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Money in the United Kingdom, 1833–80

1. INTRODUCTION

BRITISH MONETARY BEHAVIOR has long been a fascination of economists; yet even today, when econometric investigations of the British data have become almost commonplace, there still are no systematic statistical studies of early nineteenth century experience that span more than a decade or so at a time.[1] Our objective in this paper is to fill in at least part of the gap. To do so, we have combined Bank of England data with estimates made by private scholars to derive a series for high-powered money in the United Kingdom for the years 1833–80. We use these

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[1]As in the United States, the demand for money has been the area most frequently investigated econometrically. Both [31] and [42] include summaries of some of the literature appearing in the 1960s and early 1970s. More recent results are reported in [12, 14, 33, 34].

In addition to several of the demand for money studies, such as [38], there are a number of works that cover the later decades of the nineteenth century as part of investigations of longer term monetary behavior. These include [5, 22, 36, 37, 50, 54, 57]. Two papers that we know of deal with the 1830s and 1840s alone, [1, 13]. Two other studies of interest that are concerned exclusively with the gold standard period are [20] and [46].

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data to investigate both the cyclical and the secular role of money in the U.K. economy during those years.

Our main reason for working with high-powered money, as opposed to a broader definition of money, is that consistent data for commercial bank deposits simply are not available for the full period. Since such a narrow definition of money is at variance with conventional procedure, we discuss its implications and appropriateness in the next section of the paper. In that section we also describe the derivation of the series and provide a brief overview of the period. We report a variety of empirical results in the third section, noting and insofar as possible attempting to explain, the similarities and differences between our findings and those of other studies. The last part of the paper contains our conclusions along with suggestions for further research.

2. HISTORICAL BACKGROUND, THEORETICAL CONSIDERATIONS, AND THE DATA

Overview of the Period

In the half century between 1830 and 1880, the British economy in general and the financial system in particular were in a state of flux. The upsurge in growth that had started in the last two decades of the eighteenth century continued throughout the period. Real income, from the cycle peak in 1836 to the cycle peak in 1886, grew at an average annual rate of 2.2 percent per year and on a per capita basis by 1.5 percent per year. Compared with the Deane and Cole [18] estimates of aggregate and per capita growth rates in the period 1700–1785, these rates are a fourfold increase.

At the same time, the structure of British national product underwent an equally rapid change. Agriculture, forestry, and fishing, which accounted for roughly one-third of national income in the first decade of the nineteenth century, fell to slightly over 10 percent of national income in 1880. Over the same period, the combined share of manufacturing, mining, and building rose from slightly over 20 percent to slightly under 40 percent, and the combined share of trade, transport, and income from abroad increased from roughly 17 percent to roughly 29 percent.

In the monetary area, two developments are particularly worthy of note: the spread of commercial banking and the Bank of England's metamorphosis into a full-fledged central bank. The impetus behind the spread of commercial banking was the legalization of joint-stock banking in England and Wales. Although such banks already existed in Scotland in the eighteenth century, they were legalized in the rest of Britain in 1826. Between 1826 and 1840, 129 such banks were established, with by far the greatest part of the increase (89) coming in the mid-1830s, presumably as a result of the further liberalization of banking regulations in the Banking Act of 1833 [45, pp. 192–200].

The Bank of England's assumption of the powers of a central bank was more gradual. Chartered in 1694 as the first privately owned corporation in Britain, it had taken on a fair number of the standard activities of a central bank by the beginning of the nineteenth century. Commercial banks in the United Kingdom already were keeping their reserves primarily in the form of Bank of England notes and deposits [20, p. 34]; the bank was acquiring government debt and rediscounting some commercial paper for other commercial banks; and its notes were gaining in moneyness relative to those of other banks. Then during 1824–25, when a run on commercial banks occurred, the bank began to serve as a lender of last resort. By the panic of 1866 it was doing so on a broad scale.

The Bank of England's position was further strengthened by the Banking Acts of 1833 and 1844. The act of 1833 not only removed the ceiling on the discount rate on some bills and notes, but it also made the bank's notes legal tender. The Act of 1844 ultimately gave the bank the exclusive right of note issue in England and Wales. Subsequent acts, moreover, set the stage for moving toward a unified note issue for the United Kingdom under the bank's control.

High-Powered Money as the Definition of Money

To study the role of monetary factors in the British economy during this period, we had to resort to the use of an extremely narrow definition of money: high-powered money. Our major reason is that no accurate and continuous bank deposit series exists before 1870. The question arises, however, whether such a narrow definition of money is justifiable. The issue is whether conditions existed such that high-powered money would be more stable in demand than alternative monetary totals. Since one of us has discussed the empirical definition of money at greater length elsewhere [43], we will only summarize the arguments here.

The key assumption is that money holders demand directly the services that monetary assets provide rather than the actual real stocks of monetary assets themselves. The demand for the stocks, therefore, is a derived demand, dependent not only upon the demand for monetary services but also upon the production functions relating the stocks to the service flows. If those production functions shift or differ accross monetary assets, then to avoid aggregation bias one would have to account for those shifts or differences empirically, either by estimating directly the moneyness weights associated with different assets as Chetty [10] has attempted or by including proxy variables for asset quality in the demand functions as a number of other authors have done (e.g., 6, 22, 39, 43, 50]). The alternative, which we have used, is to adopt a definition of money that contains a narrow range of monetary assets that are similar in moneyness per real unit and that change very little in moneyness through time.

