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Volume Title: A Retrospective on the Classical Gold Standard, 1821-1931

Volume Author/Editor: Michael D. Bordo and Anna J. Schwartz, editors

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-06590-1

Volume URL: <http://www.nber.org/books/bord84-1>

Publication Date: 1984

Chapter Title: The Gold Standard and the Transmission of Business Cycles, 1833-1932

Chapter Author: Wallace E. Huffman, James R. Lothian

Chapter URL: <http://www.nber.org/chapters/c11135>

Chapter pages in book: (p. 455 - 512)

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## The Gold Standard and the Transmission of Business Cycles, 1833–1932

Wallace E. Huffman and James R. Lothian

Descriptions of the gold standard have stressed two very different aspects of that monetary system. Modern observers, concerned with high and rising rates of inflation, have written enthusiastically and often nostalgically of the longer-term price stability that existed during the gold standard era. Many other economists during the past century and a half, however, have rendered a less kindly judgment, emphasizing instead the frequent and sometimes severe business contractions that characterized the period as well as the substantial shorter- and intermediate-term swings in the price level.

Irving Fisher (1920, p. 65), for instance, phrased his criticism thus:

The chief indictment, then of our present [gold] dollar is that it is uncertain. As long as it is used as measuring stick, every contract is necessarily a lottery; and every contracting party is compelled to be a gambler in gold without his own consent. . . . One of the results of such uncertainty is that price fluctuations cause alternative fluctuations in business; that is, booms and crises, followed by contractions and depressions.

The objective of this paper is to investigate the incidence of cyclical fluctuations within countries adhering to the gold standard and the transmission of these fluctuations among countries. In investigating these

The authors' affiliations are Iowa State University and Citicorp Investment Bank, respectively.

Moses Abramovitz, Michael Bordo, Michael Connolly, Barry Falk, Arthur E. Gandolfi, Thomas Huertas, Robert Lewis, Anna J. Schwartz, and Harvey Segal provided useful comments on various aspects of this paper. Richard M. Timberlake, Jr. read and commented in detail on an earlier draft of the historical section. The authors would like to thank all of these individuals without implicating them in the end result. In addition, the authors wish to thank Donna Bettini, Connie McCarthy, and Mark McNulty for extremely able assistance.

topics we first review each of the important cyclical contractions in the United Kingdom and United States during the century 1833–1932. We then present the results of more formal tests of hypotheses about the causes of such contractions and their dissemination across countries. The basis of these tests is a vector autoregressive model estimated for both countries for the combined subperiods 1837–59 and 1882–1914.

The main objective of the historical narrative is to see whether a monetary explanation of the business cycle is at least broadly consistent with the data for the two countries. To do so we analyze the movements in the U.K. and U.S. money and gold stocks, the apparent causes of those movements, and their relationships to one another and to output over the cycle.

In the course of this analysis, we track over territory touched upon to varying degrees by a number of other authors. Insofar as possible, we have tried to integrate their accounts with ours. Our analysis, however, differs from most of these earlier analyses both in its breadth of coverage, spanning both the United Kingdom and the United States and a century of data, and in its emphasis, being concerned almost exclusively with cyclical fluctuations and with monetary, as opposed to credit or interest-rate, data.

The vector autoregressive model and associated hypothesis tests are direct complements of the historical narrative. They enable us to evaluate in a more rigorous fashion the apparent relationships uncovered by the simpler historical approach. Again our chief concerns are the association of monetary shocks and cyclical declines in output within each of the two countries and the strength of possible alternative channels of transmission between the two countries. The latter include specie flows, price and interest-rate arbitrage, asset-market adjustments, and direct absorption effects.

Since the historical and econometric sections contain separate summaries of results and the last section of the paper an overall summary, we skip a detailed synopsis at this juncture. Instead, we merely mention the two principal findings: monetary shocks were the main source of cyclical fluctuations during this period, and the monetary system itself—the gold standard—was the main mechanism through which the shocks and associated fluctuations in output were disseminated.

### **10.1 Historical Overview**

At the start of our sample period, the United Kingdom was a large country, London the main financial center of the world, and the Bank of England a central figure in international monetary activity. The United States, in contrast, started the period as a significantly smaller economy. During most of the nineteenth and early twentieth centuries, however,

the United States grew rapidly. Immigration rates were high, except for during the Civil War and major economic depression years, and the frontier moved steadily westward. As a result, by 1914 the U.S. net national product was about three times that of the United Kingdom versus roughly three-quarters that of the United Kingdom in 1834.

In the eighteenth century, the United Kingdom and most other countries had been on a bimetallic standard, primarily gold and silver. The United Kingdom restored specie payments in 1821 after the Napoleonic Wars and remained on the gold standard continuously through 1914. Then in 1915, with the economic and financial disruptions of World War I, the United Kingdom left the gold standard and in its stead adopted a managed fiduciary standard that lasted until the middle of the next decade. The United Kingdom returned briefly to gold in 1925, this time a gold-exchange standard, but that system was short lived. In 1931, faced with the massive balance-of-payments deficits engendered by the deflation then underway in the United States, the United Kingdom left gold for good.

The United States came to the gold standard later than the United Kingdom (1834), but stayed on it two years longer. Like the United Kingdom, the United States too had a temporary break with gold, the episode beginning in 1862 after the start of the Civil War and lasting de facto until 1879, de jure until 1900.

Gold during those years remained an official currency along with the greenbacks issued to finance the war. The United States was in effect on a dual monetary standard with the price of one currency, greenbacks, in terms of another, gold, determined by the market. And since gold remained the international currency, flexible exchange rates prevailed between the United States and the rest of the world. Only after the United States deflated its price level did convertibility of the dollar with gold at the pre-Civil War parity become possible.

The international gold standard that the United States and United Kingdom participated in during the period 1834–1914 was a mixed rather than a pure gold standard. Under the latter, the only money in use is gold coins or notes backed by 100 percent gold reserves, and gold is transferred between countries to meet balance-of-payments obligations. The modified gold standard of 1834–1914, however, had many of the features of a fiat currency system: domestic central-bank operations, international reserve currencies, and domestic fiduciary monies that functioned as substitutes for gold coins. Nonetheless, the monetary systems were operational gold standards whether pure or not.

Under the modified gold standard, central banks engaged in open-market operations of buying and selling domestic securities. Some, like the Bank of England, reputedly “played by the rules of the game,” permitting the domestic money supply to adjust in the direction required

for long-run international economic equilibrium.<sup>1</sup> Other central banks, though, frequently followed temporary policies of sterilizing gold flows, buying or selling domestic securities, and hence changing the domestic-credit component of the money supply to offset the monetary effects of such flows in the short run. Over the longer run, however, the ability to intervene was necessarily limited unless, of course, as often happened in time of war, a country left gold and thereby let its exchange rate float.

Under this system, the Bank of England maintained its reserves in gold, but most other countries held their reserves in gold and sterling assets. Thus, balance-of-payments adjustments could be made by transferring currencies and titles to securities and gold in financial centers rather than by shipping gold *per se*. Given that London was the world financial center and that sterling was a reserve asset, the Bank of England could have a significant effect on money supplies abroad via its open-market operations and manipulations of Bank rate.

## 10.2 Theoretical Considerations

As an empirical proposition, the link between money and business fluctuations has long been known to exist. Well before our own era, monetary economists such as David Hume, Henry Thornton, and Irving Fisher took this association as a datum, second in importance perhaps only to that between money and the price level. These writers, moreover, seem to have been well aware of the apparent contradiction between the two relationships. One of the questions they, like modern economists, sought to answer was how changes in the stock of money, a nominal variable, could in the long run affect only the price level, another nominal variable, but in the short run affect output and employment, real variables.

The distinction made by Fisher, for one, to rationalize these seemingly anomalous effects, was between the expected and the unexpected effects of monetary changes: unexpected changes giving rise to "money illusion" and thereby impinging upon output and employment. In the past two decades, Milton Friedman (e.g., 1968) has used a similar line of reasoning. Output in this view will fall below its permanent level or unemployment rise above the natural rate as a consequence of some economic agents' inability to see through monetarily induced expenditure and price changes to their ultimate source. In the empirical implementation of this model, a sudden change in the nominal stock of money or in the price level (or in their rates of change) is, therefore, the causative variable.<sup>2</sup>

Over the past decade, this approach has been extended and otherwise recast by proponents of the rational-expectations hypothesis. In these models, economic agents as a general proposition are posited to take

account of more than simply the past behavior of money or the price level in forming their expectations. They are assumed instead to know the structure of the relevant economic relationships and to make unbiased forecasts of the relevant economic variables. In empirical applications of this rational-expectations approach, output or unemployment depends upon deviations in money (or other variables) from the values individuals predict on the basis of that knowledge.

Until very recently, models of this sort, with their emphasis upon expectations and dynamic adjustment, were almost exclusively applied to closed economies. The standard models of open economies and international adjustment that dealt with behavior of output were all in the Meade-Mundell tradition—static rather than dynamic and devoid of any distinction between actual and anticipated values.<sup>3</sup>

In the past several years, however, the two strains of the literature have begun to merge. Michael Darby and Alan Stockman (1983) have estimated a simultaneous model for the United States and seven other industrialized countries during the Bretton Woods era that is consistent with a natural-rate-rational-expectations approach. And Nasser Saidi, in two separate theoretical papers (1980, 1982), has applied a rational-expectations model to questions of international transmission under both floating and fixed-exchange-rate regimes.

Underlying our empirical analyses of U.S. and U.K. business cycles under the gold standard is a set of maintained hypotheses of a similar sort. For each country the proximate determinant of output fluctuations was sudden, unanticipated changes in domestic monetary variables. Transmission between countries occurred mainly via specie flows and the monetary reactions they induced, either on the part of the monetary authorities or on the part of the banking system.

An unanticipated decrease in monetary growth in the United Kingdom, for example, initially reduced output growth in the United Kingdom, raised (real) interest rates, produced downward pressure on the rate of rise of prices, and induced a balance-of-payments surplus and hence inflows of specie and capital from the United States. Monetary growth in the United States decreased as a result of the specie outflow, the real rate of interest rose, and output growth and the rate of rise of prices fell. After the shocks worked their way through both economies, output in each returned to a level consistent with its permanent rate of growth, real interest rates to their initial levels, and the nominal stocks of money to levels consistent with worldwide monetary equilibrium.

Part of the adjustment to the initial monetary deceleration could also have occurred via price and interest-rate arbitrage. Whether the former in turn had a depressing influence on output would depend, however, upon the underlying model. If price shocks rather than monetary shocks

affected aggregate supply, then price arbitrage would be a channel through which monetary disturbances in one country could have real effects in another.<sup>4</sup>

The alternative view is that cyclical fluctuations in the two countries resulted from some common real shock. According to this explanation, contractions in the money stock were an effect rather than the cause of the declines in income. Declines in American and British real output due, say, to decreased demands for their exports on the part of other nations led to deficits in the balance of payments, gold outflows, and declines in the nominal stocks of money in the two countries.

The role of financial panics—an integral part of the history of the period—also differs according to the two sets of hypotheses. Under the first, it was purely monetary. Panics were shocks largely if not completely unrelated to prior income movements. They affected output only via their impact on the nominal stock of money. Under the second, the reverse held. Panics resulted from prior declines in income or one of its components and were a method by which the requisite reduction in the nominal stock of money was produced.<sup>5</sup>

In pure form, the two sets of hypotheses are, therefore, competing. In actuality, one can easily envision a more complex situation, feedback from income to money, or vice versa, also being of some importance in the one case or the other.

### 10.3 Historical Evidence on the Cyclical Behavior of Money and Output

The National Bureau of Economic Research's chronology of reference cycles serves as a convenient point of departure for discussion of the cyclical contractions in the two countries. For the United States, this chronology begins in 1834, the start of our sample period; for the United Kingdom—actually Great Britain—it begins forty-three years earlier. Table 10.1 lists the calendar-year reference-cycle dates for the two countries, starting with 1836, the peak in both countries for the first full contraction encompassed by our data, and ending with the Great Depression of the 1930s. In the United Kingdom over this period there were nineteen reference-cycle contractions. In the United States there were either twenty-five or twenty-three depending upon the treatment of the contractions of 1847–48 and 1892–94. If viewed as distinct entities, as the official NBER classification does, there were twenty-five. If, however, we combine the first with the earlier contraction of 1845–46 and the second with that of 1890–91, which is done in the table and which may make more sense from the standpoint of intercountry comparisons, the total for the United States reduces to twenty-three.

One aspect of these data that has attracted attention is the tendency for

**Table 10.1** U.S. and U.K. Calendar-Year Reference-Cycle Dates

----- Peak -----			----- Trough -----		
U.K.	U.S.	Both	U.K.	U.S.	Both
		1836	1837	1838	
		1839	1842	1843	
		1845		(1846)	1848
	(1847)				
1854	1853				1855
		1856	1857	1858	
		1860	1862	1861	
1866	1864		1868	1867	
	1869		1870		
		1873	1879	1878	
1883	1882		1886	1885	
	1887			1888	
		1890		(1891)	1894
	(1892)				
	1895			1896	
1900	1899		1901	1900	
		1903			1904
		1907			1908
	1910			1911	
		1913			1914
1917	1918				1919
		1920			1921
1924	1923		1926	1924	
1927	1926		1928	1927	
		1929			1932

Source: Burns and Mitchell 1946.

