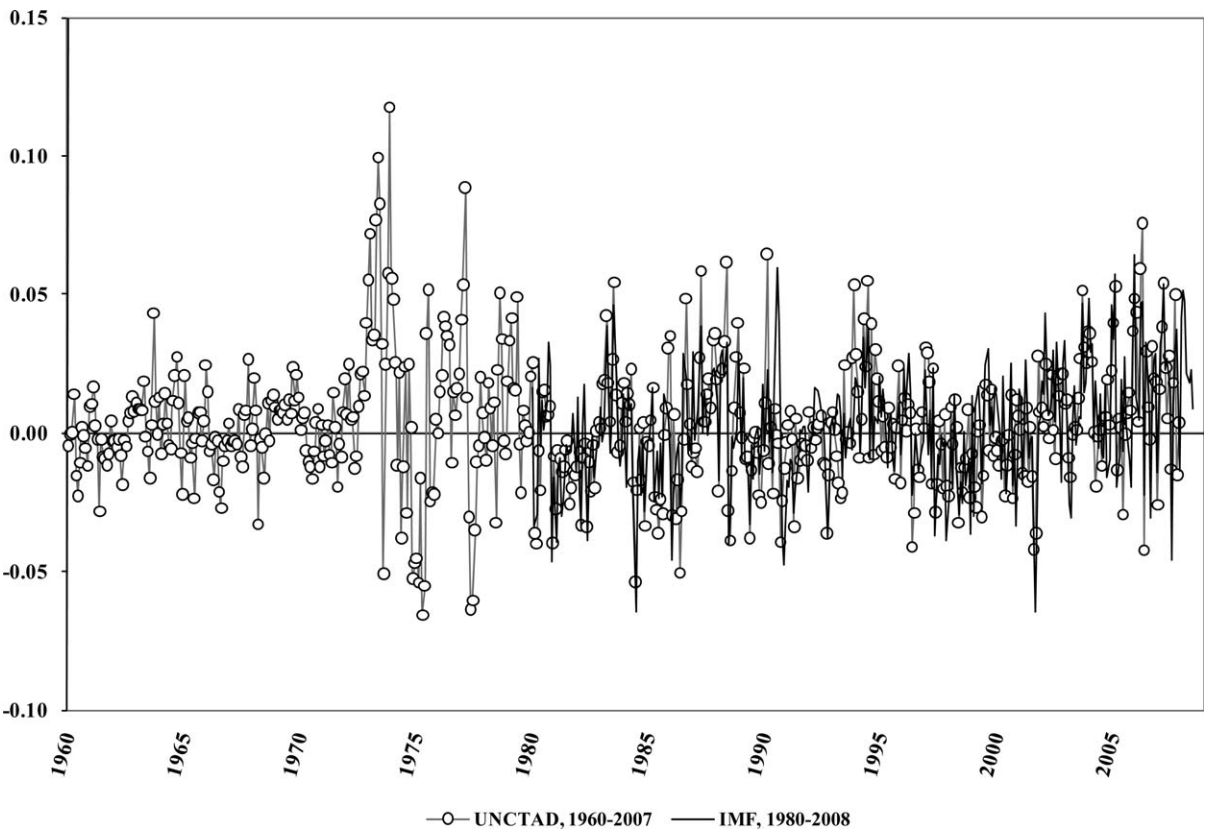


FIGURE 3.—ANNUAL CHANGES IN COMMODITY PRICES, 1700–1950



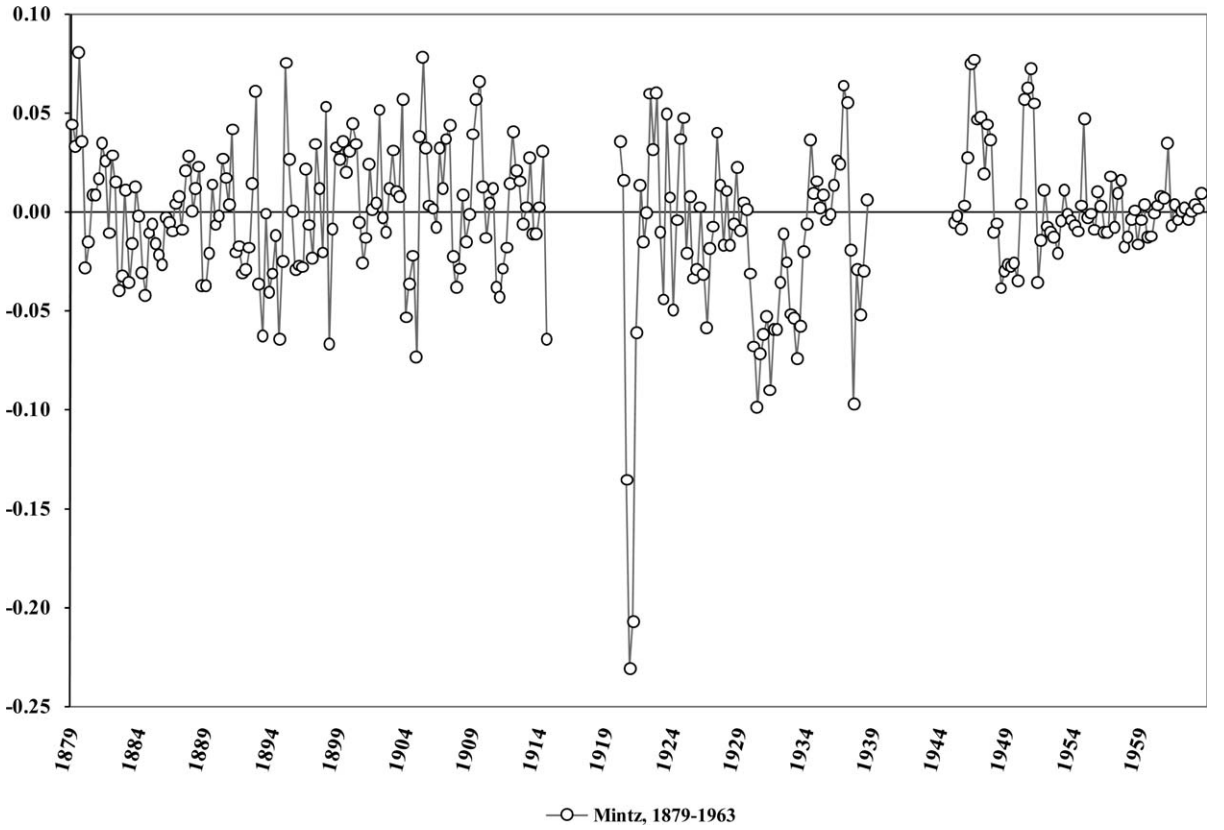
Clark (2005); Statist (1951).