Two narrow definitions of money have been suggested—high powered money and currency held by the nonbank public [24, pp. 143–45; 43]. For this study, we chose high-powered money as it is usually defined, the sum of notes, coins, and deposits with the monetary authorities. The argument for working with high-powered money is based on a two-part view of deposits. According to this view, deposit holders are participants in a tie-in sale. They indirectly hold both high-powered money (bank reserves) and interest-bearing assets (bank loans and other investments). Because the high-powered money part of deposits, like currency held by the nonbank public, always yields monetary services, in circumstances such as those existing in Britain in the mid-nineteenth century, when the development of financial institutions was particularly rapid, it may be useful to treat the high-powered money part of deposits and currency as close substitutes and the define money as high-powered money alone.

Description of the Monetary Data

We define high-powered money as the sum of notes and coin outside banks, bankers' and other private deposits at the Bank of England, and commercial bank vault cash. To derive our series for high-powered money, we first constructed annual series for coin in circulation outside the Royal Mint and the Bank of England, bank notes in circulation outside the Bank of England, and bankers' and other private deposits at the Bank of England.

To construct the coin series we proceeded as follows. For the period 1833–79, we estimated coin in circulation by working backward from Sheppard's estimates for 1880 [54, Table A3.2, pp. 180–81]. First we adjusted his 1880 figure to mid-year; then for each year we subtracted an estimate of the net annual additions to coin in circulation. For 1858–79. our estimate of net annual additions was the amount of gold and silver coined, adjusted for redemptions, plus net imports of British coin [49, Appendix 9, p. 104]. For 1833–57, our estimate was the value of the net imports of bullion and specie for balance-of-payments purposes for the United Kingdom [35, pp. 70–75].

For bank notes in circulation, we used the sum of the annual averages of weekly estimates of Bank of England notes, as reported by the Bank of England [2], plus end-of-year estimates of Scottish, Irish, and other English bank notes, taken from [47, Table 6, pp. 450–51] and adjusted to a mid-year basis. Bankers' deposits and other private deposits at the Bank of England are annual averages of weekly data, drawn from a variety of sources. Weekly data on private deposits at the Bank of England were taken from [51, appendix 16, pp. 106–246] for the period 1833–40; from [52, appendix 6, pp. 261–76] for 1840–41; and [53, appendix 8, pp. 25–153] for 1841–47. For 1847–79 annual averages of private deposits were taken from [47, Table 2, pp. 444–45]. Before 1880 our high-powered money series was formed as the summation of the series on coin in circulation outside the Mint and the Bank of England, bank notes in circulation and banker's and other private deposits at the Bank of England. For the period starting at 1880, we used Sheppard's series, adjusted for discontinuities in currency outside banks and centered at mid-year.[2]

3. EMPIRICAL FINDINGS

Our discussion of empirical results is divided into four parts: a description of velocity behavior, both longer term and cyclical; a brief analysis of the relationship between high-powered money growth and cyclical fluctuations; tests of "causality"

[2]Anna Schwartz has pointed out what may be an error in Sheppard's data: a possible overstatement of the amount of coin in circulation in 1880. The result of such an error would be to cause our figures for high-powered money growth from 1830 to 1880 to be biased upward and of velocity growth downward.

between high-powered money and income; and a presentation and analysis of single-equation estimates of the demand function for high-powered money.

Velocity Movements

The data for nominal and real per capita GNP (source: [17] for 1834–1912, and [19] after 1912), the GNP deflator, the nominal stock of high-powered money, and the velocity of high-powered money are plotted in Figure 1 for 1833–80. Most apparent are the sustained upward movements in both the nominal stock of high-powered money and nominal GNP over this period. From 1833 to 1880 the trend rate of growth of high-powered money averaged 2.1 percent per year and of nominal GNP averaged 2.6 percent per year. The arithmetic result was an average rate of increase in the velocity of high-powered money of 0.5 percent per year. This apparent upward trend in the velocity of high-powered money in the United Kingdom does not continue throughout the twentieth century. From roughly 1900 on, the velocity of high-powered money moves very similarly to the velocity of M_2, showing a long-term downward drift up to the post–World War II period and a rise thereafter.

The rise in velocity in the nineteenth century, although slight, marks one difference between our findings and those reported in other longer-term studies of velocity

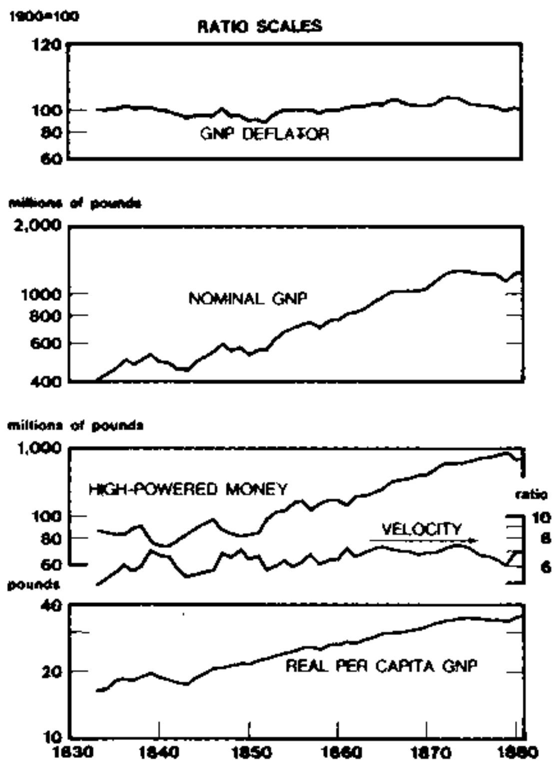

Fig. 1. High-Powered Money, Income, Prices, and Velocity in the United Kingdom

behavior, such as [12, 61, 38, 22, 50]. In all of these studies, the authors have defined money "broadly" to include commercial bank time and demand deposits, and they have reported a secular decline in velocity. We discuss these differences in results at greater length below when we present our estimated demand functions.