Note: Parentheses indicate NBER reference-cycle contractions in the United States, subsumed in our analysis into a longer corresponding cycle for the two countries.

the U.K. reference cycles to lag slightly those in the United States. Judged in terms of the yearly dates, the lag for peaks and troughs combined is approximately four-tenths of a year. The popular interpretation of this lag views it as indicative of a systematic causal relationship running from the United States to the United Kingdom. We present evidence later on, however, that contradicts this interpretation, particularly as it applies to the cyclical contractions prior to the Civil War. Before we turn to that evidence, however, it may be useful to examine the output and monetary data themselves. To that end we present tables 10.2 and 10.3 in which we detail the movements in the neighborhood of reference-cycle peaks in the United States and United Kingdom, respectively, of business activity and of two monetary variables, the monetary gold (or total specie) stock, and either the M2 definition of the overall



**Table 10.2** Rates of Change of Real Income, Money, and the Monetary Gold Stock before and during Reference-Cycle Contractions in the United States, 1834-1932

Contraction (peak-trough)	Periods			Real Income			Money			Gold		
	Precon- traction			Contraction			Contraction			Precon- traction		
1836-1838	1834-1836			-9.8	-0.1	24.2	9.2	18.1				
1839-1843	1838-1839			-5.4	-6.8	2.4	1.8	3.3				
1845-1846	1843-1845			1.0	4.3	10.0	-1.0	-0.7				
1847-1848	1846-1847			-6.9	-2.6	13.6	-2.1	15.0				
1853-1855	1851-1853			1.4	5.1	14.1	13.0	15.1				
1856-1858	1855-1856			-7.1	0.1	12.9	6.2	11.8				
1873-1878	1870-1873			3.7	-0.5	6.1	10.3	-14.5				
1882-1885	1879-1882			0.0	2.9	15.3	5.2	26.4				
1887-1888	1885-1887			-3.4	2.7	7.1	8.0	5.3				
1890-1891	1888-1890			4.0	4.0	7.1	-8.7	-0.9				
1892-1894	1891-1892			-5.1	-1.7	8.2	-4.5	1.9				
1895-1896	1894-1895			-2.6	-1.8	3.4	-8.6	0.0				
1899-1900	1897-1899			3.2	8.0	13.6	6.4	18.7				
1903-1904	1900-1903			-2.2	6.3	9.1	6.6	6.8				
1907-1908	1904-1907			-11.4	-1.4	7.6	9.9	6.7				
1910-1911	1908-1910			1.7	5.7	7.7	6.9	0.6				
1913-1914	1911-1913			-10.4	4.1	5.4	1.1	3.3				
1918-1919	1915-1918			4.0	14.9	13.9	-1.3	15.5				
1920-1921	1919-1920			-4.3	-5.8	11.5	13.5	-8.2				
1923-1924	1921-1923			2.8	5.3	5.4	10.1	10.5				
1926-1927	1924-1926			1.0	2.4	6.2	3.2	-0.4				
1929-1932	1927-1929			-14.5	-11.9	2.0	-7.1	-3.1				

Source: See appendix A.

Notes: Real income pre-1870 is an index of total trade, thereafter NNP. Money is M2. Rate of change is from initial to terminal dates; computed by dividing the difference between the natural logarithms of the terminal and initial values by the time interval between them.

**Table 10.3** Rates of Change of Real Income, Money, and the Monetary Gold Stock before and during Reference-Cycle Contractions in the United Kingdom, 1834–1932

Contraction (peak-trough)	Periods			Real Income			Money			Gold		
	Contraction	Precon- traction	Precon- traction	Contraction	Contraction	Precon- traction	Contraction	Contraction	Precon- traction	Contraction	Precon- traction	
												Contraction
1836–1837	1835–1836			-1.5	1.2	0.9	3.7	-3.8				
1839–1842	1837–1839			-2.4	0.8	-4.3	3.9	-5.4				
1845–1848	1842–1845			2.7	-3.5	5.5	-2.8	9.3				
1854–1855	1851–1854			2.7	7.2	8.3	6.3	8.7				
1857–1858	1855–1857			-2.3	4.1	-2.5	8.7	-2.6				
1860–1862	1858–1860			1.5	1.8	2.0	3.4	-0.3				
1866–1868	1864–1866			2.3	1.7	5.0	2.6	4.2				
1873–1874	1871–1873			2.8	3.7	7.5	0.8	2.8				
1883–1886	1881–1883			0.8	1.0	2.1	-0.3	-2.9				
1890–1894	1888–1890			0.9	1.9	3.7	4.9	0.2				
1900–1901	1898–1900			2.4	0.9	3.0	2.5	-0.2				
1903–1904	1901–1903			1.3	-1.2	0.4	0.6	0.5				
1907–1908	1906–1907			-1.0	0.8	2.1	1.7	3.4				
1913–1914	1911–1913			0.7	8.5	3.7	8.8	0.1				
1917–1919	1915–1917			-6.9	15.6	14.3	22.4	n.a.				
1920–1921	1919–1920			-4.9	-2.3	10.4	9.2	30.3				
1924–1926	1922–1924			0.6	-0.2	-3.0	7.8	0.1				
1927–1928	1926–1927			1.6	2.1	1.5	3.5	1.1				
1929–1932	1927–1929			-1.9	0.6	1.4	-4.0	-1.3				

Source: See appendix A.

Note: Real income is real GNP. Money is high-powered money pre-1871 and M2 thereafter. A proxy series for money for the pre-1871 period—net public liabilities of joint-stock banks—showed the following peak-to-trough average annual rates of change (in percent): 1845–48, -5.8; 1854–55, 14.1; 1857–58, -12.5; 1860–62, 8.1; 1866–68, -6.8. Rate of change is from initial to terminal dates; computed by dividing the difference between the natural logarithms of the terminal and initial values by the time interval between them.

money stock or, in the case of the United Kingdom prior to 1871, high-powered money.

Judged on the basis of these data, severe business contractions were a common occurrence in both countries, in the United States even more so than in the United Kingdom. During such episodes, output generally contracted sharply in absolute terms. (Appendix B lists severe contractions.) In many of the milder NBER reference cycles, however, the movements are virtually imperceptible: real output actually increased and at an average rate close to its secular rate of growth. The contraction that occurred in those episodes was in the rate of growth relative to the rate in the previous expansion phase rather than in the level of output or in the rate of growth relative to its secular average.

The most striking feature of the data is the clearcut association between decreases in the rate of growth of money (or high-powered money) and cyclical fluctuations in output. In the great majority of cycles in both countries, the monetary stringency preceded or was coincident with the downturn in output. The degree of stringency, moreover, in general conformed to the severity of the cycle.

The gold stock often exhibits the same general patterns as M2. The movements in gold, however, sometimes failed to account for anything close to the full movement in M2. Furthermore, in several instances there was little or no correspondence between the two. In many of these episodes, as the narrative below indicates, the cause of the monetary decline was a financial panic that reduced the ratios of M2 and high-powered money to gold.

To investigate these relationships further we turn to the analysis of severe individual cyclical contractions in the two countries, neglecting mild cyclical contractions. We divided the seven episodes and the accompanying narrative into four parts based on their chronological ordering. As it turned out, these groups are also of some economic significance, with the direction of transmission between the two countries differing considerably among the groups. In the antebellum period, the United Kingdom appears to have exerted the predominant influence. By the early twentieth century the situation was reversed—the United States becoming the senior partner in the process, the United Kingdom the junior.

### 10.3.1 Antebellum Cycles

The four major antebellum business contractions with which we deal are those of 1836, 1839, 1845, and 1857. All four were relatively severe in at least one of the two countries. Most of these severe contractions, moreover, were accompanied by substantial monetary decelerations. And all provide evidence of a causal relationship running primarily from the United Kingdom to the United States.

1836

According to Burns and Mitchell (1946), the first of the two cyclical contractions that marked the second half of the 1830s began in both the United States and the United Kingdom in 1836, ended in the United Kingdom in 1837 and in the United States a year later. In both countries, monetary factors appeared to have played an important role, with declines in either the stock of specie or its rate of growth taking place at the onset of the business declines and a further panic-induced decrease in the U.S. money stock accompanying the more protracted and more severe drop in output there (see appendix B for further discussion). This latter monetary contraction, moreover, appears attributable in large part to the restrictive policies of the Bank of England, themselves in turn the result of the Bank's reaction to the drain of specie.

By all the measures we examined, the cyclical contraction in the United States was relatively severe: Smith and Cole's (1935) separate domestic- and foreign-trade indexes fell by average annual rates of 5.5 percent and 16.5 percent, respectively, between 1836 and 1838; Ayres's (1939) index of business conditions at an annual rate over the same period of 8 percent; and Gallman's (1966) real-capital-formation series by 13.8 percent between 1837 and 1838. In the United Kingdom, the contraction was not only of shorter duration but also apparently much milder, real GNP falling by 1.5 percent from 1836 to 1837 and then rebounding by 5.6 percent the next year.

Growth in the U.S. money stock began to decline prior to the cyclical peak and then turned negative: from an increase of 31.5 percent in 1835–36, to 16.9 percent in 1836–37, to –3.4 percent in 1837–38. Specie accounted for all the change in the rate of change of money between 1834 and 1836. The next year, as a result of the banking panic, a decrease in the ratio of M2 to specie became of primary importance.

For the United Kingdom, we have data only for specie and for high-powered money. The total monetary specie stock exhibits a substantial decline in each of the years from 1834 through 1836, as do the specie holdings of the Bank of England, the more accurately measured component of that total. High-powered money, after declining in 1834 and 1835, increased by just under 1 percent in 1836 and just over 1 percent in 1837.

According to John Francis's (1862) account, the loss of specie by the Bank prior to 1836 was a reflection of overseas investments gone sour. The Bank's specie stock, which in 1833 had reached a high of £10.9 million, fell from an average of £8.2 million in mid-1834 to an average of £6.2 million in mid-1835. Then in the first quarter of 1836 the Bank's holdings temporarily rose, only to resume their decline a quarter later as pressure from the United States developed.

The Bank's reaction—belatedly, in the eyes of some contemporary

observers—was to increase its discount rate from the 4.0 percent that had prevailed for close to a decade to 4.5 percent in July 1836 and then to 5 percent in September. At the same time, the Bank imposed quantitative controls, refusing to discount the bills of joint-stock banks or to handle acceptances of Anglo-American discount houses (Matthews 1954, p. 58).

The first signs of a financial crisis in the United Kingdom came with the suspension of payments of the Agricultural and Commercial Bank of Ireland in November 1836 and the near demise of the Northern and Central Bank, a recently formed Lancashire joint-stock bank. The panic in the United States began in the spring of 1837 with the failure of a New Orleans bank. A run soon developed on New York banks and payment was suspended in May of that year. What heightened the monetary effects of these actions was the legislation enacted by most states that prohibited banks that had suspended payments from expanding their note and deposit liabilities. "Under these conditions," Clark Warburton (1962) has claimed, "suspension of specie payments provided relief from an immediate banking panic but led to a curtailment of bank loans and discounts and contraction of bank supplied circulating medium."

Considerable debate has centered around the exact events that triggered the U.S. crisis; the specie circular, the actions of the Bank of England, and the sharp decline in the price of cotton all figure prominently in the various explanations offered. Those who have emphasized the first, moreover, ascribe crucial importance to it as a cause of the business contraction itself.

The monetary data belie that explanation. As we have shown, the first year of the cycle in the United States was accompanied by a decline in monetary growth that was wholly due to a decline in the rate of growth of the monetary specie stock.<sup>6</sup> That decline in turn was the result of the Bank of England's restrictive posture and one of the causes of the ensuing banking crisis. What added to the pressures on the banking system and indeed may have been the key exacerbating element was the disbursement of the Treasury surplus to state treasuries and hence drain of specie from the banking system (Timberlake 1978). As the U.S. money stock fell, the economy deteriorated further. That of the United Kingdom, which has escaped the contractionary monetary effects of the panic, recovered.

### 1839

The depression of 1839 was one of the most severe on record in both countries. Real GNP in the United Kingdom fell for three years running for a total decline of 7.2 percent, making the depression comparable in both magnitude and duration to that of 1929–32. In the United States the contraction lasted a year longer, and, as near as one can tell, was equally sharp. Smith and Cole's total trade index fell by 21.4 percent from its

peak in 1839 to its trough in 1843; their domestic index fell by 10 percent over the same period (12 percent from 1839 to 1842); Gallman's capital-formation series fell by 26.3 percent; and Ayres's index of business activity declined by 22.0 percent. The only difference, other than duration, between the U.K. and U.S. contractions was that the latter appears to have been made up of two separate episodes: All four real series for the United States show a substantial drop from 1839 to 1840, a slight pickup over the next year (next two in the case of capital formation), and then in two of the remaining three instances a further decline of roughly the same magnitude as that of 1839–40.

As in 1836, monetary fluctuations appear to have played important causative roles in the two countries. In the United Kingdom, both gold and high-powered money reached peaks in 1838, gold declining by 11.9 percent per annum over the next two years and high-powered money by 6.6 percent per annum. Then between 1840 and 1841 the U.K. gold stock reversed direction, increasing by 4.4 percent, while high-powered money remained roughly constant.

In the United States, the monetary contraction began a year later than in the United Kingdom. Gold fell by 6.9 percent and M2 by 11.1 percent between 1839 and 1840 and continued to decline the following year, though at slower rates. In 1841–42, the decline in M2 accelerated and the gold stock fell somewhat further. By the time the trough in both monetary series had been reached, the gold stock had decreased by a cumulative total of 12 percent and M2 by a cumulative total of 32 percent. The only comparable period of monetary contraction in the hundred years that our data span is the Great Depression of 1929–33.

The lag between monetary changes in the two countries at the beginning of the cyclical declines suggests a chain of causation that ran from the United Kingdom to the United States. Historical accounts buttress this conclusion. In early 1839, the Bank of England began to experience another specie drain. The cause, according to Matthews (1954), was an increase in expenditures on imports of grain, due in turn to a crop failure the year before. A contributing factor, according to some commentators, was a lack of trust on the Continent in the Bank's ability to maintain specie payments.

The Bank reacted to the outflow by raising its discount rate in May of 1839 from 4 percent to 5 percent. By that time its specie reserve had been almost halved, from £9.0 million in January to £5.0 million in May. In late June it raised Bank rate further to 5.5 percent and finally in the beginning of August to 6 percent. As a result of these actions, out-and-out panic never really took place in the United Kingdom.

More harmful repercussions of the Bank's actions were, however, felt in the United States. Interest rates rose markedly, Bigelow's commercial-paper-rate series showing an increase from 6 percent in January to 15

percent in August. At the same time, banks in the United States were losing specie. In July, the Bank of the United States, by then a Pennsylvania-chartered bank, began experiencing trouble. By early October it failed and a run on Philadelphia banks began. They suspended payments in response and banks in the South and West soon followed suit. The New York banks held out, but according to the state bank commissioners cited by Sumner (1896), they experienced a \$20 million decrease in their liabilities in the space of three months ending in late January 1840.

### 1845

According to the National Bureau's chronology, the United Kingdom in the second half of the 1840s experienced a three-year contraction, lasting from 1845 to 1848, and the United States two one-year contractions spaced one year apart. Output data, however, tell a different story.