FIGURE 4.—MONTHLY CHANGES IN COMMODITY PRICES, 1960–2008



UNCTAD (2007); IMF (2008).

FIGURE 5.—QUARTERLY CHANGES IN COMMODITY PRICES, 1879–1963



Mintz (1967).

TABLE 3.—COMMODITY VERSUS MANUFACTURES PRICE VOLATILITY, 1700–1896

	All Items (ALL)	Commodities (COM)	Manufactures (FG)	*p*-Value of *F*-Test on the Equality of Volatilities
American prices: Bezanson et al. (monthly)				
1720–1775	0.084	0.085 (101)	0.082 (98)	0.040
1770–1790	0.122	0.126 (103)	0.104 (85)	0.000
1784–1861	0.067	0.073 (109)	0.048 (72)	0.000
1852–1896	0.074	0.079 (107)	0.056 (76)	0.000
1873–1884	0.068	0.072 (107)	0.051 (76)	0.000
1885–1896	0.052	0.058 (110)	0.032 (60)	0.000
English prices: Clark (annual)				
1700–1819	0.137	0.143 (104)	0.108 (79)	0.000
1820–1869	0.131	0.137 (105)	0.105 (80)	0.000
British prices: Gayer-Rostow-Schwartz (monthly)				
1790–1819	0.056	0.057 (102)	0.051 (91)	0.000
1820–1850	0.056	0.057 (102)	0.047 (84)	0.000
Dutch prices: Posthumus (monthly)				
1750–1800	0.043	0.044 (102)	0.037 (86)	0.000
Danish prices: Friis-Glamann (monthly)				
1750–1800	0.076	0.082 (108)	0.020 (26)	0.000

The Sauerbeck-Statist series does not report data for FG, so it is not used in this table. The numbers in parentheses under the COM and FG entries are relative to the total = ALL. Volatility is defined as the standard deviation of monthly changes in logged prices.

reports the price volatility of all items, primary product commodities (COM), and final manufactured goods (FG) for the two centuries between 1700 and 1896. Volatility throughout this section is calculated as the unweighted standard deviation of period-over-period percentage changes in price across all commodities. Thus, rather than considering a single aggregate commodity price index, we prefer to use all the available data on individual commodities. This metric has been widely used in the macroeconomics literature, and we follow this lead here.[5]

[5] The results presented here are invariant to employing another definition of price volatility, namely, calculating the standard deviation of period-over-period changes in prices for every commodity price series individually and then averaging across all commodities. Details are available on request.

In the first row of table 3, we calculate our metric for volatility over the entire set of 672 (=56×12) monthly observations available for the nineteen commodities in Philadelphia from 1720 to 1775. In the case of annual prices, as in the seventh row of table 3—that for England from 1700 to 1819—we likewise gather all available observations on the logged price ratio (in this case, 120) and calculate the standard deviation. The volatility of COM and FG relative to all items is also reported in parentheses. In every case over these 200 years, the relative volatility indicator is less than 100 for FG. In some cases where the FG sample is very small, the difference between the volatility of the two commodity categories is small. This is particularly true of the data for 1720 to 1775 in Philadelphia, where we have just three observations for the FG category (and they are all for spirits). However, even in this case, an *F*-test on the equality of variances suggests that the volatilities of COM and FG are significantly different from one another (table 3, column 3). Apart from that case, price volatility for manufactured goods ranged from 74% less (Denmark, 1750–1800) to 9% less (Britain, 1790–1819) than the average volatility for all goods. The unweighted average between 1700 and 1896 tells us that manufactured goods prices were 25% less volatile than all items, while commodity prices were 5% more volatile; alternatively, the price volatility for commodities was 40% higher than for manufactures.

The figures for U.S. export price volatility, 1880–1963 (table 6), are very similar: manufactured goods prices had 25% less volatility than all items, while commodity prices had 19% more; alternatively, the price volatility of commodities was 59% higher than that of manufactures.

While commodity prices have always been more volatile than those of manufactures, given what we know about the much greater terms-of-trade volatility in poor countries than in rich (Williamson, 2008, 2011), one might have expected an even bigger difference than the 40% to 59% average over the two and a half centuries before 1950. Recall, however, that the higher terms-of-trade volatility in primary product exporting countries has two parts: they specialize in commodities that are 40% to 59% more price volatile, and they have higher product concentration and thus lower diversification.

The results in table 3 offer little support for the hypothesis that commodity prices became more volatile than industrial prices because movements in the latter have been dampened by the rise of the modern industrial corporation. If this were the case, then the gap between the volatility for the two categories should have emerged only in the late nineteenth century. To be sure, the data for Philadelphia indicate that the difference between COM and FG was notably less pronounced before 1790 than afterward, but as has been suggested already, this may be a function of the small number of goods included in the database for the earlier years. More to the point, the timing of this shift is too early to fit the Prebisch hypothesis. Moreover, there is little difference between the relative volatility of manufactured goods prices during the two subperiods 1784 to 1861 and 1852 to 1896 (with the relative volatility of industrial prices actually being somewhat lower in the latter period). As the next section will make clear, the latter comparison may be affected by the fact that both subperiods included episodes of war as well as of peace, and so table 3 also provides a comparison between 1873 to 1884 and 1885 to 1896. These results do show a decline in the relative volatility of manufactured goods over the course of the late nineteenth century, and the timing here is consistent with the rise of the modern corporation. Overall, however, the main message emerging from these data is that commodity prices have been more volatile than manufactured goods prices over the past three centuries, not just today, or since 1950 when Singer and Prebisch were writing, or even since 1870, which marked the start of W. Arthur Lewis's new international economic order (Lewis, 1978).