To explore velocity movements further, we have computed standard deviations of the logarithims of velocity, high-powered money, and nominal income for the full period 1833–80, for the subperiods beginning and ending with 1865, and for various other periods. A comparison of these standard deviations shows that for 1833–80, and for most of the other years too (1881–1968), velocity had a good deal of stability. Over the whole period 1833–80 the percentage variation in velocity was one-third or less than that of either its numerator or denominator viewed separately. Over the two sub-periods it is still less, although the differences are smaller for 1833–56 than for the period thereafter. A comparison with the years after 1880 reinforces these findings. Variations in velocity are again considerably smaller than variations in either nominal income or higher-powered money.

This apparent stability of velocity is also illustrated in another way by the figures presented in the last two columns of Table 1. They show the fraction of the variation of either nominal income or the nominal stock of high-powered money predictable from knowledge of the other series and of the average value of velocity.[3] In almost

TABLE 1

VARIATIONS IN NOMINAL INCOME, HIGH-POWERED MONEY, AND THE VELOCITY OF HIGH-POWERED MONEY IN THE UNITED KINGDOM, 1833–80 AND SELECTED OTHER PERIODS

	Percentage Variation in*			Explained Fraction of Variation in†	
Period	Nominal Income	High-Powered Money	Velocity	Nominal Income	High-Powered Money
1833–80	0.367	0.307	0.101	0.925	0.893
1833–56	0.149	0.129	0.101	0.544	0.386
1856–80	0.202	0.188	0.055	0.925	0.913
1880–1968	1.014	1.057	0.164	0.974	0.976
1833–1968	1.219	1.176	0.170	0.981	0.979

Sources: Nominal income (GNP) before 1912 came from [17], after 1912 from [19]. The high-powered money series, derived by us, is explained in the text.

*Defined as standard deviations of the logarithms of the variable.

†Defined as one minus the ratio of the variance of the logarithm of velocity to the variance of the logarithm of the other variable. All of these coefficients of determination are significant at 0.05 or below except the second one in the last column, which is significant at 0.10.

every instance they indicate a substantial and statistically significant degree of explainability. Thus, regardless of which variable—nominal income or the nominal stock of high-powered money—is viewed as being largely exogenous and, hence, is used to predict the other, the constant velocity model provides a convenient first approximation.

[3]To understand the calculation of the percentage of the variance explained, consider the relationship log $U = a + b \log W$. The coefficient of determination of a regression based on this relationship would equal $1 - (S_{u.w}^2)(n-k-1)/S_u^2(u-1)$, where n is the number of observations, k the number of independent variables, $S_{u.w}$ is the standard error of the regression and S_u the standard deviation of log U. If b were constrained to equal 1, the expression for the coefficient of determination would reduce to $1 - (S_{u/w}^2)/(S_u^2)$, where $S_{u/w}$ is simply the standard deviation of log (U/W).

Constant velocity is, however, only an approximation. In addition to the observed downward trend, velocity exhibits pronounced cyclical movements. We illustrate these in the upper half of Figure 2, where we present a plot of the average reference cycle behavior of velocity over the seven full and one partial reference cycle, measured trough to trough in the years 1833–79 (reference cycle data were taken from [28] before 1850 and from [7] thereafter). Our computations of cycle averages and relatives were based on the procedures outlined in [7]. Figure 2 shows a definite procyclical pattern of velocity, with both peaks and troughs being coincident with the corresponding reference-cycle turning points. A comparison of these movements with the cyclical movements in the velocity of M_2 plotted by Friedman [21] for a later period in the United States reveals a close correspondence between the two series.

This cyclical pattern of velocity has been given several interpretations, which are not mutually exclusive. Some have stressed differences between measured and permanent income over the cycle as a major determinant; others have assigned the

