Harvests and Business Cycles in Nineteenth-Century America

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Economists have long been intrigued by the possibility that business cycles are caused by a few types of identifiable, exogenous shocks to the economic system. For the postwar U.S. economy, the most plausible candidate is increases in oil prices, following Hamilton's (1983) observation that (with one exception) the "tendency...for oil price increases to be followed by recessions has in fact characterized every recession in the United States since World War II" (p. 229). This purported pattern has been explained in a variety of ways: some argue that it results from interactions between oil price changes and the monetary system (Bernanke, Gertler, and Watson, 1997); others propose that oil price hikes reduce the productivity of existing capital or directly "disrupt certain categories of spending by consumers and firms" (Hamilton, 2000, p. 35).

Before the 1930s, the most discussed candidate was natural shocks to agricultural output, caused by weather or crop diseases. William Stanley Jevons (1884) famously speculated that sunspots caused variations in British industrial activity through their effect on crop yields in tropical countries. Many economists claimed that an effect of agricultural shocks on industrial output was clearly evident in the United States (Moore, 1914; Robertson, 1915; Pigou, 1927; Timoshenko, 1930; H. Stanley Jevons, 1933). Looking back at U.S. experience from the 1900s, A. Piatt Andrew (1906) claimed that "one cannot review the past forty years without observing that the beginnings of every movement toward business prosperity and the turning-points toward every business decline… were closely connected with the out-turn of crops" (p. 351).

Recent literature has paid little attention to the possible role of harvest shocks as a cause of business cycles (as opposed to the effects on farming of macroeconomic shocks originating elsewhere, discussed by Ardeni and Freebairn [2002]). It is clear that in some countries, for example India, natural events affecting farm output have been an important cause of cyclical-frequency variations in industrial production (Chitre, 2001; Patnaik and

Sharma, 2002). But early NBER researchers and most others examining U.S. data from the late nineteenth and twentieth centuries concluded that farm output was entirely unrelated to real activity in other sectors of the economy. In his study of U.S. industrial production in the period between the War Between the States and the First World War, Edwin Frickey (1942) concluded: "The causal relationships between the agricultural and non-agricultural groups certainly did not express themselves in the form of any simple correlation" (p. 229). According to Wesley Mitchell, "In no other great industry for which we have records are the cyclical fluctuations so irregularly related to business cycles as in crop husbandry" (1951, p. p. 58). Arthur Burns (1951) observed that farm output and employment "undergo cyclical movements, but they have little or no relation to business cycles" (pp. 7-8). Robert A. Gordon (1952) concluded: "It is unlikely that regular cycles in crop production play an important role in business fluctuations," though "Agriculture may have played a more important role than this implies during the nineteenth century, particularly when farm products bulked much larger in American exports than they do now and when agriculture accounted for a much larger share of total economic activity" (p. 386).

In this paper, we re-examine the relation between farm production and American business cycles from the early nineteenth century through the First World War. To indicate business-cycle movements in nonagricultural output, we rely mainly on the annual indexes of industrial production recently developed by Davis (forthcoming), which are significantly better for this purpose than the standard NBER business-cycle reference dates or the output series available for previous studies of business cycles across the whole of the nineteenth century.[1]

Using the Davis index along with other data, we observe some patterns that have escaped the notice of modern economists, including economic historians. In the period

[1] Robert Gallman's well-known series on real GNP, used by Temin (1969) and James (1993), was not designed to reveal output movements on a business-cycle frequency (Rhode, 2002). Thomas Berry's annual real GNP series (Berry, 1988) relies on a set of spectacularly heroic assumptions (Calomiris and Hanes, 1994, p. 410). NBER business-cycle reference dates for the antebellum period are unreliable: they were based on movements in money price levels and anecdotal reports of business conditions, especially conditions in financial markets (Moore and Zarnowitz, 1986, pp. 744), which arguably did not bear the same relation to real activity in the antebellum period that they did in later periods (Temin, 1969).

from the late 1870s through the First World War, variations in the size of the cotton harvest were strongly associated with fluctuations in the next year's industrial output. The magnitude of the relation is economically, as well as statistically, significant. In various regressions with annual industrial production indices as dependent variables, the addition to the right-hand side of the previous year's cotton crop size, expressed as deviation from a long-term trend, boosts the R-squared by about one-fourth. The size of the cotton harvest accounts for most of the cyclical peaks and troughs between the late 1870s and 1913. The relation does *not* appear to hold for the wheat crop, or for the cotton crop in the antebellum period. We explore a variety of explanations for the pattern, both monetary and "real."

In the first section of the paper, we discuss the possible links between agricultural fluctuations and business cycles suggested by old-fashioned and modern economic theories, and the effects attributed to crop fluctuations in some existing accounts of nineteenth-century American business cycles. In the second section, we describe the role of agriculture in the nineteenth-century U.S economy, the nature of markets for cotton and wheat, and natural shocks to crop production. In the third section, we briefly describe the available data from the period (the data appendix gives detailed description of data series and sources), the way we define business cycles in industrial production, and what we take to be exogenous shocks to crop production. In the fourth section, we present statistical results that indicate the relations between crop shocks and business cycles. We also examine patterns with respect to crop prices, crop revenue, export revenues and international specie flows that bear on possible explanations for the apparent relation between postbellum cotton harvests and business cycles.

I. American Agriculture and Business Cycles in Economic Theory and History

The relationship between industry and agriculture in the American economic development has long been a highly contentious issue. A number of studies consider questions about long-term effects and trend growth rates, such as the role of agriculture in nineteenth-century Kuznets cycles or "long swings" (for example Williamson, 1964;

North, 1966), and whether agriculture and industry retarded each others' development by competing for labor, or complemented each other through gains from trade between the two sectors.[2]

In this paper, we focus specifically on the relation between agricultural production and the short-term fluctuations in industrial output that are generally referred to as business cycles. Theoretical discussions and historical narratives or accounts of U.S. business cycles refer to many ways that natural shocks to crop output could have affected industrial production. Some are essentially monetary, having to do with interactions between harvest shocks and money supplies or interest rates under the gold standard. Others are "real," in the sense that they could operate in an economy with perfectly flexible prices, or, more relevantly, under any monetary regime. These real mechanisms can be viewed in light of the modern "real business cycle" literature, though it is important to keep in mind that weather-related harvest shocks differ from the economy-wide or sector-specific "productivity shocks" that appear in many real-business-cycle models. Sector-specific productivity shocks are assumed to be persistent, affecting expected future factor productivity. Variations in harvests caused by weather affect the outcome of factor inputs applied in the past rather than the productivity of current or future inputs. Thus, there is no reason for a single good harvest to be associated with a

[2] The authorities– Benjamin Franklin and Alexander Hamilton – that Meyer (2003) identifies with the two positions reflect the high profile of this long dispute. Stressing the competition between the sectors, Franklin observed "Manufactures are founded in poverty…. no man, who can have a piece of land of his own, sufficient by his labor to subsist his family in plenty, is poor enough to… work for a master. Hence while there is land enough in America for our people, there can never be manufactures to any amount or value." This position is consistent with a standard trade model where industry and agriculture compete for a given stock of labor and sell their products into large international market.

By way of contrast, Hamilton viewed agriculture and industry as complementary and, indeed, argued their prosperity was "intimately connected." A prosperous agricultural sector encouraged manufacturing by supplying less expensive raw materials as well as food for workers and by providing larger markets for industrial products. Manufacturing development in turn created a larger and more reliable market for agricultural products, one subject to fewer "injurious interruptions" to demand. The role of competition for labor was less problematic in Hamilton's view because manufacturing could employ women and child workers who were underutilized in farming and could attract new migrants from abroad.

Building on Callender and Schmidt, North (1966) offered an approach that bridges these positions. This approach treats the labor markets of the North and South as separate and non-competing. The South possesses such a comparative advantage in cotton production as to preclude local manufacturing. But the South provides a product market for northern manufacturing as well as key raw materials (cotton).

transfer of labor or capital into farming, except to the degree that they are needed to bring in a larger crop.[3]

Monetary channels

The United States was part of a functioning gold standard system from 1834 (when a revision of the official bimetallic silver-gold exchange ratio left silver undervalued at the mint) through 1861, and again from 1878 through 1914. Under the gold standard, natural shocks to the harvest of tradable crops could affect the domestic economy through the relation between foreign trade and the supply of high-powered money. If international demand for the crop were sufficiently elastic, a good harvest would tend to increase the country's net export revenue for any given levels of domestic prices and interest rates relative to the rest of the gold-standard world. Unless international capital markets were perfect (in which case all adjustments could have taken place through capital flows, with no change in relative interest rates), such an exogenous increase in net exports would cause some combination of a gold inflow (or smaller outflow) and a decrease in the country's relative interest rates. The resulting decrease in required returns to domestic assets could spur all forms of interest-sensitive spending. In the words of Andrew (1906), "in a country where agricultural products form an important factor in foreign commerce, the size of the crops will exert a considerable influence upon the balance of trade and the international movement of gold. The extent of the bank reserves in the great financial centres and the contraction or expansion of general credit may in consequence depend most importantly upon the output of the season's harvests...When the American crops are abundant, our exports very naturally tend to increase, and gold imports are apt to occur. That in turn means large cash holdings in the banks, with, under normal conditions, the accompaniments of expanding credit and buoyant trade" (p. 326).

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[3] Real business cycle theorists have proposed a wide variety of shocks as causes of business cycles, including rapid changes in the productivity of "home production", (Benhabib, Rogerson and Wright [1991]), but discussions of agricultural shocks are oddly absent from the literature. Da-Rocha and Restuccia (forthcoming) argue that the presence of a large farm sector in an economy amplifies the effects of productivity shocks *outside* agriculture, by increasing the elasticity of labor supply to non-agricultural sectors.

Historical accounts of nineteenth-century business cycles often refer to monetary effects of harvest shocks. Within the antebellum period, the focus is usually on the policies followed by the Bank of England and their interactions with the fragile U.S. banking system. Harvests in the U.S. and elsewhere are often cited as a factor affecting the British balance of payments and hence the Bank's actions aimed at maintaining its gold reserve (for example Ward-Perkins, 1950; Temin, 1969, p. 175; Hoffman and Lothian, 1984, pp. 467, 469). For the postbellum period, both Fels (1959) and Friedman and Schwartz (1960) refer several times to the relation between the wheat crop, wheat export revenues, and gold inflows. According to Fels, "Crop conditions affected business as a whole primarily through international trade when the United States was on the gold standard. Prior to 1879, the paper currency tended to offset any effect of crop conditions on business generally" (p. 60). When crop export revenues are high, "gold imports are increased (or exports decreased), thus increasing the money supply and bank reserves... Under freely fluctuating exchanges, increased demand for exports merely increases the exchange rate or, in this case, lowers the gold premium" (p. 87). In their *Monetary History of the United States*, Friedman and Schwartz argue that the cyclical expansion from 1879 to 1882 was "powerfully reinforced by accidents of weather that produced two successive years of bumper crops in the United States and unusually short crops elsewhere. The result was an unprecedentedly high level of exports… of crude foodstuffs" causing "a large inflow of gold… In classical gold-standard fashion, the inflow of gold helped produce an expansion in the stock of money and in prices" (pp. 97-98). Through the same mechanism, they assert, the accidental occurence of good grain crops in the U.S. and bad crops abroad was a factor in the upturn from "the mild contraction of 1890-91" (p. 107) and the recovery from a major business cycle after 1896 (pp. 140-141). Neither Fels nor Friedman and Schwartz mention the cotton harvest.

Contemporary descriptions of postbellum financial markets refer to both the cotton and wheat harvests as determinants of money-market conditions, associating big crops with higher export revenues, gold inflows, high reserve ratios in New York banks and lower short-term interest rates. Examples include Monetary Convention (1898, p. 220); Sprague (1903, p. 50; 1915, p. 499).

Real channels

The most obvious real effects of harvest shocks are on output in the specific industries that move crops, or for which farm-produced raw materials make up an important fraction of production cost. Robertson (1915) asserted, "the effect of an increased crop volume is to increase the demand for both land and sea transport, and so indirectly for the products of the iron and steel trades. The general view is that the volume of the United States wheat crop has an important effect upon the gross receipts of the railway companies and upon their orders for new rolling stock and so forth...The effect upon United States railway receipts of variations in the cotton crop (which is carried on the average a much shorter distance) and in the corn crop (of which a very large proportion is consumed on the farm) seems, however, to be considerably less important than that of variations in the wheat crop" (pp. 75-77). After referring to the importance of crop volumes for U.S. railroads, Andrew (1906) also pointed out that "A failure of the wheat crop will obviously depress the milling industry, and a failure of the cotton crop will curtail the earnings of the cotton factories, not only those in the vicinity of the cotton-growing states, but those in New or old England as well. A failure of the corn crop similarly will diminish the profits of cattle raising, may work injury to the packing interests, and to some extent may affect also the distillers of whiskey" (p. 328). According to Haberler (1948), crop variations had direct effects on output in "food and textile industries...A bumper crop will lower the price of the raw material in relation to that of the finished product, till either the manufacturers decide to absorb it all by increased output or the holders decide to keep the surplus in store. In any case, the activity of the later stages will be increased, because the holding of stocks never completely offsets harvest fluctuations" (pp. 158, 159). As Haberler noted, the effects of crop volume on crop-intensive manufacturing is diminished to the degree that stocks of raw or partially-processed crops are carried over from year to year. That depends in turn on the cost of storage and the quality of the capital markets that finance speculation in commodities.