In the United Kingdom, real GNP increased by 6.4 percent from 1845 to 1846 before slowing to an average annual growth rate of slightly less than 1 percent the next two years. In the United States, Smith and Cole's trade indexes show peaks in 1844, slight declines between 1844 and 1845, and then offsetting increases the next year. The level of the total index (the combination of domestic and foreign) was the same in 1847 as 1844; the domestic index alone, the same in 1846 as 1844. Between 1847 and 1848 both indexes then decreased substantially, the total by 6.9 percent and the domestic alone by 5.7 percent. Gallman's capital formation series, after rising by 25.7 percent from 1845 to 1846, shows a 1.1 percent increase during the next year and then a 7.4 percent average annual rate of decline the following two.

In both countries, therefore, the pattern is similar even though the reference-cycle chronology differs. Whatever contraction took place in 1845-47 was relatively mild. Over the next year, the situation worsened—in the United States apparently by a considerable degree.

The monetary data are in rough agreement with the movements in output. High-powered money in the United Kingdom rose at an average annual rate of 4.2 percent from 1844 to 1846 and in the next three years fell at an average annual rate of 6.1 percent. In the United States, M2, after rising by 10.4 percent per year from 1842 to 1844, increased by only 4.1 percent per year over the next two, accelerated the following year, and then declined by 2.6 percent between 1847 and 1848. The only surprise in the data is that the U.K. recession does not appear to have been worse, given the amplitude and duration of the monetary contraction.

Movements in the gold stock of the two countries in general conform to those of the other monetary aggregates. The U.K. gold stock decreased slightly between 1844 and 1846, after rising by 14.0 percent per year the

prior two years, and then fell by 2.6 percent per year from 1846 to 1849, with the largest annual decrease, 9.8 percent, coming in 1847–48. The U.S. gold stock behaved in like fashion, increasing by 11.3 percent per year between 1842 and 1844, falling by 2.9 percent per year over the next two years, then increasing by 15.0 percent from 1846 to 1847, and finally between 1847 and 1848 dropping by 2.6 percent.

In both countries, therefore, the decreases in gold in the earlier part of the period were at least partially offset while those at the end of the period led to actual decreases in broader monetary aggregates. As in the two earlier contractions, the sequence of events seems to have been a specie drain in the United Kingdom, in this instance, particularly due to a trade deficit brought about by the Irish potato famine, subsequent increases in Bank rate (in 1847) to check the drain, and as a result a sizable gold outflow from the United States.

In the United Kingdom, an exacerbating factor, at least as far as the monetary situation was concerned, was the widespread financial panic that began in the summer of 1847 and continued through the fall (see Dornbusch and Frenkel, this volume). The cause, contemporary observers claimed, was the gold outflow and the Bank's failure to contract its note issue gradually when the outflow began. Sir Robert Peel phrased his criticism thus: "If the bank had possessed the resolution to meet the coming danger by a contraction of its issues, by raising the rate of discount, by refusing much of the accommodation which they granted between the years 1844 and 1846 . . . the necessity for extrinsic interference might have been prevented; it might not have been necessary for the Government to authorize a violation of the Act of 1844" (MacLeod 1896, p. 148).

The United States also experienced a panic, though not nearly so severe as the one in the United Kingdom: "embarrassments were slight and brief," according to Juglar (1916). The reason, as Warburton (1962) has pointed out, quite likely was the U.S. Treasury's purchase of government securities under a resale agreement that offset the initial declines in the money multiplier.

### 1856

The business contractions in the late 1850s—1856–58 in the United States, 1857–58 in the United Kingdom—took on familiar dimensions: pressure on domestic gold stocks, a reaction by the Bank of England, panic, and then a monetary contraction in both countries.

The only difference between this and past cycles was in the accidentals. The Bank's defensive actions, for example, in this episode came in two stages rather than the heretofore usual one. Similarly, the major focus of investment in the period preceding the panic was different from those of



the 1830s and 1840s. Hence, so also were the areas—both geographic and economic—in which the most notable bankruptcies and failures occurred.

The behavior of output requires only slight elaboration. A relatively severe contraction took place in both countries. In the United Kingdom it was brief, but, as reference-cycle dates suggest, in the United States it was somewhat more protracted.

The pattern of movements in the various monetary totals was similar to that described for earlier cycles. In the United Kingdom, a net gold inflow, which had produced a 6.3 per year increase in the monetary gold stock from 1854 to 1855, ceased the year after, and the gold stock remained nearly constant on a yearly basis. Then in 1857 the drain began, and gold declined by 5.5 percent. High-powered money behaved in a virtually identical manner with annual rates of change of 7.2 percent, 1.3 percent, and  $-6.3$  percent in the three years, respectively.

In the United States gold never decreased absolutely, but between 1856 and 1857 it rose by only 2.2 percent after having increased at an average annual rate of 12.6 percent in the preceding three years. The data for M2 show movements similar to those of gold: a 7.7 percent average annual rate of growth from 1853 to 1856, a 0.9 percent drop the next year, and then a slight 1.0 percent rise the year after.

These yearly data, therefore, suggest that the slowdown in gold inflows in 1856 was the initiating factor in the cyclical declines. As its gold reserves decreased, the Bank of England raised its discount rate by 250 basis points in the space of a week in October of that year. That, in turn, intensified the pressure on the United States where banks in New York and on the rest of the East Coast were already trying to cope with an internal drain. They reacted by building up their reserves (Temin 1975), thus adding to the contraction in money. Insolvencies and suspension of payments followed in the late summer and early fall.

The panic and run on the banks then spread to the United Kingdom. In November, even after having raised its discount rate from 5.5 percent to 10 percent in the short span of five weeks, the Bank of England asked for a suspension of the Banking Act of 1844. Suspension allowed it to expand its note issue, and by December the panic was over. The number of failures, however, rose considerably. A recession that initially had a mild impact in both countries, intensified and spread, mainly in the United States.

Given the linkages between the two countries, it is doubtful that the end result could have been much different in any event. Had the Bank of England not reacted to the pressure on its reserves in 1856, a contraction in money, and presumably the recession, would have taken place sooner than that year in the United Kingdom. The Bank's actions merely staved off both for a while. That, however, added to the problem in the United

States. As the U.S. recession became more and more severe, the feedback to the United Kingdom became greater and greater. A panic in the United Kingdom resulted and recession began there in earnest as well.

### 10.3.2 The Greenback Period

During the seventeen years the United States was off the gold standard, the close economic linkages with the United Kingdom that existed prior to the Civil War broke down. Cyclical fluctuations took place at one time in one country and not in the other. And even in the instances in which there was a temporal coincidence, the channels through which these fluctuations might have spread were less than obvious. As illustrations of the two types of episodes respectively, we discuss the U.K. contraction of 1866 and the coincident contractions of 1873.

#### *1866*

The contraction of 1866 and associated panic in the United Kingdom produced no reaction in the United States. The contrast between this episode and the four just described thus provides one bit of evidence on the role the gold standard played in the transmission of fluctuations among countries. This evidence, however, is not totally unambiguous. The contraction in the United Kingdom was not severe. One could argue—though 1836 seems to run counter to this hypothesis—that the nonmonetary linkages between the two countries were more important than the monetary and that their operation, in turn, hinged on the severity of the initial contraction.

In terms of yearly GNP, the contraction of 1866 to 1868 manifested itself as a decline in the rate of growth, not an absolute decrease. Commensurate declines occurred in the rates of growth of gold and high-powered money and in the level of joint-stock-bank liabilities. The decline in gold, however, came in 1867–68, the second year of the recession.

The decrease in the ratio of high-powered money to gold and, judging from Collins's (1981) series for liabilities of joint-stock banks, probably the ratio of M2 to gold as well, was due to the banking difficulties that began in early 1866. The cause of the decrease, both Clapham (1945) and MacLeod (1896) claim, was a drain on the Bank's specie reserves that began in late 1865 and induced the by-then-usual sharp increase in Bank rate. In February 1866 the first failure occurred, that of the Joint Stock Discount Company. In March Barned's Bank in Liverpool stopped payment. The highlight of that decade's panic was, however, the failure of Overend, Gurney and Company on 10 May with liabilities of over £10 million. The next day, the Banking Act of 1844 was suspended and the panic subsided.

1873

The contraction of 1873 in the United States by Burns and Mitchell's reckoning was the longest on record, not ending until 1878. The period of actual decline or sluggish growth in real income, however, was much shorter—1873 through 1875. From then on, real NNP rose rapidly, though prices continued to fall.

The panic that took place in September of 1873 in the United States seems to have been largely domestic in origin. Friedman and Schwartz (1963b) cite the financial difficulties of certain U.S. railroads and the resulting default on their debt as the precipitating factor. What seems to have set the stage for the panic was the substantial reduction in U.S. greenbacks and hence in bank-reserve ratios that occurred in the first half of 1873.

The United Kingdom escaped the worst part of the U.S. panic. Equity prices were affected which led to a crisis on the London Stock Exchange, but there were no further monetary repercussions. The Bank of England, as it had throughout 1873, altered its discount rate promptly, increasing it to a high of 9 percent on 7 November 1873, and then in the space of four weeks lowering it back to 5 percent. Peel's Act, contrary to the fears of the time, was not suspended and a full-fledged panic was averted. "After 1873," Clapham (1945) states, "neither 9, nor 8, nor even 7 percent was announced again for a whole generation. An occasional 5 and a very occasional 6 was all that proved necessary."

The rate of growth of M2 slowed appreciably in the United Kingdom in 1873, to 5.6 percent versus 9.3 percent the year before, while the rate of growth of the monetary gold stock declined by less than a percentage point during the same period. Real GNP grew at an average annual rate of 2.7 percent in 1873–74, about equal to that of 1872. Not until 1875 did real growth slow to any great extent; but from then until the reference-cycle trough, its average rate of increase was only 0.4 percent per year.

Movements in M2 in the United Kingdom from 1874 ran roughly parallel to those in real GNP: a further fall in the rate of increase of M2 between 1874 and 1875, near constancy in 1875–76, and then absolute declines in the stock during the last three years of the contraction.

The cause of the restrictive movements in U.K. money was to a large extent, particularly in the years 1873–75, a series of declines in the rate of growth of high-powered money. These declines in turn were only partially the result of gold flows. In the later part of the period, a decline in the ratio of M2 to high-powered money became important.<sup>7</sup> That in turn appears to have been the result of the failure of the City of Glasgow Bank in early October 1878 and the substantial increase in Bank rate in the middle of that month.

The cyclical contraction of the 1870s, therefore, had two elements in common with the U.K. contraction of 1866: the United States was off the

gold standard and the channels of transmission of the type that were important prior to the Civil War appear not to have operated. Unlike 1866, however, these contractions were severe—one small bit of evidence in favor of our interpretation of 1866. If the sole reason that the earlier episode was confined to the United Kingdom was its lack of severity, there ought to have been some discernible linkages between the cycles in the two countries in 1873. The fact that there were none, or almost none, suggests that the monetary system rather than moderation of the episode was the key reason there was no transmission to the United States in 1866.

### 10.3.3 The Heyday of the Gold Standard

The United States returned to gold in 1879. During the next three-and-a-half decades the United Kingdom and the United States underwent three common business cycles of more than average severity. None of the three, however, was an exact replica of the antebellum episodes. In the first, which began in 1882 in the United States and a year later in the United Kingdom, developments in the United States affected the United Kingdom at the start of the cycle; not until later did feedback occur. In the second, direct links between the two countries seem to have been minimal. Only in the third, the short-lived but nonetheless substantial contraction of 1907, was a strong influence running from the United Kingdom to the United States apparent at the onset of the cycle.

#### *1882*

The contractions of the early 1880s were moderately severe in both countries. In the U.K. contraction, dated 1883–86, real income grew at an average annual rate of less than 1 percent; in the U.S. contraction, dated 1882–85, real income was virtually constant for three years as a whole.

The decline in the rate of growth of the U.S. money stock was particularly dramatic. The rate fell from an average of 19.3 percent per year in 1879–81, to an average of 6.9 percent in 1881–83, to virtually zero in 1883–84—reflecting a similar series of declines in the rate of growth of the monetary gold stock.

In contrast, only a mild decrease in rates of growth occurred in the U.K. money stock during the contraction—in average terms, they were about a percentage point lower in 1883–86 than in 1881–83. High-powered money, however, declined in absolute terms in each year of the contraction; and the gold stock declined in two of those three years.

The drain of gold from the United Kingdom was the culmination of a movement that had begun in 1879 and that by 1882 had resulted in a cumulative decrease of close to 10 percent. The direction of movement was from the United Kingdom and other European countries to the

United States; its cause was poor harvests in most of the world and exceptionally good ones in the United States.

The response of the Bank of England to these drains was to raise its discount rate from 2.5 percent in April 1881 to 6 percent in January 1882. The end result was a cessation of inflows to the United States and a diminished rate of outflow, followed by an actual inflow of gold to the United Kingdom.

According to Friedman and Schwartz (1963b), the reversal of the gold flow was one of the factors, along with foreigners' decreased confidence in investment in the United States and in the country's ability to remain on the gold standard, that precipitated a short-lived financial panic in New York in May 1884.

The antebellum problems, therefore, reemerged in the postbellum period. The major differences were the milder fluctuations in output in the 1880s episode than in earlier ones and the reversed direction of causation at the start of the contraction—from the United States to the United Kingdom rather than the other way around.

### *1890*

The U.K. cyclical decline began in 1890 and ended in 1894, making it one of the longest in that country's history. During the same period, the United States experienced two contractions: an exceedingly mild decline between 1890 and 1891 followed by a sharp rise in real growth the next year, and then a much more severe decline between 1892 and 1894.

The U.S. contraction of 1890–91 manifests itself in the yearly data as a one-percentage-point decline in the growth of real NNP and a four-percentage-point decline in the growth of industrial production from their respective averages during the preceding two years. The money stock never fell but its growth rate declined. The cause was a gold outflow brought about by a shift of British investment to Argentina in mid-1890 at the same time that New York banks were experiencing the usual seasonal drain of specie reserves to agricultural areas of the country. As a result, a number of bank failures in the United States occurred during early November, and then on 15 November Baring Brothers, a major British merchant bank, suspended payment and the panic intensified.

A month later, the panic in the United States was over. In the United Kingdom, it threatened to become severe but never did. The Bank of England immediately prior to the demise of Barings, as it became cognizant of what was likely to happen, raised the discount rate from 5 percent to 6 percent. Early the next week, it borrowed £0.3 million in gold from the Banque de France and bought another £1.5 million from Russia, thus further bolstering its reserves.

