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10 Money and Interest Rates

No part of this book has been so subject to obsolescence between first draft and final version as this chapter. When the first draft was completed (1966), the Keynesian liquidity preference approach held full sway. It was widely taken for granted that more money meant lower interest rates and a faster rate of monetary growth meant declining interest rates, and conversely. Hume's warning of two centuries earlier—"Lowness of interest is generally ascribed to plenty of money. But money, however plentiful, has no other effect, *if fixed*, than to raise the price of labour"—was mostly neglected. Irving Fisher's pathbreaking work, dating from 1896, distinguishing between nominal and real interest rates and examining the empirical role of inflationary expectations was hardly known and was certainly not part of the received wisdom. Accordingly, our first draft, which presented a full theoretical analysis incorporating Fisher's work, was devoted mostly to testing his conclusions with our United States data.

In the interim there has been a veritable explosion of work in this area, some stimulated by our first draft, the theoretical part of which was published in 1968,[1] but most in reaction to the emergence in the advanced countries of accelerating monetary growth and rising interest rates that made it impossible to continue to regard a stable Keynesian liquidity preference function relating the nominal quantity of money inversely to nominal interest rates as an adequate tool for analyzing the effect of monetary changes on interest rates.

The first round of the explosion, like our first draft, consisted largely of studies along the lines pioneered by Irving Fisher, both redoing his work

1. Milton Friedman, "Factors Affecting the Level of Interest Rates," in *Proceedings of the 1968 Conference on Savings and Residential Financing* (Chicago: United States Savings and Loan League, 1968), pp. 10–27.

and extending it by introducing more sophisticated devices for estimating inflationary expectations. These studies largely confirmed Fisher's results—in particular, his conclusion that inflationary expectations were formed on the basis of a long past period and only slowly adjusted to experience. This conclusion was the centerpiece of his work and the basis for his interpretation of the Gibson paradox—the long-observed positive correlation between interest rates and the *level* of prices.[2] But then some disturbing notes crept in. Results for recent years seemed drastically different from those for the earlier periods, suggesting that the period of experience on which expectations were based shortened drastically after the mid-1960s.[3] In addition, examination of the statistical properties of the estimates constructed by Fisher and by more recent investigators raised doubts about their interpretation.[4]

A second round of the explosion carried the analysis on to a different plane by linking it to the theory of "rational expectations" pioneered by John Muth and the theory of efficient markets developed by Eugene Fama and others.[5] This approach fully accepts Fisher's theoretical framework but rejects his hypothesis about the formation of expectations on the ground that it assumes that profitable market opportunities are neglected. The "efficient market" approach appears to work well in the United States for the period since World War II,[6] but unfortunately not

2. Irving Fisher, *Appreciation and Interest* (Cambridge, Mass.: American Economic Association, 1896); idem, *The Rate of Interest* (New York: Macmillan, 1907); idem, *The Theory of Interest* (New York: Macmillan, 1930); William E. Gibson and George G. Kaufman, "The Sensitivity of Interest Rates to Changes in Money and Income," *Journal of Political Economy* 76 (June 1968): 472–78; William E. Gibson, "Price-Expectations Effects on Interest Rates," *Journal of Finance* 25 (March 1970): 19–34; Thomas Sargent, "Anticipated Inflation and the Nominal Rate of Interest," *Quarterly Journal of Economics* 86 (May 1972): 212–25. Richard Roll, "Interest Rates on Monetary Assets and Commodity Price Changes," *Journal of Finance* 27 (May 1972): 251–78, is a useful survey of these studies.

3. William P. Yohe and Denis S. Karnosky, "Interest Rates and Price Level Changes," *Federal Reserve Bank of Saint Louis Review* 51 (December 1969): 19–36; William E. Gibson, "Interest Rates and Inflationary Expectations," *American Economic Review* 62 (December 1972): 854–65; Karen Johnson, "Inflation and Interest Rates: Recent Evidence," Discussion Paper no. 10, Stanford Workshop on the Microeconomics of Inflation (May 1977).