Output in sectors far removed from crop handling can be affected by agricultural shocks if the harvest affects the rate of exchange between their products and other goods and services, that is, the sectoral terms of trade. This mechanism would resemble the response of a country's industries to changes in international terms of trade as described in real business cycle models such as Medoza (1995). If the crop is not exported or foreign demand is inelastic, a bad harvest must hike the relative price of the crop, which is to say it must worsen the rate of exchange between products of domestic nonagricultural sectors and crops or crop-intensive goods such as food. If the crop is exported with sufficiently elastic foreign demand, a bad crop may have little effect on the relative crop price, but it must depress farmers' incomes. Unless capital markets are perfect (in which case farmers could ensure or self-ensure against such transitory income shocks), that may depress farmers' demand for products of domestic industry, especially if farmers are subject to fixed debt payments.

Along these lines, William Stanley Jevons (1884) argued that sunspots could cause variations in British industrial activity because they affected crop yields and real incomes in tropical countries, hence those countries' demand for British exports (p. 219).[4] H. Stanley Jevons (1933) asserted that "The buying power of rural areas, at home and abroad, is the major factor in demand for both production and consumption goods...The income of the agriculturist depends on the quantity harvested of each product and its price" (p. 549). The elasticity of demand for crops might be low, but "When the price does not give the farmer much increase of purchasing power there are other ways in which trade is stimulated by good harvests. The lower cost of food means a distinct

[4] In a series of recent articles and working papers, Solomos Solomou, Weike Wu, and company have used semi-parametric time series techniques to explore the impact of weather variables on agricultural output, consumer price levels, and other macroeconomic variables in the United Kingdom and western Europe over the late 19th and early 20th centuries. They generally found that annual precipitation and temperature (measured over the growing season) have non-linear effects on production and prices. For example, increased precipitation initially increases output (and reduces prices) and then decreases output (increases prices). This is as one might expect, but in the European context, the negative effects of deviating into excessive moisture tended to be greater than those associated with deficient moisture. When explaining price changes in Britain and Germany over the 1880-1913 period, they found that "(i)ncluding weather information improves the fit of the estimated models of inflation by approximately 10 per cent." Solomou and Wu (2002c) p. 10. In models examining the weather sensitivity of British macro-economy in the pre-1914 period, they concluded that weather effects accounted for about "50 per cent of the variation in aggregate agricultural output(,)… 6 per cent of the annual growth rate variations of the construction sector output (, and) 15 per cent of the variations in the growth of domestic coal demand." Solomou and Wu. (2002a) p 18. For Western Europe as a whole, they found weather shocks "account for approximately one third to two thirds of variations in agricultural production." Solomou and Wu (2002b) p 10.

increase of purchasing power by the non-agricultural population" (p.550). Pigou (1927) listed "variations in the yield of harvests, enabling industrialists to obtain better or worse terms for their products from the agricultural community," among the possible "real" causes of business cycles (others were changes in the taste for leisure and variations in the rate of technological innovation): when crops are especially good, "agriculturalists... will offer a larger demand in terms of agricultural produce – will raise their real demand schedule – for the products of industry" (p. 41). Andrew (1906) made similar points, adding "the very solvency of a large part of the agricultural population, and of those connected by business relations with them, depends to a considerable degree upon the outcome of the year's harvest. Whether or not the farmer will be able to repay loans which he has contracted, whether or not he will be able to settle his bills with tradesmen and dealers, and whether or not he can pay for his agricultural machinery and farm improvements, will in many cases be decided by the size of the crop" (p. 326). Surveying these arguments, Haberler (1946) judged that "in many or most cases, an increase in the crop of one country, unaccompanied by any change in the crops of other countries, will result in an increase in the money receipts of the agriculturalists in the country concerned...This initial increase in the receipts and incomes of the country which has been blessed by a good crop will provide an inflationary stimulus to the industry of that country" (p. 163).

Historical studies of nineteenth-century business cycles do not mention real effects of harvest shocks as often as monetary effects, but Temin (1969) argued that unexpected falls in cotton prices contributed to financial crises "because a large part of the antebellum financial system used cotton for security" (p. 176).[5] Fels (1959) asserted that good crop exports spurred the economy not only by inducing gold inflows but also because "prices and incomes in the export trades go up, with multiplier effects" (p. 87); "larger exports of crops meant more spending by farmers on American products" (p. 127, footnote 47). Fels also argued that the effects of crop volume on railroad revenues were very important: "Good crops meant business for railroads, giving them both means and

[5] Temin (1969) focuses on such international forces in accounting for the financial difficulties of the late 1830s. See Rousseau (2002) for a treatment highlighting the role of domestic policies (specifically the 1836 Specie Circular and interbank transfers of government balances).

need to buy railroad equipment and encouraging them to build more road; and this in turn meant business for iron and steel. Moreover, since poor crops could have a serious effect, assurance that crops were not poor helped confidence" (p. 138).

II. Agriculture in the Nineteenth-Century American Economy

The nineteenth-century U.S. economy represents a close to ideal environment to search for such effects because the agricultural sector represented a large share of national product and yet the industrial sector was robust and growing. The data in Figure 1 and Table 1 shed light on the place of agriculture and industry in the American economy over the long nineteenth century. Figure 1 shows trends over the 1800-1920 period in the labor force shares for agricultural sector and the industrial sector (combining mining and manufacturing) derived from S. Lebergott's numbers (U.S. Bureau of the Census, 1975, p. 139, series D 167, 170, 172, 174). The figure also displays the more recent estimates of the agricultural labor force share based on the careful work of Thomas Weiss (as cited in Margo (2000), p. 213). It is generally accepted that these numbers better capture the trends, especially in the first half of the nineteenth century. In 1800, agriculture employed about three-quarters of the labor force and manufacturing/mining was virtually non-existent. (The remainder of the labor force was primarily engaged in construction, transportation, trade and other services.) With the emergence of modern economic growth, the agricultural share declined, falling to just over one-half of the labor force by 1870, and the manufacturing/mining share rose, reaching about 20 percent by that date. These trends accelerated after 1900 and by 1920, the labor force share in manufacturing/mining exceeded that in agriculture. The 1910s were a watershed decade in another important respect. They represented the first period when the national agricultural labor force fell in absolute terms. (Prior to 1910, the relative decline of agriculture was still associated with expansion in absolute size of its labor force.)

Table 1 shows the distribution of GNP in the agriculture and manufacturing-mining sectors over the 1840 to 1900 period (Gallman, 2000, p. 50). The income data reveal that the same pattern of a rising industrial share and a declining agricultural share. As one would expect from the findings of Simon Kuznets regarding the development gap, industry passed agriculture earlier in terms of income – the 1880s—than in terms of the labor force – the 1910s.

Given the nature of America's comparative advantage, agriculture continued to play much larger role in U.S. trade. Figure 2 graphs the shares of three key crops – cotton, tobacco, and wheat—in the total value of U.S. merchandise exports from 1800 to 1915. Except briefly in times of war, cotton was the nation's number one export commodity. This staple accounted on average for over one-half of total revenue during the 1825-60 period and for over one-quarter of revenues during the 1880-1915 period. Rising exports of wheat (and flour) offset some of the decline, growing to make up almost one-fifth of revenues over the middle years (1875-93) of the postbellum period. Over this period, farm products comprised over three-quarters of all exports and even on the eve of the Great War, they still made up over one-half of the total. This fraction obviously was much larger than the sectors' share of the labor force or income.

Our empirical analysis focuses on the two great cash crops, cotton and wheat. These two commodities, as the series in Figure 3 indicate, made up roughly comparable shares of national product over the late nineteenth century.[6] Exports accounted for a far larger share of the U.S. cotton crop than of its wheat crop, as the data of trade shares in Figure 4 reveal. The U.S. was typically the leading international producer of both crops, but its position in the cotton trade was far more dominant than its place in the wheat market. Figure 5 shows the American shares in global production of each crop during the 1909-13 period. Over this period, the country produced about one-fifth of the world's wheat and three-fifths of the world's cotton. Russia had attained rough parity with the U.S. in grain production, but there were no close contenders for cotton.

It was not always so. During the 1790s and 1800s, the West Indies was a major source of cotton supplies before the U.S. South came on line. During the Cotton Famine of the 1860s, India, Brazil, Egypt, and several other competitors expanded production to replace lost American output. Figure 6 charts the sources of supply for cotton

[6] Given the income shares of these two crops, it seems more likely that the major channel whereby fluctuations in agricultural production influenced the business cycle involved the export markets.

consumption in Europe and American by five-year periods from 1821 to 1894 (Ellison, 1968, p. 99 and U.S. Treasury, 1895, p. 305). These data show the effect of the War and the path of recovery of the American South during the postbellum period. Scholars of the cotton trade are quick to cavil with aggregating different supplies as is done in the Figure (though they invariably do so as well). These scholars properly object to this treatment, noting that raw cotton is not a homogeneous product. The U.S. fiber was an imperfect substitute for the foreign fibers. Egyptian and Brazilian cottons, which possessed long staple lengths, sold at a premium compared with the US, medium-staple upland cottons. Indian cottons, which were short staple, traded at a 20-30 percent discount. The available evidence on price differentials between types of wheat sold in leading European markets suggests the grain products of various nations were closer substitutes.

From the birth of econometrics as a field of analysis, economists have carefully studied the operations of these two commodity markets. Indeed, such pioneering econometrician as Henry Moore, Holbrook Working, and Henry Schultz developed many of the basic techniques examining the wheat and cotton markets (Christ, 1985). But this does not mean that the voluminous resulting empirical literature has generated much consensus about the magnitude of such fundamental parameters as the price-elasticities of supply and demand.[7]

A sample of the available estimates of the price-elasticity of demand for U.S. wheat and cotton during the relative period appear in Table 2. All of the estimates have the U.S. cotton producers facing a downward sloping demand curve. The slope appears to change over time as the new competitors expand and then retreat from the market. As an example, Wright's estimates "put the elasticity of demand at roughly 1.0 during 1830-1860, 1.5 for the period 1866-1895, but back to 1.0 for 1879-1913." (Wright, 1979, p. 102-3).[8] Wheat demand appears to be less elastic. This is somewhat paradoxical because the U.S. represented a smaller share of world markets. The net elasticity facing US

[7] Indeed one might conclude that both elasticity pessimists and elasticity optimists have found it possible to identify specifications and approaches that confirm their priors. This is too negative but it does temper one's impulse to believe everyone would come around if one did it right.

[8] Schultz (1938) p. 321 reports a similar pattern: "the effect on an increase on 1 per cent in the (deflated) price of cotton was to decrease the annual per capita consumption by approximately 0.51 percent in the first period [1875-95], by 0.25 per cent in the second [1896-1913], and by 0.12 per cent in the third [1914-29]."

producers would combine the effects of the elasticity of demand from importers and the elasticity of supply from other exporters.[9] Differences in the price elasticities of demand for wheat and cotton do not appear to be driving the differences we observe in the impacts of harvest shocks on the American business cycle (see below).

Production shocks in American agriculture

Agricultural production was subject to myriad random weather shocks. In addition, farmers confronted recurrent and evolving threats from plant diseases and insects. The effects of such pests represent the type of persistent or a cluster of negative shocks to technology assumed in real business cycle (and related) models. (Critics often argue such shocks are implausible and require that economic agents forget how to produce.) In the context of American agriculture, new pests were periodically introduced from outside and other new threats emerged as mono-crop production created conditions favorable to their evolution or extensive reproduction. Over the nineteenth centuries, U.S. farmers repeatedly experienced pest-related shifts to lower production possibility frontiers. They did not forget how to produce, but rather their existing knowledge depreciated as new threats appeared from an inherently unstable biological environment. In one example cited in the literature on business fluctuations, the Hessian fly (together with winter-kill) destroyed much of the American wheat crop in 1836. These negative shocks, following on the heels of a short crop in 1835, induced a "very high price" and reversed the direction of the international wheat trade. The U.S., which was almost always a grain exporter, imported wheat from Britain and northern Europe in 1836/37. This development added to trade balance pressure and, according to the literature, contributed to the financial difficulties of the late 1830s.[10]

[9] There are several additional complications. One of particular note (Meinken, 1955, pp. 22-25) was that the price of wheat relative to those of competing grains mattered crucially for the use of wheat as livestock feed. In most feed operations, 1 pound of wheat was equivalent to about 1.05 pounds of corn. When the price premium on wheat was large (as was common), little wheat was fed to livestock. The demand elasticity depended primarily on human food consumption and was relatively low. When the price spread fell, use of wheat for feed increased rapidly. Thus, demand became more elastic as prices fell.