B. Have Commodity Prices Become More Volatile over Time?

Has the price volatility of commodities risen over time, so that modern commodity exporters suffer more economic volatility than they did 300 years ago? The answer here is again unambiguous, but this time, it is no. This finding requires two qualifications. First, since it is unwise to make comparisons between market locations—the samples being different between them—we can explore this question only by looking within market locations. Table 3 offers no support for the rising volatility hypothesis within the Philadelphia 1720–1896 series, within the English 1700–1869 series, or within the British 1790–1850 series. Table 4 offers more evidence, since the Sauerbeck-Statist data have been added. Comparing peacetime with peacetime (see below), the Clark data show higher volatility between 1820 and 1860 than between 1700 and 1775; however, the Sauerbeck-Statist data show no evidence of a secular peacetime rise from 1850 onward, and the same is true of U.S. export prices from 1880 to 1963 (table 6). We will have more to say about the war and interwar evidence in a moment.

The second qualification to this finding comes from the post-1960 data in table 5. Neither the IMF nor the UNCTAD data show a clear rising trend in commodity price volatility from the 1980s onward. However, the UNCTAD data do show that price volatility was considerably lower in the 1960s than subsequently. In order to conclude unambiguously that this constituted an upward trend following World War II rather than that the 1960s were simply a period of unusually low price volatility, we would need data documenting the late 1940s and 1950s compared to what followed. Mintz (1967, table A-3) offers the only evidence that we have been able to uncover that can be used to confront the issue of unusually low price volatility during this period, and her quarterly data are used to calculate the price volatility reported in table 6. U.S. export prices between 1950 and 1963 exhibited about one-third the

TABLE 4.—PRICE VOLATILITY DURING WAR, PEACE, AND AUTARKY 1700–1950

	1700–1775 Peace	1776–1819 War	1820–1860 Peace	1850–1860 Peace	1861–1872 War	1873–1896 Peace
Monthly: Bezanson	0.0647	0.1431				
Monthly: Bezanson		0.0731	0.0621			
Monthly: Bezanson				0.0743	0.1005	0.0610
Monthly: Friis-Glamann (1958)	0.0744	0.0784				
Monthly: Posthumus (1946)	0.0395	0.0464				
Monthly: Gayer et al. (1953)		0.0564	0.0559			

	1700–1775 Peace	1776–1819 War	1820–1860 Peace	1850–1860 Peace	1861–1872 Peace	1873–1896 Peace	1897–1913 Peace	1914–1950 War and Autarky
Annual: Clark (2005)	0.1180	0.1475	0.1321					
Annual: Sauerbeck-Statist				0.1251	0.1193	0.1153	0.1153	0.2205

The volatility statistics are for ALL = all items. Clark's English data for 1861–1869 are ignored since the U.S. Civil War did not directly affect England except for the cotton famine. Volatility is defined as the standard deviation of monthly changes in logged prices.

TABLE 5.—MODERN COMMODITY PRICE VOLATILITY, 1960–2005

	All Commodities	Food	Agricultural Raw Materials	Minerals, Ores, and Metals
UNCTAD data				
1960–1965	0.0493	0.0553	0.0462	0.0422
1965–1970	0.0497	0.0576	0.0414	0.0436
1970–1975	0.0776	0.0867	0.0745	0.0667
1975–1980	0.0672	0.0805	0.0593	0.0527
1980–1985	0.0618	0.0752	0.0532	0.0483
1985–1990	0.0735	0.0827	0.0625	0.0698
1990–1995	0.0679	0.0822	0.0535	0.0541
1995–2000	0.0593	0.0709	0.0502	0.0453
2000–2005	0.0603	0.0711	0.0498	0.0525
2005–2007	0.0691	0.0665	0.0512	0.0848
IMF data				
1980–1985	0.0701	0.0772	0.0582	0.0573
1985–1990	0.0763	0.0820	0.0602	0.0742
1990–1995	0.0713	0.0793	0.0598	0.0538
1995–2000	0.0668	0.0738	0.0610	0.0460
2000–2005	0.0634	0.0694	0.0511	0.0557
2005–2008	0.0803	0.0804	0.0608	0.0990

UNCTAD (2008) and IMF (2008). Volatility is defined as the standard deviation of monthly changes in logged prices.

volatility that they did between 1880 and 1950. Prices of U.S. food and finished manufactured exports exhibited pretty much the same pattern, as did prices of U.S. semimanufactured and crude material exports (although neither can be documented over the full period). We also know that the 1960s was a period of macroeconomic and exchange rate stability, relative to what came subsequently, and this might perhaps explain the contrast between what is called the Bretton Woods period and what followed. Indeed, Cuddington and Liang (2003) show that over the period 1880 to 1996, there was greater volatility in the relative price of commodities to manufactured goods during periods of floating exchange rates than during periods of fixed exchange rates. The evidence in tables 5 and 6 shows that what was true of this relative price was also true of both the numerator and the denominator by themselves. This result mirrors the findings reported by Cashin and McDermott (2002) that there was an increase in the volatility of the *Economist*'s industrial commodity price index after 1971.

C. *Are Commodity Prices More Volatile during War and Antiglobal Autarkic Regimes?*

If local shocks to supply and demand matter less for domestic prices when the local economy trades with the large world economy, commodity prices should be less volatile when the world is more pro-global. Thus, did commodity prices become less volatile when the world went global in the nineteenth century after the European wars, and did commodity prices become more volatile when the world went autarkic between the world wars? Table 4 strongly confirms these predictions.