In the initial year of the U.K. cycle, the growth of both real GNP and industrial production slackened. During the next two, industrial produc-

tion fell by 6.7 percent and real GNP remained virtually flat. By 1895, the rebound was underway. Growth in the U.K. money supply for the cycle as a whole declined, but the major part of that came after 1892. Hence, even though the reference-cycle dates differ between the two countries, the time pattern of output movements did not.

In the United States, gold movements figured prominently in the explanation of movements in the money stock as a whole. The monetary gold stock, after falling by 8.7 percent in 1890–91, increased slightly the next year and then contracted sharply in 1893. The external drains reflected distrust of the Treasury's ability to maintain silver at parity with gold, as well as price deflation abroad. At the same time, an internal drain took place caused by distrust of the solvency of banks. This distrust, in turn, had its roots in the deflation that declines in capital and gold inflows had brought about earlier.

In the United Kingdom, a reduced gold inflow was associated with the initial declines in monetary growth between 1891–92 and very likely 1892–93. Thereafter, the nongold component of high-powered money arithmetically accounted for the low rate of monetary growth.

The U.S. contraction, therefore, quite clearly had international roots, but not as in many earlier cycles ones that extended directly back to Threadneedle Street. In the United Kingdom, the links with other countries were less obvious.<sup>8</sup>

### 1907

The contractions of 1907–8 had many of the earmarks of earlier episodes. From the spring of 1906 on, by Sayers's (1976) account, it became more and more evident that financial difficulties were liable to break out in the United States. In May and again in September of that year the Bank of England took defensive actions, in both instances increasing Bank rate from 3.5 percent to 4.0 percent, a decrease having been effected in June. At the same time, it imposed quantitative restrictions, refusing to discount paper used to finance American speculation. On 5 October it increased Bank rate further to 5 percent, and then on 19 October to 6 percent, the highest level since the Baring Crisis in 1890. "These measures," Friedman and Schwartz (1963b, p. 156) state, "served first to reduce, then to reverse, the flow of gold to the United States, and in this and other ways contributed to a change in the economic situation in the United States."

The changes in gold flows, however, only show up to a minor extent in the annual data. The monetary gold stock in the United States, after increasing by 4.4 percent per year on average in 1904 and 1905, rose dramatically in 1906, a 9.0 percent increase relative to the preceding year. In 1907 the increase was only slightly less—8.8 percent.

The monthly high-powered-money series, which is apt to be more

dominated by gold than the money stock itself, registered a 2.8 percent annualized decrease from May to September 1907 versus an 8.4 percent annualized decrease in the stock of money. From then until February 1908, the money stock continued to fall (at a 12.3 percent annual rate) while high-powered money rose continuously. Not until July had money regained its May 1907 level. The major factor accounting arithmetically for the decrease in money, therefore, was the panic that broke out on 21 October 1907. The panic in turn was at least to some extent the result of the previous gold outflow and its impact on the reserve position of banks.

The contraction in output in the United States, though lasting only a year, was sizable. Real NNP fell by 11.4 percent from 1907 to 1908 and industrial production by 17.0 percent.

In the United Kingdom, the movements in both money and income were considerably more moderate. Real GNP decreased by 1.0 percent, industrial production by 8.4 percent, and the rate of monetary growth by the same amount as that of GNP. The cause of the monetary deceleration was a decrease in the rate of growth of the monetary gold stock, from 3.4 percent in 1906–7 to 1.7 percent in 1907–8. As in the case of the United States, though, these movements may well have been somewhat more severe when viewed intrayearly. Bank of England gold holdings, one of the few such series available, in March 1907 stood at £36 million. After rising by £2 million between then and September, holdings dropped to a low of less than £30 million on 4 November.

The Bank's response to this outflow, as in the past, was to increase its discount rate. It did so by successive fifty- and then a hundred-basis-point amounts from 4.5 percent in September 1907 to 7 percent on 4 November. These increases, though probably necessary from the U.K. standpoint, worsened the problem in the United States.

#### 10.3.4 The Interwar Period

Taken together, the severe interwar contractions beginning in 1920 and 1929 provide almost a controlled experiment, the outcome of which demonstrates the important roles played during business contractions by monetary fluctuations within countries and by the gold standard in disseminating these fluctuations among countries.<sup>9</sup> In both periods, the United Kingdom and the United States experienced sharp decreases in monetary growth beginning before the onset of recession. In 1921, the U.S. money supply rose while the U.K. money stock declined further. The rebound in the U.S. economy was both rapid and strong; the rebound in the U.K. economy was weaker and came later. In 1931 the United Kingdom broke with the gold standard, thereby severing the monetary link with the United States. As a consequence, the United Kingdom was able to increase its money supply over the next two years, even as the U.S. money supply continued to decline. The depression in

the United Kingdom was thus cut short while that of the United States intensified.

### 1920

The 1920–21 contractions in the United Kingdom and the United States were two of the most severe one-year contractions of record. Both were accompanied by equally severe monetary contractions. In the United Kingdom, the annual data show a change in monetary growth of fourteen percentage points: from 12.1 percent per year in 1919–20 to –2.3 percent in 1920–21. In the United States, the monetary deceleration was equally dramatic: from 11.5 percent in the one year to –0.58 percent in the next.

The U.K. monetary contraction, like that of 1873 in the United States, was prompted by the desire to return to gold at the pre-World War I exchange rate. Given the inflation that had taken place in the interim—an inflation appreciably greater than in the United States—a substantial decrease in the U.K. money stock was necessary. Monthly data compiled by Lothian (1976) show monetary deceleration beginning in June 1919, nine months before the cycle peak. The peaks in the annual (1920) and monthly (October 1920) money series were followed by absolute declines that continued through 1925. In the United States, the money supply began to grow again in 1922.

The real sides of the two economies reacted accordingly. In the United States, both real income and industrial production picked up rapidly, thereby cancelling out their initial declines a year sooner than in the United Kingdom. There the process dragged on, and not until 1924 did both U.K. series return to levels consistent with a modest 2 percent per year rate of growth. A year later, when the actual return to gold took place, a new recession began.

The problems of the 1920s in the United Kingdom, therefore, appear to have been largely monetary in nature. Underlying the monetary fluctuations in turn were international considerations, in particular the return to gold at a price consistent with a \$4.86/£ exchange rate.

Keynes's assessment in the *Treatise of Money* (1930, 2: p. 181) seems to have been essentially correct:

Looking back, we can see that the extreme prolongation of the slump was due to the Profit Deflation which occurred in the first half of 1921. This was doubtless inspired by the object of cancelling some part of the Income Inflation of the war and post-war periods . . . but from the standpoint of national prosperity it was a mistake. We might have avoided most of the troubles of the last ten years . . . if we had endeavoured to stabilise our monetary position on the basis of the degree of Income Inflation existing at the end of 1920.



1929

Data for the U.K. money stock at the start of the contraction show a mild deceleration. Yearly figures indicate a rise of 0.6 percent in 1928–29 versus an average rise during the two preceding years of 1.8 percent. The monthly data show a somewhat sharper falloff, from 3.2 percent growth over the twenty-four months ending January 1929—five months prior to the cycle peak—to a 3.6 percent decline in the money stock between then and January 1930.

From 1929 until the end of the cycle, the yearly data show a sluggish 0.6 percent annual rate of increase—an average of 0.8 percent increase in 1929–30, 1.2 percent decrease the next year, and 2.3 percent increase the year after that. Movements in gold were largely responsible for the monetary stringency. With the exception of 1929–30 when it rose by 5.4 percent, the monetary gold stock declined in three of the four years from 1928 to 1932. It fell by 6.1 percent in 1928–29, by 10.2 percent in 1930–31, and then finally by 7.1 percent in 1931–32. Real GNP in the United Kingdom over the whole period fell by 5.7 percent and industrial production by 11.4 percent.

In the United States, the money supply declined by a much greater amount during the period of the U.K. contraction—8.7 percent per year from 1929 to 1932. Moreover, it continued to decline at a 2.0 percent average annual rate from 1932 to 1934. Both real income and industrial production fell precipitously as a result: real NNP by a total of 34.5 percent from 1929 to 1932 and industrial production by a total of 62.7 percent. The U.S. declines continued into 1933. And, contrary to the experience of the United Kingdom, neither reached its 1929 level until almost the end of the decade.

The 1929 contraction thus was marked by a reversal of the U.S. and U.K. roles in 1920. In the 1920 cycle, the United States became expansive earlier and thus escaped the problems that plagued the U.K. economy in the 1920s. In the second cycle, the U.K., abandoning gold in 1931, was able to avoid the further monetary contraction that took place in the United States. As a result, the U.K. economy rebounded more quickly in the 1930s than the U.S. economy did.<sup>10</sup>

During both interwar cycles, gold was in one way or another a key. The commitment to the return to the gold standard provided the impetus for British deflation in the first instance; the abandonment of gold was the *sine qua non* for avoidance of further deflation in the second.

### 10.3.5 Conclusions from the Historical Analysis

Our analysis of individual reference-cycle contractions, to our minds, strongly suggests that money was an, and most likely the, important causative factor in the major cyclical contractions in both countries. In almost all of the episodes a clearcut association is evident between

monetary decelerations and movements in output. That association, moreover, does not appear to be simply a reflection of reverse causation.

For one thing the monetary shocks, as we have measured them, in almost all instances preceded or were coincident with the cyclical contractions. In relatively few instances did the monetary deceleration come after the fact. Nor do we find it plausible to believe that the association between money and output is largely the result of some common third factor that affects both variables. For one thing, the proximate causes of the monetary declines differed considerably across cycles, suggesting the absence of any simple mechanism to account for either feedback or the operation of such a third variable.

Similarly, additional comparisons (described in appendix B) allow us to rule out one potential and often-suggested candidate—financial panics. A final bit of evidence is the difference in the incidence and duration of cyclical fluctuations between gold and non-gold standard periods. Direct monetary linkages were weaker in the latter; so also was the association between the cycles in the two countries.

These results also provide evidence on how the transmission mechanism worked. Gold flows clearly were of direct importance in a considerable number of episodes. They also appear to have had an indirect effect in a number of others, acting as the proximate cause of financial crises that in turn led to substantial reductions in the ratios of commercial-bank-note and deposit liabilities relative to gold.

The analysis of the individual cycles, however, is rather moot with respect to other possible channels of influence—price and interest-rate arbitrage and direct-absorption-type effects on output. It also provides only limited information on the extent of feedback in the system. In addition it is almost solely concerned with severe cycles, which according to Cagan (1965) differ qualitatively from the less severe. At the same time it raises a number of questions about the stability of the relationships between the two countries over time. To try to resolve some of these issues, we now turn to the more formal statistical investigation.

#### **10.4 Econometric Evidence**

We estimate vector autoregressive models for the two countries combined and then use these models as the basis for conducting a series of tests of Granger causality.<sup>11</sup> The advantage of these models is that they allow for simultaneous dynamic interaction among the variables while at the same time requiring relatively few identifying restrictions. We view these traits as particularly desirable in a study such as ours, which is concerned with short-run adjustment within and between economies of somewhat uncertain degrees of openness. The models require neither answers before the fact to the series of largely unsettled issues surround-

ing cross-country channels of transmission and feedback mechanisms linking within-country variables, nor explicit modeling of a host of possible alternative dynamic relationships of both sorts.

Given the attention they have received, however, the objections to these models and the associated Granger tests also require mention. Foremost among these objections are specification errors of the types outlined by Zellner (1979) and by Sims (1982). Having some notion of the possible temporal orderings of variables under different hypotheses and initially choosing those variables on the basis of theoretical considerations can reduce the likelihood of such errors and thus limit the effects on the statistical inferences being made.<sup>12</sup>

#### 10.4.1 Model and Method

We consider a two-country macroeconomic model that emphasizes monetary variables. Each variable in the model is represented as a multivariate vector stochastic process (Sims 1980). In particular, the general, unrestricted autoregressive-reduced form is:

$$(1) \quad \begin{matrix} X_t & = & \pi(L) & X_{t-1} & + & U_t, & t = 1, \dots, T, \\ (m \times 1) & & (m \times m) & (m \times 1) & & (m \times 1) \end{matrix}$$

where

$X_t [X_{t-1}]$  = a vector containing current (one-period lagged) values of  $m$  different economic variables (or their rates of change);

$\pi(L)$  = an  $m \times m$  matrix that contains polynomials in the lag operator that are one-sided on the past;

$U_t$  = a vector containing a random disturbance for each of the  $m$  equations;  $U_t$  is multivariate normal with  $E U_t = 0$ , and  $E U_t U_t' = \Sigma$ .

In this specification, all variables contained in  $X_t$  are considered (potentially) endogenous, and in simultaneous-equation terminology, the set of predetermined variables that are regressors contains only lagged values of endogenous variables. The set of current exogenous variables is empty.

This model is used to conduct the Granger tests. To illustrate these tests in a single-equation context, consider the first equation of the  $m$ -equation system (1):

$$(2) \quad \begin{aligned} X_{1t} &= \pi_1(L) X_{t-1} + U_{1t} = \sum_{j=1}^m \pi_{1j}(L) X_{jt-1} + U_{1t} \\ &= \pi_{11}(L) X_{1t-1} + \pi_{12}(L) X_{2t-1} + \dots \\ &\quad + \pi_{1m}(L) X_{mt-1} + U_{1t}, \quad t = 1, \dots, T, \end{aligned}$$

where  $\pi_{ij}(L)$  is the  $(n + 1)$ th order polynomial in the lag operator applicable to the  $j$ th variable in the  $i$ th equation. The null hypothesis that

$X_m$  does not Granger cause  $X_1$  is the restriction that all coefficients of the polynomial lag operator  $\pi_{1m}(L)$  [ $\pi_{12}(L)$  to  $\pi_{1m}(L)$ ] are zero, i.e., that all lagged values of  $X_m$  are excluded from the equation.

We perform the test that  $X_m$  does not cause  $X_1$  by comparing the error sum of squares of a model with  $q$  linear restrictions imposed on the coefficients of  $\pi_1(L)$  [ $ESS(\hat{\omega})$ ] with the error sum of squares of an unrestricted model [ $ESS(\hat{\Omega})$ ]. We use the statistic

$$(3) \quad F = \frac{[ESS(\hat{\omega}) - ESS(\hat{\Omega})]/q}{ESS(\hat{\Omega})/[T - k]},$$

which has an  $F$ -distribution with  $q$  and  $T - k [= T - m(n + 1)]$  degrees of freedom.<sup>13</sup> If we *fail to reject* the null hypothesis, then  $X_m$  *does not* Granger-cause  $X_1$ . If we *reject* the null hypothesis, then  $X_m$  is said to Granger-cause  $X_1$ , and we would like to think there is a behavioral structure underlying the reduced-form specification of the equation system (Sims 1980).

