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THE GOLD STANDARD AND THE TRANSMISSION OF BUSINESS CYCLES: 1833-1933*

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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 topics we first review each of the important cyclical contractions in the United Kingdom and United States during the century 1833-1933. 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 1837-1859 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 will skip a detailed synopsis at this juncture. Instead, we merely mention the two principal findings: that monetary shocks were the main source of cyclical fluctuations during this period and that the monetary system itself--the gold standard--was the main mechanism through which the shocks and associated fluctuations in output were disseminated.

1. Historical Overview

At the start of our sample period, the United Kingdom was a large country, London the main financial center of the would, 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 19th and early 20th centuries, however, the United States grew rapidly. Immigration rates were high, except for Civil War and major economic depression years, and the frontier moved steadily westward. By 1914, as a result, 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 18th 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, it too had a temporary break with gold, the U.S. 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 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.[1] 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.

2 Theoretical Considerations

As an empirical proposition, the link between money and business fluctuations has long been know 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 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.[2]

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. They were static rather than dynamic and devoid of any distinction between actual and anticipated values.[3]

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 were 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 of 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.[4]

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 completed 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.[5]

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 or the other case.

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 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 43 years earlier. Table 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 19 reference-cycle contractions. In the United States there were either 25 or 23 depending upon how we treat the contractions of 1847-48 and 1892-94. If we view them as distinct entities, as the official NBER classification

does, there were 25. If, however, we combine the first with the earlier contraction of 1845-46 and the second with that of 1890-91, which is what we do in the table and which may make more sense from the standpoint of inter-country comparisons, the total for the United States reduces to 23.

One aspect of these data that has attracted attention is the tendency for 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 2 and 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 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 stiuation was reversed, the United States becoming the senior partner in the process; the United Kingdom the junior.

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, 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, themeselves 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' (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 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 Angol-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 figuring 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 U.S. 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.[6] 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 had 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 it 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 by 26.3 percent; and Ayres' index of business activity 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 frm 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 contracton 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 in 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 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), 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 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 and in the United States apparantly 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 too expereinced 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 somewhat more protracted.

The pattern of movemetns 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 percent 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 virtually identical manner: 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.

Then, the panic and run on banks 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 would have taken place sooner than that year in the United Kingdom and presumably so also would the recession. The Bank's actions merely staved both off for awhile. That, however, added to the problem in the United States. As it 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 in earnest there too.

3.2 The Greenback Period

During the 17 years when the Untied 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 in the United Kingdom and associated panic, 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. It is important to note, however, that this evidence 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 non-monetary 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 of 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 also the ratio of M2 to gold, was due to the banking difficulties that began in early 1866. Its cause in turn, 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 the 10th of 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 (1963a) 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. It affected equity prices and led to a crisis on the London Stock Exchange, but there were no further monetary reprecussions. The Bank of England, as it had through 1873, altered its discount rate promptly, increasing it to a high of 9 percent on November 7, 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 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 on 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 in turn, were only partially the result of gold flows. In the latter part of the period, a decline in the ratio of M2 to high-powered money became important.[7] 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. That, in turn, is 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 discernable 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.

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. cycle, dated 1883-86, real income grew at an average annual rate of less than 1 percent; in the U.S. one, 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, from an average of 19.3% per year in 1879-81, to an average of 6.9 percent in 1881-83, to virtually zero in 1883-84. It reflected 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 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 and its cause 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 (1963a), 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 New York banks were experiencing the usual seasonal drain of specie reserves to argicultural areas of the country. As a result, a number of bank failures in the United States occurred during early November and, then, on November 15, 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 production 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, the cause of which was distrust of the solvency of banks. The latter, in turn, had its roots in the deflation that declines in capital 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, it was the nongold component of high-powered money that 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.[8]

1907

The contractions of 1907-08 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 October 5, it increased Bank rate further, to 5 percent, and then on October 19 to 6 percent, the highest level since the Baring Crisis in 1890. "These measures," Friedman and Schwartz (1963a, 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 a 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 October 21, 1907. It 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 gorwth 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 1906-07 to 1.7 percent in 1907-08. As in the case of the United States, though, these movements may well have been somewhat more severe when viewed interyearly. 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 November 4.

The Bank's response to this outflow, as in the past, was to increase its discount rate. It did so by successive 50 and then 100 basis point amounts from 4.5 percent in September 1907 to 7 percent on November 4. These increases, though probably necessary from the U.K. standpoint, worsened the problem in the United States.