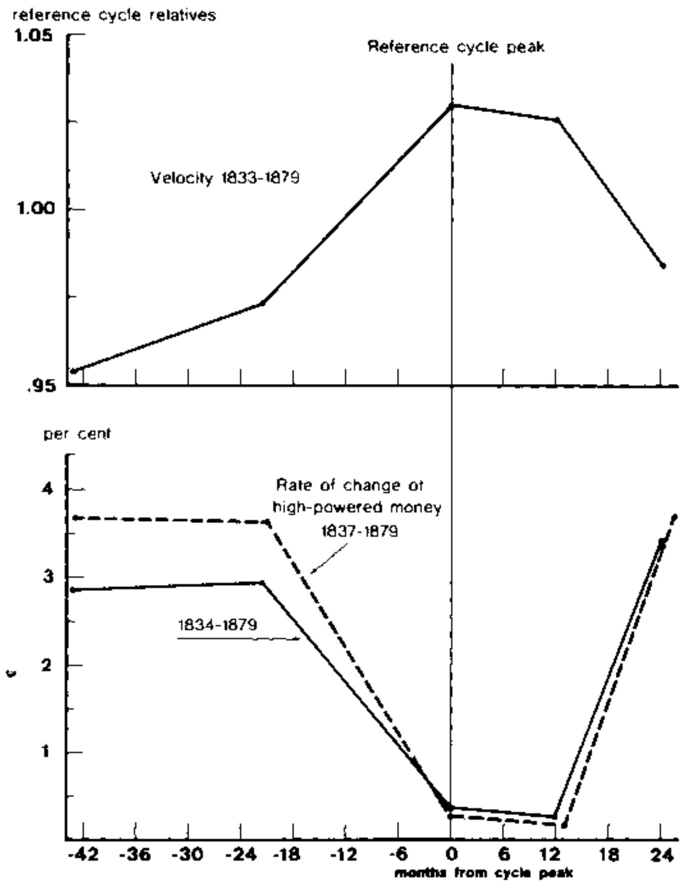

Fig. 2. Reference Cycle Patterns of Velocity and High-Powered Money

dominant role to interest rates. Both appear to be important over this period. The three-month interest rate and the consol rate exhibit a similar cylical pattern to that of velocity, whereas transitory income by construction conforms positively to the cycle. Moreover, in our investigation of the form of the money demand function reported below, we find that permanant income performs better than measured income and that the three-month interest rate has a consistently significant negative effect.

High-Powered Money and the Business Cycle

Another topic that has generated substantial interest in recent years has been the cyclical impact of monetary changes. Monetary theories of the business cycle currently have a number of strong proponents and a fair amount of empirical support. According to such theories, a major—although not the only—force leading to contractions in business activity is sudden and unanticipated decreases in monetary growth. Such decreases initially affect real output and unemployment rather than prices alone. The reason usually given is that prices are set largely on the basis of the anticipated rate of inflation. A sudden decrease in money growth, therefore, will catch people unaware. For a time, prices will continue to be set at higher levels than the new slower money growth would ultimately justify. The consequence is a temporary decrease in real output and rise in unemployment.

To examine the *plausibility* of these theories of the cycle, we present several kinds of results. In the lower half of Figure 2, the average reference-cycle pattern of the continuously compounded annual growth rates of high-powered money are plotted both for the seven cycles for which we have full data and for the one additional cycle for which we have only partial data.[4] These plots show that changes in the rate of growth of high-powered money, on average, led the cycle, falling precipitously from mid-expansion to the cycle peak, edging down slightly thereafter until mid-contraction, and then rising substantially. This pattern, moreover, prevailed in all of the individual cycles themselves, except one: 1862–68. In that cycle, the change in the rate of high-powered money came after the peak. Moreover, when we examined these individual cycles further, we found a direct relationship between the magnitude of the decrease in the growth of high-powered money and the duration of the corresponding cyclical contraction. The rank correlation between the two was 0.59, which is statistically significant at close to the 0.05 level.

All of these results are consistent with monetary theories of the business cycle, from the earlier and simpler version expounded by Friedman and Schwartz [25] to explain their results to the later and more sophisticated versions advanced under the general heading of "rational expectations" (see [3, 44] as examples). They are, however, hardly conclusive.

For one thing, they use yearly data, which tend to blur lead and lag relationships. For another, they involve little formal statistical analysis, and hence provide only a

[4]We have used rates of change rather than levels in an effort to capture the "surprise" element of monetary changes, the logarithm of last period's level being taken as a measure of anticipated. If past values of the series alone were used as the basis for forming anticipations, our measure would be correct if the logarithm of high-powered money followed a random walk.

rough idea of the strength of those relationships and of the degree of confidence to be placed in them. To investigate the timing question further, we have conducted a series of "causality" tests of the Granger variety. To implement these tests we ran regressions of the following general form for the full period up to 1968 and for several subperiods:

$$X_t = a + \sum_{k=1}^{m} b_k X_{t-k} + \sum_{k=1}^{m} c_k Z_{t-k} + e_t, \qquad (1)$$

in which nominal income and the nominal stock of high-powered money alternated as dependent and independent variables. In one set of regressions we used logarithms of both variables throughout, included a time trend in addition to the constant, and set m equal to 3; in the other we used first differences of the logarithms of the variables, included a constant alone, and set m equal to 2. In each instance we were interested in testing the null hypothesis $c_k = 0$ for all k, that is, Z does not Granger-cause X.

This form of the test differs in several respects from the test of Granger causality Sims [55] has developed. Since his work has generated substantial interest and since his version of the test has had a number of applications in the U.K. context, one of which we deal with below, we thought it useful to enumerate those differences.

TABLE 2

GRANGER CAUSALITY TESTS:
HIGH-POWERED MONEY AND NOMINAL INCOME
IN THE UNITED KINGDOM, 1837–1968 AND SUBPERIODS

Period	Dependent Variable	F Ratio	Dependent Variable	F Ratio
1837–70	log Y	9.42	log H	0.08
1870–1914		0.13		1.27
1914–68		3.17		4.63
1837–1968		9.20		3.18
1837–70	Δ log Y	19.42	Δ log H	0.93
1870–1914		0.02		0.68
1914–68		5.18		6.00
1837–1968		13.43		4.21

Source: See Table 1.
Note: The test equations were of the form $X_t = a + \Sigma_{k=1}^{m} b_k X_{t-k} + \Sigma_{k=1}^{m} c_k Z_{t-k} + e_t$, where nominal income and the nominal stock of high-powered money, in log e and Δlog e form, alternated as the dependent and independent variable. In the level equations m was equal to 3 and a time trend was included along with the constant; in the differenced equations m was equal to 2 and the constant alone was used.