[10] One of the authors (Rhode) would like to thank Kenneth Sokoloff for calling this episode to his attention. Thorp, (1926) p. 122 notes in 1836 there was a "Wheat shortage, due chiefly to the Hessian fly, very high price." This shortage followed a "Wheat crop failure" of unspecified origin in 1835. p. 121. One of Thorp's sources, McGrane, (1965) p. 92 also notes "there was a crop shortage, due to the devastating effect

The reports complained of winter-kill and attacks by Hessian flies (*Cecidomyia destructor*). Winter kill occurs when severely cold weather damages fall-sown wheat. The Hessian fly, introduced to the U.S. in the 1770s, spread across the continent by little more than a century. It proved a serious scourge to grain growing until farmers learned to change to less susceptible varieties and alter planting date. Other evolving insect threats to wheat include the grain midge (or weevil), introduced in the 1820s, the chinch bug, first observed in the 1780s, and locust. Epidemics of stem and leaf rust, caused by fungi, could also lead to widespread crop failures and periods of temporary abandonment of production. Such shocks tended to be correlated with weather events, but also had independent, persistent components (Olmstead and Rhode, 2002 and 2003). The notable bad years for wheat include, besides 1835 and 1836, the harvests of 1854, 1864, 1866, 1876, 1881, 1885, 1888, 1890, 1904, 1910, and 1911. (1904 was associated with a major outbreak of stem rust, 1911 with drought.) Among the years of bumper crops were 1869, 1873, 1874, 1882, 1891, 1892, 1898, 1901, 1905, 1906, 1914, and 1915 (Thorp, 1926).

Cotton production suffered from similar weather and pest shocks. In the early nineteenth century, cotton production was ravaged by anthracnose rot (a disease caused by the fungus *Colletotrichum capsici*). Among the insect pests attacked the crop were cotton worms (aka caterpillars or *Aletia argillacea*) that were allegedly introduced by French cotton planters from the West Indies in 1802, and boll worms, *Helithis armiger* (See Comstock, 1879 and Watkins, 1908). The most serious threat, however, occurred after western expansion pushed U.S. cotton cultivation into contact with the Mexican boll weevil *(Anthonomus grandis*) which crossed into Texas in 1892 and spread across the

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of the Hessian fly." McGrane in turn cites (among other sources) an extensive article in the *Niles' Register*, 23 July 1836, pp. 357-59 on "The Crops" reprinted from the *Baltimore American*. Based on complaints of injuries to the wheat crop by "the severity of the winter, and… the ravages of the Hessian fly…" that when beyond the 'crop-croaking' normal in the period, the *Baltimore American* sent out a circular to postmasters throughout the middle states to survey "enterprising and intelligent citizen(s)" about local conditions. Of the 54 counties covering in the reports, 2 reported the wheat crops were very good, 4 good, 10 average, 14 fair or indifferent, 6 bad, and 18 very bad or failures. Thus the modal response, representing one-third of the reports, was in the lowest category. Pennsylvania, Maryland, and Virginia (which included what is now West Virginia) were the hardest hit. Given that the middle states produced about one-half of the nation's wheat crop circa 1839, crop failures in the regions could have a significant effect. (The Hessian fly did not invade Illinois until 1844, and therefore, could not have reduced crops in that region in the late 1830s.) We also know that country imported, on net, the equivalent of 2.4 million bushels of wheat in 1836/37. This contrasts with net exports averaging 4.3 million bushels over the 1831/32 to 1834/35 period and 7.9 million over the 1838/39 to 1841/42 period. Such a shift represents roughly ten percent of the typical crop.

entire South by 1922. As with wheat, cotton enjoyed readily identifiable periods of good crops (1829, 1837, 1839, 1842, 1857, 1859, 1870, 1897. 1898, 1904, 1911, 1914) and of bad crops (1838, 1846, 1866, 1868, 1871, 1881, 1892, 1895, 1909, 1915). Often the bad years were associated with insect attacks, such as infestations of cotton worms in 1846, 1866, 1968, and the early 1870s, of the boll worm in 1881, and of the boll weevil in 1909 and 1915 (Thorp, 1926).

III. Available data

Extended descriptions of data series and sources are given in the appendix. Here we briefly describe the series we use, and their limitations.

U.S. industrial production

For American industrial production, we rely mainly on a new index of industrial production constructed by Joseph Davis (forthcoming) for the period from 1790 to 1915. Davis assembled the index from annual data on physical output or inputs for 43 industries in manufacturing and mining. The goal was to create a series that compares conceptually to the Federal Reserve Board's historical monthly industrial production index available since 1919. Davis selected component series based on two principal criteria advocated by Romer (1991) and Calomiris and Hanes (1994). First, the annual series employed had to pertain either directly to actual output, or to a related physical-quantity proxy. Thus, the index is devoid of nominal data and its changes reflect purely fluctuations in real output. The index's exclusive focus on physical quantities stands in sharp contrast to various late-nineteenth century "business condition" indexes that utilize wholesale prices, equity prices, and other financial variables. Second, the industrial components had to be available annually for sufficiently long periods to preserve index consistency and comparability over time. Thus, Davis omitted existing products whose aggregate coverage did not run at least 30 years before and after the Civil War. Many of the component series are unavailable before 1829. Thus, the reliability of the series is greater beginning with 1829, and we will examine movements in industrial production starting with that year.

Two important components of the index are directly related to agricultural production: U.S. consumption of raw cotton, used to indicate cotton textile production; and shipments of barrels of milled wheat flour. To observe the behavior of industrial production in sectors not directly related to agriculture in this way, we constructed for this paper an index *excluding* these components, which we refer to as the index "excluding textiles and flour." Within the postbellum period, results derived from the Davis series can be compared with results using the well-known Frickey index of manufacturing production, which covers years from 1860 through 1914 (Frickey, 1947).

As our definition of "business cycle" movements in industrial production, we use the deviation of the log of a production index from the Hodrick-Prescott (HP) trend in the series with the conventional parameter of 100 for annual data (described in Kydland and Prescott, 1990). We use this definition because it is common in recent literature, especially real-business-cycle literature, and represents a notion of business cycles as very short-term movements in output. The Hodrick-Prescott trend as conventionally estimated is strongly affected by output movements that would appear as deviations from trend, under other definitions (for example, the depression of output during the 1930s). Trends were estimated over 1827-1860 and 1868-1914. We will refer to an IP deviation from the HP trend as the "output gap."

Table 3 shows standard deviations, maximum and minimum values of output gaps over antebellum and postbellum periods, for the Davis IP index including and excluding textiles and flour. By these measures, the overall amplitude of cyclical movements was quite similar in the two periods. The index excluding textiles and flour shows larger fluctuations.

Crop production

Beginning in 1866, the U.S. Department of Agriculture created annual estimates of yields, acreage, and production for each major U.S. crop, including cotton and wheat. USDA statisticians also collected and published annual estimates of cotton production, based on commercial sources, dating back to 1790. Several sources provide (see data appendix) have generated annual estimates of wheat production for parts of the antebellum period, but these series require further analysis before we can judge them suitable for this study. By many accounts, 1869 was the first "normal" crop year for cotton following the War Between the States. Thus, our postbellum samples will begin with 1870 for analysis using the cotton crop with a one-year lag.

We use two definitions of short-term fluctuations in crop output, acreage and yield. One is the deviation of the log of the variable from the HP trend. The other is the deviation of the log from a quadratic time trend. Both are defined over periods 1826-1860 and 1869-1914. The lower portion of Table 3 shows standard deviations, and maximum and minimum values, of crop deviations from trend, on these two definitions. On either definition, the amplitude of cotton crop fluctuations was about the same in the postbellum period as in the antebellum period, and the amplitude of wheat deviations was similar to that of cotton deviations. The quadratic trend gives bigger deviations. We will refer to the crop deviations from trend as "crop deviations."

Were these crop deviations a response to business-cycle phenomena, or exogenous shocks to the economy? Tables 4 and 5 show regressions results that suggest the crop deviations were indeed exogenous to business-cycle phenomena. For Table 4, left-hand side variables were crop harvest deviations. Right-hand side variables included the current and previous years' output gaps in the Davis IP index. For cotton in the antebellum period, the right-hand side also includes the previous year's cotton crop deviation. For cotton and wheat in the postbellum period, the right-hand side includes the current and lagged deviation in the other crop. The lower rows of the table show F-statistics to test the hypothesis that all of the coefficients are equal to zero, and the hypothesis that the coefficients on the output gaps are zero. The associated p-values show the significance levels at which one would fail to reject these hypotheses. For both crops, under either definition of trend, one would fail to reject the hypothesis that the coefficients on the output gaps are zero, at conventional significance levels. Thus, there is no evidence that industrial production affected the crop deviations from trend. For the cotton crop, there is no indication that crop deviations from either trend were related to *any* of the right-hand side variables – at conventional significance levels, one would fail to reject the hypothesis that *all* of the coefficients are zero. For the wheat crop, there is some evidence that the crop deviation was related to the previous year's cotton crop deviation – at the ten percent level or thereabouts, one would reject the hypothesis that the coefficient on the previous year's cotton crop is zero.

For Table 5, left-hand side variables were deviations from HP trends in crop acreage or yield. Right-hand side variables were the previous year's acreage or yield deviation and industrial production deviations. Results using deviations from quadratic trend are not shown because they were essentially identical to these. For cotton, neither acreage nor yield appears related to any of the right-hand side variables. For wheat, acreage appears positively related to the previous year's acreage, but not to output gaps.

Crop prices

For cotton, Cole (1938) presents apparently reliable monthly series of New York prices through 1861. Monthly cotton prices beginning in 1870 can be found in the NBER macro history database, series m04006a. For wheat, we use wholesale prices in Chicago from the NBER macro history database, series m04001a.

As crop prices vary significantly from month to month, farmer's incomes from a given year's crop and materials costs to manufacturers would depend significantly on the relative volumes of trade taking place within each month (in addition to the differences between their transaction prices and the prices in our sources). It is clearly inappropriate to value crops at a price equal to a simple annual average of monthly prices. But there is no way to know month-by-month trade volumes, so we use October prices, as harvests for both cotton and wheat were well under way or completed by this month.

Other prices

The standard measure of the "price level" over the nineteenth century is the Warren and Pearson wholesale price index for years preceding 1890, and the BLS wholesale price index thereafter. Prices of raw cotton, wheat and wheat flour have considerable weight within these series. We use a price index constructed from the groups within the Warren and Pearson and BLS series that do *not* include raw cotton, wheat and wheat flour (that is, all groups other than "farm products" and "food products" groups). Groups were aggregated with Warren and Pearson's weights (Warren and Pearson, 1932, p. 184).

Export revenues

In 1820, U.S. customs officials began to collect fairly reliable annual data on dollar values of exports by sea (North, 1960, p. 602). Published data, found in standard sources such as U.S. Bureau of the Census (1975), include estimates of export values for specific crops, including cotton, wheat and wheat flour, and for broad classes of goods such as "crude materials," "crude food" and "manufactured food." The sum of these three classes should contain cotton, wheat and wheat flour.

Unfortunately, the span of months covered by an annual observation does not match up very well to the months in which a year's crop would be shipped. For 1842 and earlier years, the figure for a given year refers to trade occurring from 1 October of that year to 30 September of the following year. For the period from 1843 on, they refer to trade occurring from 1 July of that year to 30 June of the following year. There are no usable figures for the year 1842. (That year's figures cover trade from 1 October 1842 of that year to 30 June 1843.)

Gold flows

Data on imports and exports of specie – gold and silver – were collected along with other import and export data. Annual series are available starting with 1821 (U.S. Bureau of the Census, 1975, series U 197-200). Unfortunately, for years before 1864, gold exports cannot be distinguished from silver exports, and figures do not include exports of bullion until 1895.

IV. Relations between Industrial Production and Crops

Effects of crop deviations on industrial production

Tables 6, 7, and 8 show results of OLS regressions that treat output gaps or log levels of IP series as dependent variables, and current and lagged crop or yield deviations as independent variables. This statistical approach is reasonable to the degree that crop deviations are determined by factors exogenous to the economy system, such as weather and crop diseases. Recall that the results shown in Tables 4 and 5 were consistent with that assumption. All regressions were performed using both definitions of trend for crop deviations. Results using quadratic trends were nearly identical to results using HP trends. We present only the results using HP trends. We use four time periods as samples: the entire antebellum period 1829-1860; the antebellum gold-standard period 1834-1860; the entire postbellum period 1870-1913; and the postbellum gold standard period 1879-1913.

Generally, the results indicate that, within the postbellum periods, deviations in the cotton crop or cotton yield had a strong positive relation to the next year's output gap. Such a relation did *not* hold within the antebellum periods, or for the wheat crop in the postbellum periods.