We perform these Granger tests in two different contexts: (a) single equations (univariate models) independent of the other eleven equations in the macroeconomic model system, and (b) two or more equations jointly within the twelve-equation system (multivariate models). Our single-equation tests of the null hypothesis that  $X_m$  does not Granger-cause  $X_1$  are themselves of two types, weak and strong. The weak tests are essentially pairwise comparisons in which the “unrestricted” version of the test equation contains values of only two variables and is of the form:

$$(4) \quad X_{1t} = \pi_{11}^*(L) X_{1t-1} + \pi_{1m}^*(L) X_{mt-1} \\ + U_t, t = 1, \dots, T$$

where an asterisk indicates that the relevant terms are part of a two-variable rather than the more general  $m$ -variable system. On this we impose the restriction that the coefficients of  $\pi_{1m}^*(L)$  are all zero. The disadvantage of this test is that one might falsely reject the null hypothesis because of omitted variable bias in the estimates of  $\pi_1^*(L)$ , resulting from exclusion of lagged values of  $X_2$  through  $X_{m-1}$ . One or more of these may be truly Granger-causing  $X_1$ , but we could erroneously reach the opposite conclusion if the variable being analyzed were correlated with one or more of the other variables. Accordingly, we also employ a single-equation strong test that  $X_m$  does not Granger-cause  $X_1$  by imposing the restrictions on equation (2) that the coefficients of  $\pi_{1m}(L)$  are all zero. The test tells us whether  $X_m$  contributes significantly to explaining the variance in  $X_1$ , holding variables  $X_2$  through  $X_m$  constant. Tables 10.4 and 10.5 contain the results of these two sets of tests, respectively; table 10.7 contains an overall summary of these and of subsequent test results.

The final tests that we perform are tests of multiple causes. These also

**Table 10.4 Weak Tests of Granger Causality in a Two-Country Macroeconomic Model: U.S.-U.K. Gold Standard Period, 1837-59 and 1882-1914<sup>a</sup> (*F*-statistics)**

Equation	YS	PS	FRS	IS	DCS	NS	YK	PK	FRK	IK	DCK	NK
(regressor with coefficients restricted to zero in null hypothesis) <sup>1</sup>												
United States												
YS	3.13 <sup>b</sup>	1.61	1.64	7.15	1.35	.07	.82	.54	6.17	1.86	.99	.32
PS	1.22	2.60	2.92	3.95	3.29	.79	.04	.43	2.10	.07	.57	.32
FRS	1.60	.42	1.54	1.84	1.29	2.84	.07	.28	.96	.40	2.15	1.13
IS	6.67	5.26	2.44	9.39	4.34	1.43	3.41	3.53	.96	1.33	4.75	.78
DCS	.25	2.13	.52	5.08	.89	.02	.56	.34	3.25	1.00	2.29	.47
NS	.04	.86	.03	1.05	.42	2.68	1.19	1.73	1.22	.08	.22	.36
United Kingdom												
YK	.30	2.92	2.69	4.42	.43	.06	1.43	.56	6.51	1.34	.20	.97
PK	.56	4.58	1.69	.50	.76	1.75	2.56	1.26	4.08	.47	7.76	.08
FRK	.03	2.15	.56	.92	2.26	.17	7.02	.04	2.44	.31	1.31	.80
IK	2.84	3.29	1.38	3.42	.43	.18	7.22	.44	1.54	2.62	9.59	.84
DCK	.31	.29	1.23	.65	.16	2.44	2.15	.66	.42	.18	6.94	1.60
NK	.45	.66	.86	1.73	.91	.09	4.64	.22	1.68	.40	.08	71.26

<sup>a</sup>Each "unrestricted" model contains four regressors: the one- and two-period lagged values of the dependent variable, the one- and two-period lagged values of one other variable (except when a variable is regressed on the lagged values of itself), a dummy variable (= 1 for pre-Civil War years), and an intercept. All variables are expressed as percentage rates of exchange except for interest rates that are differences of levels; the *FR* and *DC* terms were weighted by their respective shares in high-powered money.

<sup>b</sup>For off-diagonal tests, the critical *F*-values for 2 and 51 degrees of freedom at 10, 5, and 1 percent significance levels are 2.41, 3.18, and 5.06 respectively.

**Table 10.5** Strong Tests of Granger Causality in a Two-Country Macroeconomic Model: U.S.-U.K. Gold Standard Period, 1837-59 and 1882-1914<sup>a</sup> (*F*-statistics)

Equation	<i>YS</i>	<i>PS</i>	<i>FRS</i>	<i>IS</i>	<i>DCS</i>	<i>NS</i>	<i>YK</i>	<i>PK</i>	<i>FRK</i>	<i>IK</i>	<i>DCK</i>	<i>NK</i>
	(regressor with one- and two-year lagged values having coefficients restricted to zero in null hypotheses) <sup>a</sup>											
United States												
<i>YS</i>	2.28 <sup>b</sup>	1.22	2.20	1.40	.97	.05	1.40	1.65	1.72	.30	1.36	1.48
<i>PS</i>	2.58	.46	5.27	2.78	3.09	.29	.44	1.55	1.21	.76	2.30	1.31
<i>FRS</i>	.71	1.44	1.10	.92	5.98	4.04	2.16	2.79	2.57	.45	2.31	2.64
<i>IS</i>	.61	7.94	6.56	6.25	1.15	5.58	.84	.90	.46	1.41	.62	1.97
<i>DCS</i>	.21	1.58	.72	.99	.51	.25	.99	.08	1.00	2.35	4.47	1.07
<i>NS</i>	1.12	1.68	1.08	.69	.45	4.40	.46	1.36	1.91	.33	.32	1.66
United Kingdom												
<i>YK</i>	.36	1.96	2.64	.04	1.19	.46	.06	.14	1.77	.04	1.43	1.79
<i>PK</i>	3.54	3.57	1.91	.52	1.44	.54	1.06	3.27	4.51	2.67	6.37	1.40
<i>FRK</i>	1.31	.64	.94	.53	.55	.30	6.27	.40	3.49	1.75	.88	2.25
<i>IK</i>	.12	1.98	3.87	2.18	2.69	.59	2.51	.02	.06	1.94	5.26	1.39
<i>DCK</i>	.27	.31	.03	1.49	.04	1.63	4.06	1.24	.96	1.10	4.33	1.05
<i>NK</i>	.94	1.49	5.68	2.61	.02	1.17	4.47	.09	3.28	.64	.60	55.20

<sup>a</sup>Each "unrestricted" model contains one- and two-year lagged values of the twelve different variables (twenty-four regressors), a dummy variable (= 1 for pre-Civil War years), and an intercept; the two high-powered-money variables are excluded. All variables are expressed as percentage rates of change, except for interest rates that are differences of level. The *FR* and *DC* variables were weighted by their respective shares of high-powered money.

<sup>b</sup>Critical *F*-values at 10, 5, and 1 percent significance levels for 2 and 30 degrees of freedom are 2.49, 3.32, and 5.39 respectively.

are of two types. The first multiple-cause tests are on each of the single equations taken independently of the other eleven equations of the system. In these tests, the unrestricted regression is of the form of equation (2). The restriction is that all coefficients of all of the polynomial lag operators applying to either all foreign variables or all domestic variables other than the regressand are zero.

The other multiple-cause tests are tests on two or more equations jointly. In conducting these tests, we take account of the contemporaneous correlations across all twelve equations of our macroeconomic system. These tests are the direct analogues in a multiequation context of the single-equation multiple-cause tests just described. Under the various null hypotheses we impose restrictions on entire blocks of the coefficient matrix  $\pi(L)$  rather than on portions of one particular row.

The  $F$ -statistics for multiple-cause tests on single equations are reported in table 10.6, part A, and chi-squared statistics for joint tests across two or more equations in part B. For the latter test, we base our conclusions on Sims's (1980) version of the chi-squared statistic, which is reported in columns (1a) and (2a) of table 10.6, but we also report the other frequently used chi-squared statistic in columns (1b) and (2b).<sup>14</sup>

To make the model operational for the study of macroeconomic interrelationships between the United Kingdom and the United States during the gold standard period, we initially assigned the following twelve variables to the  $X$  matrix in equation (1):

$YS$  = U.S. real NNP, or prior to the Civil War a proxy

$PS$  = U.S. NNP deflator

$FRS$  = U.S. specie reserves

$IS$  = U.S. short-term interest rate

$DCS$  = U.S. domestic-credit component of high-powered money

$NS$  = U.S. population

$YK$  = U.K. real GNP

$PK$  = U.K. GNP deflator

$FRK$  = U.K. specie reserves

$IK$  = U.K. short-term interest rate

$DCK$  = U.K. domestic-credit component of high-powered money

$NK$  = U.K. population

We used annual data to estimate the model over the combined subperiods 1837–59 and 1882–1914.<sup>15</sup> We omitted the Civil War and greenback periods since the United States was off the gold standard during those years. Additional observations at the start of each subperiod were lost in differencing and in the process of taking lags.

With the exception of interest rates and monetary variables, we entered all variables in the model as percentage rates of change. For interest rates we used first differences of levels and for the monetary variables first differences of levels scaled by the level of high-powered money. The latter is equivalent to weighting the percentage rates of change of the *DC* and *FR* variables by their shares in high-powered money. In each instance the equations included an intercept term, a dummy variable for the second subperiod, and two lagged values of each of the independent variables.<sup>16</sup> We estimated all equations using ordinary least squares. In our multivariate, multiple-cause tests we do, however, take account of contemporaneous cross-equation correlation of error terms. These cross-equation correlations may capture sources of business cycle transmission omitted from the model (table 10.7).

#### 10.4.2 Tests Based upon the Full Model

Since our principal interest is in the real-income tests, we turn to these first and find the results are rather mixed. In the single-equation weak-form tests we find some direct influence of monetary variables on real income in the two countries: *FRK* is a significant predictor of both *YK* and *YS*, and *FRS* (as well as *PS*) approach significance in the *YK* relationship. In addition *IS*, which in turn is influenced by *FRS*, *DCS*, and *DCK*, significantly affects both *YK* and *YS*. In the strong-form tests, however, most of these relationships break down: *FRS* is significant at the 10 percent level in predicting *YK*, at somewhat less than the 10 percent level in predicting *YS*. Nothing else apparently matters.

The single-equation multicausal tests reported in the top half of table 10.6 are even less informative. For both *YK* and *YS* we are unable to reject either the null hypothesis of no-domestic-cause or of no-other-country-cause.

A number of possible reasons can be found for our failure to discover much in the way of a relationship here. One is that a strict version of the rational-expectations–natural-rate hypothesis holds (Sargent 1976; Leiderman 1980). Another is that some subset of the variables—say foreign reserves and domestic credit—is jointly significant but that the effects are being masked by the inclusion of a large number of truly insignificant variables. A third, related to the second, and to which we return below, is that we have misspecified the monetary variables. A further possible reason for little or no influence of other variables on real



**Table 10.6** Tests of Granger Causality in a Two-Country Macroeconomic Model: U.S.-U.K. Gold Standard Period, 1837-59 and 1882-1914<sup>1</sup>

Model	Null Hypothesis	
	No Domestic Cause <sup>2</sup> (1)	No Other-Country Cause <sup>3</sup> (2)
<b>A. Univariate Model<sup>4</sup></b>		
1. <i>YS</i>	1.24	1.51
2. <i>PS</i>	3.73	1.52
3. <i>IS</i>	3.36	1.18
4. <i>FRS</i>	2.39	1.73
5. <i>DCS</i>	.93	1.68
6. <i>NS</i>	.85	.99
7. <i>YK</i>	1.46	1.27
8. <i>PK</i>	3.80	1.69
9. <i>FRK</i>	2.62	.99
10. <i>IK</i>	2.52	1.78
11. <i>DCK</i>	1.60	.97
12. <i>NK</i>	2.41	1.72

		$\chi^2$ -statistic			
		$(T-k) \cdot 1n   \dot{\Sigma}_w / \dot{\Sigma}_n  $ (1a)	$T \cdot 1n   \dot{\Sigma}_w / \dot{\Sigma}_n  $ (1b)	$(T-k) \cdot 1n   \dot{\Sigma}_w / \dot{\Sigma}_n  $ (2a)	$T \cdot 1n   \dot{\Sigma}_w / \dot{\Sigma}_n  $ (2b)
<b>B. Multivariate Model<sup>5</sup></b>					
13.	Y.S, P.S, IS	87.9 (50.9) <sup>6</sup>	164.2 (50.9)	57.7 (58.6)	107.7 (58.6)
14.	YK, PK, IK	81.3 (50.9)	151.7 (50.9)	68.2 (58.6)	127.3 (58.6)
15.	= 13 & 14	161.5 (84.4)	301.4 (84.4)	120.0 (102.8)	224.0 (102.8)
16.	All 6 U.S. dependent var.	123.2 (84.4)	230.0 (84.4)	110.2 (102.8)	205.8 (102.8)
17.	All 6 U.K. dependent var.	125.3 (84.4)	233.8 (84.4)	116.3 (102.8)	217.0 (102.8)

**Notes:**

1. Each unrestricted equation contains one- and two-year lagged values of the twelve different variables (twenty-four regressors), a dummy variable (= 1 for pre-Civil War years), and an intercept; the high-powered-money variables are excluded. All variables are expressed as percentage rates of change, except for interest rates that are differences of levels. The *FR* and *DC* variables were weighted by their respective shares of high-powered money.
2. Each equation in the restricted model has ten coefficients set equal to zero, all lagged values of the domestic country's variables except lagged values of the dependent variable.
3. Each equation in the restricted model has twelve coefficients set equal to zero, all lagged values of the other country's variables.
4. The tests ignore potential contemporaneous cross-equation correlation-of-error terms. The critical *F*-values of 5 and 1 percent significance levels for 10 and 30 degrees of freedom are 2.16 and 2.98, respectively, and for 12 and 36 degrees of freedom are 2.07 and 2.80, respectively.
5. All tests are performed within a twelve-equation system where cross-equation contemporaneous correlation-of-error terms are taken into account. In column (1), rows 13 and 14, a total of 30 zero restrictions are imposed; for rows 15-17, 60 zero restrictions are imposed. In column (2), rows 13 and 14, a total of 36 zero restrictions are imposed; for rows 15-17, 72 zero restrictions are imposed. For the distinction between 1a and 1b and 2a and 2b, see note 14.
6. Critical  $\chi^2$  values at the 1 percent significance level are reported in parentheses.