One difference is that Sims filters both series to eliminate serial correlation before estimating his test equation. The other lies in the form of the equation itself. To test the hypothesis that Z does not Granger-cause X, Sims runs the following regression

$$\tilde{Z}_t = \sum_{k=-m}^{m} \lambda_k \tilde{X}_{t-k}\, e_t, \qquad (2)$$

where a tilde indicates prefiltered data. He then tests the null hypothesis $\lambda_k = 0$ for k going from $-m$ to -1, that is, all of the coefficients on the future values of $\tilde{X}$ are zero.

We chose the method we used, rather than Sims's, because it seemed to us to be both more direct and more easily interpretable. No prefiltering is involved. The time trend or differencing, together with the autoregressive terms, are assumed to eliminate serial correlation. Moreover, since the equation uses no future values as right-hand-side variables, it corresponds more closely to standard econometric procedures.

Over the period of greatest interest, the direction of influence is unambiguous; from high-powered money to nominal income. In both sets of regressions ($\log_e$ and $\Delta\log_e$), the monetary terms contribute significantly to the explanation of income after allowing for the effects of lagged income, but income contributes little to the explanation of money. In the period 1870–1914, the relationship is very weak in both directions. Finally, in both the period 1914–60 and the full span of years from 1837–1968, the influence runs both ways.

The results for 1837–70 might seem surprising. Sterling was rigidly linked to gold during these years. And on one view of how open economies operate, the simplest model of the monetary approach to the balance of payments, nominal income might have been thought to lead rather than lag the nominal stock of high-powered money. The reason, a proponent of this view would maintain, is that price arbitrage eliminates divergences in prices among countries adhering to a gold standard relatively quickly, whereas equilibrating financial flows only occur with a lag.

So, for example, consider a permanent increase in monetary growth abroad. Initially inflation will increase abroad; then, given arbitrage, it will increase in Britain. The result will be an excess demand for money in Britain, followed by a balance-of-payments surplus and gold inflow and then finally by an increase in the equilibrium rate of monetary growth.

That, however, is not the only possible sequence of events. If arbitrage were less rapid, then specie flows might well provide the major initial link. In this case, changes in monetary growth could lead changes in nominal income growth even though the economy were fully open and the nominal stock of money an endogenous variable.

The point is, therefore, that there is no one-to-one correspondence between the timing relationships between money and income and either the degree of openness or the potential importance of domestic as opposed to foreign influences. In this situation, as Zellner has pointed out in a more general context [61], we would need additional knowledge about the structure of the model to make inferences about causation from timing.

One way to get such knowledge is to examine the behavior of the asset components of high-powered money. If international factors operating through specie flows were important in this period, then specie movements would determine movements in high-powered money. In additional regressions of the same type reported above, we found no such influence. Lagged specie had only insignificant effects on either high-powered money or the domestic asset component of high-powered money. The latter finding, moreover, casts doubt on the alternative mechanism through which international forces might have operated: expansion or contraction of domestic assets by the Bank of England in response to balance-of payments pressures. Either domestic factors were of primary importance during this period or the effects of international factors worked their way through the system completely within a year.

One reason to suspect that domestic forces were the major cause is that, even though Britain was on a gold standard during this period, it was more a domestic commodity standard that the worldwide gold standard of the later nineteenth century. Many major countries such as Germany, France, United States (1860–79, in particular), Belgium, the Austro-Hungarian Empire, Russia, and Italy were not adherents. Consequently, much of the external influence that one would normally associate with an international gold standard may have been absent.

Another possible reason for this finding is the predominant role of the United Kingdom during the mid-nineteenth century. Its size relative to that of the rest of the world, coupled with the reserve currency status of sterling, also would explain why we find an influence from money to income, rather than either the reverse or some mixture of the two. In this sense, the United Kingdom at that time was analogous to the United States during the Bretton Woods era. Hence, the same analysis others [16, 48] have applied to U.S. experience then may very well pertain to the United Kingdom.

The results for the period 1870–1914 also deserve comment because they seem to conflict with results reported by Mills and Wood [46] in their study of the same period. We find a somewhat stronger relationship from income to high-powered money than from high-powered money to income, but neither is significant at anything close to conventional levels. Mills and Wood, who use a test similar to Sims's version, find a significant effect of income on M_1 but not the reverse.

Why the difference in results? Lack of comparability of test procedures is one possibility, but it can be ruled out since in retesting using Mills and Wood's procedure we achieved results similar to those reported above. We found no consistently significant relationship in either direction but, unlike our other results, a somewhat stronger influence from high-powered money to income.

Another set of possibilities is related to the data themselves. Possible sources of difficulty could be our use of a slightly different income series from that of Mills and Wood and their use of M_1 in a period in which the distinction between current (demand) and deposit (time) accounts was blurred. If data problems are not the cause, however, then the difference in results must reflect differences in the behavior of high-powered money and the M_1 multiplier, since it is the latter that provides the arithmetic link between the two aggregates. The greater association of M_1 than of high-powered money with lagged income must reflect a greater association of the multiplier with lagged income. This in turn could be due to international influences, commercial banks changing their deposit-reserve ratios as the Bank of England altered its discount rate in response to foreign-induced price changes and incipient gold flows, all of which would be consistent with Mills and Wood's explanation. Or it could be due to domestic factors that influence income and interest rates and with them deposit-reserve and deposit-currency ratios.

