Volume Title: Monetary Trends in the United States and United Kingdom: Their Relation to Income, Prices, and Interest Rates, 1867-1975

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7 Velocity and the Interrelations between the United States and the United Kingdom

The preceding chapter demonstrates that a single demand curve for money can be used for the United States and the United Kingdom, provided only that adjustment is made for a difference in the currencies used in the two countries and in the income elasticity. The largely common demand curve by itself does not, however, explain the striking finding in chapter 5 that velocity in the United States and velocity in the United Kingdom show parallel movements for most of the century our data cover, and that the rates of change of velocity are nearly identical in the two countries. If the variables affecting the demand for money and velocity had behaved very differently in the two countries, the same demand curve would have generated different realized time series of velocity. The similar behavior of velocity therefore requires in addition to a largely common demand curve the similar behavior of the variables affecting the demand for money. One possible explanation for the similar behavior of such variables is that the two countries were part of a single economic entity. National boundaries may have great political importance and economic significance in other respects, yet be consistent with a financial system that is unified over a much larger area. The international financial community presumably included (and includes) not only the United States and the United Kingdom but other countries as well. However, we perforce limit ourselves to the connections between the United States and the United Kingdom that are reflected in the similar behavior of velocity in these two countries. It would be highly desirable to extend the analysis to other countries as well, but we leave that to other scholars.

There is nothing novel or surprising about the existence of a unified financial community. What is novel and surprising is that the links should have been so close as to produce the degree of parallelism in velocity that

is recorded in chart 5.5—given the extent to which the two countries failed to conform to the "law of one price," especially after 1931 (see chart 6.5, which plots the ratio of the purchasing-power-parity exchange rate to the market exchange rate).

From 1879 to 1914 and again from 1925 to 1931, the United States and the United Kingdom were both on a gold standard, and neither imposed appreciable controls on the movement of capital or engaged in exchange controls of the modern type (such exchange controls were invented only in 1934 by Hjalmar Schacht in Germany as part of the Nazi economic policy).

Before World War I, the United Kingdom had no tariffs. The United States did, but the tariffs were changed at infrequent intervals and were not used as an instrument of monetary or exchange policies. The United States and the United Kingdom almost literally had a single monetary system—a gold standard or, almost as descriptively, a sterling standard. As we demonstrated in *A Monetary History* (and as chart 6.5 confirms), there was a good deal of leeway for domestic monetary policy over short periods, but over periods of more than a few years, the quantity of money in each country was determined by the requirement that the price levels of the two countries move roughly in step in order to preserve equilibrium in the balance of payments. Similarly, the capital markets of the two countries were linked. There was little scope for interest arbitrage, since the exchange rates had to stay within the narrow gold points, so market interest rates could not differ much between the two countries. Hence rates of change in both prices and nominal interest rates were linked in the two countries.[1]

During World Wars I and II, the two countries were linked more fundamentally, the United States being either a major supplier of goods to the United Kingdom for wartime use or a partner of the United Kingdom. From 1925 to 1931, the gold standard was less rigid than in the pre–World War I period but even so, fixed exchange rates were maintained without effective capital or exchange controls,[2] so the links were still close. During the rest of the interwar period exchange rates were not rigidly fixed, yet the United States imposed neither exchange controls nor capital controls, and the United Kingdom imposed them only to a very minor extent. Interest arbitrage had more scope, but not much more,

1. A view that presents some empirical evidence for the United States and the United Kingdom for part of the period we cover is contained in Donald N. McCloskey and J. Richard Zecher, "How the Gold Standard Worked, 1880–1913," in *The Monetary Approach to the Balance of Payments*, ed. J. A. Frenkel and H. G. Johnson (London: George Allen and Unwin, 1976), pp. 357–85.

2. See D. E. Moggridge, "British Controls on Long-Term Capital Movements, 1924–1931," in *Essays on a Mature Economy: Britain after 1840*, ed. D. N. McCloskey (Princeton: Princeton University Press, 1971), pp. 113–38.

since exchange rate fluctuations were fairly small most of the time. Yet the years 1918 to 1925 and 1931 to 1939 were marked by a looser financial relation between the United States and the United Kingdom than the years 1879 to 1914 and 1925 to 1931.

The post–World War II period is more difficult to interpret. Until 1972, the sterling-dollar exchange rate was temporarily fixed but subject to change from time to time by official action. Sterling was devalued in 1949, again in 1967, and was permitted to float in 1972. Until October 1979, there was extensive exchange control in the United Kingdom, more sweeping in the early postwar period than later on, but significant throughout. Moreover, in the 1960s and until the early 1970s, the United States introduced restrictions on the movements of capital and exchange—the interest equalization tax, the tying of foreign aid and other foreign capital transfers, restrictions on bank loans and foreign investment by United States enterprises. Hence these postwar years are characterized by the loosest monetary linkage between the United States and the United Kingdom. They also display the most disparate movements of velocity (see chart 5.5) and of the ratio of the purchasing-power-parity exchange rate to the market exchange rate (chart 6.5).

7.1 The Reference Chronology

To judge from chronologies that we have used to define our basic phase observations, the financial linkages between the two countries were accompanied by—indeed, presumably were the source of—parallel movements in general economic activity.

As table 7.1 shows,[3] of thirty-nine United Kingdom turning points in the 109 years from 1867 to 1975, twenty come in the same year as a United States turning point of the same kind (i.e., a trough in the same year as a trough; a peak in the same year as a peak); eleven come one year later; four come one year earlier; and only four have no corresponding turning point within one year.[4] Of these four, three are in the post–World War II period, one in 1926. The 1926 trough, the only miss for the period of a gold standard, marked the end of the British general strike, which undoubtedly distorted cyclical behavior.

For the United States, recorded turning points total fifty-three rather than thirty-nine, so that fourteen additional turns do not match United Kingdom turns, making eighteen nonmatching turns in all for the United States. Twelve come before World War I, one in 1924, and the remaining

3. For comparison of datings, we have used the whole period after 1866 for which we have both chronologies and United States money data and not simply the period after 1870, when the United Kingdom money data begin.

4. A precise test of significance is not easy to make because of the condition that troughs and peaks alternate. But approximate tests of significance for troughs and peaks separately

five after World War II. The twelve before World War I all reflect extra movements (6 extra cycles) recognized in the United States chronology but not in the United Kingdom chronology, and so do two (one extra cycle) of the other six nonmatching turning points.

The extra United States turning points have generally been regarded as evidence of more marked cyclical movements in the United States than in the United Kingdom, leading to both briefer and larger cycles in the United States than in the United Kingdom. Our examination of the data leads us to enter a caveat. The extra United States turning points may simply reflect a greater plenitude of statistics for the United States than for the United Kingdom and a more searching examination of the United States data for cyclical movements.[5]

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indicate that the agreement between the two chronologies is greater than could readily be expected from chance. Consider a contingency table for troughs (table 7.N.1).

Table 7.N.1 **Comparison of Trough Reference Dates for the United States and the United Kingdom**

Years from 1867 to 1975 That	Number of Years That Contain		
	United Kingdom Troughs	No United Kingdom Troughs	Total
Contain United States troughs	10	17	27
Precede United States troughs	2	25	27
Follow United States troughs	6	20	26[a]
Are none of above	2	27	29
Total	20	89	109

[a]Not 27, because the year following the 1975 trough is not included.

Chi-square for this table is 10.7, which is at the .02 level of significance for 3 degrees of freedom. The corresponding table, with years classified by United Kingdom troughs, yields a chi-square of 10.4. For peaks, the two corresponding tables yield chi-squares of 14.6 and 10.2. Adding the chi-squares for the corresponding trough and peak tables gives 25.3 and 20.6, which, for 6 degrees of freedom, would be exceeded by chance less than one time in a thousand.

5. The reference chronologies we use are based on the work done at the NBER, particularly by Arthur F. Burns and Wesley C. Mitchell. They did a far more exhaustive study of United States data than of United Kingdom data and had more United States data to study. In the course of our own reexamination of parts of the chronology that seemed questionable for one reason or another, we found that we were almost always inclined to recognize more turning points the broader the range of data we could examine. The concentration of extra turning points in the pre–1914 period strengthens the suspicion that we may be dealing with a statistical artifact: in the forty-eight years from 1866 to 1914, there are twenty-five United States turning points, 13 United Kingdom turning points; in the remaining sixty-one years, there are twenty-eight United States turning points, twenty-six United Kingdom turning points. There is a far greater difference between the statistical data available for the United States and the United Kingdom, and also between the effort that has been devoted to their analysis, for the pre–1914 than for the post–1914 period.

The major hesitation we have in accepting this interpretation is that the role of the British economy in the world was changed so drastically by World War I that the United Kingdom

Table 7.1 **Relation between United Kingdom and United States Cyclical Turning Points, 1867–1975**

		Number of Turning Points		
		Trough	Peak	Both
1	Corresponding turning points (within one year of each other)	18	17	35
1a	United Kingdom one year earlier than United States	2	2	4
1b	United Kingdom same year as United States	10	10	20
1c	United Kingdom one year later than United States	6	5	11
2	No corresponding turning points (within one year of each other)			
2a	United Kingdom	2	2	4
2b	United States	9	9	18
	Total number of turning points			
1 + 2a	United Kingdom	20	19	39
1 + 2b	United States	27	26	53

One fascinating detail in table 7.1 is the tendency for nonsynchronous turning points in the United Kingdom to follow those for the United States. Of the fifteen matching turning points that do not come in the same year in the United Kingdom and the United States, eleven come one year later in the United Kingdom and only four come one year earlier. Of the twenty that come in the same year, monthly reference dates indicate that twelve came later for the United Kingdom than for the United States, and six earlier (for two—1944 and 1946—we have no monthly United Kingdom chronology). One possible explanation is that cyclical fluctuations mostly originated in the United States and spread from the United States to the United Kingdom, rather than the other way—which would also be consistent with the greater amplitude and frequency of cyclical fluctuations in the United States. It is also the conclusion that we documented in *A Monetary History* for the worldwide contraction that began in 1929.[6]

cyclical pattern may also have changed. Britain's financial preeminence in the world before World War I may have enabled it to ride out fluctuations in the world that would have left echoes at home after World War I.