Table 6 shows results using output gaps in the various industrial production indexes. Right-hand side variables included the crop deviations from the current and previous years, and the output gaps in the previous two years. (Adding more lags of IP to the right-hand side had little effect on the other coefficients, and added no explanatory power to the regressions.) The lower rows of the table show F-statistics and p-values to test the hypothesis that both wheat crop coefficients are zero. For the first set of columns in the table, the IP index was the Davis IP index including textiles and flour. In the antebellum periods, one cannot reject the hypothesis that the coefficients on the cotton crop deviations are zero. In the postbellum periods, one cannot reject the hypothesis that the coefficients on wheat crops and the *current* year's cotton crop are zero. But the coefficient on the previous year's cotton crop is positive and statistically different from zero at the one percent level.

The next set of columns in Table 6 shows results using the Davis IP index excluding textiles and flour. The last set of columns shows results using the Frickey manufacturing index – the alternative IP index for the postbellum period. Results are very similar to those using the Davis IP index including textiles and flour: within the postbellum periods, but not in the antebellum periods, the coefficients on the previous year's cotton crop are positive and different from zero at conventional significance levels.

Table 7 shows results of regressing the log *level* of the Davis IP index on two lags of the index and the same crop deviations from trend used for Table 6 (*not* the log levels of the crops). In the antebellum samples, cotton crop coefficients are not significantly different from zero. In the postbellum samples, the coefficient on the previous year's cotton crop deviation is positive and significantly different from zero at the one percent level. Coefficients on wheat crops are not different from zero.[11]

Figure 7 displays the relation between the Davis IP output gap and the previous year's cotton crop graphically. For the figure, the output gap was regressed on two lags of the output gap over the 1870-1913 sample. The residual from this regression was scattered against the previous year's cotton crop deviation. A positive relation is obvious, at least for observations in the 1879-1913 gold standard period. Arguably, the relation does not hold as well within the 1870-1878 period: the two largest crop deviations within that period are not accompanied by corresponding output gaps. Of course, it is impossible to make any meaningful statistical distinction between eight observations and the rest of the sample.

Table 8 compares the effect on the Davis IP output gap of variations in the cotton crop, cotton yield, and cotton acreage. (Recall there are no data on acreage from the antebellum period.) In specification (1), right-hand side variables were lagged output gaps and the previous year's cotton crop deviation. In (2), the crop deviation was replaced with the deviation from HP trend in the cotton yield. For (3), the crop was replaced with deviation from the HP trend in cotton acreage. For (4), the right-hand side includes both the cotton crop deviation and the cotton acreage deviation. (Recall that the yield is the ratio of the crop to acreage, so it should not be on the right-hand side along with either the crop or acreage.) In (2), the coefficient on the yield is significantly different from zero and larger in magnitude than the coefficient on the crop. In (3), the coefficient on acreage is also positive and significantly different from zero. In (4), the

[11] To check the robustness of these results, we have also employed filter using the approximate pass-band approach suggested in Baxter-King (1995). Again, in the postbellum period, cotton production had a significant effect on next year's industrial product whereas wheat production did not.

coefficient on the crop is positive and significant; the coefficient on acreage is not significantly different from zero at conventional levels. These results indicate that the variable fundamentally related to industrial production was not cotton acreage *per se* – the measurable input to cotton production – but the size of the cotton crop itself, as affected by both yield and acreage.

What was the relative importance of the cotton crop as a determinant of postbellum business cycles? One way to judge is by comparing the R-squared of regression (1) with that of regression (5), which omits the cotton crop deviation from the right-hand side. This reduces the R-squared by more than 25 percent. Thus, one could say that cotton crop variations account for about one-fourth of business cycle movements as defined to be deviations from trend in industrial production.

Figure 8 provides another way to judge. The figure plots the Davis index output gap along with the value of the output gap implied by the previous year's cotton crop deviation and the coefficients from Table 8 regression (1) on the 1879-1913 sample. Values for lagged output gaps, as determinants of later year's output gaps, were not the true values, but the forecast values, rolled forward (starting from the true value for 1869). Observe that the cotton harvest accounts very well for the 1881 peak in the Davis series (the NBER reference cycle peak is 1882), the downturn and upturn around the 1885 trough (also an NBER trough), and the downturns and upturns of the 1890s, including the short-lived upturn and downturn around 1895. The cotton harvest fails to account for the downturn from 1903 or the depth of the 1907 trough, but it does account for the upturn from 1904 and the 1911 trough. Within the 1870-1878 period, the cotton harvest does not appear to explain much: it does not account for the 1873 downturn or the 1878 trough.

What explains for the relation between the cotton harvest and industrial production?

How can we explain the apparent relation between the cotton crop and the following year's industrial production in the postbellum period, along with the absence of a relation between industrial production and the wheat crop, and the absence of a relation between cotton and industrial production before the War? The theories and historical accounts discussed above suggest a number of possibilities.

Recall that a monetary channel from harvest shocks to industrial output, in gold standard periods, would be through the effect of the harvest on gold flows. That argument would have two implications we can easily test, as long as crop deviations are indeed exogenous to the economic system. First, the cotton harvest should be positively related to U.S. industrial output, but not to industrial output in other gold-standard countries. Second, the cotton crop but not the wheat crop should be positively associated with specie inflow in the postbellum period, and the cotton crop should not be associated with specie inflow in the antebellum period.

Table 9 shows regression results bearing on the first point. In specification (1), the Davis IP output gap was regressed on the previous year's cotton deviation and the deviation from the HP trend in an index of British industrial production (the Hoffman [1955] index excluding building). In all periods, the coefficients on British IP are positive and significantly different from zero; in the postbellum period, so is the coefficient on the lagged cotton crop. In specification (2), the two country's output gaps were reversed: the British output gap was regressed on the cotton crop and the American output gap. In these regressions, the coefficients on the cotton crop are far from significant in the postbellum period, and not strongly significant in the antebellum period. Thus, the cotton crop deviation appears to have been positively associated with American output but not British output in the postbellum period. That is consistent with a monetary channel.

Table 10 shows results of regressing annual net imports of specie (gold and silver) on crop deviations. In the antebellum periods, including the antebellum gold standard period, coefficients on cotton crop deviations are not significantly different from zero. In the postbellum period, coefficients on the current and previous year's cotton crop deviations are positive and significantly different from zero at the one percent level. The coefficients on the previous year's wheat harvest, but not those on the current harvest, are positive and significantly different from zero. (When the two-year's previous wheat deviation was added to the right-hand side of the regressions in Table 6 and 7, the estimated coefficient was not significantly different from zero, and its value was actually negative.)

Why would cotton deviations be associated with specie flows in the postbellum period, but not in the antebellum period? Why would the relation between wheat crops and specie flows be weaker than the relation between cotton crops and specie flows? Tables 11, 12, and 13 present results bearing on those questions.

For Table 11, the log of export revenue in the classes containing cotton, wheat and flour exports was regressed on crop deviations, along with logs of the current and previous years' WPI's (excluding farm products and foods) and quadratic time trend terms. In the antebellum period, the cotton crop deviation was not related to export revenue. In the postbellum period, the cotton crop was positively related to export revenue. That would explain the difference between the antebellum and postbellum periods in the apparent effect of cotton. But observe that postbellum coefficient on wheat crop deviations are larger than the coefficients on cotton crop deviations. Recall from Table 3 that wheat crop deviations are of similar magnitude to cotton crop deviations. So why do wheat crop deviations appear to have weaker effects on specie flows?

For Table 12, the log of a year's crop revenue, valued at the October price, was regressed on crop deviations, the log of the WPI and quadratic time trends. In the antebellum period, cotton revenue was not related to the current cotton crop. The difference for cotton between the antebellum and postbellum periods must be in the behavior of the crop price. For Table 13, the log of the October crop price was regressed on the same variables on the right-hand side of the regressions in Table 12. Coefficients on cotton crop deviations are more negative – larger in absolute value - in the antebellum periods. Apparently, in the antebellum period, the short-run elasticity of demand for American cotton was small enough to eliminate any positive relation between harvest shocks and crop revenue. In the postbellum period the short-run demand elasticity was greater, so a large crop was associated with greater crop revenue. Coefficients on crop deviations for wheat are a bit smaller than postbellum cotton coefficients, implying greater demand elasticities for wheat than cotton. To the extent that this greater responsiveness arose from competition with other domestic grains, higher wheat crops would not necessarily result in greater specie flows. Understanding this relationship requires further investigation.

V. Conclusion

Economists have long been intrigued by the possibility of identifying real exogeneous shocks that drive the business cycle. This paper tests this hypothesis for the nineteenth century U.S. where the economic structure was especially conductive to an affirmative finding. Agriculture was a sector possessing a large weight in the economy and was subject to productivity shocks from weather and pests. (The recurrent attacks of plant diseases and insects represent a type of persistent negative shocks to technology that requires economic agents forget how to produce.) A key advance allowing us to subject this hypothesis to fuller investigation is the development of the Davis IP index that provides a consistent quantity-based annual index of industrial production from 1790 to 1915. Our main finding is that shocks in cotton production did drive the Davis IP series in the postbellum period. Based on our current analysis, shocks to wheat production do not appear to have a strong effect over this period nor do cotton shock have such effect earlier, in the antebellum period.

These results are surprising for three reasons. First, previous scholarship (North) have asserted an important role for cotton in the antebellum period but generally viewed the industry as weak after the war when King Cotton was dethroned. Second, early observers often placed wheat at the center of the postbellum business-cycle story. As a representative example, Joseph Stancliffe Davis (1935, p. 2) noted that the coincidence of good wheat crops here with short crops in Europe in 1879, 1891, and 1897, "led to large exports at attractive prices and gave a pronounced stimulus to business in this country, twice facilitating revival from depression, and once (1891-1892) helping materially to reverse a recession under way." What such observations may fail to register is what happens when good crops in the U.S. coincide with good crops in Europe. Third, our findings are surprising because cotton shocks appears to work indirectly, not by directly changing output, but rather through specie accumulation. Exploring this mechanism further is the next step in our ongoing research.

Data Appendix

Davis Industrial Production (IP) series

The physical output for the 43 manufacturing and mining industries were aggregated and expressed as an index number from 1790 through 1915 with the base census year 1849/50. The index was constructed in several steps. First, each component series, ip_{it}, was indexed by expressing the physical quantity of output of series i for each year t, q_{it} relative to the quantity produced for series i in base year t=0, q_{i0}, equal to census year 1849/50. Next, the individually indexed components were weighted by their relative importance, or value added v_{i0}, in census year 1849/50 in order to arrive at an annual industrial production, IP_t, using a standard Laspeyres fixed-weighted index formula:

(1) $IP_t=(\Sigma_{i=1}\ ip_{it}\ v_{i0})/(\Sigma_{i=1}\ v_{i0})$, where $v_{i0}=p_{i0}\ v_{i0}$ and $ip_{it}=(q_{it})/(q_{i0})$,

where the weighted sum in (1) yielded a fixed-weighted index of industrial production based in census year 1849/50. When certain series disappeared on account of data attrition, Davis followed the standard approach of computing the index as if the growth in the missing series equaled the growth in the weighted average of the remaining series in those years. This sequential linkage through ratio splices served to prevent discontinuous jump-offs when series dropped out of the sample. Other industries died (e.g., hand-drawn fire engines) and new industries emerged (e.g., locomotives or pocket watches) over the course of the sample period. When a series disappeared because a good was not produced, the absent good still entered the index with a positive weight, multiplied by a quantity of zero. The indexing procedure above was then repeated for the 1879/80 census year using value-added weights.

Armed with two overlapping indexes based in 1849/50 and 1879/80 value-added weights, Davis linked the two series were linked in chronological segments. The percentage changes in the final index reflect the fixed-weight index with the 1849/50 base from 1790 through 1850, and reflect the other with the 1879/80 base from 1879 through 1915. For the intercensal observations from 1851 through 1878, Davis used a linear time-weighted average of the annual percentage changes of two indexes. This last step was chosen because it more effectively captured the emergence of new industries during the 1850s than would have an arbitrary splicing of the two overlapping series at the period's midpoint centered the end of the Civil War.[12]

The resulting U.S. index covers the 1790–1915 period. The index commences with the calendar year in which the last of the thirteen original colonies ratified the Constitution. With the power to regulate commerce transferred from those colonies to the U.S. government, the American economy was officially "national" beginning in 1790. The index has been carried through 1915 (the standard terminus of the prewar period) in light of the deficiencies and comparability concerns that characterize earlier indexes constructed for the post-Civil War years, in particular the Frickey index. (The Frickey index covers the 1860-1914 period and appears as Series P 17 in U.S. *Historical Statistics*, Pt. 2, p.667.)

Components of Davis IP index for the food, textile, wood/paper, leather, chemical/fuel, machinery, and metal sectors are available from 1827 to 1900. In addition, Davis constructed a series excluding flour milling and cotton textiles.