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.[9] 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 May 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 itensified.

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 14 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 -.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 thoe 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, II, p. 181) seems to us to have been essentially correct:

> Looking back, we 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 concelling 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 24 months ending January 1929--5 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 incrase 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 that 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.[10]

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.

3.5 Conclusions from the Historical Analysis

Our analyses 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 nongold 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.

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.[11] 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. They require neither answers before the fact to the series of largely unsettled issues surrounding 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, however, can reduce the likelihood of such errors and thus limit the effects on the statistical inferences being made.[12]

4.1 Model and Method

We consider a 2-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:

$$(1)\quad \underset{(m\times 1)}{X_t} = \underset{(m\times m)}{\pi(L)}\ \underset{(m\times 1)}{X_{t-1}} + \underset{(m\times 1)}{U_t},\quad t = 1, \ldots, T,$$

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 $E\,U_tU_t' = \Sigma$.

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 is the model that we then use to conduct the Granger tests. To illustrate these tests in a single equation context consider the first equation of the m-equation system (1):

$$(2)\quad X_{1t} = \pi_1(L)\,X_{t-1} + U_{1t} = \sum_{j=1}^{m} \pi_{1j}(L)\,X_{jt-1} + U_{1t}$$

$$= \pi_{11}(L)\,X_{1t-1} + \pi_{12}(L)\,X_{2t-1} + \ldots + \pi_{1m}(L)\,X_{mt-1} + U_{1t},$$

$$t=1,\ldots, T,$$

where $\pi_{ij}(L)$ is the (n+1)-th order polynominal 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 [$ESS(\hat{\Omega})$]. To do so 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.[13] 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 11 equations in the macroeconomic model system and (b) two or more equations jointly within the 12-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:

$$(4) \quad X_{1t} = \pi^*_{11}(L)\, X_{1t-1} + \pi^*_{1m}(L)\, X_{mt-1} + U^*_t$$
$$t = 1, \ldots, T \quad .$$

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. It tells us whether X_m contributes significantly to explaining the variance in X_1, holding variables X_2 through X_m constant. Tables 4 and 5 contain the results of these two sets of tests, respectively; table 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 are of two types. The first multiple-cause tests are on each of the single equations taken independently of the other 11 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 12 equations of our macro-economic system. These tests are the direct analogues in a multi-equation context of the single-equation multiple-cause tests we have 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 the tests on single equations are reported in table 6, part A, and chi-squared statistics for joint tests across two or more equations are reported in part B. For the latter test, we base our conclusions on Sims' (1980) version of the chi-squared statistic, which is reported in columns (1a) and (2a) of Table 6, but we also report the other frequently used chi-squared statistic in columns (1b) and (2b).[14]

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 12 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.[15] 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.[16] 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 be an important source of business-cycle transmission.

4.2 Tests Based Upon The Full Model

Since our principal interest is in the real income tests, we turn to these first. Here 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, signficantly 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 multi-cause tests reported in the top half of table 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.

There are a number of possible reasons for our failure to find 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 their effects are being masked by the inclusion of a large number of truly insignificant variables. A third, which is 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 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 multi-cause tests reported in the bottom of table 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. They 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 there is also

Granger-causation running from the U.S. price level. A similar arbitrage relationship appears to exist between interest rates in the two countries.[17] 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. It 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, it views domestic credit as only affecting 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. 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 effects of U.K. monetary pressures on the fiduciary component of commercial bank note issues.

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, since it is all that is available, U.K. high-powered money in place of the other monetary variables. We report the test results based upon this model in table 8.

The results paint quite a different picture than the previous ones. Unlike the earlier results, they 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 what we are capturing with other-country money is the effect of monetary shocks abroad on the money multipliers and, hence, on real income in the 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 it 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.[18]

4.4 Conclusions from the Tests

Some of the explanation of results have been conjectural. In addition, certain relationships appear implausible a priori; certain others appear inconsistent with findings that are capable of rationalization. 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 and transmission of business cycles is strongest when money is included directly in the econometric analysis rather than its proximate determinants, reserves and domestic credit. An additional source of business-cycle transmission uncovered by the econometric analysis is through cross-equation correlation of residuals in a multiple-equation monetary system.

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. The focus of that analysis was 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 com-

plementary, we have greater confidence in those findings that are common to the two approaches. Here there are two items in particular that deserve comment.