First, consider the wars of 1776 to 1815, which severely disrupted commodity markets worldwide (O'Rourke, 2006), especially in the Atlantic economy from whence our data are drawn. The Clark and Gayer-Rostow-Schwartz series for England, the Friis-Glamann series for Denmark, the Posthumus series for the Netherlands, and the Bezanson series for Philadelphia all show higher price volatility during war (1776–1819) than in either the previous or the subsequent period. In all cases bar one (the Gayer et al. series), the differences between subperiods are statistically significant.[6] It seems that the French and American Revolutionary Wars, the Napoleonic Wars, and the War of 1812 did not just lead to terms-of-trade deteriorations across the Atlantic economy, and hence to sizable welfare losses (Irwin 2005; O'Rourke, 2007). They also increased price volatility. The historical evidence suggests that, price volatility had the same negative impact on investment a century or two ago as it does in developing countries today (Roumasset, 1976; Roumasset, Boussard, & Singh, 1979; Rosenzweig & Wolpin, 1993; Jacoby & Skoufias, 1997; Frankenberg et al., 1999; Jensen, 2000; Bleaney & Greenaway, 2001; Fafchamps, 2003; Dercon, 2004; Thomas et al., 2004). Following their lead, and taking United Kingdom country-specific capital exports as a proxy for missing poor country investment data, Blattman, Hwang, and Williamson (2007) were

[6] The p-value of an F-test on the equality of variances in the latter case is equal to 0.1467.

TABLE 6.—VOLATILITY OF U.S. EXPORT PRICES, 1880–1963

	Total	Finished Manufactures	Semimanufactures and Crude Materials	Semimanufactures	Crude Materials	Foods
1880–1885	0.0246	0.0277	0.0234			0.0341
1885–1890	0.0302	0.0167	0.0174			0.0254
1890–1895	0.0376	0.0254	0.0538			0.0405
1895–1900	0.0366	0.0322	0.0448			0.047
1900–1905	0.0359	0.0181	0.0633			0.0226
1905–1910	0.0308	0.0117	0.0606			0.027
1910–1914	0.0279	0.0128	0.0405			0.0283
1920–1925	0.0627	0.0428		0.0639	0.1184	0.0921
1925–1930	0.0295	0.0231		0.0349	0.0736	0.0425
1930–1935	0.0376	0.0505		0.0392	0.0612	0.0487
1935–1938	0.0264	0.0177		0.0494	0.0505	0.0459
1945–1950	0.039	0.0432		0.0395	0.0358	0.0515
1950–1955	0.0206	0.0164		0.0415	0.0366	0.0366
1955–1960	0.0082	0.0073		0.0347	0.0142	0.0137
1960–1963	0.0089	0.0074		0.0141	0.0176	0.0066
1950–1963	0.0125	0.0104		0.0225	0.0216	0.0177
1880–1950	0.0349	0.0263				0.0417

These volatility measures are based on the quarterly data reported in Mintz (1967, table A-3). Volatility is defined as the standard deviation of monthly changes in logged prices.

able to show that for the period 1870 to 1940 a 1 standard deviation increase in volatility was associated with a 33% to 58% decrease in capital inflows into poor countries. During episodes of international conflict (and greater autarky), more price volatility would have reduced growth over and above the negative effects that wartime investment crowding out would have implied on its own (Williamson, 1984) and could thus help to explain the relatively slow growth experienced during the British Industrial Revolution.

These data can also be used to explore the impact of the American Civil War on commodity price volatility. Again, we know from the literature on the cotton famine that the Civil War had an impact on the terms of trade in cotton-importing and cotton-exporting parts of the world, but did it increase commodity price volatility? In Britain, which was not a belligerent, the answer appears to be no, according to the Sauerbeck-Statist evidence. Britain's terms of trade may have deteriorated as a result of greater U.S. cotton scarcity, but it was still trading freely with the rest of the world, and there was no increase in price volatility there. The United States underwent a quite different experience: the Bezanson price data show a very large (and statistically significant) increase in volatility between 1861 and 1872 as compared to what came before or after, a result consistent with the fact that much of the American economy was cut off from world markets during the conflict. The biggest antiglobal world regime in our period, however, was 1914 to 1950, which saw two world wars and an intervening period characterized by depression and autarky. During the four decades 1914 to 1950, price volatility was twice as great as it was in the peacetime decades that preceded them, at least according to the Sauerbeck-Statist evidence. The Mintz quarterly price data, whose volatility is summarized in table 6, certainly confirm this finding for the autarkic interwar decades: the average volatility figure for all commodities 1920 to 1950 is 0.039, or half again higher than the average for 1880 to 1914 and 1950 to 1963 (0.026). This result mirrors that of Frederick Mills (1926) who almost a century ago found that two-thirds of the commodities whose prices he was investigating displayed greater price volatility during 1922 to 1925 than during 1906 to 1913. His conclusion was that "the influence of the wartime disturbances upon individual prices has persisted, apparently, and, in so far as the four years from 1922 to 1925 may be used as a criterion, has left us with more variable prices than we had during the years immediately preceding the war" (p. 46).