As checks on the Davis IP index we will also employ the following manufacturing-related series: New England (and Massachusetts) Textile Output from L. Davis and H. L. Stettler, Studies on Income and Wealth, 1966, Vol. 30 p. 221 for 1826-60. New England Textile Employment are from Layer for 1832-60. British cotton output from Huberman (1991) for 1822-52; British producer goods production from Hoffman for 1800-68; British pig iron (and steel) from Hoffman for 1800-66; British Industrial Production (exc. Building) Index from *British Historical Statistics*, p. 271 for 1801-95; British Cotton Textile Cloth Exports (in million yards) from *British Historical Statistics*, p. 182, for

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[12]Let $x_t^{1849/50} = \ln(IP_t^{1849/50}) - \ln(IP_{t-1}^{1849/50})$ and $x_t^{1879/80} = \ln(IP_t^{1879/80}) - \ln(IP_{t-1}^{1879/80})$ represent the log growth rates in the two overlapping indexes. Define the growth rate of the *final* industrial production index as a $x_t^{final} = (1 - w_t)x_t^{1849/50} + w_t x_t^{1879/80}$, where $w_t = 0 \;\forall\; t \le 1850$, $w_t = 1 \;\forall\; t \ge 1880$, and, to link the indexes, $w_t = ((t - 1850)/30) \;\forall\; 1850 < t < 1880$. Thus, the final industrial production index reflects the accumulation of x_t^{final} to $IP_{1850}^{1849/50}$ forward from 1850.

1815-64, British Cotton used in Production from *British Historical Statistics*, p. 179, for 1811-61.

Export values

Cotton export values from D. North, Table A-8 for 1815-60.
Export values of raw materials, crude food products, processed food products from D. North, 1966, Table V for 1820-60, with a gap in 1843 when the definition of the year shifts. Import and export price indices for D. North 1966, Table 1 for 1815-60.

Crop Exports:

Wheat Exports and Net Exports: Measured in 1000 bushels. Flour is converted into wheat at a ratio of 1 barrel of flour equals 5 bushels wheat up to 1879 (and following the USDA, 4.75 bushels for 1880-1908; 4.7 bushels 1909-17 and 1921-39, 4.5 bushels 1918-19, 4.6 bushels in 1920). Net Exports are negative in for Oct. 1836 through Sept. 1837. U.S. Treasury, *Annual Reports on Commerce and Navigation*, various years; "The Grain Trade of the United States," *Monthly Summary for Commerce and Finance*, Jan. 1900, 56th Cong, 1st Sess., Doc No 15, pt. 7, p. 2022; linked to USDA, *Agricultural Statistics*: 1940, pp. 9-10.

Cotton Exports and Net Export: Measured in 1000 bales of 500 pound equivalents. USDA Bureau of Statistics "Cotton Crop of the United States, 1612-1911" *Circular 32* (1912) linked to USDA, *Agricultural Statistics*: 1940, pp. 108-09.

Tobacco Exports: Millions of pounds of unmanufactured tobacco leaf, from USDA Bureau of Statistics "Tobacco Crop of the United States, 1612-1911" *Circular 33* (1912). The data cover 1790 to 1911.

Corn Exports: Measured in 1000 bushels. Corn meal is converted into corn at a ratio of 1 barrel of meals equals 4 bushels of corn. The data cover 1790 to 1908. U.S. Treasury, *Annual Reports on Commerce and Navigation*, various years;
U.S. Census Office, *Agriculture: 1860*, p. cxxxix; U.S. Bureau of Statistics, "Exports of Farm Products From the United States, 1851-1908" *Bulletin 75*. Imports are negligible.

Crop Production

Wheat: The postbellum production data are from U.S. *Historical Statistics* K 507, Pt 1, pp.510-12.

For the antebellum period, the data are from Robert E. Gallman worksheets. The figures for the 1850s are reported in Robert E. Gallman, "Gross National Product in the United States, 1834-1909" Studies in Income and Wealth, Vol. 30. p. 69. Gallman estimated series on U.S. annual wheat production and consumption (production minus net exports) to interpolate flour and bread output. Explaining the series he wrote:

"Pieced together from the following sources: David A. Wells, The Year-Book of Agriculture, Philadelphia, 1856, pp. 375, 377 (which includes estimates for the crop year 1855 from the Cincinnati Price Current, the New York Herald, and the New York Times, and estimates for crop years 1839-55 by Charles Cist); the New York Times for Sept. 22, 1855 (the original source of the Cist estimates, cited above, which also contains estimates for the crop year 1855 by the Courier and Enquirer and the Economist); DeBow's Review, Vol. 18, pp. 467, 471; Vol. 25, p. 575; Hunt's Merchant's Magazine, Vol. 41, p. 252; Vol. 43 (which contains estimates for the U.S. for each year of the decade, together with estimates for 1853-57 for Ohio and Indiana from Vol. 40, p. 762, the former evidently taken from the Annual Reports of the Auditor); Annual Report of the Auditor of the State of Ohio, 1860 p. 86 (data for Ohio for each of the years of the decade. collected by tax assessors); Transactions of the California State Agricultural Society, 1859, p. 325 (data for 1852, probably Census data, 1855-59). The estimates for 1855 vary widely, mainly because the estimators differ with respect to the output of Ohio (see Cist's article in the Times). Subsequently, the returns of the Auditor became available and, with these data in hand, it is simple enough to settle the issue. A second difference of some importance has to do with output in Indiana. The data later appearing in Hunt (see above) appear to be official, although we have been unable to locate the official source. If the official Ohio and Indiana data are substituted for the estimates, and if we assume that the Hunt U.S. total includes the official Ohio and Indiana data, the range of the estimates narrows to 140-160 million bushels. The Price Current estimates for the main producers suggest an even lower national total (perhaps about 130 million bushels), but there is no question that the Price Current estimates are low. For example, the Iowa Census of 1856 returns almost 5.5 million bushels for the crop year 1855, while the Price Current estimate is only 2.5 million. In addition, the Price Current gives Michigan only 6 million bushels, whereas the state produced a million more than this two years previously (Michigan Census of 1854). For the remaining years, the various sources are roughly consistent. Our estimates are as follows (in millions of bushels):

1850	107	1855	145
1851	118	1856	153
1852	122	1857	153
1853	135	1858	148"

We have reviewed most these sources independently and find Gallman's numbers reasonable if not definitive for the 1850s. As stated in a *N. Y. Courier* article, "The Grain Crop of the United State, 1860," reprinted in *DeBow's Review* 29:5 (Nov. 1860): 658-60:

> Estimates of the wheat crop must necessarily be approximate, from the fact that our information is obtained is through trade and the compilations of individuals. For among the many privileges of free government, we certainly have one of judging each one for himself every year … the product of bread and meat. Of this vital question, … it is thought better to let all be free to guess, rather

> than to try by well-directed official effort to obtain returns with exactitude. Availing ourselves of the liberty to make a guess, we propose to give value to it by some figures collated with care.

Gallman's figures on the worksheet for the 1840s rely on those are reported in Robert E. Gallman "A Note on the Patent Office Crop Estimates, 1841-1848," *Journal of Economic History*, 23:2 (June 1963): 185-95. Gallman uses his census benchmarks for 1839, 1849, 1854, 1859 and interpolated for missing values in 1840 and 1846 using data for wheat and flour shipped arriving at tidewater on the New York canals. He estimated domestic wheat consumption (domestic wheat production minus wheat exports) over the 1834-1838 period by using the New York shipment series to extrapolate back from his 1839 benchmark. We added net exports of wheat (but not flour) to his consumption data to derive wheat production estimates for the 1830s comparable to his later series. Note that net wheat exports were negative in 1836-37.

As a check we utilize total receipts of flour and wheat at tide water by New York canals for the 1835-62 from U.S. Census Office, *Agriculture: 1860*, p. cxlvi linked to data for 1862-76 from the *First Annual Report on the Internal Commerce of the United States 1876*, 44th Cong .2d Sess., HR Ex Doc. 46 Pt. 2 1877 Appendix No. 39 p. 251 (SS 1761).

Cotton: Production data for 1790-1915 from U.S. *Historical Statistics* K 554, Pt 1, pp.517-18.. These include 1790-1865 data from U.S. Department of Agriculture, Bureau of Statistics, Circular 32, August 1912 which were initially compiled by U.S. Treasury Secretary Levi Woodbury and the Latham firm.

Prices: Wholesale Prices for selected crop divided by the general wholesale price index. Philadelphia wholesale corn and wheat prices (in cents/bu) and upland middling cotton (in cents/bu) for 1790-1861 from Bezanson. Note these are annual average prices and do not correspond to the harvest year. The Bezanson crop prices may be divided by either an all-commodity WPI or a manufacturing WPI.

Specie Flows: Specie stock in the US from U.S. Comptroller of the Currency, *1906 Annual Report*, Washington, D.C.: GPO, 1906, Pt. 1, pp. 113-15 and Temin (1969) pp. 186-87

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Figure 1: Labor Force Shares, 1800-1920