One is the role of money in cyclical contractions. Taken together the two types of analyses 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, they appear to have been the most important causative factor.[19]

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

(a) 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.

(b) 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.

(c) 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.

(d) During the relatively short periods during which 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.

(e) 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 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.

The author's affiliations are Citibank, N.A., and Iowa State University, 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. We would like to thank all of these individuals without implicating them in the end result. In addition, we want to thank Mark McNulty for computational assistance and Donna Bettini and Connie McCarthy for their extremely able assistance.

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 (1963) study of business cycles, for example, changes in monetary growth were the causative variable. Fisher (e.g., 1934) 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% while high-powered money increased at an average annual rate of 1.7%.

[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 it 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 Choudri 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. However, Hernandez-Iglesias and 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 relies 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 ration principle, we then arrive at the test statistic $(T-k)\ \ln|\hat{\Sigma}_\omega/\hat{\Sigma}_\Omega|$, which has an asymptotic χ^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 intra-year 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 hetrogeneity 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 (1976) 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 (1983) in summarizing the findings

of the National Bureau study The International Transmission of Inflation 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 the United States post-1914. The standard comment of further study of the question being 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, and our earlier (1980) study for the United Kingdom in the nineteenth century contain results consistent with this conclusion.

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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)	
	(1847)				1848
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)	
	(1892)				1894
	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

NOTE: Parentheses indicate NBER reference cycle contractions in the United States that we have subsumed in our analysis into a longer corresponding cycle for the two countries.

SOURCE: Burns and Mitchell (1946).

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, 1834-1933

Periods		Real Income	Money		Gold	
Contraction Peak-Trough	Precontraction	Contraction	Contraction	Precontraction	Contraction	Precontraction
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

NOTE: 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.

Source: See Appendix A.

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, 1834-1933

Periods		Real Income	Money		Gold	
Contraction Peak-Trough	Precontraction	Contraction	Contraction	Precontraction	Contraction	Precontraction
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

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.

Source: See Appendix A.

TABLE 10.4

Weak Tests of Granger Causality in a Two Country Macroeconomic Model: U.S.-U.K. Gold Standard Period 1837-1859, 1882-1914[a]

Equation	Regressor with coefficients being zero in null hypothesis											
	YS	PS	FRS	IS	DCS	NS	YK	PK	FRK	IK	DCK	NK
United States	F-statistics											
YS	3.13[b]	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

a - Each "unrestricted" model contains four regressors, the one and two period lagged values of the dependent variable and 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 which are differences of levels; the FR and DC terms were weighted by their respective shares in high-powered money.

b - 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 1837-1859, 1882-1914. (F-statistics)

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

a - Each "unrestricted model" contains one and two year lagged values of the 12 different variables (24 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 which are differences of level. The FR and DC variables were weighted by their respective shares of high-powered money.

b - 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.

TABLE 10.6

Tests of Granger Causality in a Two Country Macroeconomic Model: No Domestic Cause Versus No Other-Country Cause, U.S.-U.K. Gold Standard Period 1837-1859, 1882-1914[a/]

Model-dependent variable(s)	Null hypothesis[b/]: No domestic cause (1)	No other-country cause (2)
A. Univariate model[c/d/]		
(1) YS	1.24	1.51
(2) PS	3.73	1.52
(3) IS	3.36	1.18
(4) FRS	2.39	1.73
(5) DCS	.93	1.68
(6) NS	.85	.99
(7) YK	1.46	1.27
(8) PK	3.80	1.69
(9) FRK	2.62	.99
(10) IK	2.52	1.78
(11) DCK	1.60	.97
(12) NK	2.41	1.72

	χ^2-statistic			
	$(T-k)\cdot\ln\lvert\hat{\Sigma}_\omega/\hat{\Sigma}_\Omega\rvert$ (1a)	$T\cdot\ln\lvert\hat{\Sigma}_\omega/\hat{\Sigma}_\Omega\rvert$ (1b)	$(T-k)\cdot\ln\lvert\hat{\Sigma}_\omega/\hat{\Sigma}_\Omega\rvert$ (2a)	$T\cdot\ln\lvert\hat{\Sigma}_\omega/\hat{\Sigma}_\Omega\rvert$ (2b)
B. Multivariate model				
(13) YS, PS, IS	87.9 (50.9)[e/]	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)

TABLE 10.6 CONTINUED

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a - Each unrestricted equation contains one and two year lagged values of the 12 different variables (24 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 which are differences of levels. The FR and DC variables were weighted by their respective shares of high-powered money.

b - Column (1): Each equation in the restricted model has 10 coefficients set equal to zero, all lagged values of the domestic country's variables except lagged values of the dependent variable.