R. C. O. Matthews accepts fewer post–World War I turning points than we do, but even he reports phases of shorter average duration after 1914 than earlier, except for interwar upswings—resulting from his treatment of 1921–29 as one long expansion ("Postwar Business Cycles in the United Kingdom," in *Is the Business Cycle Obsolete*? ed. M. Bronfenbrenner (New York: Wiley, 1969), pp. 102–3).

6. Oskar Morgenstern reached the same conclusion for the pre-World War I period for three European countries (Great Britain, France, Germany): "In general in the prewar period the United States cycle led those of the three European countries at both peaks and troughs. . . . After the war the pattern was less definite although the United States cycles continued to lead British and French cycles at peaks" (*International Financial Transactions and Business Cycles*, Studies in Business Cycles, no. 8 [Princeton: Princeton University Press for NBER, 1959], p. 51).

This apparent lead of cyclical movements in the United States is not reflected in a simple correlation of annual velocity estimates for the United States and the United Kingdom. For the 105 years 1871 through 1975, the synchronous correlation coefficient is .492 and is slightly higher than the correlation for United States velocity leading (.486) or lagging United Kingdom velocity by one year (.46). Similarly, the synchronous correlation for year-to-year rates of change in velocity is .42, which is higher than the correlation for the rate of change in United States velocity leading (.19) or lagging (.29) the change in United Kingdom velocity by one year.

The close relation between the two chronologies suggests the desirability of using a single chronology for the two countries in order to provide matching observations that would permit a more detailed statistical investigation of the relations between them. The best way to get a single chronology would be literally to treat the United Kingdom and the United States as a single economic entity and construct a reference chronology for the combined entity comparable to the chronologies constructed for each country separately. However, that would be extremely laborious. Instead, we have substituted computer time for historical research. We have recalculated the United Kingdom phase bases on the United States chronology and the United States phase bases on the United Kingdom chronology. We then started out making two parallel analyses, one using the United States chronology for both countries, the other using the United Kingdom chronology for both countries. However, the results of the two parallel analyses were so close that we have simplified the exposition and analysis by generally using only the United States chronology.

One exception is in chart 7.1 which duplicates chart 5.5 except that velocity and its rate of change are calculated for the same chronological time units for the United States and the United Kingdom—in chart 7.1, panel A, the United States chronology, in chart 7.1, panel B, for the United Kingdom chronology.

Using the same chronology for both countries does not alter in any important way the story told by the earlier charts.

7.2 Correlation of United States and United Kingdom Velocities and Their Determinants

The visual impression given by chart 7.1, panels A and B, is confirmed by the numerical correlation coefficients in table 7.2 covering more than a century: .49 for velocity and .76 for its rate of change.

Of greater interest are the correlations for the variables we singled out in chapter 6 as most closely related to the demand for money and hence velocity: real per capita income; the differential interest rate on alterna-

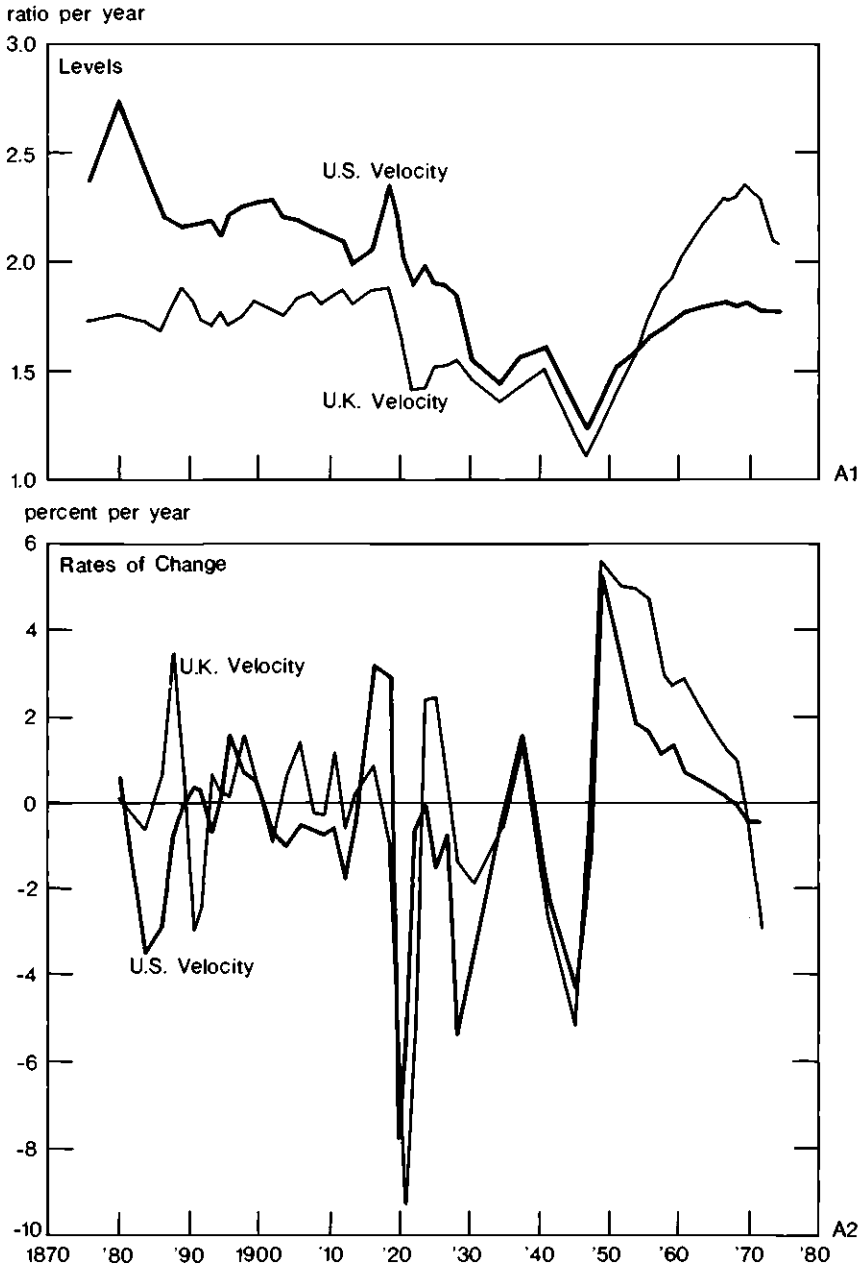
tives to money (the short rate times the ratio of high-powered money to money); the rate of change of nominal income (as a proxy for the nominal yield on physical assets); and the demand shift and postwar shift dummies.[7] Both the levels and the rates of change of these variables are highly correlated between the two countries, except only for the rate of change of real per capita income. Much of the common movement of velocity can therefore be attributed, as suggested above, to common movements of the determinants of velocity.

From this point of view, the exception is as significant as the high correlations. The low correlation between the *rates of change* of real per capita income means that the factors affecting the movements in real income over periods longer than a cycle but shorter than a sizable fraction of a century are largely independent in the two countries—apparently the high correlation for *levels* is primarily between trends. This result is entirely consistent with our interpretation of the common movements in velocity as reflecting a unified *financial* system. A unified financial system leaves much room for different physical development—as witness the differences among regions within the United States and the United Kingdom.

The contrast between *financial* unification and *physical* independence is brought out sharply by the correlations we have added at the bottom of table 7.2 for prices, nominal income, and money. The correlation for the level of prices is as high as for any other level variable; for the rate of change of prices it is decidedly higher than for any other rate-of-change variable. The correlation for the level of nominal income matches that for prices, but for the rate of change of nominal income is decidedly lower than for the rate of change of prices, reflecting the low correlation of the rate of change of per capita real income.

Although the quantity of money is as highly correlated between the countries as income and prices—reflecting the dominance of the trend—the rate of change of money displays the same correlation as the rate of change of income, and both are decidedly lower than the correlation for the rate of change of prices. At first glance this result may seem inconsistent with our interpretation of the United States and the United Kingdom as part of a larger monetary system, but it is not. The key linkage between the two countries is that prices, expressed in a common currency (i.e., adjusted for changes in exchange rates) must move in a way that will keep international payments in adjustment, which, broadly speaking, means that prices must move in harmony. If they do not, they will lead to exports or imports or capital movements that will produce balance-of-payments

7. For the United States, changing financial sophistication should also be listed. Allowance has implicitly been made for that variable by adjusting the quantity of money in the United States for phases before 1903.0.