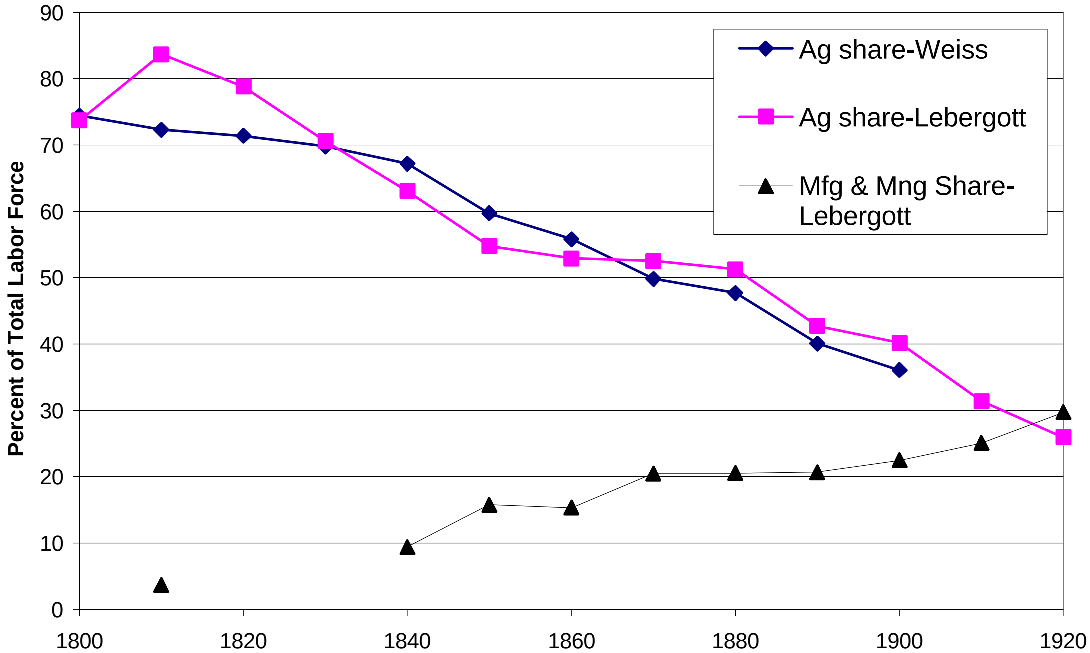


Figure 2: Agricultural Shares of Export Values, 1802-1915

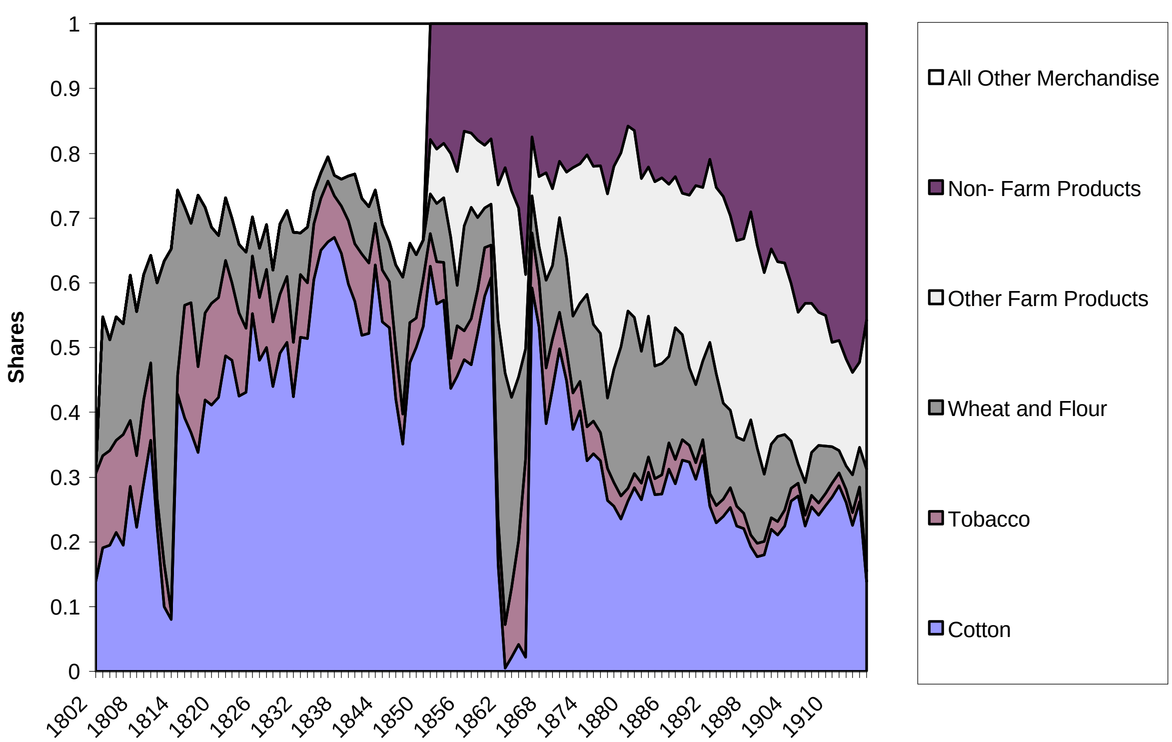


Figure 3: Gross Income from Wheat and Cotton Relative to Nominal GNP

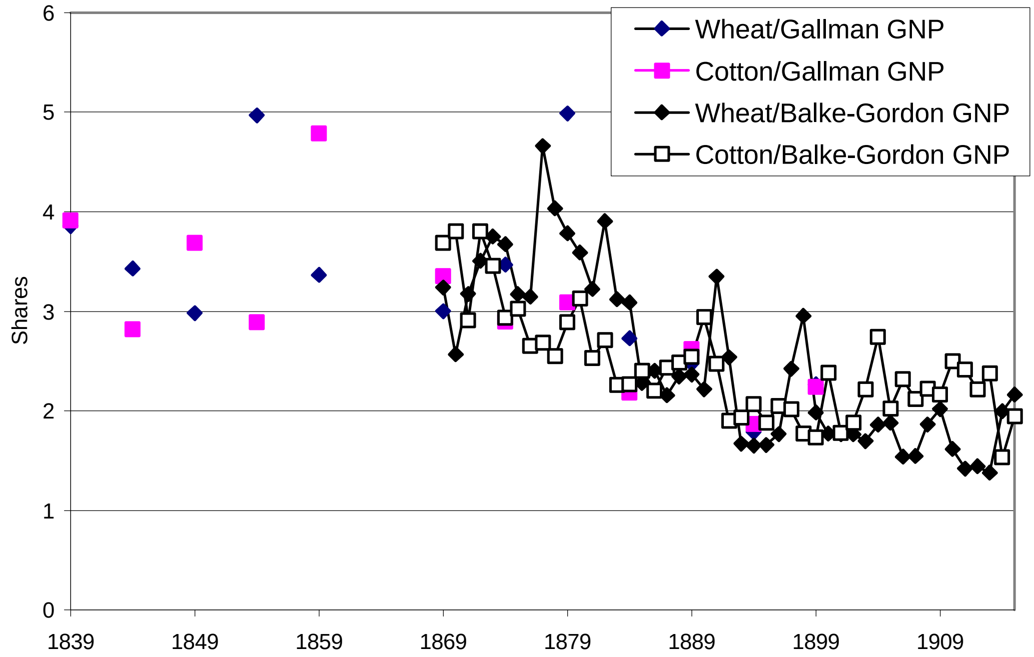


Figure 4: Share of U.S. Crops Exported

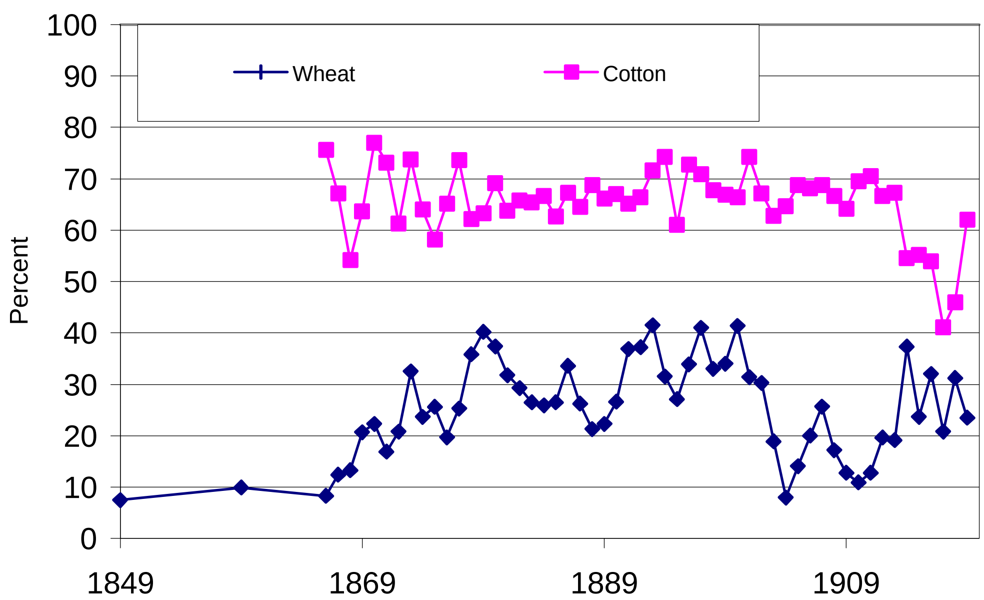
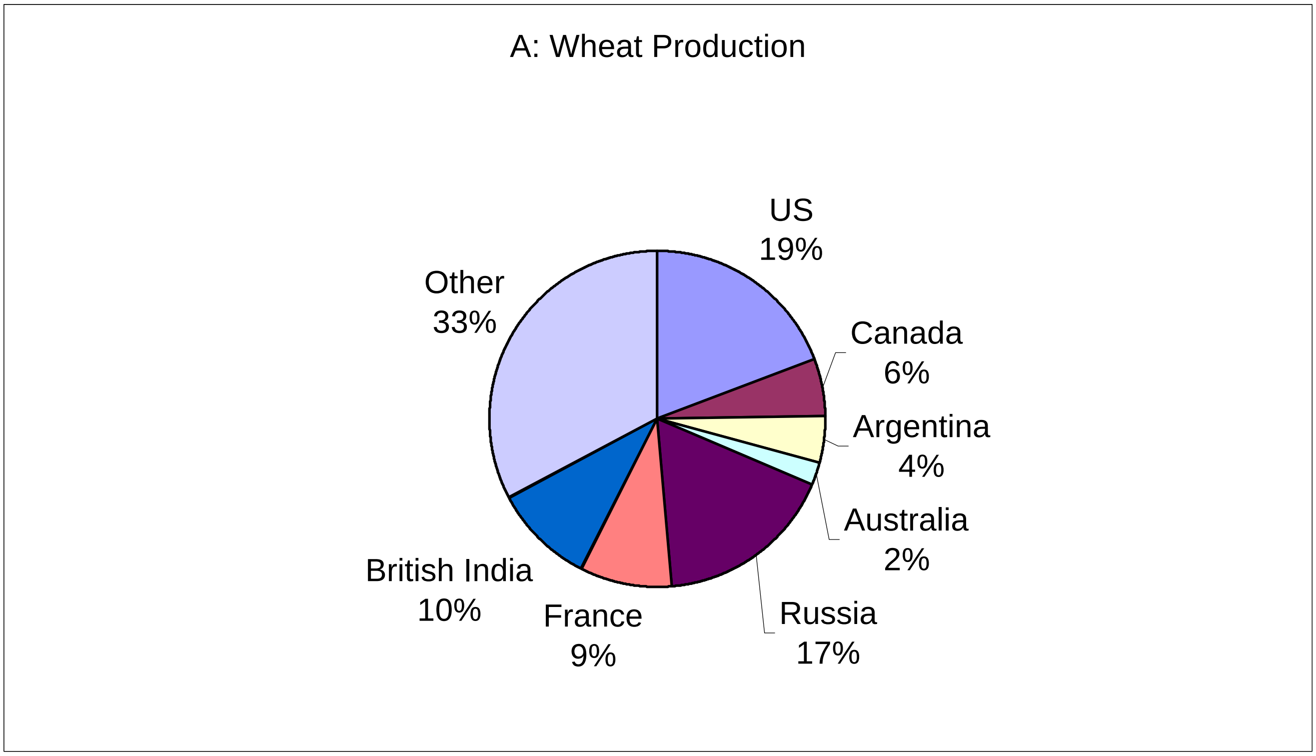
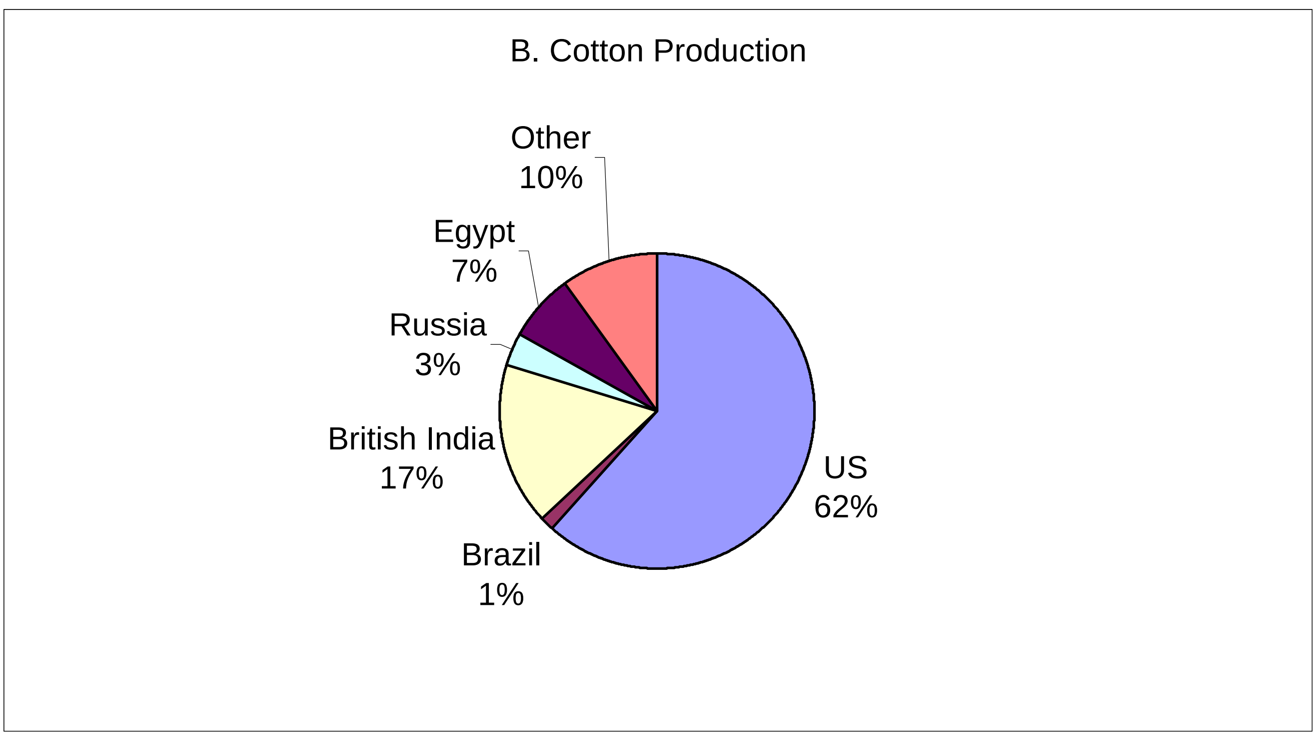


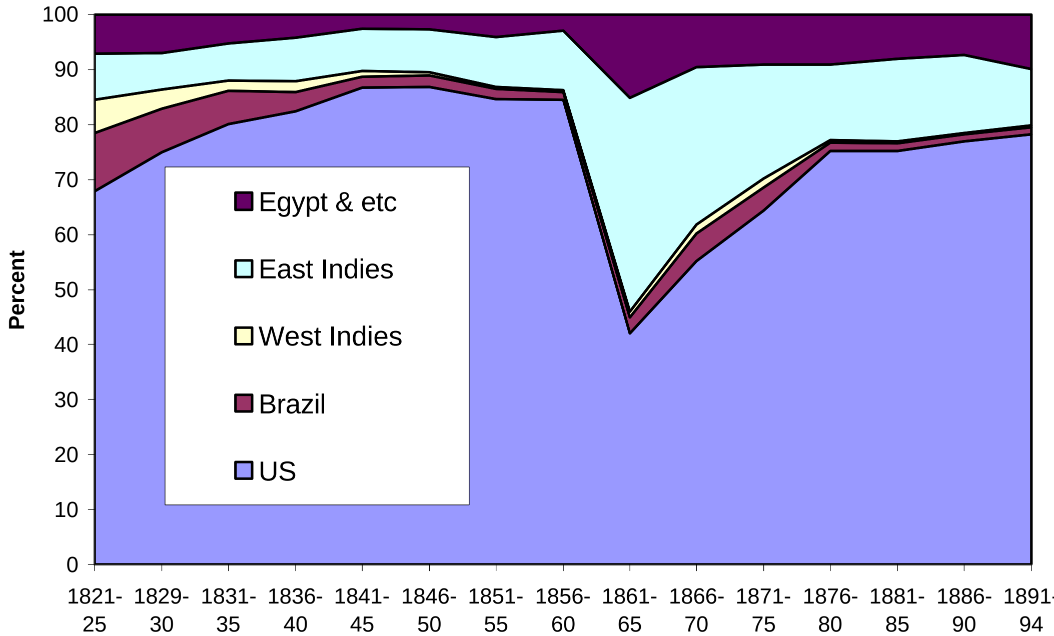
Figure 5: U.S. Shares of World Wheat and Cotton Production, 1909-13





Source: USDA *Yearbook of Agriculture 1920*, pp. 547-48.