Table 10.7 Three Sets of Causality Tests in a Two-Country Macroeconomic Model: U.S.-U.K., 1837-59 and 1882-1914

Dependent Variable	Granger-causing Variables											
	YS	PS	FRS	IS	DSC	NS	YK	PK	FRK	IK	DCK	NK
YS: weak strong multicause	—	N	N	Y	N	N	N	N	Y	N	N	N
	—	N	N	N	N	N	N	N	N	N	N	N
PS: weak strong multicause	N	—	⊗	Y	Y	N	N	N	N	N	N	N
	⊗	—	Y	⊗	Y	N	N	N	N	N	N	N
FRS: weak strong multicause	N	N	—	N	N	⊗	N	N	N	N	N	N
	N	N	—	N	Y	Y	N	⊗	⊗	N	N	⊗
IS: weak strong multicause	Y	Y	⊗	—	Y	N	Y	Y	N	N	Y	N
	N	Y	Y	—	N	Y	N	N	N	N	N	N
DSC: weak strong multicause	N	N	N	Y	—	N	N	N	Y	N	N	N
	N	N	N	N	—	N	N	N	N	N	Y	N
NS: weak strong multicause	N	N	N	N	N	—	N	N	N	N	N	N
	N	N	N	N	N	—	N	N	N	N	N	N

**YK:** weak  
strong  
multicause

N	N	Ⓝ	Ⓝ	Y	N	N	N	N	N
N	N	Ⓝ	Ⓝ	Y	N	N	N	N	N
N									
—	—	N	N	Y	N	N	N	N	N

**PK:** weak  
strong  
multicause

N	Y	Y	Ⓝ	N	N	N	N	N	N
N	Y	Y	Ⓝ	N	N	N	N	N	N
N									
Ⓝ	Ⓝ	—	—	Y	Y	Ⓝ	Ⓝ	Y	Y

**FRK:** weak  
strong  
multicause

N	N	N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N	N	N
N									
Y	Y	N	N	—	—	Y	Y	N	N

**IK:** weak  
strong  
multicause

Ⓝ	N	Y	N	Y	Ⓝ	N	N	N	N
N	N	N	Y	Ⓝ	Ⓝ	N	N	Y	Y
N									
Y	Ⓝ	N	N	N	N	Y	Y	N	N

**DCK:** weak  
strong  
multicause

N	N	N	N	N	N	Ⓝ	N	N	N
N	N	N	N	N	N	Ⓝ	N	N	N
N									
N	Y	N	N	N	N	N	N	—	—

**NK:** weak  
strong  
multicause

N	N	N	Y	Ⓝ	N	N	N	N	N
N	N	N	Y	Ⓝ	N	N	N	N	N
N									
Y	Y	N	N	Y	N	N	N	—	—

**Notes:** Y = yes = reject the null hypothesis of no cause at the 5 percent significance level; N = no = fail to reject the null hypothesis of no cause; Ⓝ = reject the null hypothesis of no cause at the 10 percent significance level.

income in the two countries is that there are common shocks—financial panics are an obvious example—that we have failed to take into account.

In the multivariate multicause tests reported in the bottom of table 10.6, we allow for such shocks by taking account of contemporaneous cross-equation correlation of the errors. In these tests, when either of the real-income variables is examined in conjunction with the domestic price and interest variables or with all five other domestic variables, we almost always reject the null hypotheses of no-domestic and no-other-country causes.

These last results, therefore, suggest that there was a set of mechanisms by which disturbances were transmitted internationally. The results say nothing, however, about either the relative importance of the different variables in the different equations or the specific channels of transmission.

We can get some notion of both by examining some of the other single-equation test results. The price equations are particularly interesting in both regards. For the United Kingdom as well as the United States in both the weak and strong forms of the tests, own-country foreign reserves and domestic credit as well as own-country rate of interest are significant predictors of own-country price level. For the U.K. price level, Granger-causation results from the U.S. price level. A similar arbitrage relationship appears to exist between interest rates in the two countries.<sup>17</sup> The U.S. rate Granger-causes the U.K. rate in both the weak- and strong-form tests.

The results are consistent with the existence of a specie-flow channel linking the two countries and, to a lesser extent, direct price and interest-rate-arbitrage channels. They are, however, inconsistent with the simplest model of the monetary approach to the balance of payments. The model assumes that arbitrage is complete within the period, suggesting, therefore, that the domestic price level either Granger-causes or is contemporaneously correlated with money. Correspondingly, the model views domestic credit as affecting only the stock of foreign reserves and not the nominal money stock or the price level. More general models of the types estimated by Darby and Stockman (1983) appear to be required to describe the historical data.

The foreign-reserve and domestic-credit tests for the two countries contain additional information bearing on these subjects. In the strong tests (but not the weak) we find Granger-causation of *FRS* by *FRK*. The reverse relationship, however, does not hold. At the same time, we find Granger-causation of *FRS* by *DCS*. There is, therefore, a further suggestion of a specie-flow channel as well as of a relation between domestic credit and foreign reserves of the kind posited in a broad class of monetary models. No consistency in these relationships between countries is, however, shown. Moreover the direction of influence uncovered for

foreign reserves, United Kingdom to United States, is the reverse of that suggested by the price-level and interest-rate tests.

The remaining set of relationships that are of some interest are those for domestic credit. U.K. real income appears to Granger-cause domestic credit, being significant at the 5 percent level in the strong-form tests and at close to the 10 percent level in the weak-form ones. The U.S. weak-form tests give evidence of Granger-causation of *DCS* by *FRK* and *IS* and perhaps also by *DCK* and *PS*. In the strong-form tests *DCK* and perhaps *IK* Granger-cause *DCS*. One possible interpretation of the U.K. results is in terms of a reaction function of the Bank of England. In the case of the United States, which over this period had no central bank, what we may be capturing are the effect of U.K. monetary pressures on the fiduciary component of commercial-bank-note issues.

#### 10.4.3 Further Tests of the Real-Income Relationship

As mentioned, a potential source of bias in the real-income tests stems from the way we entered the monetary variables. For both countries we disaggregated high-powered money into domestic and foreign components. By using high-powered money alone, we ignore any contribution the money multiplier might have made. And to the extent that domestic credit and foreign reserves are perfect substitutes in their effects on real income, treating them separately may bias the case against finding Granger causation.

Testing the two monetary variables jointly would solve the second problem but not the first. Accordingly, we reran the real-income tests using U.S. M2 and U.K. high-powered money (the only measure available) in place of the other monetary variables. We report the test results based upon this model in table 10.8.

The results paint quite a different picture than the previous ones. Unlike the earlier results, these show a clearcut association between own-country money and real income. In all four instances—*YK* vs. *HK* and *YS* vs. *MS*, in both forms of the test—we find Granger causation from the monetary variable to income. The relationships, however, are not simple. Other-country money also has significant effects both on own-country money and on own-country real income in all the comparisons. Similarly, for the United Kingdom there is evidence of reverse causation, *YK* having a significant effect on *HK*. We thus find what we failed to establish in the earlier set of results. At the same time, additional evidence emerges of a complex system of interaction between the two countries operating through monetary channels.

The relations uncovered between other-country money and own-country real income are particularly intriguing. One possible explanation is that we are capturing with other-country money the effect of monetary shocks abroad on the money multipliers and, hence, on real income in the

Table 10.8 Additional Granger Tests: U.S.-U.K. Monetary Models, 1834-1914<sup>1</sup>

Dependent Variable	Weak Tests		Strong Tests		Multiple Cause	
	Causing Variable	F	Causing Variable	F	Own Variables	Foreign Variables
YS	MS	5.01	MS	3.63	1.97	1.94
	HK	6.80	HK	3.59		
MS	YS	3.49	YS	0.35	1.03	2.24
	YK	0.02	YK	1.47		
YK	HK	4.32	HK	4.27	1.91	1.71
	MS	1.69	MS	4.02		
HK	YK	1.62	YK	4.52	2.51	1.46
	YS	0.10	YS	1.23		
			MS	2.92		
Degrees of freedom for column		2, 50		2, 34	8, 34	10, 34
Critical F at 5% level		3.19		3.29	2.23	2.12
10% level		2.42		2.47	1.86	1.80

1. All equations included both an intercept and (1, 0) dummy variable for pre- and post-Civil War years.

two countries. For the United Kingdom we have been forced to use high-powered money alone, so this explanation is particularly plausible. For the United States the deposit data for the antebellum period are likely to be subject to substantial error. Movements in U.K. high-powered money, therefore, may be a proxy for movements in the true U.S. money stock that are not reflected in movements in the measured money stock.

The alternative explanation is that the result is a reflection of some underlying behavioral relationship. One possibility is that the two monies were close substitutes from the standpoint of domestic money holders in the two countries. In that case, the true money stock in each country would be some weighted average of measured U.K. money and of measured U.S. money, with the weights most likely varying from the one country to the other. A further possibility is that we are capturing some aspect of the adjustment mechanism linking the two countries, rather than some aspect of a steady-state equilibrium relationship such as currency substitution. Asset-market adjustment across a wider spectrum than the short-term financial assets whose yields we include in the model is a potential candidate.<sup>18</sup>

#### 10.4.4 Conclusions from the Tests

Some of the explanation of results has been conjectural. In addition, certain relationships appear implausible a priori; certain others appear

inconsistent with findings that can be rationalized. Viewed as a whole, however, the results do tell a story of simultaneous dynamic interaction between the United Kingdom and the United States that in broad outline jibes with the inferences already drawn from the analysis of the data for individual reference cycles. The monetary system appears to be of considerable importance in the transmission mechanism. Monetary decelerations appear to be a significant determinant of cyclical contractions in real income. The evidence for monetary causes of transmission of business cycles is strongest when money itself is included directly in the econometric analysis. The analysis that allowed for cross-equation correlation of the residuals indicates that there probably were additional sources of transmission omitted from the model.

### 10.5 General Summary and Conclusions

In investigating the causes and transmission of cyclical fluctuations under the gold standard, we pursued two different research strategies. We began with an examination of each important cyclical episode on an individual basis and focused that analysis on the cyclical behavior of the monetary data, the cross-country interrelationships between movements in the specie and money stocks of the two countries, and the within-country interrelationships of those series and output. We then proceeded to estimate vector-autoregressive macroeconomic models for the United Kingdom and United States combined using variables that alternative hypotheses about cyclical fluctuations and transmission during this period suggest are important. We used the models in conducting a series of Granger tests, appropriate to both sets of hypotheses.

Because the historical and the econometric exercises are largely complementary, we have greater confidence in those findings that are common to the two approaches. Two items in particular deserve comment.

One item is the role of money in cyclical contractions. Taken together the two types of analysis indicate that monetary shocks were important independent factors leading to or worsening the severity and duration of the contractions in the two countries. During severe contractions, moreover, the shocks appear to have been the most important causative factor.<sup>19</sup>

The other item is the part played by the gold standard in the process. Both the historical and the econometric analyses point to it as a key element in the transmission mechanism. Reestablishment of the equilibrium conditions of the system after a monetary shock in one country, typically produced both gold flows and also price and capital-market adjustments. These in turn induced cyclical fluctuations in output in the other. Gold outflows, moreover, were particularly important in transmission, having two avenues of influence not only affecting high-powered



money but also, in a considerable number of episodes, leading to financial crises and subsequent declines in the money multiplier.

The two types of analysis, separately and combined, also suggest a number of other conclusions of less importance, which we merely list:

1. During the course of the sample period the United States and the United Kingdom appear to have reversed their roles: the United Kingdom seems to have been the senior partner prior to 1860, the United States in the first three decades of the twentieth century; neither was clearly predominant during the intervening years.

2. Within those subperiods, however, causation was not geographically unidirectional. Shocks initiated in one country that spilled over to the other appear to have reverberated back to the originating country to greater or lesser degree depending upon the particular episode.

3. Within countries there is evidence of a similarly complex transmission mechanism. Income had feedback effects on money of at least occasional and probably of general importance in both the United Kingdom and the United States.

4. During the relatively short periods when either the United Kingdom or United States was off gold, transmission of cyclical fluctuations is clearly less evident. Flexible exchange rates appear, therefore, to offer some and perhaps a considerable degree of insulation against cyclical contractions.

5. Short-term independence of monetary policy was possible even under the gold standard. The Bank of England often undertook defensive actions that halted and then reversed specie outflows. Those actions, in turn, appear to have had subsequent effects on income in both countries, moderating the decline in the United Kingdom and aggravating the decline in the United States.

From these findings, we draw several conclusions relevant to monetary policy. Given the attention the gold standard has received in the United States in recent years, these findings deserve explicit mention. The benefits of a gold standard, as usually enumerated, are that it is both automatic and impersonal and that it effectively constrains governments from using money creation as a taxation device. Our analysis suggests that the automaticity and impersonality were less than complete. The Bank of England's intervention alluded to above was a prime example. More important, because cyclical fluctuations were transmitted internationally with apparent ease under the gold standard, one has to weigh the costs of a greater incidence of such fluctuations against the benefits of a greater degree of secular price stability.

## Appendix A

### The Data

#### *United States: Individual Series and Sources*

*High-Powered Money.* High-powered money is defined as the sum of notes and specie held by the banks and the nonbank public. Data for 1833–59 are from Rutner 1974, table 28, col. 15 plus col. 19; for 1879–1933 from Friedman and Schwartz 1982, table 4.8, col. 9. Since Rutner's data were reported for varying monthly bank-statement dates, we took appropriate weighted averages of the original data to arrive at figures approximately centered on the end of June.

*Money.* Money is defined as the sum of currency (notes and specie) and commercial-bank demand and time deposits held by the nonbank public. Data for 1833–59 are from Rutner 1974, table 57, col. entitled "Calendar Year"; for 1870–1933 from Friedman and Schwartz 1982, table 4.8, col. 1.

*Specie.* Specie is defined as that held by banks and the nonbank public plus specie held by the Treasury and, from 1914 on, the Federal Reserve. Data for 1833–59 are from Rutner 1974, table 28, col. 1, adjusted by us to a yearly (June-centered) average; for 1879–1914 from Friedman and Schwartz 1963a, tables 5 and 8; for the remaining years from worksheets underlying Friedman and Schwartz 1963a.

*Real Income.* Data for 1833–59 are from the Smith and Cole index described below; for 1870–1933, real net national product from Friedman and Schwartz 1982, table 4.8, col. 3.