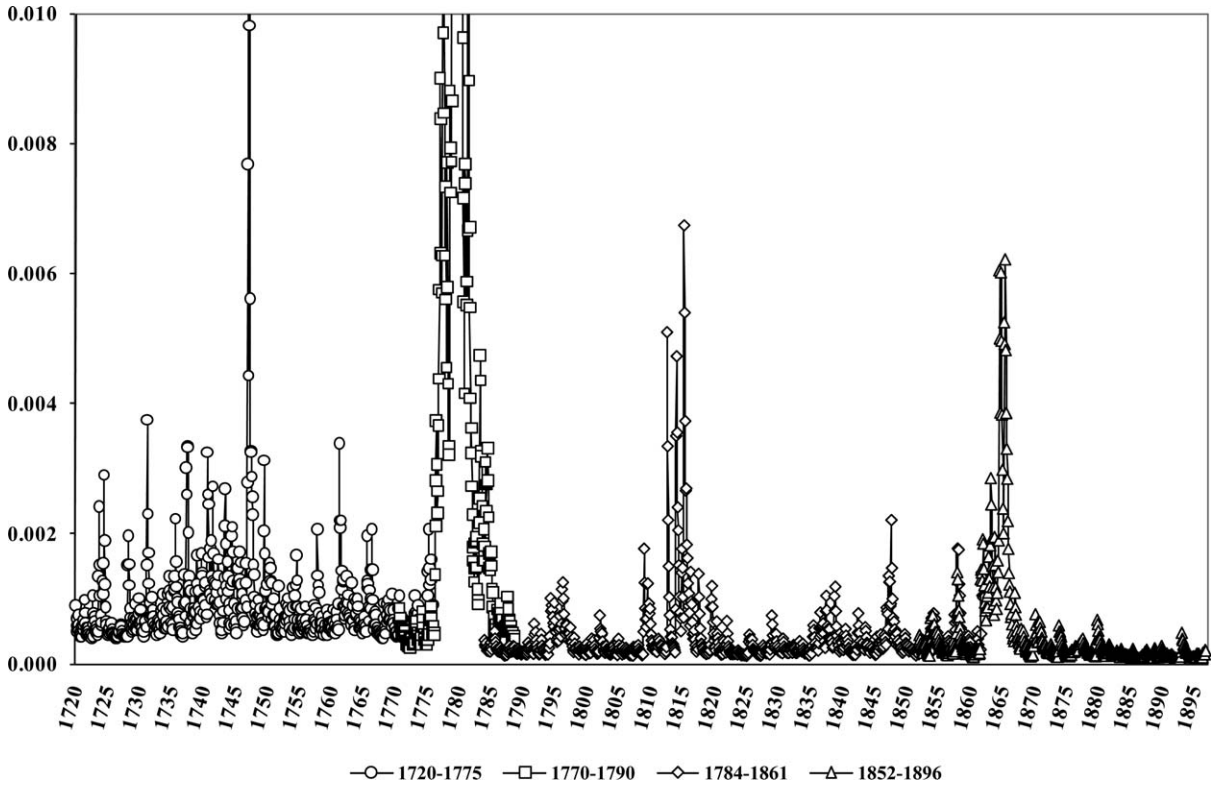
As previously mentioned, Cuddington and Liang (2003) have explored the volatility of the price of commodities relative to the price of manufactured goods. Using Grilli and Yang data (1988), they find that volatility was lower between 1946 and 1971 than in any other subperiod between 1914 and 1938 (although volatility then increased substantially after 1972).[7] Cashin and McDermott (2002) find that the *Economist*'s annual industrial commodity price index from 1862 to 1999 documents a volatility increase in the early 1900s (with World War I appearing to be an important break point), and again after 1971. Unfortunately they do not present the data in such as way as to be able to see clearly if the Bretton Woods period saw lower volatility than the 1914–1950 period. However, and as we have seen, the Mintz data in table 6 do confirm lower price volatility during the Bretton Woods era.

D. Robustness

Finally, we consider a more rigorous exercise that models commodity price changes as a GARCH(1,1) process. Beginning with the work of Engle (1982) and especially Bollerslev (1986), the generalized autoregressive condi-

[7] On the other hand, using the Boughton (1991) data, they find that although 1946–1971 volatility was lower than 1927–1938 volatility, it was higher than volatility between 1914 and 1926, and that volatility after 1972 was higher still.

FIGURE 6.—CONDITIONAL VARIANCE OF COMMODITY PRICES, PHILADELPHIA, 1720–1896



tional heteroskedastic (GARCH) framework has proved to be an extremely robust approach to modeling the volatility of time-series data. This success is mainly attributable to its recognition of the difference between unconditional and conditional variances and its incorporation of long memory in the data-generating process and a flexible lag structure. In general, where e_t is the t^{th} error term from an autoregressive model, the GARCH(p,q) specification assumes that the conditional variance equals

$$\sigma_t^2 = E\left(e_t^2|\Omega_t\right) = \alpha + \sum_{i=1}^{p} \gamma_i e_{t-i}^2 + \sum_{j=1}^{q} \delta_j \sigma_{t-j}^2. \qquad (1)$$

Thus, the conditional variance depends on its own past values as well as lagged values of the residual term. Even in a very parsimonious GARCH(1,1) specification, the time-series behavior of changes in commodity prices is well captured, as noted by Deb, Trivedi, and Varangis (1996), among others.