ratio per year
3.0
Levels
2.5
U.S. Velocity
2.0
1.5
U.K. Velocity
1.0
A1
percent per year
6
Rates of Change
4
U.K. Velocity
2
0
-2
U.S. Velocity
-4
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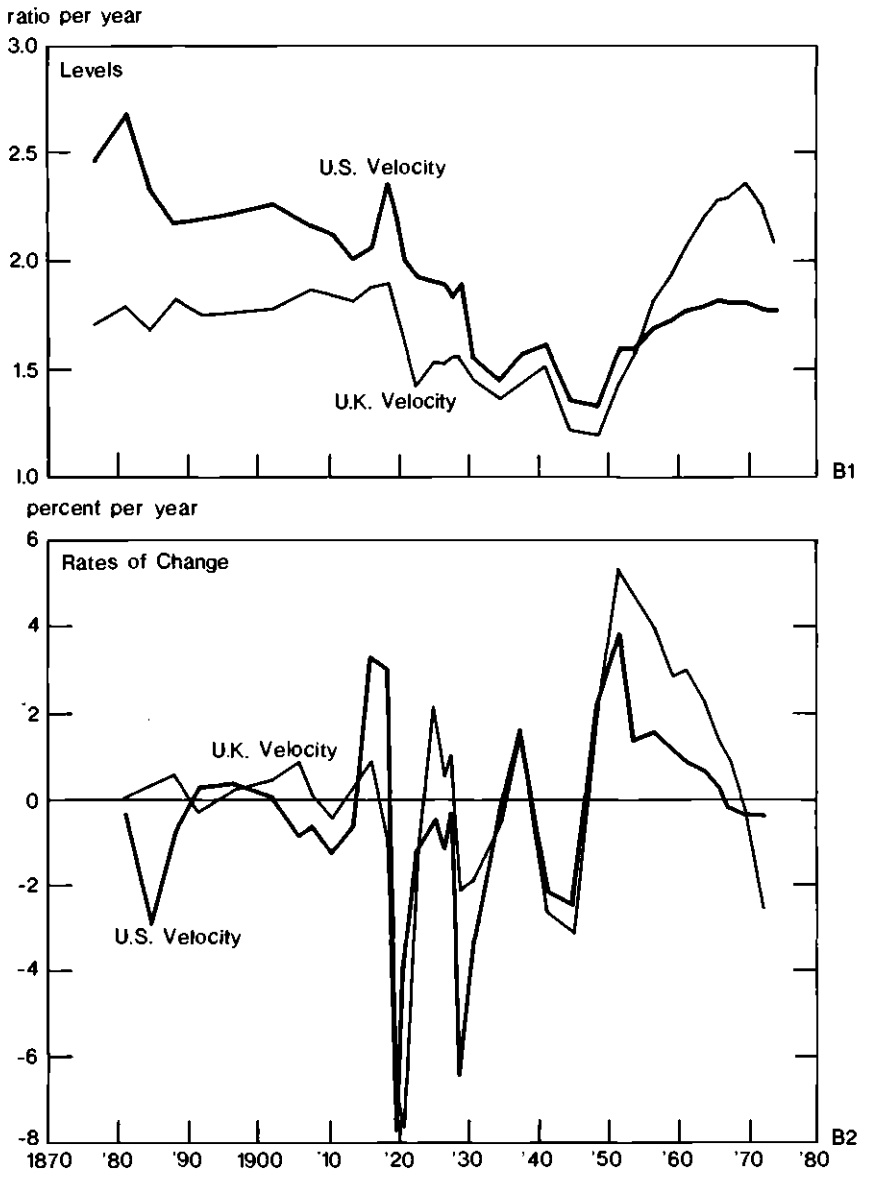

Chart 7.1 Levels and rates of change of United States and United Kingdom velocity on United States and United Kingdom dates.

Table 7.2 **Correlations of United States and United Kingdom Velocities and Their Determinants, and Also Prices, Nominal Income, and Money: Levels and Rates of Change, United States Dates**

Variable	Correlation Coefficient
1. Velocity (log V)	.49
2. Real per capita income (log y)	.96
3. Differential yield on money (R_N)	.22
4. Rate of change of nominal income (g_Y)[a]	.71
5. Demand shift dummy	.84
6. Postwar shift dummy	.66
7. Rate of change of velocity (g_V)	.76
8. Rate of change of real per capita income (g_y)	.17
9. Rate of change of differential yield on money [$D(R_N)$]	.65
10. Rate of change of rate of change of nominal income (Dg_Y)	.66
11. Rate of change of demand shift dummy	.48
12. Rate of change of postwar shift dummy	.50
13. Prices (log P)	.99
14. Rate of change of prices (g_P)	.90
15. Nominal income (log Y)	.99
16. Rate of change of nominal income (g_Y)[a]	.73
17. Quantity of money (log M)	.99
18. Rate of change of money (g_M)	.73

[a]Level weights used to calculate line 4; rate of change weights used to calculate line 16.

deficits or surpluses, setting in motion the specie-flow mechanism. The requirement for money and nominal income (or exchange rates) is that they adjust in such a way as to keep prices in the appropriate relation. But this requirement is likely to imply a lower correlation for money and income than for prices, since, to keep prices in harmony, the quantity of money will have to adapt to differential changes in the demand for money (in the sense, of course, of "demand schedule" or "function"), and income will have to adapt to differential changes in output. Put differently, divergent movements in money and income will occur precisely in order to keep prices in line. Hence, the lower correlations for money and income than for prices are entirely consistent with, and indeed strengthen the evidence for, the two economies being part of a larger monetary system in which monetary adjustments serve as the key mechanism keeping the separate parts aligned with one another.

The linkage between prices in the two countries is reflected in chart 6.5. For the whole period before the Great Depression, the ratio of purchasing power parity to the exchange rate fluctuates within a rather

narrow range—between a low of 1.00 (in 1896) and a high of 1.23 (in 1910)—and displays no clear trend. The loosening of the financial links between the two countries as a result of the depression, the 1931 departure of sterling from the gold standard, the wartime introduction and postwar continuation of exchange controls, and postwar devaluations, produced a major increase in the variability of the purchasing power ratio: from a low of .93 (in 1938) to a high of 1.62 (in 1950). The post–World War II period saw also the widest divergences in the movement of velocity in the two countries.

7.3 Role of Common Determinants of Velocity

Table 7.3 gives estimates of the role of various factors in accounting for the common and idiosyncratic movements of velocity in the two countries.[8] Consider first the columns for the level of velocity. If velocities

8. Five sources of variation in the velocity of each country can be distinguished:
1. The common movement in the two countries of the specified determinants
2. The common movement in the two countries of other common determinants
3. Differential movements in the specified determinants
4a. Differential movements in other common determinants
4b. All other determinants of measured velocity, including those specific to each country, chance, and measurement error.

We shall not be able to estimate the effects of 4a and 4b separately; so hereafter we refer to the two together as 4.

If items 1 and 2 were nonexistent, and yet velocity had varied in each country as it in fact did, the variance of the differences in the logarithms of velocities ($\log V_{uk} - \log V_{us}$) would be equal to the sum of the variances, or

A. $$\sigma^2_{\log v_{uk} - \log v_{us}} \text{ (hypothetical)} = \sigma^2_{\log v_{uk}} + \sigma^2_{\log v_{us}}.$$

The actual differences in velocity eliminate the effect of items 1 and 2. Hence

B. $\sigma^2_{\log v_{uk} - \log v_{us}}$ (measured) is an estimate of the combined effects of items 3 and 4.

Regressing the differences in velocity on the differences in the specified determinants eliminates the effect of item 3 as well as items 1 and 2. Hence

C. $(\text{SEE})^2_{\log v_{uk} - \log v_{us}}$, or the squared standard error of the residuals from such an equation, is an estimate of the effect of item 4.

Regressing velocity in each country on the specified determinants for that country eliminates the effects of items 1 and 3 for that country. Hence

D. $(\text{SEE})^2_{us} + (\text{SEE})^2_{uk}$, or the sum of the squared standard errors of the residuals from such regressions, is an estimate of the combined effects of items 2 and 4.

It follows that the entry in column 1 of table 7.3 in

Line 5 is A
Line 4 is C
Line 3 is B minus C
Line 2 is D minus C
Line 1 is line 5 minus the entries in lines 2, 3, and 4.

The same analysis applies for the rate of change of velocity by simply replacing velocity by the rate of change of velocity, so that the entries in column 3 of table 7.3 are derived in the same way.

Table 7.3 **Role of Various Determinants in Producing Common Movements in Velocity in the United States and the United Kingdom**

	Difference in Level of Velocity		Difference in Rates of Change of Velocity	
	Variance (1)	Percentage Distribution (2)	Variance (3)	Percentage Distribution (4)
Variances[a]				
Contribution to hypothetical variance of common movement in				
1. Specified determinants[b]	.0285	47.50	.000459	38.64
2. Other common determinants	.0019	3.17	.000441	37.12
All common determinants	(.0304)	(50.67)	(.000900)	(75.76)
3. Differential movements in specified determinants	.0236	39.33	.000116	9.76
4. Other factors	.0060	10.00	.000172	14.48
5. Hypothetical variance, if no common determinants	.0600	100.00	.001188	100.00
Standard Deviations[c]				
Factors considered				
6. Other factors only	.077		.013	
Factors other than common movements in:				
7. All determinants	.172		.017	
8. Specified determinants only	.178		.027	
9. Hypothetical, if no common determinants	.245		.034	

[a]For basis of computation, see footnote 8 of text.
[b]Log y, R_N, g_Y and demand and postwar shift dummies for levels; g_y, DR_N, Dg_Y, demand shift and postwar shift dummies for rates of change.
[c]Line 6: square root of line 4; line 7, of sum of lines 3 and 4; line 8, of sum of lines 2, 3, and 4; and line 9, of line 5.

in the two countries had been completely independent (i.e., the correlation between them had been zero) but velocity in each country had varied as much as it actually did, the variance of the difference between the logarithms of the two velocities ($\sigma^2_{\log V_{uk} - \log V_{us}}$) would have been the sum of the variances in each country separately or the .0600 in line 5 of column 1 of the table. The common movement of the determinants we have explicitly specified would have accounted for almost half of that hypothetical variance; together with other unspecified but common determinants, it would have accounted for slightly more than half. Differential movements in the specified determinants accounted for almost 40 percent, leaving 10 percent to be accounted for by all other factors—chance, measurement error, differential movements in unspecified but common determinants, and determinants of velocity specific to each country.