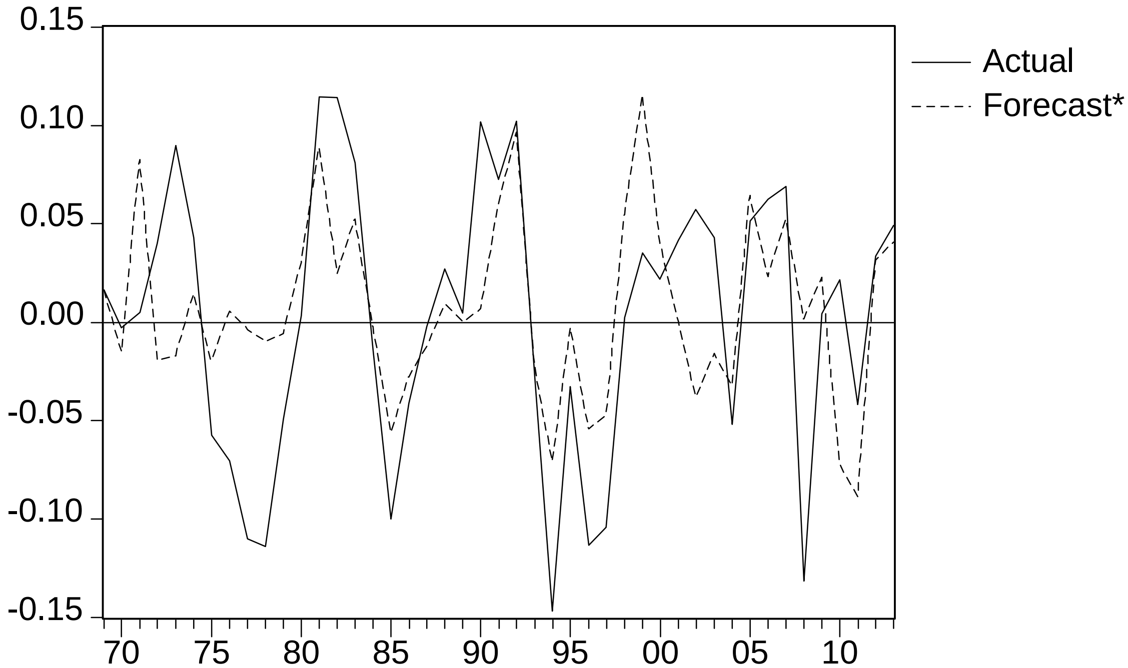
Figure 6: Shares of Cotton Consumption, 1821-94



Sources: Ellison (1968) p. 99; U.S. Treasury (1895) p. 304.

Figure 7:

Deviations from HP Trend in Davis IP Index, Actual and Forecast
1870-1913



*Using coefficients from regression on 1879-1913 sample,
starting with 1869 IP deviation and rolling forward forecast IP for subsequent years

Table 8:

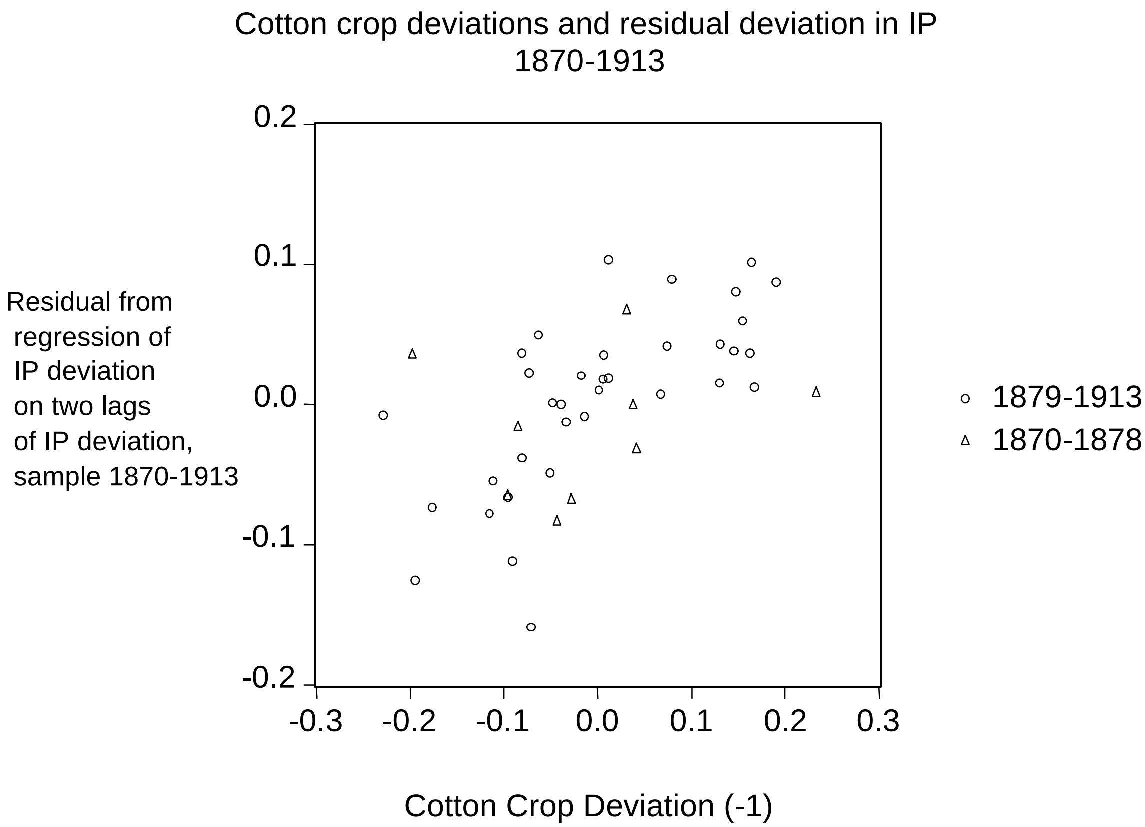

Cotton crop deviations and residual deviation in IP
1870-1913
0.2
0.1
0.0
-0.1
-0.2
Residual from regression of IP deviation on two lags of IP deviation, sample 1870-1913
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
1879-1913
1870-1878
Cotton Crop Deviation (-1)

Table 1: Sectoral Distribution of GNP, 1840-1900

Percent of U.S. GNP

Year	Agriculture	Manufacturing/ Mining
1840	41%	17%
1850	35	22
1860	35	22
1870	33	24
1880	28	25
1890	19	30
1900	18	31

Source: Gallman (2000) p. 50. Manufacturing and Mining includes “Hand trades.” Agriculture includes “land clearing, breaking, and fences as well as home manufacturing.” The remainder of activity was in transportation and public utilities, commerce, government, and shelter.

Table 2: Summary of Estimates of the Price-Elasticity of Demand for U.S. Wheat and Cotton Relevant to the Long Nineteenth Century **Preliminary and Incomplete**

Commodity/Market	Price-Elasticity	Time Period	Source
Wheat			
US crop	-0.36	1896-1913	Working 1937, pp. 185-6.
US crop	-0.24 ±0.09	1921-1935	Working 1937, pp. 185-6
US crop	-0.21±0.04	1921-1934	Schultz 1938, p. 399.
Per Capita Flour	-0.07	1922-1941	Fox 1953, p. 69.
Domestic Food	-0.04	1921-38	Meinken, 1995, p. 43.
World Crop/ World Price	-0.70	1921-38	Meinken, 1995, p. 43 (calculation based on price flexibility)
Cotton			
US crop	-0.51	1875-1895	Schultz 1938, p. 321.
	-0.25	1896-1913	Schultz 1938, p. 321.
	-0.12	1914-1929	Schultz 1938, p. 321.
British Demand for US crop.	-0.31 to -0.65	1830-1860	Wright 1971, p. 119.
World Crop	-0.6	1830-1860	Surdam 1998, p. 11.
US Crop	-0.88	1830-1860	Surdam 1998, p. 11
For US Crop	~ -1.0	1830-1860	Wright 1971, p. 119
	~ -1.5	1860-1895	Wright 1979, p. 119
	~ -1.0	1880-191	Wright 1979, p. 1193
Foreign Demand For US crop	-1.49	1820-1859	Irwin 2001, p. 23.

Notes: Lehfeldt (1914) computed one of the first estimates of the elasticities of demand for wheat. Using the price of wheat imported to England and the previous year's world crop, he calculated elasticity of –0.61 for the 1888-1991 period. His approach was subject to considerable criticism (Christ 1985).

Table 3: Characteristics of IP and Crop Deviations from Trend, 1828-1860 1869-1913

		HP			Quadratic		
Series	Period	Std. Dev.	Max.	Min.	Std. Dev.	Max.	Min.
IP including textiles, flour	1828-1860	0.066	0.116	-0.151			
	1869-1913	0.069	0.115	-0.147			
IP excluding textiles, flour	1828-1860	0.077	0.140	-0.151			
	1869-1913	0.077	0.138	-0.160			
Cotton crop	1828-1860	0.111	0.208	-0.222	0.115	0.234	-0.221
	1869-1913	0.112	0.233	-0.229	0.116	0.207	-0.241
Wheat crop	1869-1913	0.111	0.239	-0.192	0.121	0.236	-0.191

Table 4: Determinants of harvest variations, 1829-60 and 1870-1913

LHS variable: log crop, deviation from trend

Coefficient
[Standard error]
p-value

	A) Cotton				B) Wheat	
Trend:	HP		Quadratic		HP	Quadratic
Period:	1829-1860	1870-1914	1829-1860	1870-1913	1870-1913	
Crop(-1)	-0.239	-0.298	-0.191	-0.256	-0.179	-0.024
	[0.181]	[0.189]	[0.183]	[0.193]	[0.152]	[0.151]
	0.20	0.12	0.31	0.19	0.25	0.87
Other crop		0.180		0.260	0.160	0.255
		[0.170]		[0.158]	[0.150]	[0.155]
		0.30		0.11	0.30	0.11
Other crop(-1)		-0.065		0.004	0.293	0.398
		[0.164]		[0.152]	[0.178]	[0.184]
		0.70		0.98	0.11	0.04
IP	-0.000	-0.085	-0.079	-0.159	0.303	0.197
	[0.361]	[0.400]	[0.373]	[0.346]	[0.317]	[0.342]
	0.99	0.80	0.83	0.64	0.35	0.57
IP(-1)	-0.379	0.107	-0.421	-0.159	0.027	-0.023
	[0.362]	[0.309]	[0.374]	[0.346]	[0.292]	[0.317]
	0.30	0.73	0.27	0.65	0.93	0.94
F-statistic	0.99	0.975	0.96	0.920	1.721	2.016
p-value	0.41	0.45	0.43	0.48	0.15	0.10
R bar sqr	-0.00	-0.00	-0.00	-0.01	0.08	0.11
IP & IP(-1)						
F-stat		0.062		0.107	0.729	0.210
p-value		0.94		0.90	0.49	0.81

Table 5: Determinants of yields and acreage, 1870-1913

LHS variable at head of column

Coefficient
[Standard error]
p-value

	Cotton		Wheat	
	Acreage	Yield	Acreage	Yield
Acreage or Yield(-1)	-0.126	-0.284	0.397	-0.294
	[0.177]	[0.174]	[0.147]	[0.148]
	0.48	0.11	0.01	0.05
IP	0.016	-0.096	0.166	0.316
	[0.129]	[0.234]	[0.125]	[0.209]
	0.90	0.68	0.19	0.14
IP(-1)	0.034	0.055	-0.052	-0.150
	[0.118]	[0.222]	[0.126]	[0.211]
	0.77	0.80	0.68	0.48
F-statistic	0.248	1.583	3.86	1.962
p-value	0.86	0.21	0.02	0.14
R bar sqr	-0.06	0.04	0.17	0.06

Table 6: Industrial Production and Crops, Deviations from HP Trends, 1829-60 and 1870-1913

LHS variable: IP series

Coefficient
[Standard error]
p-value

IP series:	Davis including textiles, flour			
Period:	1829-1860	1834-1860	1870-1913	1879-1913
Cotton	-0.011 [0.098] 0.91	0.050 [0.093] 0.60	-0.057 [0.076] 0.46	-0.121 [0.080] 0.14
Cotton(-1)	-0.053 [0.098] 0.59	0.004 [0.093] 0.96	0.300 [0.080] 0.00	0.360 [0.085] 0.00
Wheat			0.040 [0.080] 0.62	0.042 [0.082] 0.61
Wheat(-1)			0.032 [0.076] 0.67	0.004 [0.080] 0.96
IP(-1)	0.679 [0.187] 0.00	0.597 [0.207] 0.01	0.650 [0.141] 0.00	0.617 [0.144] 0.00
IP(-2)	-0.262 [0.187] 0.17	-0.063 [0.210] 0.77	-0.286 [0.138] 0.05	-0.312 [0.135] 0.03
R sqr	0.35	0.33	0.53	0.61
R bar sqr	0.25	0.21	0.46	0.52
Wheat & wheat(-1)				
F-statistic			0.176	0.133
p-value			0.84	0.88

Table 6 (cont.)