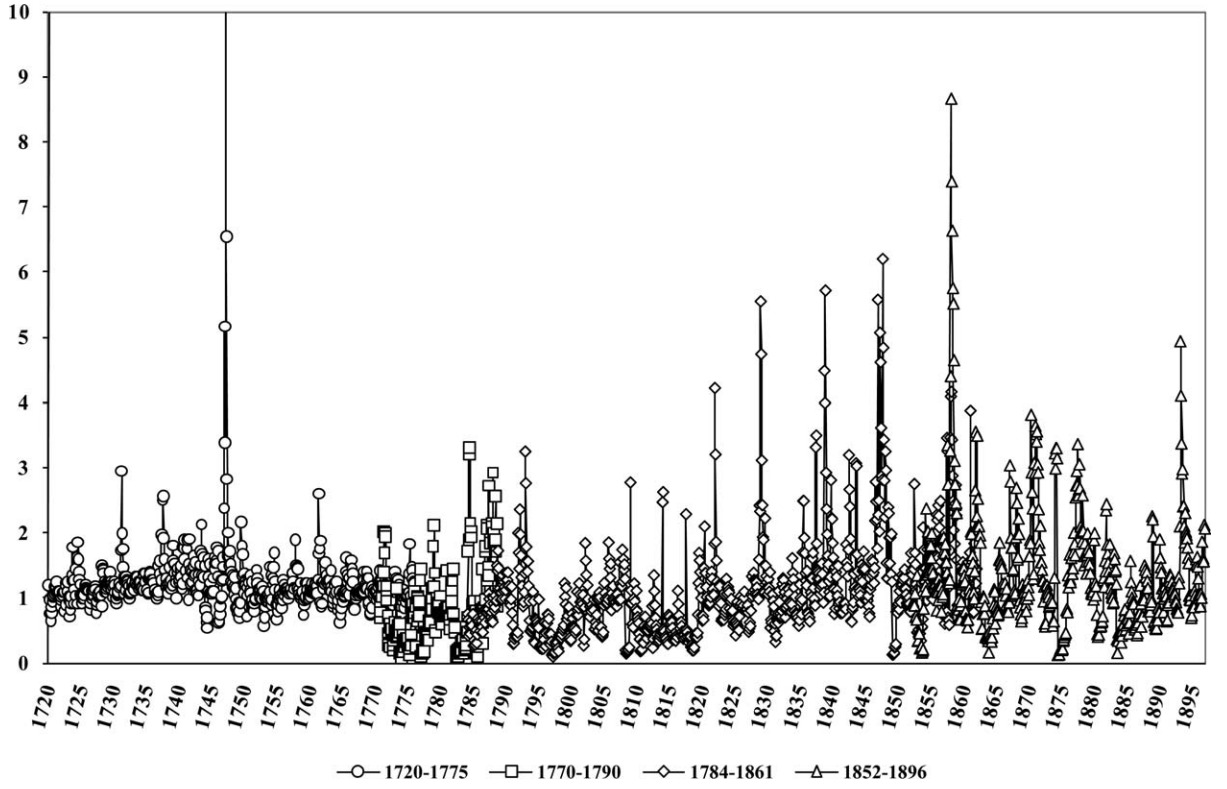
The use of GARCH also addresses the concern that by using the standard deviation of period-over-period percentage changes in prices, we are in effect capturing ex post outcomes rather than ex ante perceptions of commodity price volatility. By now, it has become standard to treat the conditional variance recovered from estimating a GARCH process as just such an ex ante measure of commodity price volatility. Thus, the conditional variance should fully incorporate any systematic changes in prices that might impart greater volatility to commodities but are fully anticipated by market participants, for example, any seasonality in agricultural prices.

Here, we use the commodity price indices underlying figure 1 for Philadelphia. Again, the price series for individual commodities have been transformed into index form. For example, in the case of wheat in Philadelphia for 1720 to 1775, the average of prices in the period 1746 to 1750 is set equal to 100, and an index for the price of wheat for all other years is calculated accordingly. The average value of the price indices across commodities is then computed for each period. This average is then first differenced and estimated as a GARCH(1,1) process. The resulting series of conditional variances for Philadelphia in the period from 1720 to 1896 is plotted in figure 6.

The results corroborate the findings above regarding whether commodity prices have become more volatile over time, in that the conditional variances demonstrate little trend over these two hundred years. The series also demonstrate the marked effects of conflict on commodity price volatility, with the spikes in conditional variance almost exclusively being associated with times of war.

As to the question of whether commodity prices have always been more volatile than manufactures, we can perform a similar exercise with the price series for finished goods at our disposal. Again, the price series for individual finished goods have been transformed into index form. The average value of the price indices across finished goods is then computed for each period. This average is then first differenced and estimated as a GARCH(1,1) process. We

FIGURE 7.—RATIO OF CONDITIONAL VARIANCES, COM VERSUS FG, PHILADELPHIA, 1720–1896



then plot the ratio of conditional variances for the commodity price series versus the finished-good price series in figure 7. Values of this ratio greater than 1 would then suggest higher commodity price volatility relative to finished-good price volatility. Consistently, over this entire period, commodity prices are shown to be more volatile, with the average value of the ratio being equal to 1.1507.

IV. Conclusion

This paper was motivated by the common observation that poor countries are more volatile than rich countries and that this volatility impedes their growth performance. Here we explore price data for primary products (commodities) and manufactures over the past three centuries to answer three questions. First, has commodity price volatility increased over time? The answer is unambiguously no. Indeed, there is little evidence of a trend since 1700. Second, have commodities always shown greater price volatility than manufactures? The answer is unambiguously yes. Higher commodity price volatility is not some Prebisch-like modern product of asymmetric industrial organization—monopolistic and oligopolistic manufacturing versus competitive commodity markets—that appeared only with the industrial revolution. Instead, it was a fact of life deep in the preindustrial eighteenth century. Third, do globalization and world market integration breed more or less commodity price volatility? The answer is less. One can imagine a tug of war between two offsetting forces: on the one hand, the impact of supply shocks in commodity-exporting countries is diminished by the integration of small local markets with large world markets; but on the other hand, by their integration into world markets, commodity-exporting countries expose themselves to world demand instability generated by cyclical booms and busts in the industrial countries. Three centuries of history show unambiguously that the former effect dominates the latter: economic isolation caused by war or autarkic policy has been associated with much greater commodity price volatility, while world market integration associated with peace and pro-global policy has been associated with less commodity price volatility.

Given specialization and comparative advantage, globalization has been good for growth in poor countries to the extent that it has reduced commodity price volatility. But, of course, specialization is not given, but rather is endogenous to policy regimes. Thus, globalization also increased poor country specialization in commodities after the world went open in the early nineteenth century, but it did not do so after the 1970s as the Third World shifted to labor-intensive manufactures (Martin, 2007). Whether the price volatility or the specialization effect dominates may thus be conditional on the century. In any case, since this issue deals with countries, while this paper deals with individual commodities, the answer must be left to future research.[8]

[8] Some answers are already beginning to emerge in Blattman et al. (2007) and Williamson (2011).