In terms of standard deviations, the standard deviation of that part of the difference between the two velocities that arises from all other factors is 7.7 percent; from these other factors plus the differential movement of the specified determinants, 17.2 percent. Common movements in unspecified determinants are of minor importance; including them raises the standard deviation only to 17.8 percent. Finally, the hypothetical standard deviation if the velocity series had been unrelated in the two countries would have been 24.5 percent.

The results are even more striking for rates of change. Common movements in determinants—those specified and others—account for over three-quarters of total variance. If there were no common determinants, the standard deviation of the difference between the rates of change of velocity in the two countries would be 3.4 percent. As it is, it is 1.7 percent.[9] For rates of change, the common movements in unspecified common determinants are more important than for levels: including them would raise the standard deviation to 2.7 percent.

7.4 Money and Income

Another way to explore the interrelations between the United States and the United Kingdom is to examine the effect of changes in the quantity of money in one country on income in the other.

9. We can use the residual difference in velocity between the two countries to get additional estimates of the effect of the several specified determinants by regressing these differences on the corresponding differences between the determinants in the two countries; and similarly for rates of change. We have done this with the phase data for both levels and rates of change and, for rates of change only, also with annual data. The results simply reinforce those of the previous chapter, without adding anything to them, so we simply summarize them in the appendix to this chapter.

A simple example will indicate the relevance of this approach. Suppose there were accurate estimates of nominal income and of the quantity of money in the state of Illinois. Suppose we then examined the relation between changes in income for the state of Illinois and changes in the quantity of money in Illinois or in the rest of the country. It would come as no surprise if income changes in Illinois were more closely related to monetary changes in the rest of the country than to monetary changes in Illinois itself. The reason is that Illinois is a small part of a broader economy using the same money. The quantity of money in Illinois is endogenous—determined by the amount that people in Illinois want to hold. They can always get the amount they want by bidding it away from other states. The forces running from income to money will dominate those running the other way. Moreover, in such a small unit there is much room for random perturbation in the demand for money.

For the country as a whole, on the other hand, the quantity of money comes closer to being exogenous. The forces running from money to income are likely to be more important relative to those running from income to money than for Illinois alone. And in such a large unit, random perturbations have more of an opportunity to cancel out.

At first glance, these considerations suggest only that the income-money relation for the United States as a whole will be closer than for Illinois alone. However, the free mobility of men, money, capital, and goods between Illinois and the rest of the country also makes it likely that Illinois income will be more closely related to the quantity of money in the United States as a whole than in Illinois alone. Income movements in Illinois must be highly correlated with income movements elsewhere. The random perturbations in that relation are likely to be less than the random perturbations in the Illinois demand for money. The Illinois relation alone may best be viewed in terms of Illinois income serving as a proxy for United States income; Illinois money, for United States money. Substituting actual United States money for its proxy removes one source of random disturbance.

Note that the question at issue is not simply whether economic developments in the rest of the country influence Illinois. Of course they do—very strongly. However, as in the classical specie-flow mechanism, or the more recently fashionable monetary theory of the balance of payments, that influence might operate primarily through balance-of-payments deficits or surpluses between Illinois and the rest of the country, or through arbitrage operations reflecting the "law of one price." Either adjustment mechanism forces the quantity of money in Illinois to change in line with prices and the quantity of money in the rest of the economy and so would be fully reflected in the Illinois quantity of money. The question is whether the monetary changes in the rest of the country

exert an influence on Illinois beyond those influences reflected in the Illinois quantity of money.[10]

A similar example, closer to the United States–United Kingdom relation, is between Canada and the United States. This example is similar to the Illinois–United States example in the relative size of Canada and the United States and in the closeness of the economic links between them. It differs in the existence of two formally independent monies—Canadian dollars and United States dollars. This formal independence was largely irrelevant in those years when the two monies were connected by a fixed exchange rate and there was no extensive governmental exchange control. It was potentially much more relevant when exchange control was extensive and when the monies were linked by floating exchange rates. However, the periods of extensive exchange control were few, the controls were never thoroughly effective, and the floating rate has tended in practice to be relatively stable.

For this example, a number of empirical studies have indicated that the expectations expressed above for Illinois are indeed fulfilled for Canada: changes in nominal income in Canada are more closely related to changes in the quantity of money in the United States than to changes in the quantity of money in Canada, and still more closely related to a weighted average of the two.[11]

10. Note also that the question is not the one that has so preoccupied the proponents of the monetary theory of the balance of payments—whether movements in the balance of payments and in gold reflect (*a*) changes in the demand for money arising either from internal causes or from the direct effect on prices and income of the "law of one price" or (*b*) differential changes in prices in different countries reflecting perhaps autonomous changes in domestic quantities of money, which in turn set in motion the classical specie-flow mechanism.

In our opinion the much-exaggerated contrast between the classical specie-flow mechanism and the monetary theory of the balance of payments concerns the differential speed of adjustment of variables that all recognize as significant. The basic issue is empirical—the lag in reaction to different stimuli. However, some proponents of the monetary theory of the balance of payments mistakenly translate the question about the balance of payments into one of whether money determines income or, in an open economy with fixed exchange rates, income determines money.

In practice, both directions of influence are operative all the time. In any event, the lags in reaction would largely average out in our phase data. Whatever may cause the changes in the quantity of money within a country, those changes can in turn be expected to have predictable effects on nominal income, output, prices, and interest rates. We are dealing with a dynamic feedback system, not a one-way process. Hence, the controversy about the monetary theory of the balance of payments is largely irrelevant to the kind of relations between money and other variables that we explore in this book.

11. See Glenn P. Jenkins, "The Role of the United States Monetary Stock in a Model of the Canadian Economy," unpublished paper, Money and Banking Workshop, University of Chicago (April 1971); R. Argarwala, J. Drinkwater, S. D. Khosla, and J. McMenomy,

The United Kingdom economy is larger than the Canadian economy, geographical barriers to the movement of resources between the United Kingdom and the United States are greater than between Canada and the United States, and exchange controls have been more extensive and lasted longer in the United Kingdom. The empirical question is whether these differences are sufficiently important to seriously blur the effects of one country on the other beyond those that are incorporated in each country's money supply via the specie-flow mechanism or the "law of one price" or, for the period of floating exchange rates, via the adjustment of exchange rates, which alters relative money supplies expressed in a common currency.

7.4.1 Combined Money Stock

One simple test is to relate income (or prices) in each country separately to the total money stock in the two countries together rather than to the money stock in the country in question. Table 7.4 gives the results of such a test for both levels and rates of change of income and prices.

Before we can add the two money stocks, they must first be expressed in a common currency. We have done this by using the market exchange rate ruling in each year. This gives two series: one in dollars, one in pounds, depending on which country's money stock is converted into the currency of the other. When exchange rates are constant, as from 1879 to 1914, the two level series are of course, in a fixed ratio and the two rate-of-change series are identical. But, when exchange rates vary, neither property holds. To allow for the difference, we regressed the United States variables on the dollar combined money stock series and its rate of change and regressed the United Kingdom variables on the pound combined money stock series and its rate of change.

Columns 2 and 3 of table 7.4 give the regression coefficients for the two regressions (described as "simple," though in fact demand shift and postwar readjustment effects are allowed for); columns 9 and 10, the standard errors of estimate; and columns 13 and 14, the squared correlation coefficients.

"A Neoclassical Approach to the Determination of Prices and Wages," *Economica*, n.s., 39 (August 1972): 250–63.

Indirect evidence for closer relations between Canadian income and the United States quantity of money than between Canadian income and Canadian quantity of money is provided by a simulation of the effects of monetary restraint in the United States and Canada on the two countries. The United States restraint had a greater effect on Canada than Canadian restraint. This result, however, is critically dependent on the particular multiple-regression models for Canada and the United States employed in the simulation. See John Helliwell and Tom Maxwell, "Monetary Interdependence of Canada and the United States under Alternative Exchange Rate Systems," in *National Monetary Policies and the International Financial System*, ed. R. Z. Aliber (Chicago: University of Chicago Press, 1974), pp. 82–108.

The results are quite different for income and prices, and for prices, for the United States and the United Kingdom. For income, the combined money stock uniformly gives higher standard errors and lower correlations than own-country money; for prices, on the other hand, the combined money stock gives lower standard errors and higher correlations than own-country money for the United States, but higher standard errors and lower correlations for the United Kingdom. There is clearly something here requiring further exploration: Why should the United Kingdom money stock affect United States prices but not the other way around? And why should there be a greater effect on prices than on income?

7.4.2 Own-Country Money, Other-Country Money, and Other-Country Velocity

As a first step, instead of combining the two money stocks, we have included them as separate variables in multiple regressions. In the United States regressions, the United Kingdom money stock is converted to dollars; in the United Kingdom regressions, the United States money stock is converted to pounds. These results (columns 4 and 5, 11, and 15 in table 7.4) largely confirm those from combined money. For three out of the four income regressions, the standard error of the multiple regression is larger than for the simple regression with own-country money. The exception is for the United Kingdom level of income, for which United States money has a significant positive coefficient. For prices, the two United States equations again show a significant effect of United Kingdom money on United States prices. The two for Britain give a slightly mixed picture—the rate-of-change equation again showing no significant effect and the level equation showing an effect on the borderline of significance but in a negative direction; that is, a rise in United States money tends to lower United Kingdom prices for a given stock of United Kingdom money.