The results for 1914–68 and for the full period 1837–1968 are what one might expect to find under the varied exchange rate regimes, and presumably varied domestic policy goals that prevailed.

Estimates of Demand Functions

In investigating the demand for money, we use a standard model in which the quantity demand of real per capita cash balances is a function of real per capita income and the opportunity cost of holding money. The specific form of the model for which we report results is

$$\log (H/PN)_t = a + b \log (y_p/N)_t + ci_t, \tag{3}$$

where H is the nominal stock of high-powered money, P is the GNP deflator, y_p is permanent real GNP, i is a short-term (three-month) rate of interest, t denotes the time period, and log a natural logarithm. We chose this functional form because of its widespread use in other studies and its theoretical appeal, namely its assumption of homogeneity and of a constant interest rate coefficient and, hence, of no liquidity trap.[5] We used permanent, as opposed to measured, income because it produced a slightly smaller standard error of estimate in all periods in our preliminary tests.[6] Similarly, we used the short-term interest rate (three-month commercial bill rate up to 1938 and the three-month Treasury bill rate thereafter; [47, Table 10] and [48], respectively) rather than the consol rate because it proved superior in terms of goodness of fit within periods and stability of coefficients across periods.[7]

Since ordinary least-squares estimates of the money demand equation (3) gave evidence of positive first-order autocorrelation, we reestimated the equation using a generalized least-squares routine from the NBER TROLL package that is asymptotically equivalent to the Cochrane-Orcutt iterative procedure. Estimates of both corrected and uncorrected equations are reported in Table 3.

Before discussing those results, we should note one additional potential problem,

[5]We ran a series of regressions over the same time periods as those in Table 3 to test the propositions that the demand function was homogeneous of degree zero in the price level and of degree one in population. In all three of the OLS regressions and two of three regressions employing a correction for autocorrelation, we were unable to reject the first hypothesis at the 0.05 level; in the three corrected regressions we were unable to reject the second hypothesis at the same level.

[6]To construct our series for permanent income, we first regressed the log of actual real GNP on time for the period 1830–1972. The intercept of that regression was taken as the value of permanent income in 1829. Subsequent yearly values of the series were then generated according to the formula

$$\log y_{p,t} = (1-\beta) \log y_{p,t-1} + \beta \log y_t + (1-\beta) \log (1+c),$$

where y is real income, p signifies permanent, t is a time subscript, c is the slope of the semilogarithmic trend regression and β is a coefficient assumed equal to 0.10. The method is similar to Darby's [15] except that we work with logarithms and he uses arithmetic values. The coefficient of 0.10, also used by Darby, was chosen primarily for the sake of convenience. It did, however, produce a slightly lower standard error of estimate than the one other series we tried in which we used a $\beta = 0.33$, as in [21].

[7]In OLS regressions that we ran, the consol rate produced a fairly large (-0.28) and significantly negative coefficient for the period 1833–80; a much smaller (-0.055) but still significantly negative coefficient for the period 1880–1968; and a slightly negative and insignificant coefficient for the two periods combined. When we entered both the consol rate and the three-month rate together, only the three-month rate was consistently significant with a negative sign.

namely, the assumption implicit in our model of stock equilibrium within a year. If that assumption is incorrect, we would have to fit a more complex relationship in which we specified some type of adjustment mechanism. The standard procedure in such instances has been to resort to a simple stock-adjustment formulation that, when combined with the equilibrium demand relationship, results in the inclusion of a lagged dependent variable in the estimated equation. We have not taken that approach for two reasons: the statistical problems associated with the use of such variables, particularly in small samples (see [32]) and the economic problem of specifying exactly what is adjusting to what—money demand to money supply or vice versa. This second difficulty is particularly severe in this case, given the varied policy regimes, both domestic and international, that existed over our sample period. Attempting to solve it would take us considerably beyond the scope of this paper (see [9, 27, 40, 59] for discussions of various aspects of this problem).

TABLE 3

ESTIMATED DEMAND FUNCTIONS FOR HIGH-POWERED MONEY IN THE UNITED KINGDOM 1833–1968 AND SUBPERIODS

	Variables				
Period	Constant	Log y_p/N	i_s	D − W $\hat{\rho}$	$\bar{R}^2$ SE
1833–80	−1.048	0.890	−0.020	0.70	0.899
		(29.570)	(2.973)		0.060
1880–1968	−2.808	1.118	−0.056	0.31	0.898
		(36.381)	(7.640)		0.111
1833–1968	−0.965	0.876	−0.032	0.17	0.907
		(55.487)	(4.543)		0.128
1833–80	−0.839	0.859	−0.021	1.64	0.674
		(13.854)	(3.957)	0.67	0.046
1880–1968	−1.967	0.999	−0.024	1.86	0.423
		(8.614)	(3.829)	0.92	0.053
1833–1968	−0.882	0.863	−0.022	1.87	0.463
		(13.545)	(5.440)	0.92	0.051

Note: The top half of the table contains the OLS estimates; the bottom half GLS estimates obtained with the NBER's TROLL package. The dependent variable throughout was log (H/PN). Absolute values of t statistics are beneath the coefficients in parentheses.