Column (2): Each equation in the restricted model has 12 coefficients set equal to zero, all lagged values of the other country's variables.

c - Part A: The tests ignore potential contemporaneous cross-equation correlation of error terms. Part B: All tests are performed within a 12 equation system where cross-equation contemporaneous correlation of error terms is taken into account. In column (1), rows (13)-(14) a total of 30 zero restrictions are imposed and rows (15)-(17) 60 zero restrictions are imposed. In column (2), rows (13)-(14), a total of 36 zero restrictions are imposed, and rows (15)-(17) 72 zero restrictions are imposed.

d - The critical F values at 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.

e - Critical χ^2 values at the 1 percent significance level are reported in parentheses.

TABLE 10.7

A Summary of Three Sets of Causality Tests in a Two Country Macro-Economic Model: U.S.-U.K. 1837-1859, 1882-1914

Dependent variable		Granger causing variables											
		YS	PS	FRS	IS	DSC	NS	YK	PK	FRK	IK	DCK	NK
YS:	weak	–	N	N	Y	N	N	N	N	Y	N	N	N
	strong	–	N	N	N	N	N	N	N	N	N	N	N
	multicause				N						N		
PS:	weak	N	–	(N)	Y	Y	N	N	N	N	N	N	N
	strong	(N)	–	Y	(N)	Y	N	N	N	N	N	N	N
	multicause				Y						N		
FRS:	weak	N	N	–	N	N	(N)	N	N	N	N	N	N
	strong	N	N	–	N	Y	Y	N	(N)	(N)	N	N	(N)
	multicause				Y						N		
IS:	weak	Y	Y	(N)	–	Y	N	Y	Y	N	N	Y	N
	strong	N	Y	Y	–	N	Y	N	N	N	N	N	N
	multicause				Y						N		
DCS:	weak	N	N	N	Y	–	N	N	N	Y	N	N	N
	strong	N	N	N	N	–	N	N	N	N	N	Y	N
	multicause				N						N		
NS:	weak	N	N	N	N	N	–	N	N	N	N	N	N
	strong	N	N	N	N	N	–	N	N	N	N	N	N
	multicause				N						N		
YK:	weak	N	(N)	(N)	Y	N	N	–	N	Y	N	N	N
	strong	N	N	(N)	N	N	N	–	N	N	N	N	N
	multicause				N						N		
PK:	weak	N	Y	N	N	N	N	(N)	–	Y	N	Y	N
	strong	Y	Y	(N)	N	N	N	N	–	Y	(N)	Y	N
	multicause				N						Y		
FRK:	weak	N	N	N	N	N	N	Y	N	–	N	N	N
	strong	N	N	N	N	N	N	Y	N	–	N	N	N
	multicause				N						Y		
IK:	weak	(N)	Y	N	Y	N	N	Y	N	N	–	Y	N
	strong	N	N	Y	(N)	N	N	(N)	N	N	–	Y	N
	multicause				N						Y		
DCK:	weak	N	N	N	N	N	(N)	N	N	N	N	–	N
	strong	N	N	N	N	N	N	Y	N	N	N	–	N
	multicause				N						N		
NK:	weak	N	N	N	N	N	N	Y	N	N	N	N	–
	strong	N	N	Y	(N)	N	N	Y	N	Y	N	N	–
	multicause				N						N		

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;

(N) = Reject the null hypothesis of no cause at the 10 percent significance level.

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TABLE 10.8

Additional Tests of Granger Causality in a Two Country Macroeconomic Model, U.S.-U.K. Gold Standard Period 1837-1859, 1882-1914[a]

	Weak Tests[b]		Strong Tests[c]		Multiple Cause[c]	
Dependent Variable	Causing Variable	F	Causing Variable	F	Own Country Variables[d]	Other Country 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		
			HK	4.27		
YK	HK	4.32	HK	3.30	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

a - All variables are expressed as percentage rates of change except for interest rates which are differences of levels.

b - Each "unrestricted" model contains the one and two year lagged values of the dependent variable and of the causing variable, a dummy variable (=1 for pre-Civil War years) and an intercept.

c - Each "unrestricted" model contains one and two year lagged values of the 10 different variables (20 regressors), a dummy variable (=1 for pre-Civil War years) and an intercept. No FR or DC variable is included.

d - Excluding lagged values of the dependent variable.