So far we have been considering only the effects operating through money stock. However, as we have seen earlier, a unified monetary system may require divergent movements in the stock of money in the several countries composing the system in order to offset autonomous changes in the quantity of money demanded. The linkage between prices and income is more fundamental than that between money stocks and may operate in other ways than through changes in the quantity of money of the other country (for example, through the "law of one price"). One way to allow for these more subtle effects is to include velocity in the other country as an additional variable.[12]

12. Statistically, the inclusion of velocity is equivalent to including income in the other country. For example, consider (Continued on p. 324)

Table 7.4 **Regressions of Level and Rate of Change of Income and Prices in the United States and the United Kingdom on Level and Rate of Change of Own-Country, Other-Country and Combined-Country Money[a] and Other-Country Velocity: United States Dates, Full Period**

Dependent Variable (1)	Regression Coefficient (and Absolute t Value) of Simple Regression		Regression Coefficient (and Absolute t Value) of Multiple Regression on				
	Own-Country Money (2)	Combined Money (3)	Own-Country Money (4)	Other-Country Money (5)	Own-Country Money (6)	Other-Country Money (7)	Other-Country Velocity (8)
Log Y_{us}	0.94	1.04	0.96	−0.03	0.91	0.03	0.27
	(171)	(147)	(21)	(0.04)	(21)	(0.45)	(3.3)
Log Y_{uk}	1.05	0.74	0.76	0.19	0.82	0.18	0.57
	(92)	(87)	(7.1)	(2.7)	(8.9)	(3.1)	(4.2)
$g_{Y_{us}}$	0.92	0.94	0.85	0.09	0.96	0.14	0.61
	(14)	(12)	(8.6)	(0.92)	(12)	(1.8)	(5.1)
$g_{Y_{uk}}$	0.80	0.63	0.78	0.03	0.81	−0.004	0.73
	(11)	(8.3)	(7.2)	(0.31)	(12)	(0.06)	(8.3)
Log P_{us}	0.36	0.40	0.10	0.44	0.08	0.47	0.14
	(28)	(31)	(1.0)	(2.7)	(0.75)	(2.7)	(0.69)
Log P_{uk}	0.63	0.44	0.91	−0.13	1.01	−0.19	0.98
	(42)	(36)	(6.2)	(1.9)	(9.1)	(2.6)	(6.1)
$g_{P_{us}}$	0.68	0.76	0.33	0.46	0.39	0.48	0.32
	(11)	(15)	(5.4)	(7.5)	(7.1)	(9.2)	(4.0)
$g_{P_{uk}}$	0.88	0.70	0.84	0.05	0.87	0.02	0.63
	(13)	(10)	(8.4)	(0.53)	(13)	(0.30)	(6.9)

Table 7.4 (Continued)

Dependent Variable	Standard Error of Estimate				R^2			
	Simple Regression		Multiple Regression		Simple Regression		Multiple Regression	
	On Own-Country Money (9)	On Combined Money (10)	Money in Two Countries (11)	Money in Two Countries and Velocity in Other Country (12)	On Own-Country Money (13)	On Combined Money (14)	Money in Two Countries (15)	Money in Two Countries and Velocity in Other Country (16)
Log Y_{us}	.0572	.0662	.0577	.0523	.9986	.9981	.9986	.9988
Log Y_{uk}	.0888	.0935	.0833	.0707	.9949	.9943	.9956	.9969
$g_{Y_{us}}$	.0176	.0198	.0176	.0139	.8886	.8589	.8908	.9336
$g_{Y_{uk}}$	.0206	.0248	.0209	.0129	.7523	.6412	.7529	.9074
Log P_{us}	.1322	.1207	.1241	.1248	.9474	.9561	.9547	.9552
Log P_{uk}	.1171	.1370	.1138	.0845	.9757	.9668	.9776	.9879
$g_{P_{us}}$	.0166	.0137	.0110	.0094	.7920	.8696	.9117	.9367
$g_{P_{uk}}$	.0190	.0236	.0192	.0132	.8030	.6981	.8043	.9096

[a]Also on dummies to allow for demand shift and postwar readjustment. Other-country money is converted to the currency of own-country money.

The multiple regression including the other-country velocity systematically gives a lower, and mostly substantially lower, standard error than the simple regression on own-country money, and with one minor exception (log P_{us}), also than the multiple regression on own- and other-country money. The inclusion of velocity does not appreciably alter the calculated coefficient of other-country money, though in several cases, notably the effect of United States money on United Kingdom income, it does substantially increase the corresponding t value. Clearly, the inclusion of velocity allows for a largely independent set of effects.

With two exceptions, velocity accounts for a much larger fraction of the variation not accounted for by own-country plus other-country money than other-country money does of the variation not accounted for by own-country money alone.[13] With these two exceptions, money in the

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(a) $$\log Y_{us} = a + b \log M_{us} + c \log M_{uk} + d \log V_{uk}.$$

Now

(b) $$\log V_{uk} = \log Y_{uk} - \log M_{uk},$$

so (a) can be rewritten:

(c) $$\log Y_{us} = a + b \log M_{us} + (c-d) \log M_{uk} + d \log Y_{uk}.$$

The coefficient d and its associated partial correlation coefficient measure the relation between that part of log Y_{uk} which is not correlated with log M_{us} and log M_{uk} and that part of log Y_{us} which is not correlated with log M_{us} and log M_{uk}. They thus measure the additional connection between the two countries over and above the effect operating through the money supply.

13. Consider table 7.N.2, derived from the entries in columns 13, 15, and 16 of table 7.4.

Table 7.N.2 Explanatory Value of Other-Country Money and Velocity

	Percentage of Variation Not Explained by	
	Own-Country Money	Own-Country and Other-Country Money
	Explained by	
	Other-Country Money[a]	Velocity[b]
Y_{us}	0	14.3
Y_{uk}	13.7	30.0
$g_{Y_{us}}$	2.0	39.2
$g_{Y_{uk}}$	0.2	62.5
P_{us}	13.9	1.1
P_{uk}	7.8	46.0
$g_{P_{us}}$	57.5	28.3
$g_{P_{uk}}$	0.7	53.8

[a] 100 times (Column 15 minus column 13)/(1 minus column 13).
[b] 100 times (Column 16 minus column 15)/(1 minus column 15).

other country is clearly a less potent vehicle for the transmission of influences from one country to another than are the forces that are reflected in velocity. Indeed, for the most part, other-country money has no significant effect at all.

The two exceptions are the level of and rate of change of prices in the United States—the same two that have been idiosyncratic throughout. They raise the most intriguing question of interpretation.

For a fuller analysis of these results, it is desirable to allow for the possibility that wartime observations are distorting the results; and to distinguish between different exchange-rate regimes.[14] Under a fixed-exchange-rate regime, changes in one country affect another through actual or potential discrepancies between the countries in the prices of identical goods and in relative prices of traded and nontraded goods, which in turn alter trade flows and produce specie flows and capital movements. Under variable exchange rates, exchange rate changes replace specie flows wholly or in part, depending on whether the exchange rate floats freely or is partly controlled by central bank intervention. If exchange rates float freely, the own-country money stocks are insulated from one another, and one channel of influence is closed off. There remain the other two—other-country money converted into own-country currency, which will reflect changes in exchange rates as well as in the nominal quantity of money, and velocity. But it would not be surprising if the closing off of one channel affected the operation of the others.

14. An example of the usefulness of separating out periods with different exchange-rate regimes is an article by Terry C. Mills and Geoffrey E. Wood, "Money-Income Relationships and the Exchange-Rate Regime," *Federal Reserve Bank of Saint Louis Review* 60 (August 1978): 22–27.

For the rest, their analysis is not directly relevant to the problem of this chapter, since the money-income relationship they examine is within each country separately whereas our main concern is with the effect of monetary and other changes in one country on income in the other country.

They correctly point out, as we have, that in a fixed exchange rate regime the quantity of money in one country is endogenous and cannot be determined, except for brief periods, by the monetary authorities. They use this insight to interpret statistical tests of "causality," arguing that the endogeneity of money means that "monetary policy cannot affect income, but rather income fluctuations produce accommodating monetary flows" (p. 24).

This statement, taken literally, is correct but, as written, highly misleading. Monetary policy cannot affect the quantity of money except temporarily; nonetheless, changes in the quantity of money, however produced, will affect income. Indeed, it is precisely because they do that a gold standard or other fixed exchange rate regime is self-adjusting. Similarly, while "income fluctuations [whether in the country in question or other countries to which it is linked] produce accommodating monetary flows," it is also true that monetary flows produce accommodating income fluctuations.

In short, the exchange rate regime does not affect the existence of a "causal" influence from money to income; it affects the forces determining the quantity of money and thereby whether the situation is one of a largely unidirectional influence from money to income or of simultaneous determination and interaction.

The fixed-exchange rate period includes 1879 to 1914 and 1925 to 1931. However, given the small number of phases in the period from 1925 to 1931, and the even smaller number of triplets of phases from which rates of change are calculated, there seems little loss, and a considerable gain in simplicity, in treating the whole period from 1914 on as corresponding to a variable-exchange-rate regime, and the pre-1914 period to a fixed-exchange-rate regime. Unfortunately, this confounds the effect of temporal change with the effect of exchange-rate regime, but history makes that inevitable, and the confounding would not be significantly reduced by including the six years from 1925 to 1931 with the thirty-six years before 1914.

Multiple regressions between the level and rate of change of income and prices, as dependent variables, and own-country money, other-country money, and velocity, as independent variables, are summarized in tables 7.5 and 7.6 for the whole period, peacetime phases, pre-1914 phases, post-1914 phases and post-1914 peacetime phases—in table 7.5 for income and in table 7.6 for prices.