Our recourse has been to rely upon the correction for autocorrelation, which itself can be interpreted as a form of stock adjustment. In addition, we experimented with data averaged over reference cycles, since such averages presumably provide closer approximations to equilibrium values and, hence, will suffer less from the effects of disequilbria and other transitory disturbances than the annual data. Since the parameter estimates obtained in these equations were similar to those obtained with the annual data, we only report the results for the annual data.[8]

[8]One additional aspect of the cycle-average results deserve mention. For the pre-1880 and post-1880 subperiods separately, the Durbin-Watson statistics also improved substantially in the regressions with cycle-average data. Only for the two periods combined did significant first-order autocorrelation remain. This autocorrelation, however, was substantially reduced by allowing the intercept of the equation to differ for the two periods. Our tentative explanation of these findings is that, in addition to whatever omitted factors were operable over the shorter run and captured by the averaging, some secular influence on the demand for high-powered money was not taken into account by our equation. Changes in lag relationships, omitted variables such as deposit quality, and errors in the data are all potential candidates.

Several features of these results are worthy of note. Foremost is their degree of explainability. In spite of the crudeness of the earlier data, the coefficients of determination in both the OLS and the corrected regressions are all respectable. Moreover, they result in substantial improvements over the simple constant velocity formulation. The standard error of estimate for these regressions ranges from 17 to 45 percent lower than the standard deviations of the logarithm of velocity reported in Table 1.

The estimated coefficients in the regressions also deserve some discussion. In general, they are fairly stable across subperiods—a somewhat less powerful result for interest rates, since one of the criteria for our rate choice was stability. Moreover, the estimated coefficients agree reasonably well with estimates reported in other studies.

The interest rate coefficients are low, a one percentage point increase in the interest rate decreases high-powered money holdings by 2 to 5.5 percent, depending upon the period chosen, which translated implies interest elasticity estimates in the range of -0.06 to -0.15. The income elasticities all cluster about unity, with estimates for periods before 1880 falling at the low end of the range and the estimates for the period thereafter falling at the high-end.[9]

By comparison, long-term time-series studies for both the United Kingdom and the Unites States and cross-state studies in the United States using deposit-inclusive definitions of money have produces similar but somewhat larger estimates of income elasticities (1.0–1.3) and a broad enough range of estimated interest elasticities that our estimates do not seem out of line (see 22, 26, 31, 38, 42, 50]). These similarities, however, pose several potential problems.

A standard interpretation of the demand-for-money literature is that the degree of interest elasticity increases as the definition of money narrows.[10] Our estimates, which are for a very narrow definition of money, fall in the low-end of the range of time-series estimates. If they are correct, they therefore raise questions about the validity of the standard interpretation.

Our income elasticity estimates also require some explanation. Estimates for money in countries undergoing rapid development are generally much larger than unity. By contrast, none of ours is greater than 1.2, and in the pre-1880 period when the United Kingdom was undergoing its most rapid growth, they are below unity. Cast in this light, our estimates seem low.

The difficulty is that when money is defined broadly, the income elasticities estimated for rapidly developing economies are likely to be biased upward. Increases

[9]As a check on our estimates, we ran similar regressions (both OLS and corrected and alternating measured and permanent real per capita GNP as scale variables) for the subperiods 1833–56 and 1856–80. These estimates again proved reasonably stable. As a further check, we also ran a series of regressions in which we alternated the log of real per capita high-powered money balances and of real per capita measured GNP as the dependent and the independent variables, for the periods reported in Table 3 and for various overlapping 30-year subperiods. Under the assumption that the measurement errors in both variables are equally important, the average of the estimated income elasticities derived from regressions of log (H/PN) on log (y/PN) and of log (y/PN) on log (H/PN) will approximate the true elasticity. When we computed these averages, they exhibited a pattern reasonably similar to that of the coefficients reported in Table 3.

[10]Friedman dissents, referring to "The absence of a consistent tendency for the same holding period yield to give the most satisfactory statistical results" [23, p. 410]. He argues that in principle the whole term structure should matter and in ways (e.g., a steeping tilt to the yield curve reducing desired real cash balances) that are not immediately obvious.

in financial sophistication and concomitant changes in the quality of deposits are usually characteristic of such periods. Thus, not taking quality changes into account results in a specification bias. The income variable in effect does double duty, capturing the influence of quality effects as well as its own effect on demand. The relatively small pre- and post-1880 differences in our estimates is one bit of evidence that high-powered money is less affected by such changes.[11]

4. SUMMARY AND CONCLUSIONS

The purpose of this paper has been to report the results of our investigation of the role of money in the nineteenth century British economy. The analysis is based upon examination of time series for high-powered money that we have assembled for the period 1833–80. Our results, although in some senses still preliminary, have a number of important implications.

We find that the relationships between money and other economic aggregates in the United Kingdom look very familiar. They bear a fairly close resemblance to the relationships observed in other time periods in the United Kingdom and in both this and other periods in the United States and in foreign countries other than the United Kingdom.

Velocity appears reasonably stable on average. Its short-run cyclical movements are akin to those observed in the United States, although its trend in earlier years is different. Further analysis shows the potential importance of monetary fluctuations as a source of business contractions. When we examined the other side of the velocity coin, the money demand function, we found that the demand for money was statistically explainable by the same type of simple demand functions used in other studies.