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APPENDIX A

Commodity Classifications for Historical Price Data

Philadelphia, 1720–1775

AF: Beef; Bread, middling; Corn; Flour; Molasses; Pork; Rice; Salt, coarse; Salt, fine; Sugar, Muscavado; Wheat
ARM: Pitch; Staves, hogshead; Staves, pipe; Tar
FG: Rum, West Indian; Turpentine; Wine, Madeira

Philadelphia, 1770–1795

AF: Beef; Bread, ship; Chocolate; Coffee; Flour, common; Flour, middling; Flour, superior; Molasses; Pepper; Pork; Rice; Sugar, loaf; Sugar, Muscavado; Tea, Bohea; Wheat
ARM: Cotton; Indigo; Leather, sole; Tar; Tobacco
FG: Iron, bar; Rum, West Indian; Turpentine; Wine

Philadelphia, 1786–1861

AF: Almonds; Beef; Beef, mess; Bread; Bread, pilot; Butter; Cheese; Chocolate; Clove; Cocoa; Codfish, dried; Coffee; Corn; Corn meal; Currents; Flaxseed; Flour, superfine; Ginseng; Hams; Herring; Honey; Lard; Lemons; Mace; Mackerel; Mackerel 1; Mackerel 3; Molasses; Nutmeg; Oats; Peas; Pepper; Pimento; Pork; Pork, Burlington & mess; Pork, prime; Raisins; Rice; Rye; Rye meal; Salt, coarse; Salt, fine; Sugar, Havana brown; Sugar, Havana white; Sugar, loaf and lump; Tea; Tea, Hyson; Tea, Souchong; Wheat
ARM: Beaver; Beeswax, yellow; Cotton; Deer skins; Feathers; Flax; Fustic; Hemp, Russian; Hides; Indigo; Leather; Logwood; Logwood, Campeachy; Muskrat; Oil, linseed; Oil, sweet; Oil, sperm; Oil, whale; Pine, heart and panel; Pine, sap; Pitch; Rosin; Spirits of turpentine; Starch; Staves, barrel; Staves, hogshead; Staves, pipe; Tallow; Tar; Tobacco, James River; Tobacco, Kentucky
MOM: Alum; Ashes, pearl; Ashes, pot; Brimstone, rolls; Coal, Virginia; Copper, sheathing; Lead; Lead, red dry; Lead, white dry; Lead, white in oil; Saltpeter, refined; Verdigris
FG: Brandy, French; Candles, sperm; Candles, tallow; Candles, tallow tipped; Candles, tallow mold; Copperas; Cordage, foreign; Duck, bear ravens; Gin, Holland; Ginger, ground; Gunpowder; Iron, bar domestic; Iron, bar foreign; Iron, bar Swedish; Iron, pig; Iron, sheet; Nails; Plaster of Paris; Rum, New England; Sheeting, Russian brown; Shingles; Shot; Soap, Castile; Soap, white; Soap, yellow; Spanish Brown, dry; Spanish Brown, in oil; Steel, American; Steel, English; Steel, German; Steel, T Crowley; Tin, plate; Turpentine; Wine, Lisbon; Wine, Madeira; Wine, Malaga; Wine, port; Wine, sherry; Wine, Tenerife cargo

Philadelphia, 1852–1896

AF: Almonds; Beef, dried; Beef, hams; Beef, mess; Butter; Cheese; Cloves; Cocoa; Codfish, dried; Coffee; Corn; Corn meal; Currants; Flour, Superfine; Ginger, race; Hams; Herring; Lard; Lemons; Mace; Mackerel; Molasses; Nutmeg; Oats; Pepper; Pimento; Pork, Burlington and mess; Raisins; Rice; Rye; Salt, coarse; Salt, fine; Sugar, loaf and lump; Tea; Tea, Hyson; Tea, Souchong; Wheat, red Pennsylvania
ARM: Beaver; Beeswax, yellow; Cotton, LA & MS; Deer skins; Feathers; Fustic; Hemp, Russian; Hides; Indigo; Leather; Logwood; Logwood, Campeachy; Muskrat; Oil, linseed; Oil, sperm; Oil, whale; Pine, heart and panel; Pitch; Rosin; Starch; Staves, barrel; Staves, hogshead; Staves, pipe; Tallow; Tar
MOM: Alum; Ashes, pearl; Ashes, pot; Brimstone, rolls; Coal, bituminous; Copper, sheathing; Lead, bar; Lead, red dry; Lead, white dry; Lead, white in oil; Saltpeter, refined; Verdigris
FG: Candles, adamantine; Candles, sperm; Copperas; Cordage, foreign; Gin, Holland; Gunpowder; Iron, bar domestic; Iron, pig; Iron, sheet; Nails; Plaster of Paris; Rum, New England; Sheeting, Russian brown; Shingles; Shot; Soap, Castile; Spirits of turpentine; Steel, American; Steel, English; Steel, German; Tin, plate; Wine, Madeira; Wine, Malaga; Wine, port; Wine, sherry

Britain, 1790–1850

AF: Beef; Butter; Cinnamon; Cocoa; Coffee; Ginger; Liqourice; Oats; Pepper; Pork; Seeds; Sugar; Tea; Wheat
ARM: Annato; Balsam; Barilla; Beeswax; Bristles; Camphor; Cochineal; Cotton; Flax; Fustic; Hemp; Hides; Indigo; Isinglass; Leather butts; Linseed; Linseed oil; Logwood; Madder root; Mahogany; Olive oil; Quinine; Rape oil; Raw silk; Starch; Staves; Sumac; Tallow; Tar; Timber; Tobacco; Whale fins; Whale oil; Wool
MOM: Alum; Ashes; Brimstone; Copper; Lead; Quicksilver; Sal Ammoniac; Saltpetre; Vitriol
FG: Brandy; Iron; Iron, bars; Iron, pig; Rum; Silk, thrown; Soap, mottled; Soap, yellow; Tin, black; Turpentine; Wine