IP series:	Davis excluding textiles, flour				Frickey	
Period:	1829-1860	1834-1860	1870-1913	1879-1913	1870-1913	1879-1913
Cotton	0.011	0.092	-0.037	-0.131	-0.053	-0.101
	[0.109]	[0.102]	[0.089]	[0.093]	[0.095]	[0.092]
	0.92	0.38	0.68	0.17	0.58	0.28
Cotton(-1)	-0.154	-0.100	0.285	0.356	0.226	0.331
	[0.108]	[0.104]	[0.091]	[0.096]	[0.102]	[0.101]
	0.17	0.35	0.00	0.00	0.03	0.00
Wheat			0.046	0.053	0.136	0.125
			[0.091]	[0.092]	[0.100]	[0.096]
			0.62	0.57	0.18	0.20
Wheat(-1)			0.042	0.001	0.044	0.010
			[0.087]	[0.090]	[0.098]	[0.097]
			0.63	0.99	0.65	0.92
IP(-1)	0.700	0.661	0.660	0.651	0.389	0.331
	[0.185]	[0.200]	[0.146]	[0.150]	[0.153]	[0.152]
	0.00	0.00	0.00	0.00	0.02	0.04
IP(-2)	-0.155	-0.025	-0.275	-0.337	-0.217	-0.263
	[0.196]	[0.214]	[0.145]	[0.143]	[0.147]	[0.138]
	0.44	0.91	0.07	0.03	0.15	0.07
R sqr	0.42	0.47	0.50	0.58	0.34	0.49
R bar sqr	0.34	0.38	0.42	0.49	0.23	0.38
Wheat & wheat(-1)						
F-statistic			0.209	0.173	0.95	0.87
p-value			0.81	0.84	0.40	0.43

Table 7:Industrial Production and Crops, Log Levels, 1829-60 and 1870-1913

LHS variable: Davis IP series

Period:	1829-1860	1834-1860	1870-1913	1879-1913
Cotton	0.062	0.115	-0.022	-0.097
	[0.118]	[0.112]	[0.099]	[0.112]
	0.60	0.32	0.83	0.40
Cotton(-1)	0.009	0.035	0.330	0.410
	[0.118]	[0.114]	[0.103]	[0.117]
	0.95	0.76	0.00	0.00
Wheat			0.062	0.016
			[0.105]	[0.115]
			0.56	0.89
Wheat(-1)			-0.008	-0.063
			[0.099]	[0.113]
			0.94	0.58
IP(-1)	1.081	1.015	0.999	1.006
	[0.189	[0.212]	[0.157]	[0.169]
	0.00	0.00	0.00	0.00
IP(-2)	-0.103	-0.025	-0.008	-0.040
	[0.187]	[0.211]	[0.157]	[0.168]
	0.59	0.91	0.96	0.81
R bar sqr	0.987	0.98	0.99	0.98
Wheat & wheat(-1)				
F-statistic			0.198	0.201
p-value			0.82	0.82

Table 8: Industrial Production and Cotton Crop, Yield, and Acreage, deviation from HP trends, 1870-1913

LHS variable: Davis IP

Period:	1870-1913					1879-1913				
Specification:	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Cotton Crop(-1)	0.332			0.284		0.393			0.297	
	[0.069]			[0.106]		[0.074]			[0.105]	
	0.00			0.01		0.00			0.00	
Cotton Yield (-1)		0.397					0.433			
		[0.98]					[0.107]			
		0.00					0.00			
Cotton Acres (-1)			0.685	0.156				0.885	0.342	
			[0.184]	[0.261]				[0.208]	[0.268]	
			0.00	0.55				0.00	0.21	
IP(-1)	0.663	0.670	0.581	0.653	0.557	0.599	0.576	0.534	0.594	0.458
	[0.125]	[0.134]	[0.134]	[0.128]	[0.153]	[0.129]	[0.144]	[0.139]	[0.127]	[0.171]
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
IP(-2)	-0.283	-0.277	-0.237	-0.280	-0.196	-0.269	-0.258	-0.213	-0.262	-0.168
	[0.125]	[0.133]	[0.135]	[0.126]	[0.154]	[0.124]	[0.138]	[0.134]	[0.123]	[0.166]
	0.03	0.04	0.09	0.03	0.21	0.04	0.07	0.12	0.04	0.32
R sqr	0.52	0.46	0.44	0.53	0.25	0.57	0.46	0.48	0.59	0.18
R bar sqr	0.48	0.42	0.40	0.48	0.21	0.53	0.41	0.43	0.54	0.13

Table 9: U.S. and British Industrial Production and Cotton Crop, Deviations from HP Trends

	1829-1860		1834-1860		1870-1913		1879-1913	
LHS IP	U.S.	British	U.S.	British	U.S.	British	U.S.	British
Crop(-1)	-0.117	0.094	-0.076	0.080	0.207	0.010	0.259	0.006
	[0.107]	[0.055]	[0.092]	[0.054]	[0.080]	[0.03]	[0.087]	[0.066]
	0.28	0.10	0.42	0.15	0.01	0.84	0.01	0.93
RHS IP								
British	0.663		0.784		0.740		0.636	
	[0.332]		[0.294]		[0.227]		[0.237]	
	0.06		0.01		0.00		0.01	
U.S.		0.182		0.292		0.278		0.289
		[0.091]		[0.109]		[0.085]		[0.108]
		0.06		0.01		0.00		0.01
R sqr	0.13	0.178	0.23	0.27	0.36	0.25	0.41	0.24
R bar sqr	0.07	0.121	0.17	0.21	0.32	0.22	0.37	0.20

Table 10: Specie Flows and Crop Deviations from Trend 1829-60 and 1870-1913

Period	1829-1860	1834-1860	1870-1913 (1)	1870-1913 (2)	1870-1913 (3)	1879-1913 (1)	1879-1913 (2)	1879-1913 (3)
Crops								
Cotton	-22.52	-20.31	206.49	217.77		215.15	255.97	
	[39.53]	[42.92]	[57.93]	[55.21]		[63.91]	[59.16]	
	0.57	0.64	0.00	0.00		0.00	0.00	
Cotton(-1)	-6.27	-4.94	177.73	168.81		192.50	188.28	
	[39.62]	[43.06]	[57.58]	[57.95]		[63.93]	[62.77]	
	0.88	0.91	0.00	0.01		0.01	0.01	
Wheat				11.94	84.52		-27.05	66.95
				[57.56]	[63.35]		[61.24]	[72.10]
				0.84	0.19		0.66	0.36
Wheat(-1)				148.53	145.62		170.21	153.35
				[53.10]	[62.52]		[56.93]	[71.26]
				0.01	0.02		0.01	0.04
F-stat	0.163	0.112	8.738	6.959	3.257	8.737	7.950	2.491
p-value	0.85	0.89	0.00	0.00	0.05	0.00	0.00	0.10
R sqr	0.01	0.01	0.30	0.42	0.14	0.35	0.51	0.13
R bar sqr	-0.06	-0.07	0.26	0.36	0.09	0.31	0.45	0.08

Table 11: Crop Value and Crop Deviations from Trend 1829-60 and 1870-1913

LHS variable: log (crop times October crop price)

	Cotton				Wheat	
Period:	1829-1860	1834-1860	1870-1913	1879-1913	1870-1913	1879-1913
Crop	0.149	0.086	0.467	0.425	0.586	0.489
	[0.363]	[0.303]	[0.150]	[0.157]	[0.248]	[0.244]
	0.68	0.78	0.00	0.01	0.02	0.06
Crop(-1)	-0.556	-0.614	-0.326	-0.417	-0.144	-0.242
	[0.365]	[0.304]	[0.150]	[0.159]	[0.250]	[0.254]
	0.14	0.06	0.04	0.01	0.57	0.35
WPI	0.684	-0.009	1.199	1.235	0.550	0.757
	[0.524]	[0.491]	[0.202]	[0.224]	[0.341]	[0.364]
	0.20	0.98	0.00	0.00	0.11	0.05
Time	-0.012	-0.317	0.046	-0.051	0.093	-0.073
	[0.076]	[0.111]	[0.053]	[0.069]	[0.091]	[0.111]
	0.87	0.01	0.388	0.046	0.31	0.52
Time Sqr	0.001	0.003	-0.000	0.000	-0.000	0.000
	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
	0.32	0.00	0.84	0.23	0.41	0.43
R sqr	0.87	0.89	0.93	0.94	0.61	0.62
R bar sqr	0.84	0.86	0.92	0.93	0.56	0.56

Table 12: Crop Price and Crop Deviations from Trend: 1829-60 and 1870-1913
LHS variable: log (October crop price)

	Cotton				Wheat	
Period:	1829-1860	1834-1860	1870-1913	1879-1913	1870-1913	1879-1913
Crop	-0.882	-0.939	-0.543	-0.580	-0.485	-0.554
	[0.363]	[0.314]	[0.141]	[0.155]	[0.223]	[0.247]
	0.02	0.01	0.00	0.00	0.04	0.03
Crop(-1)	-0.589	-0.641	-0.342	-0.427	-0.193	-0.281
	[0.364]	[0.315]	[0.141]	[0.158]	[0.231]	[0.258]
	0.12	0.05	0.02	0.01	0.41	0.283
WPI	0.605	-0.032	1.227	1.256	0.602	0.791
	[0.524]	[0.509]	[0.190]	[0.222]	[0.315]	[0.368]
	0.26	0.95	0.00	0.00	0.06	0.04
Time	-0.127	-0.409	-0.039	-0.090	-0.018	-0.130
	[0.076]	[0.115]	[0.050]	[0.069]	[0.084]	[0.112]
	0.11	0.00	0.44	0.20	0.83	0.26
Time Sqr	0.001	0.003	0.000	0.000	0.000	0.001
	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
	0.08	0.00	0.37	0.17	0.82	0.26
R sqr	0.39	0.60	0.88	0.82	0.48	0.50
R bar sqr	0.27	0.51	0.87	0.79	0.41	0.41

Table 13: Export Revenue and Crop Deviations from Trend 1829-60 and 1870-1913

LHS variable: log (revenue from exports of crude materials, foods and partially-processed foods)

Period:	1829-1860	1834-1860	1870-1913 (1)	1870-1913 (2)	1879-1913 (1)	1879-1913 (2)
Cotton	0.029	-0.051	0.287	0.267	0.299	0.390
	[0.235]	[0.215]	[0.172]	[0.144]	[0.152]	[0.108]
	0.90	0.82	0.10	0.07	0.06	0.00
Cotton(-1)	-0.105	-0.182	0.523	0.389	0.502	0.419
	[0.252]	[0.230]	[0.175]	[0.155]	[0.162]	[0.118]
	0.68	0.44	0.01	0.02	0.00	0.00
Wheat				0.417		0.328
				[0.151]		[0.113]
				0.01		0.01
Wheat(-1)				0.551		0.638
				[0.144]		[0.114]
				0.00		0.00
WPI	1.436	0.956	0.149	-0.103	0.212	-0.280
	[0.528]	[0.501]	[0.307]	[0.262]	[0.304]	[0.225]
	0.01	0.07	0.63	0.70	0.49	0.22
WPI(-1)	-0.326	-0.419	0.364	0.508	0.356	0.666
	[0.515]	[0.464]	[0.307]	[0.257]	[0.287]	[0.204]
	0.53	0.38	0.24	0.06	0.23	0.00
Time	0.022	-0.195	0.176	0.134	0.027	-0.009
	[0.051]	[0.080]	[0.066]	[0.055]	[0.069]	[0.048]
	0.67	0.02	0.01	0.02	0.70	0.85
Time Sqr	0.000	0.002	-0.001	-0.000	0.000	0.000
	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
	0.41	0.00	0.03	0.06	0.97	0.47
R sqr	0.94	0.93	0.90	0.94	0.88	0.95
R bar sqr	0.92	0.91	0.89	0.92	0.86	0.93
Cotton, Cotton(-1)						
F-stat	0.111	0.312	4.834	3.772	5.856	10.53
p-value	0.89	0.74	0.01	0.01	0.03	0.00
Wheat, Wheat(-1)						
F-stat				9.59		16.958
p-value				0.00		0.00