Omitting the wartime phases does not have any major effect on the results. The division between the fixed-exchange-rate and variable-exchange-rate periods, on the other hand, has a major effect.

For the United States, neither other-country money nor other-country velocity has any significant influence on *income* for each period separately when own-country money is held constant. The only channel of influence appears to be own-country money.[15] The significant effect of other-country velocity for the period as a whole apparently is produced by the difference between the periods. That is true also for the *level of prices*—indeed for the pre-1914 period not even own-country money is significant. However, the situation is very different for *the rate of change of prices*: all three variables seem significant or close to significant for both the pre-1914 and the post-1914 periods, though decidedly more so for the later period.[16]

For the United Kingdom, the results for the gold standard period are the same as for the United States: only own-country money is significant

15. Note that this result is perfectly consistent, as we shall see, with prices in the United States being strongly affected by prices in the United Kingdom, provided that either the United States quantity of money reacts sufficiently rapidly to accommodate the price effect, or real output, rather than nominal income, absorbs the price effect, that is, moves in the opposite direction to prices, leaving nominal income unaffected.

16. Consider the t values for the pre–1914 and post–1914 periods:

	Own-Country Money	*Other-Country Money*	*Other-Country Velocity*
Pre–1914	5.9	2.6	1.9
Post–1914	4.7	7.3	3.0
Post–1914 peacetime	6.9	8.2	5.0

for income, none of the variables is significant for levels of prices; all are significant for rates of change of prices.

However, for the variable-exchange rate period, the results differ substantially. First, other-country money and other-country velocity have a significant influence on *income* for the whole post-1914 period and peacetime phases alike, with the exception only of rates of change of other country money.[17] Second, other-country money is not significant for *prices*, judged by either levels or rates of change; other-country velocity is significant for levels but not for rates of change for peacetime phases.[18]

Some of the puzzles raised for the period as a whole stand out in even sharper form for subperiods. (1) For the gold standard period, why should other-country money and velocity influence the rate of change of prices in both the United States and the United Kingdom but not the rate of change of nominal income? (2) For the variable-exchange-rate period, why the differences between the United States and the United Kingdom? (Both the level of and rate of change of nominal income in the United Kingdom but not in the United States are affected by other-country money and velocity. The rate of change of prices in the United States but not in the United Kingdom is affected by other-country money and velocity.)

Gold-Standard Period: Income versus Prices

The explanation for a significant effect of other-country variables on rates of change of prices but not of incomes seems straightforward. For each country separately, a relatively stable demand function for money with a close to unity real income elasticity means that the nominal quantity of money (or rate of change) and nominal income (or rate of change) must be consistent with one another, and each country is large enough so that its own money stock is a better proxy for the relevant monetary magnitude than any broader total including other countries—the interpretation we gave earlier for the corresponding income results for the period as a whole.

17. Consider these t values:

	Own-Country Money		*Other-Country Money*		*Other-Country Velocity*	
	Levels	*Rates of Change*	*Levels*	*Rates of Change*	*Levels*	*Rates of Change*
Post–1914	4.2	9.0	2.4	0.24	3.3	9.2
Post–1914 peacetime	6.5	6.8	3.1	1.5	1.5	2.4

18. Consider these t values:

	Own-Country Money		*Other-Country Money*		*Other-Country Velocity*	
	Levels	*Rates of Change*	*Levels*	*Rates of Change*	*Levels*	*Rates of Change*
Post–1914	6.3	8.9	0.24	0.61	6.5	6.2
Post–1914 peacetime	7.3	6.4	0.90	1.11	6.1	1.3

Table 7.5 **Regressions of Level and Rate of Change of Income in the United States and the United Kingdom on Level and Rate of Change of Own-Country Money, Other-Country Money, and Other-Country Velocity:[a] United States Dates, Various Periods**

Dependent Variable and Period		Regression Coefficient (and Absolute t Value)				Standard Error of Estimate	R^2
		Constant	Own-Country Money	Other-Country Money	Other-Country Velocity		
Log Y_{us}	Whole Period	1.20	0.91	0.032	0.27		
		(5.0)	(21)	(0.45)	(3.3)	.0523	.9988
	Peacetime	1.29	0.92	0.008	0.27		
		(5.3)	(21)	(0.11)	(3.0)	.0525	.9990
	Pre–1914	2.13	0.93	−0.098	0.11		
		(2.5)	(11)	(0.58)	(0.20	.0565	.9862
	Post–1914	1.25	0.94	−0.012	0.23		
		(3.7)	(16)	(0.13)	(2.1)	.0500	.9979
	Post–1914 peacetime	1.13	1.01	−0.063	0.04		
		(2.9)	(16)	(0.69)	(0.22)	.0460	.9984
Log Y_{uk}	Whole period	0.00	0.82	0.182	0.57		
		(0.00)	(8.9)	(3.1)	(4.2)	.0707	.9969
	Peacetime	0.01	0.88	0.138	0.44		
		(0.04)	(10)	(2.4)	(3.1)	.0658	.9977
	Pre–1914	0.50	0.93	0.073	0.02		
		(1.4)	(12)	(2.0)	(0.16)	.0247	.9914
	Post–1914	−0.22	0.73	0.267	0.66		
		(0.44)	(4.2)	(2.4)	(3.3)	.0840	.9934
	Post–1914 peacetime	−0.65	0.82	0.252	0.26		
		(1.7)	(6.5)	(3.1)	(1.5)	.0572	.9974

$g_{Y_{us}}$	Whole period	−0.01	0.96	0.140	0.61		
		(2.0)	(12)	(1.8)	(5.1)	.0139	.9336
	Peacetime	−0.01	1.00	0.056	0.23		
		(1.6)	(11)	(0.70)	(1.6)	.0128	.9251
	Pre–1914	0.00	0.94	−0.13	0.27		
		(0.19)	(5.1)	(0.40)	(0.67)	.0165	.6466
	Post–1914	−0.01	0.95	0.205	0.68		
		(2.3)	(10)	(2.1)	(5.4)	.0128	.9619
	Post–1914 peacetime	−0.01	1.04	0.042	0.21		
		(1.6)	(11)	(0.48)	(1.4)	.0094	.9792
$g_{Y_{uk}}$	Whole period	0.01	0.81	−0.004	0.73		
		(3.5)	(12)	(0.06)	(8.3)	.0129	.9074
	Peacetime	0.00	0.86	0.136	0.40		
		(0.74)	(11)	(1.7)	(2.7)	.0130	.8703
	Pre–1914	0.00	1.05	0.051	0.11		
		(0.14)	(5.0)	(0.44)	(0.67)	.0104	.6262
	Post–1914	0.02	0.75	0.016	0.86		
		(4.0)	(9.0)	(0.24)	(9.2)	.0116	.9356
	Post–1914 peacetime	0.01	0.72	0.192	0.60		
		(2.0)	(6.8)	(1.5)	(2.4)	.0131	.9240

[a]Also demand shift and postwar readjustment dummies.

Table 7.6 **Regressions of Level and Rate of Change of Prices in the United States and the United Kingdom on Level and Rate of Change of Own-Country Money, Other-Country Money, and Other-Country Velocity:[a] United States Dates, Various Periods**

Dependent Variable and Period		Regression Coefficient (and Absolute t Value)				Standard Error of Estimate	R^2
		Constant	Own-Country Money	Other-Country Money	Other-Country Velocity		
Log P_{us}	Whole period	−5.25	0.08	0.47	0.14		
		(9.2)	(0.75)	(2.7)	(0.69)	.1248	.9552
	Peacetime	−5.27	0.07	0.47	0.21		
		(8.7)	(0.64)	(2.6)	(0.95)	.1299	.9583
	Pre–1914	−0.43	0.10	−0.17	0.59		
		(0.28)	(0.63)	(0.54)	(0.57)	.1048	.1046
	Post–1914	−4.43	0.33	0.10	−0.10		
		(8.2)	(3.5)	(0.67)	(0.58)	.0808	.9693
	Post–1914 peacetime	−4.81	0.41	0.06	−0.34		
		(8.2)	(4.4)	(0.46)	(1.3)	.0704	.9795
Log P_{uk}	Whole period	−6.77	1.01	−0.19	0.98		
		(21)	(9.1)	(2.7)	(6.1)	.0845	.9879
	Peacetime	−6.80	1.04	−0.21	0.94		
		(19)	(8.9)	(2.8)	(5.0)	.0871	.9890
	Pre–1914	−1.51	0.08	0.01	0.31		
		(2.0)	(0.49)	(0.17)	(1.4)	.0510	.1360
	Post–1914	−6.15	0.74	−0.02	0.86		
		(18)	(6.3)	(0.24)	(6.5)	.0568	.9922
	Post–1914 peacetime	−6.00	0.78	−0.06	0.90		
		(19)	(7.3)	(0.90)	(6.1)	.0487	.9950

$g_{P_{us}}$	Whole period	−0.03	0.39	0.48	0.32		
		(9.4)	(7.1)	(9.2)	(4.0)	.0094	.9367
	Peacetime	−0.03	0.45	0.41	0.46		
		(11)	(8.4)	(8.4)	(5.1)	.0077	.9207
	Pre–1914	−0.04	0.61	0.49	0.42		
		(6.6)	(5.9)	(2.6)	(1.9)	.0092	.7722
	Post–1914	−0.02	0.32	0.53	0.27		
		(6.2)	(4.7)	(7.3)	(3.0)	.0093	.9526
	Post–1914 peacetime	−0.02	0.38	0.41	0.42		
		(9.3)	(6.9)	(8.2)	(5.0)	.0054	.9791
$g_{P_{uk}}$	Whole period	−0.01	0.87	0.02	0.63		
		(3.7)	(13)	(0.29)	(6.9)	.0132	.9096
	Peacetime	−0.02	0.81	0.20	0.24		
		(5.8)	(13)	(3.1)	(2.0)	.0105	.9021
	Pre–1914	−0.02	0.67	0.30	0.18		
		(10)	(8.1)	(6.7)	(2.9)	.0040	.8905
	Post–1914	−0.01	0.93	−0.05	0.73		
		(2.2)	(8.9)	(0.61)	(6.2)	.0147	.9114
	Post–1914 peacetime	−0.01	0.79	0.16	0.36		
		(2.2)	(6.4)	(1.1)	(1.3)	.0149	.8982

[a]Also demand shift and postwar readjustment dummies.