Denmark, 1750–1800

AF: Bacon; Barley; Barley groats; Buckwheat groats; Butter, Funen; Cheese, Holstein; Cod, Icelandic salted; Cod, split; Herring, Danish autumn; Malt; Oatmeal; Oats; Peas; Rye, Danish; Salt, Copenhagen; Salt, Spanish; Stockfish, Icelandic; Wheat, Danish
ARM: Beechwood, Holstein; Flax; Hemp; Hops, Brunswick; Tallow; Tar; Train oil
FG: Brandy, French; Iron, Norwegian; Soap, soft; Wine, French

The Netherlands, 1750–1800

AF: Barley, Frisian winter; Beans, horse; Buckwheat, Brabant; Candy, white; Cinnamon; Cloves; Cocoa, Caracas; Nutmeg; Oats, forage; Rye, Konigsberg; Salt, white; Stockfish, split; Sugar, loaf; Sugar, refined; Sugar, Surinam; Tea, Buoy; Treacle; Wheat, Polish
ARM: Camphor, refined; Codliver oil; Coleseed, Flemish; Cotton, Smyrna; Hides, native, salted; Indigo, Java; Linseed, Riga, crushed; Linseed oil; Madder, common; Opium; Rape oil; Sole leather;

Starch; Tobacco; Train, oil; Whale bones; Wool, Andalusian; Wool, Segovia, washed
MOM: Alum, English; Borax, refined; Lead, white; Potash, Dantzig; Sulphur, refined
FG: Copperas, English; Gunpowder; Iron, single, white; Sail yarn; Soap, Marseilles; Thread, card, Maastricht; Turpentine, Venetian; Wine, Bordeaux

England, 1700–1869

AF: Barley; Beans; Beef; Beer, strong; Butter; Cheese; Eggs; Flour; Milk; Mutton; Oats; Peas; Pork; Raisins; Rice; Salt; Sugar; Wheat; Wheat flour
ARM: Firewood; Hay; Hops; Lamp oil; Suet; Wood; Wool
MOM: Coal; Coal, London; Coal, rest of England
FG: Candles, tallow; Cloth, wool; Clothing; Iron manufactureds; Paper, foolscap; Shoes; Soap

Britain, 1850–1950

AF: Bacon; Barley; Beef, middling; Beef, prime; Butter; Coffee, Ceylon; Coffee, Rio; Flour; Maize; Mutton, middling; Mutton, prime; Oats; Pork; Potatoes; Rice; Sugar, Java; Tea; Wheat, English
ARM: Cotton; Cotton, Dollegargh; Flax, Russian; Hemp, Manila; Hemp, Russian; Hides, Argentine; Indigo; Jute; Leather; Linseed oil; Olive oil; Palm oil; Seeds; Silk; Timber, hewn; Wool, Adelaide; Wool, English; Wool, Merino
MOM: Coals, Export; Coals, Wallsend; Copper, Chile; Lead; Nitrate

APPENDIX B

Commodity Classifications for Modern Price Data

IMF, 1980–2008

AF: Bananas, Central American and Ecuador; Barley, Canadian no.1 western; Beef, Australian and New Zealand lean fores; Cocoa beans; Coffee, other mild arabicas; Coffee, robusta; Fish, farm bred Norwegian salmon; Groundnuts; Lamb, frozen carcass Smithfield London; Maize, U.S. No. 2 yellow; Olive oil, extra virgin; Oranges; Palm oil; Poultry, whole chicken; Rapeseed oil, Crude; Rice, milled white; Shrimp, frozen shell-on headless; Soybean meal; Soybean oil, exchange approved grades; Soybeans, United States No. 2 yellow and par; Sugar, European import price; Sugar, Free Market; Sugar, U.S. import price; Sunflower oil; Swine, hogs; Tea, Mombasa; Wheat, No.1 hard red winter
ARM: Cotton, middling; Fishmeal, Peru fish meal/pellets; Hides, heavy native steers; Logs, hard, best quality Malaysian meranti; Logs, soft, Douglas fir; Rubber, no.1 rubber smoked sheet; Sawnwood, hard, dark red meranti; Sawnwood, soft, Douglas fir; Wool, coarse; Wool, fine
MOM: Coal, Australian thermal; Copper, grade A cathode; Iron ore, fine; Lead; Nickel, melting grade; Tin, standard grade; Uranium, u3o8; Zinc, high grade

UNCTAD, 1960–2007

AF: Bananas, Central America and Ecuador; Beef, Australia and New Zealand, frozen boneless; Cocoa beans; Coconut oil, Philippines; Coffee, Brazilian and other natural arabicas; Coffee, Colombian mild arabicas; Coffee, other mild arabicas; Coffee, robustas; Copra, Philippines/Indonesia; Cottonseed oil, United States; Fish meal; Groundnut oil; Palm kernel oil, Malaysia; Palm oil, mainly Indonesian; Pepper, white Sarawak/Muntok; Rice, Thailand, white milled; Soybean meal; Soybean oil; Soybeans, United States, No. 2 yellow; Sugar, in bulk; Sunflower oil; Wheat, United States, No. 2 hard red winter
ARM: Cattle hides, United States, Chicago packer's heavy native steers; Cotton, Egypt, Giza 88, good; Cotton, Pakistan Sind/Punjab, SG Afzal; Cotton, United States, Memphis/Eastern, Middling; Cotton, United States, Memphis/Orleans/Texas, Middling; Jute, Bangladesh, BWD; Linseed oil; Rubber, in bales, No. 1 RSS; Sisal, Tanzania/Kenya, No. 2 and 3 long; Sisal, Tanzania/Kenya, No. 3 and UG; Tobacco, unmanufactured
MOM: Aluminum, high grade; Copper, grade A, electrolytic wire bars/cathodes; Copper, wire bars; Iron ore, Brazilian; Lead; Manganese ore; Nickel cathodes; Phosphate rock, Khouribga; Tin; Tungsten ore; Zinc, Prime Western; Zinc, special high grade