*Price Index.* Data for 1833–59 are from a yearly GNP deflator derived from Gallman's benchmark estimates; for 1870–1933 from an NNP deflator from Friedman and Schwartz 1982, table 4.8, col. 4.

*Interest Rate.* Data are for commercial paper rates; for 1833–59 from annual averages of Bigelow's monthly series in Macaulay 1938, appendix table 25; for 1870–1933 from Friedman and Schwartz 1982, table 4.8, col. 6.

*Population.* Data for 1833–59 are linear interpolations of census-year decennial estimates from Rutner 1974, table 37; for 1870–1933 from Friedman and Schwartz 1982, table 4.8, col. 5.

*United Kingdom: Individual Series and Sources*

*High-Powered Money.* High-powered money is defined as the sum of notes and coin held by the public plus bankers deposits and other private deposits at the Bank of England, 1833–70 from Huffman and Lothian 1980; for 1871–1933 from Friedman and Schwartz 1982, table 4.9, col. 9.

*Money.* Money is defined as the sum of currency held by the public and total deposit (current accounts and deposit accounts) at commercial banks. Data for 1871–1933 are from Friedman and Schwartz 1982, table 4.9, col. 1.

*Specie.* Specie is defined as the sum of specie held by the public and that held by the Bank of England. Data for specie held by the public for 1833–70 come from Huffman and Lothian 1980; thereafter from unpublished worksheets underlying the data reported in Friedman and Schwartz 1982, table 4.9. Specie held by the Bank for 1833–1879 comes from an unpublished appendix, “Bank of England Liabilities and Assets: 1696 to 1966,” col. entitled “Assets. Coin and Bullion,” to the article with that title in the Bank of England *Quarterly Bulletin*, June 1967, pp. 159–63; thereafter from Sheppard 1971, table A 1.12, col. 15.

*Real Income.* Real GNP is from Deane 1968 for 1833–1912; thereafter, the series is derived by us from Feinstein’s (1972, table 7, col. 7) index of real GNP at constant factor cost.

*Price Index.* Data are from the real-GNP series described above divided by nominal GNP from Deane 1968 for 1833–1912; thereafter, from Feinstein 1972, table 2, col. 10.

*Interest Rates.* Data are for first-class three-month bills; for 1833–56 from Mitchell and Deane 1962; for 1857–67, *ibid.*; for 1868–1933 from Friedman and Schwartz 1982, table 4.9, col. 6.

*Population.* Data for 1833–67 are from Mitchell and Deane 1968, p. 8; for 1868–1933 from Friedman and Schwartz 1982, table 4.9, col. 5.

**Problems with the U.S. Output Data**

As a measure of real output in the U.S. during the antebellum period, we used an index derived from Smith and Cole’s (1935) separate production indexes for the years 1831–45 and 1843–62.

Both indexes are made up of two components—domestic trade (two-thirds weight) and foreign trade (one-third weight). The domestic index for 1831–45 was derived from eleven component series, eight of which were expressed in physical units; the domestic index for 1843–62 from ten

component series, six of which were in physical units. The foreign trade indexes were both nominal measures based on the total of exports and imports in current prices in both periods. None of our conclusions about cyclical movements, however, would have been grossly different had we relied solely on the domestic indexes. We linked the two production indexes on the basis of Ayres's (1939) index of cyclical fluctuations.

The Smith and Cole indexes as published are in the form of deviations from trend. Logarithmic first differences of these indexes, therefore, overstate the decline in the non-trend-adjusted series. The overstatement in the case of a series that follows a constant semilogarithmic trend is the intercept term in that trend equation.

In spite of their deficiencies, these indexes appeared far preferable to the alternative measure of output we examined, an annual real-GNP series derived from Robert Gallman's (1966) benchmark estimates. Inspection of this series revealed almost no correspondence with the NBER reference cycles—even during the 1839–43 contraction which, by all accounts both contemporary and subsequent, was unusually severe. Most of the physical-volume series for individual industries we examined, in contrast, did exhibit cyclical movements corresponding to the NBER pattern as also did the Smith and Cole indexes. One reason for the lack of cyclical movement in the Gallman series may be its omission of inventories, usually one of the most cyclically sensitive components of GNP.

### Proxy Series for the U.K. Money Supply

Prior to 1870 the U.K. deposit data are incomplete. For a subset of these years, though, we have a proxy series—total liabilities of private and joint-stock bank in England and Wales to the nonbank public—that Michael Collins (1981) has constructed. Movements in these data are summarized in a note at the bottom of table 10.3.

We view these data as indicators of the direction but not the magnitude of movement of the overall money stock relative to that of the monetary gold stock. We regard these data as suspect from the latter standpoint because Collins was unable to obtain complete bank-balance-sheet data for the whole period. As an interpolator, he used the number of bank offices. In periods of banking panic when there were substantial bank failures, his series may therefore be more volatile than the true series.

## Appendix B

### Panics and Cyclical Contractions

Discussions of financial panics abound in the literature devoted to particular periods in the economic history of each country. More general

treatments of financial panics, either from a primarily theoretical and primarily historical standpoint, however, are few.

One group of modern studies that has dealt with the phenomenon of financial panics in some depth are those of the U.S. monetary system at the National Bureau: Milton Friedman and Anna Schwartz's *A Monetary History of the United States* (1963a) and their related article "Money and Business Cycles" (1963b), and especially Phillip Cagan's *Determinants and Effects of Changes in the Stock of Money, 1875-1960* (1965). Charles Kindleberger's *Manias, Panics, and Crashes* (1978) is a more recent work devoted to the study of such episodes in an explicitly international context.

One of Cagan's specific concerns was the interrelation of cycles in monetary growth and business. In a subsection of that title in the summary chapter of his study he concludes:

This evidence points to an important independent role of monetary factors in severe business contractions. The six largest declines in money were associated with severe depressions, and severe depressions have never occurred otherwise. . . . Panics cannot be held solely responsible for the deep declines in both money and business. Two severe contractions had no panic; in addition, some panics did not produce a large drop in monetary growth, and the accompanying declines in business did not become severe. (P. 296)

Kindleberger, though he does not refer to Cagan's study, apparently would disagree with his assessment. In Kindleberger's framework, panics are the natural culmination of the previous boom in which speculation and overtrading are rife. An increase in the money supply may alleviate the effects of the panic, but a decrease during the panic is not a necessary condition for a severe cyclical downturn.

Cagan's conclusions about the effects of panics stem in large part from the comparisons he makes between cycles that were severe and had no panics and cycles that were not severe but had panics. Of four relevant episodes—two in each category—he excludes two from consideration, ending up with one in each category. Our sample extends farther back in time than Cagan's and covers the United Kingdom as well as the United States. Hence, it offers additional degrees of freedom with which we can assess the relative importance of panics and monetary contractions as proximate causes of business contractions.

To that end table 10.A.1 classifies cyclical contractions in both countries according to both degree of severity (severe versus mild) and existence of a banking panic. We exclude cycles that occupy the cell mild, no panic. We further classify each of the cycles that we include according to the degree of monetary contraction.

As a starting point in dividing the cycles according to degree of severity, we adopted Burns and Mitchell's classification of 1857, 1873, 1893,

Table 10.A.1 The Interrelation of Panics, Money and Cyclical Contractions in the United Kingdom and United States, 1836-1933

Severity of Cycle	United States			United Kingdom					
	Date of Peak <sup>1</sup>	Panic/No Panic	Monetary Contraction <sup>2</sup>	Severity of Cycle	Date of Peak <sup>1</sup>	Panic/No Panic	Monetary Contraction <sup>2</sup>		
Severe	1836	P	S	Severe	1839	NP	S		
	1839	P	S		1857	P	S		
	1847	P	S		1873*	NP	S		
	1856	P	S		1883*	NP	NS		
	1873*	P	S		1890*	NP	NS		
	1882*	P	S		1907	NP	NS		
	1892	P	S		1920	NP	S		
	1907	P	S		1929	NP	S		
	1920	NP	S						
	1929	P	S						
	Not Severe	1887	P		S	Not Severe	1836	P	NS
		1913	P		NS		1845	P	S
				1866	P		NS		

Sources: See tables 10.2 and 10.3.

1. An asterisk denotes positive growth in real output from cycle peak to cycle trough. With the exception of 1873 in the U.S. and the U.K., these growth rates on average were all less than 1.0 percent; the average for 1873-79 in the U.S. was 3.7 percent; for the subperiod 1873-75, it was -1.1 percent; for 1873-79 in the U.K. it was 2.8 percent; for the subperiod 1875-79, it was 0.1 percent.

2. Monetary contractions are classified severe if the stock of money (or high-powered money in the case of the U.K. prior to 1870) either declined in absolute terms in the period during or immediately preceding the cycle peak or underwent a substantial decrease in its rate of growth.

1907, 1920, 1929 as severe cycles for both countries. For the United States we then added 1837, 1839, 1847, and 1882; and for the United Kingdom, 1839 and 1883. We had some doubts about the degree of severity of 1837 and 1847 in the United States and their two counterparts in the United Kingdom. On the basis of the output data in tables 10.2 and 10.3, we classified the two U.S. cycles as severe and the corresponding U.K. cycles as mild. Following Burns and Mitchell we did not include the 1913–14 contraction in the severe category. On the basis of the real output data alone, the phase clearly was severe. Had we so classified it, the case we make below would have been weakened but hardly overturned. Moreover, as Cagan (p. 223) points out, the phase is not very informative in any event since the panic was a “rather mild affair.”

By including both the United States and the United Kingdom in the period prior to 1875, we have thirteen severe cyclical contractions in addition to those Cagan examined—twelve accompanied by panics, one not, and three additional mild cyclical contractions, none accompanied by panics. As a glance at the table indicates, the deciding factor in a cycle's severity is the existence or absence of a monetary contraction rather than the existence or absence of a panic. Panics took place in only ten of eighteen severe cycles; severe monetary contractions took place in fifteen. In three of the five mild cycles during which a panic took place, the monetary contraction was also mild, and in only one (1845 in the United Kingdom) was there an absolute decline in money.

The other interesting aspect of these data is the light they shed on the question of transmission. In only three of the common cycles—1836–38 (1837–38 in the United Kingdom), 1847–48 (1845–48 in the United Kingdom), and 1856–58 (1857–58 in the United Kingdom)—were there panics in both countries. In the first two, the fluctuations in output were a good deal more severe in the United States than in the United Kingdom. The importance of panics as a direct channel of transmission of cyclical fluctuations does not appear to have been great. As an indirect channel, that is through their effects on money supplies, panics appear to have exerted a more important influence.

## Notes

1. Considerable debate has centered on this topic. See Pippenger's paper in this volume for evidence supporting this statement.
2. In Friedman and Schwartz's (1963a) study of business cycles, for example, changes in monetary growth were the causative variable. Fisher (e.g., 1935) related cyclical movements in real variables to distributed lags of past prices, the latter being identified by Fisher as an indicator of monetary pressure.
3. For a discussion of transmission in the Meade-Mundell framework see Mussa's excellent survey article (1980).

4. See Darby and Lothian 1983 for a discussion of how these various channels of transmission operated during the fixed-exchange-rate Bretton Woods period.

5. In appendix B we evaluate these two hypotheses. We conclude that the monetary decline, rather than the panic itself, was the major factor leading to cyclical contractions in output.

6. If the specie circular had been the cause of the monetary contraction, we would expect to see the ratio of money to specie rather than specie itself account for the decline in monetary growth.

7. Between 1876 and 1879, the money stock decreased at an average annual rate of 2.6 percent while high-powered money increased at an average annual rate of 1.7 percent.

8. Ultimately, however, some reduction in the U.K. money supply and price level would have had to occur given the reduction in both the United States and the rest of the world. A largely domestic-induced decrease in the money stock in this instance was the equilibrating factor. Had the decrease not occurred, an outflow of gold presumably would have been the main avenue through which monetary deflation would have taken place.

9. We stress the word "almost." The onset of the 1920–21 cycles poses a particular problem in this regard. Both countries experienced substantial monetary decelerations beginning at roughly the same time. The increase in the discount rate by the Federal Reserve and subsequent reaction by the Bank of England may have been the key factor here.

10. See Choudhri and Kochin 1980 for evidence drawn from a number of countries during the 1930s and Jonung 1981 for Sweden. Lothian 1981 contains a further discussion of the U.K. vs. U.S. comparisons presented here.

11. In the presentation and discussion of the empirical results, we concentrate exclusively on the Granger tests. An autoregressive system is difficult to describe succinctly. Moreover, it is difficult to make much sense of individual coefficients of the regressions equations since coefficients on successive lagged values of a given variable tend to oscillate in sign, and there tends to be a complicated pattern of cross-equation feedback. Additional insights into the performance of the system of equations could be obtained by analyzing the system's responses to typical random shocks.

12. Cassese and Lothian 1982 contains a discussion of some of these issues, in particular the relation between timing and causation in the context of international transmission of economic disturbances. C. Hernandez-Iglesias and F. Hernandez-Iglesias (1981) provide examples of models where economic causality may be difficult to verify with tests based upon Granger's predictive concept of causality.

13. The  $F$ -statistic is fairly robust to relaxing the assumption of normality of the errors (Judge et al. 1980). Estimation and testing with lagged endogenous variables rely on asymptotic distribution theory. Autocorrelated error terms are a serious potential source of problems.

14. Dhrymes (1970, pp. 34–40) presents the basic form of the test. Under the null hypothesis, we impose  $q$  linear restrictions on the coefficients of  $\pi(L)$ . Applying the likelihood-ratio principle, we then arrive at the test statistic  $(T - k) \ln |\hat{\Sigma}_\omega / \hat{\Sigma}_\Omega|$ , which has an asymptotic  $\chi^2_q$  distribution where  $\hat{\Sigma}_\omega$  and  $\hat{\Sigma}_\Omega$  are estimates of the variance-covariance matrix of the error terms under the restricted system associated with the null hypothesis and of the general system respectively. This form of the statistic is due to Sims (1980) who argues that standard tests are biased toward rejecting the null hypothesis when  $q$  approaches or exceeds  $T - k$  in size. He therefore suggests treating the sample size as  $(T - k)$  rather than  $T$  in these cases.

15. Ideally we would have liked to have had quarterly or perhaps even monthly data. Annual data can of course mask the timing relationships that are central to our analysis. Unfortunately, however, no such intrayear data are available in continuous form for anything even close to our full sample period.