One implication of our results is obvious. In any field of investigation, replication of experiments is a useful way of checking and refining initial hypotheses. Because our data are drawn from an era characterized by political, social, and economic arrangements so different from, say, contemporary Britain or America, the similarity between our results and results drawn from later data for these countries is all the more important.

Another obvious area for which our findings have implications is the controversy between proponents of monetary control and credit control—in its historical manifestation, the currency school-banking debate. We, like Collins [12], find little support for the banking school's view that movements in monetary aggregates were of no importance for overall economic behavior. On the contrary, the stability of our estimated demand functions, the analysis of movements in high-powered money over the course of reference cycles, and the results of the Granger tests all serve to

[11]One measure of the increase in financial sophistication in the United Kingdom over this period is the change in the deposit-currency ratio. Cameron [8] estimates a rise in this ratio in Great Britain from 0.56 to in 1800–1801 to 1.7 in 1844–45. Sheppard's [54] estimates show a deposit-currency ratio for the United Kingdom as a whole of 2.37 in 1880. Using these figures and various plausible assumptions about increases in the deposit-reserve ratio, we have derived a series of estimates of the (biased) estimated income elasticity of real per capita M_2 holdings. These range from a multiple of 1.2 to a multiple of 2.0 times our estimated income elasticities for real per capita high-powered money holdings.

substantiate a position much closer to the currency school than to the banking school.

Our results also suggest several topics of direct concern for further research. The source of the difference between the long-term behavior of velocity before and after 1880 is one question. The relationship between monetary changes and income changes in the United Kingdom and in the rest of the world is another. Analysis of the role of monetary factors in important episodes, e.g., periods of banking panic, is a third. Still another is the stability of high-powered money in demand relative to that of broader monetary aggregates.

The last question, moreover, is particularly relevant in both the United Kingdom and the United States. The post-1972 period in the United Kingdom, following the introduction of competition and credit control, and the past few years in the United States have seen substantial changes in the ratios of one type of deposits to another and to currency. In the United States, some economists have recommended using either high-powered money or the (adjusted) monetary base as an indicator.

In the United Kingdom, neither has received much attention until recently. In fact, in one of the few studies recommending a choice other than either of the two conventionally used definitions of money, M_1 and (sterling) M_3, Smith [57] has recommended the use of an even broader aggregate than M_3. Our results, however, suggest that investigation of the behavior of high-powered money in recent years in Britain may be extremely useful.

APPENDIX

HIGH-POWERED MONEY AND ITS COMPONENTS FOR THE UNITED KINGDOM, 1833–79 (MILLIONS OF POUNDS)

Year	Coin Outside Banks (1)	Notes Outside Banks (2)	Bankers' and Other Private Deposits at Bank of England (3)	High-Powered Money (4) = (1) + (2) + (3)
1833	41.4	36.9	8.2	83.6
1834	38.9	37.3	7.8	84.0
1835	38.1	36.9	7.0	82.0
1836	36.6	37.6	8.5	82.7
1837	38.6	38.0	7.1	83.7
1838	38.6	39.0	7.0	84.6
1839	34.2	38.1	4.5	76.8
1840	33.3	36.8	4.1	74.2
1841	34.3	35.6	4.1	74.0
1842	37.2	35.7	5.7	78.6
1843	40.8	35.4	7.4	83.6
1844	43.8	37.5	8.4	89.7
1845	44.8	38.3	9.6	92.6
1846	46.2	38.5	12.9	97.6
1847	40.9	36.8	8.7	86.4
1848	39.9	33.7	9.8	83.4
1849	38.9	32.4	10.1	81.4
1850	39.9	33.3	9.8	83.0
1851	41.1	33.5	9.3	83.9
1852	48.9	36.2	12.8	97.9
1853	55.4	38.1	12.5	106.0

APPENDIX *(continued)*

HIGH-POWERED MONEY AND ITS COMPONENTS FOR THE UNITED KINGDOM, 1833–79 (MILLIONS OF POUNDS)

Year	Coin Outside Banks (1)	Notes Outside Banks (2)	Bankers' and Other Private Deposits at Bank of England (3)	High-Powered Money (4) = (1) + (2) + (3)
1854	59.0	37.5	11.1	107.6
1855	66.8	37.1	11.7	115.6
1856	68.7	37.2	11.2	117.1
1857	62.2	37.0	10.7	109.9
1858	63.4	37.0	14.1	114.5
1859	67.0	38.1	14.4	119.5
1860	67.2	38.3	13.6	119.1
1861	67.3	36.6	12.5	116.4
1862	71.7	37.1	14.6	123.4
1863	73.7	36.5	14.0	124.2
1864	79.3	36.3	13.2	128.8
1865	80.9	37.1	14.0	132.0
1866	86.4	39.1	16.8	142.3
1867	87.8	38.9	18.8	145.5
1868	87.3	39.6	20.2	147.1
1869	94.1	39.6	18.1	151.8
1870	95.4	39.9	18.1	153.4
1871	100.9	41.7	21.3	163.9
1872	109.3	43.5	20.0	172.8
1873	110.3	43.6	19.1	173.0
1874	110.6	44.0	18.8	173.4
1875	110.9	45.1	21.2	177.2
1876	113.9	45.8	23.5	183.2
1877	116.7	46.1	22.6	185.0
1878	121.8	45.8	23.2	190.8
1879	120.4	43.7	28.4	192.5

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