Prices, however, are a different matter. For internationally traded goods, there is a single world price level and, as we saw in table 7.2, the correlation between the rate of change of prices in the two countries is higher than for any other rate-of-change magnitude. For a given rate of growth of nominal income in the United States, an increased rate of growth of nominal income in the United Kingdom would tend, at least in part, to take the form of a higher rate of growth of prices, which in turn would be reflected in United States prices—and conversely.

On this interpretation, the effect of both other-country money and other-country velocity is through income; that is, for fixed other-country money, a rise in other-country velocity means a rise in other-country income; for fixed other-country velocity, a rise in other-country money also means a rise in other-country income. But if both other-country money and other country velocity are affecting prices only via other-country income, their coefficients should be equal.[19] That condition is close to being satisfied for the rate-of-change equations. The coefficients are .49 and .42 for the United States and .30 and .18 for the United Kingdom, and the differences are not statistically significant.

The numerical value of these coefficients suggests roughly twice as great an effect of an increase in the rate of change of United Kingdom income on United States prices as the rate of change of United States income on United Kingdom prices. Three factors presumably combine to produce this result: first, international trade was more important for the United Kingdom than for the United States; second, during the gold standard period, the United Kingdom was the major trading country of the world. Both factors would make United Kingdom prices more representative of international prices than United States prices. Third, as chapter 9 demonstrates, other things the same, a larger fraction of a change in nominal income tends to be reflected in prices rather than output for the United Kingdom than for the United States.

The absolute sizes of the coefficients are not unreasonable on this interpretation. For the United States, a one percentage point increase in the rate of change of its own money stock (which implies roughly a one percentage point increase in the rate of change of its income), tends to produce a percentage point increase of about 0.6 in the rate of change of its prices; a one percentage point increase in United Kingdom velocity (i.e., income) tends to produce a percentage point increase of about 0.4—about two-thirds as much; perhaps somewhat high but not unreasonable considering the United Kingdom role in the world at the time. For the United Kingdom, a one percentage point increase in the rate of change of its own money stock tends to produce a slightly larger percentage point increase in the rate of change of its prices—nearly 0.7 percent-

19. See note 12 above.

age points, while a one percentage point increase in the rate of change of United States velocity (i.e., income) tends to produce an increase of only about 0.2 percentage point.

One final point: why should these effects show up on rates of change and not on levels? Presumably the answer is statistical: the level figures are dominated by trends, and so these effects show up only in the more sensitive rate-of-change figures.

Variable-Exchange-Rate Period

Different effects on nominal income, United States and United Kingdom. As we noted earlier, it would not be surprising if the partial or total blocking of one channel of influence—via specie flows—enhanced the importance of other channels of influence. That clearly happened for the United Kingdom, as judged not only by the significance of other-country money and velocity, but also by the decided decline in the coefficient of own-country money—from 0.93 and 1.05 for pre-1914 levels and rates of change of income to 0.73 and 0.75 for post-1914 phases, and 0.82 and 0.72 for post-1914 peacetime phases.

The puzzle is why the same phenomenon did not occur for the United States: with one exception, for rates of change for the post-1914 period as a whole, neither other-country money nor other-country velocity is more than marginally significant; and, with no exceptions, the coefficients of own-country money are higher after 1914 than before. The obvious explanation is the changed role of the United States and the United Kingdom. Not only did the size of the United States economy continue to rise relative to that of the United Kingdom economy, but the United States replaced the United Kingdom after 1914 as the financial center of the world. If before 1914 the world could have been said to be on a sterling standard, after 1914 it could be said to be on a dollar standard. In addition, after World War II, the United Kingdom had extensive foreign exchange and other controls. Given the continued importance of foreign trade and foreign capital to the United Kingdom, these controls could not insulate the United Kingdom from foreign influences, but they could, and presumably did, limit any reciprocal effect of United Kingdom developments on the United States.

This explanation is far from satisfactory, because, while the changes outlined could certainly be expected to produce a greater effect of United States variables on the United Kingdom than of United Kingdom variables on the United States, it seems implausible that they would eliminate any reverse effect, as they apparently did at least during post-1914 peacetime phases. However, we have been unable to find any other answer to the puzzle.

Another issue raised by our results for the United Kingdom is the channels through which the changes in the United States affected the

United Kingdom. For the gold standard period and the effect on prices, we found that our two other-country variables—money and velocity—could have been replaced by a single variable, other-country income. This is not true for the post-1914 period for United Kingdom income.[20] The coefficient of United States velocity is consistently higher —generally much higher—than the coefficient of United States money.[21] Apparently, changes in United States money and United States velocity that have the same effect on United States income have a different effect on United Kingdom income.

One reason this might be true for the post-1914 period is that other-country money reflects changes in exchange rates, whereas other-country velocity does not. For the United Kingdom income regression, United States money in dollars is converted into pounds by multiplying by the market price of the dollar in terms of pounds. As a result, a rise, for example, in United States money in terms of pounds for given velocity may reflect simply a change in the exchange rate without a rise in United States dollar income. Such a change in the exchange rate would not affect United States velocity, which is the ratio of the dollar aggregates.

However, United States money is not serving simply as a proxy for the exchange rate: if the exchange rate is substituted for other-country money in multiple regressions for United Kingdom income for the post-1914 period like those in table 7.5, three of the four coefficients are not statistically significant (t values of 0.8, .05, 1.4) though the corresponding coefficient of other-country money is.[22] The exchange rate, if anything, apparently dilutes the influence of other-country money—a result to be expected, since one of the effects of a floating exchange rate is to partly insulate countries from monetary changes in other countries.

20. In equation (c) of note 12, if $c = d$, as it apparently does for the pre–1914 period, the penultimate term has a coefficient of zero and drops out, whereas if $c \neq d$, as is true after 1914, both final terms are relevant.

21. The coefficients are as follows:

	Coefficients of	
	United States Money	*United States Velocity*
Post–1914 Period		
Levels	.27	.66
Rates of change	.02	.86
Post–1914 peacetime		
Levels	.25	.26
Rates of change	.19	.60

22. The fourth coefficient of the exchange rate, for rate of change, post–1914 peacetime, gives a t value of 2.9 compared with 1.5 for other-country money. This one case is suggestive but inconclusive.

For corresponding regressions for the United States, the t values for the exchange rate range from 0.13 to 1.3, simply duplicating the finding for other-country money.

What about United States velocity? A rise in velocity in the United States for a given United States (dollar) stock of money[23] will produce or accompany a rise in nominal income and be produced by or accompany also a rise in interest rates. The rise in nominal income will tend to raise United States imports, lower United States exports, and thus shift the current balance toward a deficit. The deficit (or reduced surplus) can be financed (1) by a money flow (the classical specie-flow movement), which would affect the own-country money term in our equations; or (2) by an offsetting capital movement stimulated by the higher interest rates; or it could be eliminated by a change in exchange rates, which would affect the other-country money term in our equations. The absence of any significant influence of other-country velocity before 1914 presumably reflects the dominance of item 1 under a gold standard; the significant influence of United States velocity on United Kingdom income after 1914, reflects the closing off of item 1, and the effect of item 2. Given a common capital market, higher interest rates in the United States would mean higher interest rates in the United Kingdom, which would in turn raise United Kingdom velocity and nominal income for a given United Kingdom stock of money.

We can test this explanation by replacing velocity in our multiple regression by a short-term interest rate. The results are favorable to the explanation: the coefficients of the United States interest rate in the United Kingdom income regressions are uniformly positive, the t values are 1.6, 1.7, 3.1, and 1.9, either approaching or exceeding a significant level, and in three of the four comparisons are less than the t values for velocity itself. This final result is favorable because the short-term interest rate is only one of the set of rates that might be expected to be associated with changed velocity, so velocity itself might be expected to have a greater influence than any single interest rate. Finally, the implied effect of the United States interest rate on United Kingdom velocity is consistent with the findings of chapter 6.[24]

Presumably the coefficient of the United States money-stock term reflects a diluted version of the same effect—diluted both because of exchange rate changes and also because a rise in United States income accompanied by a rise in United States money with constant velocity would tend to be associated with less of a rise in interest rates than a rise in

23. Note that other-country money is in pounds in our U.K. regressions.

24. The ratio of the coefficient of the interest rate term to the coefficient of the velocity term is an estimate of the interest slope (i.e., the derivative of the logarithm of velocity with respect to the interest rate). This ratio is 3.2 and 4.9 for levels of the post–1914 period as a whole and the peacetime phases, respectively, and 5.7 and 4.8 for the rates of change. These are well within the range of the corresponding lower- and upper-limit estimates (with changed sign) in note 51 of chapter 6.

United States income accompanied by a rise in velocity with constant United States money.