16. Tests presented in the earlier version of this paper based on a slightly different body of data indicated possible heterogeneity of the model across these two subperiods. For this reason, we included the dummy variable in each of the equations. Additional tests of lag length were not inconsistent with the two-year distributed lags used here.

17. Since only lagged values of the variables appear on the right-hand side of the equations, these tests are likely to understate the importance of the arbitrage relationships. We therefore ran additional regressions, in the first case, of the contemporaneous percentage change in one country's price level on the other's and, in the second, of the contemporaneous first difference of the one country's interest rate on the other's. In both instances we also included a dummy variable for intercept shift in the second subperiod. The partial correlation between the price variables was .41 and between the interest-rate variables .52. Both are significant at better than the .01 level.

The statistical significance uncovered in certain of the Granger tests, however, suggests that neither process was complete within the year. For the interest-rate relationship the lagged adjustment is suggestive of an asset-market transmission mechanism of the type posited by Branson (1968, 1970). For the price relationship, differences in the adjustment of prices of traded and nontraded goods are a possible explanation. Lags in adjustment in the goods and the bond markets, together with the successful intervention techniques followed by the Bank of England, suggest that the simplest monetary-approach models are inappropriate for the period. Similar conclusions for both the United States and the United Kingdom, as well as six other industrial countries during the post-World War II era, are presented in Darby and Lothian 1983.

18. Brittain 1981 and Miles 1978 contain evidence derived from post-World War II data for the U.S. and several other industrial countries and the U.S. and Canada, respectively, that is consistent with the currency-substitution hypothesis. Darby and Lothian, in summarizing the findings of the National Bureau study *The International Transmission of Inflation* (1983), present evidence that largely contradicts it. In their study of the United Kingdom and United States, Friedman and Schwartz (1982) find for the gold standard portion of their period that other-country money did not affect own-country nominal income in either instance but did affect the own-country price level in both. Since their data are averages taken over reference-cycle phases, the possibility of shorter-term effects on nominal (and real) income exists. Further compounding the problem is the evidence they present that such effects were significant for the United Kingdom but not for the United States post-1914. The standard comment that further study of the question is required is, therefore, more appropriate than usual.

19. Friedman and Schwartz 1963 for the United States after 1870, Warburton 1958 and 1962 for the U.S. antebellum period, Huffman and Lothian 1980 for the United Kingdom in the nineteenth century contain results consistent with this conclusion.

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## Comment Michael Connolly

The major finding of this study is that for each country the proximate determinant of output fluctuations are sudden, unanticipated changes in domestic monetary variables. Transmission between countries occurs via specie flows and the monetary reactions they induce, either on the part of the monetary authorities or on the part of the banking system.

In my comments, I will argue that some evidence, particularly of the historical-narrative kind, is provided in support of this finding. But I am less convinced by the econometric evidence.

### Evidence on Real-Income Interdependence

Two bodies of evidence are offered in support of the international transmission of business cycles. The first is an anecdotal narrative of the major contractions in the United States and the United Kingdom over the one hundred-year period; the second is econometric, involving Granger-Sims autoregressive tests of causality for the combined period 1837–59, 1882–1914.

The historical narratives are to some extent convincing, the econometric testing is less so. The major U.K. recessions were transmitted to the United States, it is argued, during the antebellum period, principally by the United Kingdom's raising Bank rate, thus triggering a slowdown of growth or an outright loss of gold in the United States. Each recession is documented and was frequently shared by both countries during this gold standard period.

The extent to which recessions were transmitted from the United Kingdom to the United States, however, is undoubtedly exaggerated by the use of the Smith and Cole and the Ayres indexes of total trade for U.S. income from 1833 to 1861. As described in appendix A, these indexes contain two-thirds domestic trade and one-third foreign trade. This series is much too volatile and, more importantly, very likely to be biased toward procyclical movements with U.K. income. The reason is simple: When the rate of growth of U.K. income expands or contracts,

U.K. imports from the United States will expand or contract. Consequently, the U.S. output index will, I suspect, reflect too dramatically the decline in U.K. income simply because it includes such a high proportion of foreign trade. These problems are illustrated in figure C10.1 which I have drawn from data supplied by Wallace Huffman and James Lothian (hereafter H-L). Expansions and contractions in the U.K. growth rate are accompanied by multiplied expansions and contractions in the U.S. growth rate the same year or a year later. Personally, I suspect a problem with the U.S. income index, although I agree with H-L that the Gallman index is unsuitable since it excludes inventories, a particularly sensitive boom-and-slump item. In any event, to the extent that the U.S. output index is biased towards procyclical behavior, the findings will be also.

I will not review each contractionary episode and the extent to which H-L argue it was shared under the gold standard. In most cases it is clear recessions were shared; in others it is not so clear. I am puzzled, however, by their interpretation of the "controlled experiment" of the 1915-25 interwar period when the United Kingdom was off the gold standard. Following the sharp 1919-21 U.K. slump, U.S. income fell 5 percent in 1920 and 4 percent in 1921, suggesting that the United States shared in the slump despite the nonexistence of the gold standard. It may be that the rebound in the U.S. economy was both rapid and strong; the U.K.

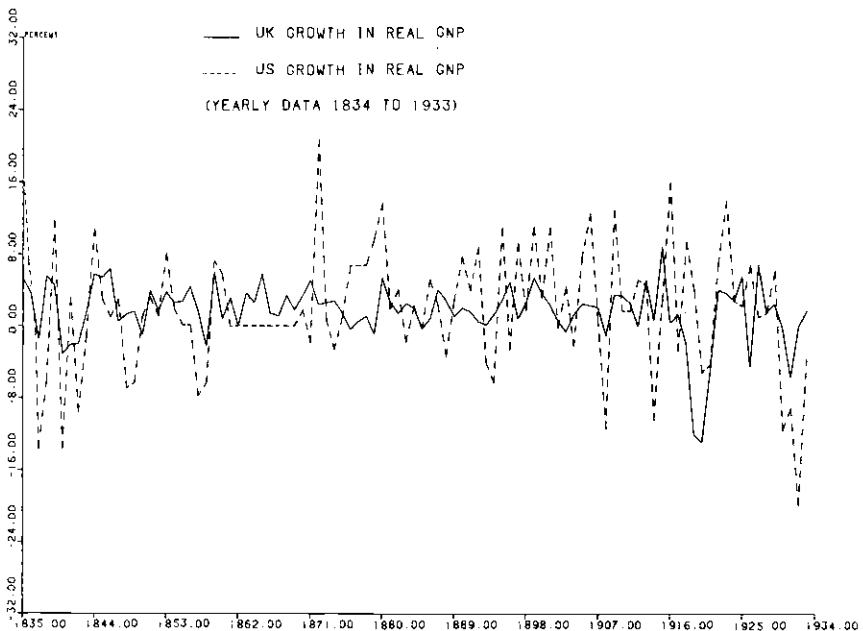


Fig. C10.1

U.S. and U.K. real GNP, yearly growth rates, 1834-1933.

economic rebound was weaker and came later. But the fact is that both economies slumped together—the United States was not insulated from the British drive to restore the gold standard at the prewar parity by deflation. I am convinced by most of the narrative stories, but in some the authors use poetic license.

As for the weak Granger-Sims causality tests reported in table 10.5, there appear to be some relationships between U.S. income and price variables and U.K. income and price variables. U.S. real-income growth is Granger-caused by U.K. monetary variables (gold, Bank rate, and high-powered money), but not by U.S. gold nor U.K. income. In turn U.K. income growth is Granger-caused by U.S. high-powered money, prices, and discount rate, but surprisingly not by U.K. prices or Bank rate. The strong causality tests reported in table 10.6 show U.S. income Granger-caused by only U.K. prices and U.S. population growth. U.K. income is not Granger-caused by any variable. These tests have problems to which I will return.

#### Evidence on the Transmission Mechanism

In general, two types of transmission mechanisms are possible: one through the direct effects of international-price and interest-rate arbitrage, the other through flows of specie and consequent effects on money growth rates. The first is not tested in this paper because the autoregressive tests impose a one-year lag on variables for the purpose of identifying causality. Since synchronous variables are excluded, the test cannot pick up rapid arbitrage. In the H-L tests, U.S. inflation is not related to *lagged* U.K. inflation, but U.K. inflation is weakly caused by past U.S. inflation. Similarly, changes in U.S. interest rates are not Granger-caused by lagged changes in U.K. interest rates, but changes in U.K. Bank rate are weakly caused by changes in lagged U.S. interest rates. Not much information on arbitrage can be drawn from this evidence because of the long lags involved.

To get at some of these relationships, it might be useful to use a priori information on the direction of causation to justify the inclusion of some contemporaneous variables. For example, the authors argue that contractions prior to 1870 in the United States are a dance to the tune of U.K. Bank rate.

In clearcut cases, contemporaneous U.K. income, prices, and Bank rate might be included in the regressions of U.S. income. (Choudhri 1983 uses this technique.) In any event, this would give greater evidence of association if not causality and, in particular, would shed light on the price- and interest-arbitrage relationship.

The narrative evidence presented for 1833–70 focuses upon the importance of jumps in U.K. Bank rate in inducing slowdowns or declines in U.S. specie and consequently in U.S. money growth, which then slows



U.S. income. A glance at figure C10.2, also reproduced from H-L's data, does suggest this pattern in the antebellum period. Declines in U.K. specie led to increases in Bank rate, provoking shortly thereafter either a slowdown or decline in U.S. specie. In the 1836–37 period, U.S. gold growth slowed; in 1840 it declined 7 percent; it slowed in 1857 and in 1882 and declined 4 percent in 1889. In the Great Contraction, the U.K. break with gold in September 1931 probably enabled money growth to expand there sooner and more rapidly (see figure C10.3). This type of evidence is quite strong—in many of the major contractions, the slowdowns and declines in U.S. gold had similar effects on the U.S. money supply. In H-L's terms, however, the movements in gold often fail to account for anything close to the full movement in M2. Furthermore, in several instances there was little correspondence between gold and M2, as reported in tables 10.2 and 10.3. Nevertheless the evidence they report on some specific episodes appears quite strong.

I would like to conclude with some remarks on the possible pitfalls of the autoregressive tests reported in the H-L paper. First, as mentioned above, lagged relationships using annual data suppress too much information and do not allow for rapid price and interest arbitrage and/or

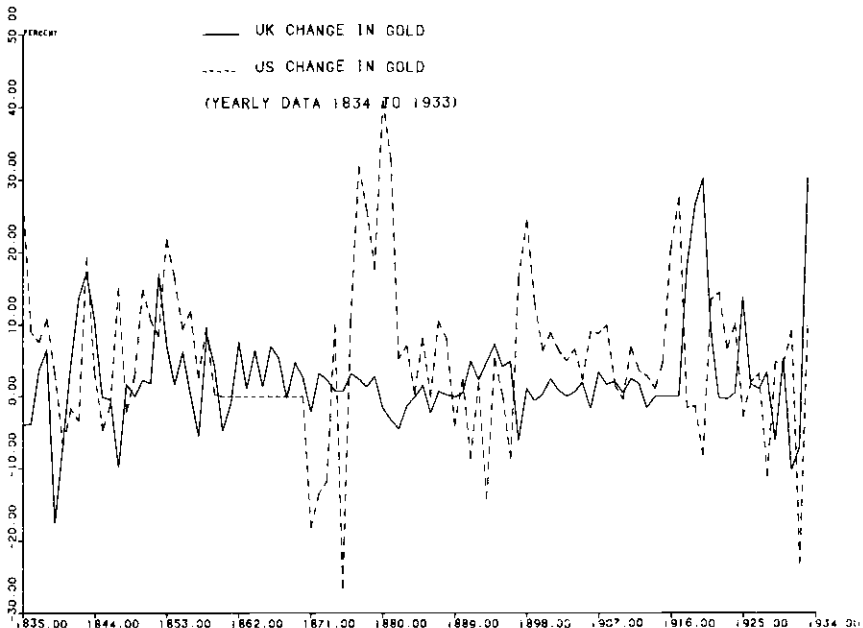


Fig. C10.2

U.S. and U.K. annual percent change in monetary gold stock, 1834–1933. The United States was not on the gold standard 1861–79; the United Kingdom was not on the gold standard 1915–25 and from 1931 on.

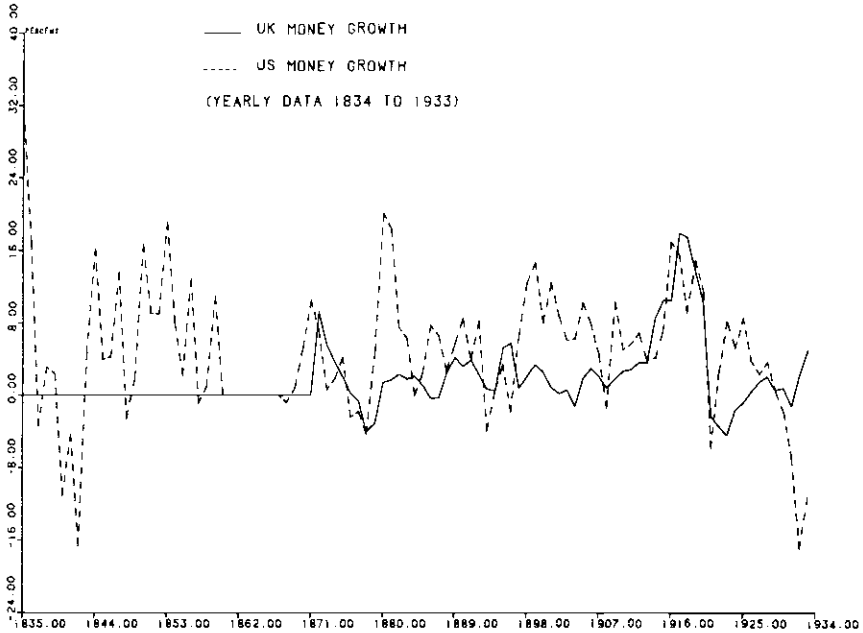


Fig. C10.3 U.S. and U.K. yearly money growth rates, 1834–1933.

causation tests. Second, reporting only the  $F$ -statistic, as is common in these tests, gives us no idea about the magnitude or even the sign of the coefficients in the regressions (on this, see note 11). Third, as specified, the test clearly picks up spurious causality; for example, U.S. population growth Granger-causes U.K. domestic-credit growth, and U.S. domestic-credit growth causes U.K. population growth.

To sum up, I found the paper interesting and some of the evidence convincing.

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