6 Appendix A

6.1 The Data

6.1.1 United States: Individual Series and Sources

High-Powered Money: The sum of notes and specie held by the banks and the nonbank public. For 1833-59 from Rutner (1974) Table 28, col. 15 plus col. 19; 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: The sum of currency (notes and specie) and commercial bank demand and time deposits (held by the nonbank public). For 1833-59 from Rutner, Table 57, col. entitled "Calendar Year;" 1870-1933 from Friedman and Schwartz (1982), Table 4.8, col. 1.

Specie: Specie held by banks and the nonbank public plus specie held by the Treasury and, from 1914 on, the Federal Reserve. For 1833-59, from Rutner, Table 28, col. 1, adjusted by us to a yearly (June-centered) average; 1879-1914 from Friedman and Schwartz (1963) Tables 5 and 8; for the remaining years from worksheets underlying Friedman and Schwartz (1963).

Real Income: For 1833-59 Smith and Cole index described below; 1870-1933, real net national product from Friedman and Schwartz (1982), Table 4.8, col. 3.

Price Index: For 1833-59, a yearly GNP deflator derived from Gallman's benchmark estimates; 1870-1933, an NNP deflator from Friedman and Schwartz (1982), Table 4.8, col. 4.

Interest Rate: Commercial paper rates. For 1833-59, annual averages of **Bigelow's monthly** series in Macaulay (1938, Appendix table 25); 1870-1933,

from Friedman and Schwartz, table 4.8, col. 6.

Population: For 1833-59, linear interpolations of census year decennial estimates from Rutner, table 37; 1870-1933, Friedman and Schwartz (1982), Table 4.8, col. 5.

6.1.2 United Kingdom: Individual Series and Sources

High-Powered Money: 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); 1871-1933 from Friedman and Schwartz (1982), table 4.9, col. 9.

Money: The sum of currency held by the public and total deposit (current accounts and deposit accounts) at commercial banks. 1871-1933 from Friedman and Schwartz (1982), Table 4.9, col. 1.

Specie: The sum of specie held by the public and specie held by the Bank of England. Specie held by the public for 1833-70 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 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 from Deane (1968) for 1833-1912; thereafter, series derived by us from Feinstein (1972, table 7, col. 7) index of real GNP at constant factor cost.

Price Index: 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: First-class three-month bills. For 1833-56, from Mitchell and Deane (1962); 1857-67, ibid., three-month bank bills; 1868-1933 from Friedman and Schwartz (1982), table 4.9, col. 6

Population: For 1833-67, Mitchell and Deane (1968, p. 8); 1868-1933, Friedman and Schwartz (1982), table 4.9, col. 5.

6.2 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 11 component series, 8 of which were expressed in physical units; the domestic index for 1843-62, from 10 component series, 6 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 (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 nontrend 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 indices 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.

6.3 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 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. The reason we regard it as suspect from the latter standpoint is that 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.

6.4 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 and far between.

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 in the early 1960s at the National Bureau: Milton Friedman and Anna Schwartz's A Monetary History of the United States (1963) and their related article "Money and Business Cycles" (1963) 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 (p. 296):

> 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.

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 bank 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 B1 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, 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 output data in tables 2 and 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, it 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 cycle is not very informative in any event since the panic was a "rather mild affair."

By including both the period prior to 1875 in the United States and the United Kingdom, we have thirteen additional severe cyclical contractions 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 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 aspect of these data that is of interest 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, they appear to have exerted a more important influence.

TABLE B10.1

The Interrelation of Panics
Money and Cyclical Contractions in
the U.K. and U.S.: 1836-1933

U.S.				U.K.			
Severity of Cycle	Date of Peak[a]	Panic/ No Panic	Monetary Contraction[b]	Severity of Cycle	Date of Peak[a]	Panic/ No Panic	Monetary Contraction[b]
Severe				Severe			
	1836	P	S		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				Not Severe			
	1887	P	S		1836	P	NS
	1913	P	NS		1845	P	S
					1866	P	NS

Source: See Tables 10.2 and 10.3.

Notes: (a) 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%; the average for 1873-79 in the U.S. was 3.7%; for the subperiod 1873-75, it was -1.1%; for 1873-79 in the U.K. it was 2.8%; for the subperiod 1875-79, it was 0.1%.

(b) 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.