Different effects on the rate of change of prices, United States and United Kingdom. United Kingdom variables might be expected to influence United States prices in the post-1914 period for the same reason as in the pre-1914 period—because changes in United Kingdom income partly mirror changes in the world price level.[25] As for the pre-1914 period, the level equations show no effect of other-country variables on prices, the rate-of-change equations do; and the coefficients of money and velocity are nearly identical for post-1914 peacetime phases (.41 and .42), though not for the post-1914 period as a whole, just as they were before 1914. The one important difference between pre- and post-1914 results is the decline in the own-country money coefficient from 0.61 to 0.38. Perhaps this reflects the greater role of the United States in the world economy.

The remaining puzzle is why the United Kingdom does not show the same effect of other-country variables on the rate of change of prices after 1914 as before. The answer apparently is because a major part of the difference in United Kingdom price movements is reflected in, or produced by, changes in the exchange rate, and the relevant equations allow for this effect only indirectly through the conversion of United States money into its equivalent in pounds. If the rate of change of the exchange rate is substituted for the rate of change of other-country money in the multiple regressions for the rate of price change in the United Kingdom, it has a significant effect (t values 3.2 and 4.5 for the post-1914 period as a whole and peacetime phases, respectively). Even more important, for given rate of exchange rate change, the rate of change of other-country velocity has a significant effect (t values of 5.9 and 5.1), and its coefficient is much higher than in the prewar period (.61 and .69 compared with .18). For given exchange rates, a one percentage point increase in the United Kingdom rate of change of money tends to raise United Kingdom prices by roughly 0.8 percentage points; a one percentage point rise in United States velocity tends to raise United Kingdom prices by 0.6 to 0.7 percentage points—indicating the much greater role of the United States relative to the United Kingdom in the post-1914 period than in the pre-1914 period.[26]

25. Note that the two United Kingdom variables largely eliminate price changes specific to the United Kingdom, the money variable because it is converted to dollars, the velocity variable because it is a ratio of two magnitudes in pounds.

26. The equations in question (omitting dummies) are as follows for the post–1914 period as a whole and peacetime phases, respectively:

7.5 Conclusion

The common movements of velocity in the United States and the United Kingdom reflect a unified financial system in which monetary variables—prices, interest rates, nominal incomes, stocks of money—are constrained to keep largely in step except as changes in exchange rates alter the number of units of one country's currency equivalent to one unit of the other country's currency. Within the unified financial system, there is much room for divergence of physical magnitudes—movements in real per capita output are least closely linked between the two countries; movements in prices, expressed in a common currency, are most closely linked. Influence ran both ways across the Atlantic, though there is some evidence that real effects were stronger from west to east and price effects from east to west. Moreover, the changing role of the United States and the United Kingdom in the world economy leaves a clear impress on our data.

During the gold standard period before 1914, the influence of each country on the other country's nominal income was manifested entirely through its influence on the other country's money—the classical specie-flow process. Each country was sufficiently large so that using the money stock for a larger area does not appreciably improve the correlation with income. That remains true for the United States after 1914, when variable exchange rates were the rule, but not for the United Kingdom, the nominal income of which was affected by changes in United States money and velocity. These changes apparently affected United Kingdom income by altering interest rates in the United States, which, given a common capital market, affected United Kingdom interest rates and thereby also United Kingdom velocity. Apparently, blocking the gold-standard channel of influence via specie flows diverted the influence of United States monetary changes into other channels. The difference in results for the United States and the United Kingdom is something of a puzzle, only partly explained by the far greater role of the United States in the post-1914 world than earlier.

$$g_{P_{uk}} = \underset{(3.1)}{-0.01} + \underset{(14.4)}{0.83} g_{M_{uk}} \underset{(3.2)}{-0.09} g_{EX} + \underset{(5.9)}{0.61} g_{V_{us}}$$

$$SEE = .0123$$

$$R^2 = .9379$$

$$g_{P_{uk}} = \underset{(1.4)}{-0.01} + \underset{(10.6)}{0.75} g_{M_{uk}} \underset{(4.5)}{-0.17} g_{EX} + \underset{(5.1)}{0.69} g_{V_{us}}$$

$$SEE = .0096$$

$$R^2 = .9577$$

where g_{EX} is the rate of change of the exchange rate.

For both the gold standard period and the later variable-exchange rate period, price changes in each country are affected by monetary changes in the other, not only through effects on own-country money but also more directly—though to isolate this effect for the United Kingdom after 1914 requires allowing explicitly for changes in exchange rates. This is the counterpart of the closer linkage of prices throughout the world than of physical magnitudes—an expression of the "law of one price."

The one world we have been exploring clearly extends beyond the geographical boundaries of the United States and the United Kingdom, and our results show reflections of this wider world especially in the changing relation between the influences running west to east and east to west. A fuller analysis of this wider world, though it is beyond our scope, would much improve our understanding of the bilateral relations to which we have restricted our own work.

7.6 Appendix: Regressions of Velocity Differences in the United States and United Kingdom on Differences in Specified Determinants

Table 7.7 presents the coefficients calculated from regressions of velocity differences in the United States and United Kingdom on differences in the specified determinants. The first two lines are based on phase data, the third on annual data. In interpreting the coefficient of the real per capita income variable, note that unity must be subtracted from the elasticity of velocity and the sign changed in order to obtain an estimate of the elasticity of real per capita money. For the other variables, the sign but not numerical size of the coefficients must be changed to obtain estimates of the corresponding coefficients for a real per capita money equation.

Table 7.8 compares the estimates of the effects of specified determinants from our earlier regressions based on data for the separate countries and the regressions in table 7.7. It is clear that, allowing for sampling error, the estimates are similar. Note that, as always, the regression effect makes these estimates lower limits of the indicated effect.[27] The upper limits are straightforward to compute for the variables other than the income elasticity, and as for the level equations (see table 6.15) are very much above the lower limits.

27. For the regressions based on velocity differences, note that

$$\log V_{uk} - \log V_{us} = (\log y_{uk} - \log y_{us}) - (\log m_{uk} - \log m_{us}).$$

Since the difference between the logs of real per capita income is included as an independent variable, the results in table 7.8 are identical with those that would have been observed from a regression in which the dependent variable was based on the difference between real per capita money balances in the two countries.

Table 7.7 **Regression of Differences between Logarithms of United States and United Kingdom Velocities and Their Rates of Change**

Dependent Variable	Period and Data	Coefficient and (Absolute t Value)						Standard Error of Estimate
		Constant Log Term	y or g_y	R_N or DR_N	g_Y or Dg_Y	S or S_g	W or W_g	
$\log V_{uk} - \log V_{us}$	Whole period	−0.03	−0.0005	19.8	1.22	−0.24	0.004	.0774
	Phase data	(0.14)	(0.005)	(7.4)	(3.7)	(5.2)	(0.38)	
$g_{V_{uk}} - g_{V_{us}}$	Whole period	—[a]	0.19	12.5	0.031	−0.0025	−0.004	.0131
	Phase data		(2.1)	(3.8)	(2.1)	(1.9)	(0.46)	
$g_{V_{uk}} - g_{V_{us}}$	1872–1975	—[a]	0.33	4.4	0.31	−0.0058	0.0062	.0401
	Annual data		(4.2)	(3.7)	(6.1)	(0.50)	(0.34)	

[a]Intercept forced to zero.

Table 7.8 **Estimates of Effects of Specified Determinants: Comparison between Results from Regressions Based on Separate Country Data and Those Based on Differences between United States and United Kingdom**

	Level Equations		Rate of Change Equations			
			Dependent Variables			
			g_m		$g_{V_{uk}} - g_{V_{us}}$	
	$\log m$	$\log V_{uk} - \log V_{us}$	Constant Term	Zero Constant	Phase Data	Annual Data
Income elasticity, m or g_m						
United States	1.15	1.00	0.88	1.09	0.81	0.67
United Kingdom	0.88		0.44	0.92		
Slope, R_N or DR_N						
United States and United Kingdom	−9.3	−19.8	−8.5	−8.7	−12.5	−4.4
Slope, g_Y or Dg_Y						
United States and United Kingdom	−0.47	−1.22	−0.29	−0.41	−0.31	−0.31
Demand shift						
United States and United Kingdom	0.19	0.24	0.0031	0.0040	0.0025	0.0058
Postwar readjustment						
United States and United Kingdom	0.019	−0.004	0.0308	0.0299	0.0040	−0.0062
Standard error of estimate	.0532	.0774	.0137	.0142	.0131	.0401
Estimated standard error of estimate for one country's level or rate of change	.0532	.0547	.0137	.0142	.0093	.0284

The final line of table 7.8 requires some explanation. The standard errors for the velocity equations in the penultimate line are for a difference between the two countries. If the errors of estimate are independent for the two countries but have the same variance for each—as we found in chapter 6, they do for the United States and the United Kingdom—then the standard error of the difference is $1/\sqrt{2}$ times the standard error for a single country. The entries for the velocity equations in the final line are therefore $1/\sqrt{2}$ times the entry in the penultimate line.

The differential velocity equations implicitly allow not only for the specified determinants allowed for by the money equation, but also for other unspecified determinants of velocity that tend to have common movements in the two countries. That might be expected to produce a smaller standard error. It does for the rate of change equations but not for the level equations—presumably because, as table 7.3 indicates, these common movements in unspecified determinants are far more important for short-term fluctuations than for longer-term ones (they account for only 3 percent of the hypothetical variance for levels, but for 37 percent for rates of change).

The higher standard error from the annual data than from the phase data reflects partly simply the longer interval to which the phase standard error refers—four years on the average for the United States, five and one-half for the United Kingdom. However, if this were the only effect, the standard error for the annual data would be between $\sqrt{4}$ and $\sqrt{5.5}$ times the standard error for the United Kingdom, or at most .0218 on the final line (.0093 $\sqrt{5.5}$). It is higher than that presumably because our phase data eliminate a systematic cyclical effect in addition to averaging out serially independent errors.