4. Thomas Sargent, "Interest Rates and Prices in the Long Run: A Study of the Gibson Paradox," *Journal of Money, Credit and Banking* 5, part 2 (February 1973): 385–449.

5. J. F. Muth, "Rational Expectations and the Theory of Price Movements," *Econometrica* 29 (July 1961): 313–35. For summaries of studies along these lines, and bibliographical references, see Maurice D. Levi and John H. Makin, "Fisher, Phillips, Friedman, and the Measured Impact of Inflation on Interest," *Journal of Finance* 34 (March 1979): 35–52; Kajal Lahiri and Jungsoo Lee, "Tests of Rational Expectations and the Fisher Effect," *Southern Economic Journal* 46 (October 1979): 413–24; J. J. Sijben, *Rational Expectations and Monetary Policy* (Germantown, Md.: Sijthoof and Noordhoff, 1980).

6. Robert J. Shiller, "Rational Expectations and the Structure of Interest Rates," Ph.D. diss., Massachusetts Institute of Technology, 1972; Eugene Fama, "Short-Term Interest

for the United States or the United Kingdom before World War II.[7] Yet the Gibson paradox seems to prevail for much of the period after as well as before World War II—though it has apparently disappeared in the decade of the 1970s. We are left with no single satisfactory interpretation of that supposedly well-documented empirical phenomenon. We start this chapter by restating the theoretical analysis that links changes in the quantity of money with interest rates (sec. 10.1). This part of the chapter is largely unchanged from our first draft. We then proceed to exploit our data for the United States and United Kingdom first, to estimate the average value over a century of the nominal interest rate and the real interest rate (sec. 10.2), and then, after a digression on the measurement of yields (sec. 10.3), to estimate the average values in subperiods (sec. 10.4). This leads into the relation between the yields on nominal and physical assets (sec. 10.5) and between nominal yields, price levels, and the rate of change of prices (sec. 10.6). We use these results as a background to evaluate alternative explanations of the Gibson paradox (sec. 10.7), and to interpret an apparent structural change since the end of World War II (sec. 10.8). Finally we return to the initial theme of the relation between monetary changes and interest rates, to find that the statistical results are far less clear-cut than the initial theoretical analysis (sec. 10.9).

10.1 The Theoretical Analysis

The complexity of the relation between money, interest rates, prices, and output derives from two main sources: the interaction between monetary and real disturbances, and the different time patterns of various reactions to either a monetary or a real disturbance. By a monetary disturbance we mean an autonomous change in the nominal quantity of

Rates as Predictors of Inflation," *American Economic Review* 65 (June 1975): 269–82. However, see Patrick J. Hess and James J. Bicksler, "Capital Asset Prices versus Time Series Models as Predictors of Inflation," *Journal of Financial Economics* 2 (December 1975): 341–60; also Charles R. Nelson and G. William Schwert, "Short-Term Interest Rates as Predictors of Inflation: On Testing the Hypothesis That the Real Rate of Interest Is Constant," *American Economic Review* 67 (June 1977): 478–86; Robert J. Shiller and Jeremy J. Siegel, "The Gibson Paradox and Historical Movements in Real Interest Rates," *Journal of Political Economy* 85 (October 1977): 891–907; Kenneth Garbade and Paul Wachtel, "Time Variation in the Relationship between Inflation and Interest Rates," *Journal of Monetary Economics* 4 (November 1978): 755–65; and John A. Carlson, "Short-Term Interest Rates as Predictors of Inflation: Comment," *American Economic Review* 67 (June 1977): 469–75. These papers criticize Fama's results, primarily on grounds that his assumption of a constant real rate is incorrect rather than that markets were not efficient. Fama contends in his reply to his critics ("Interest Rates and Inflation: The Message in the Entrails," *American Economic Review* 67 [June 1977]: 487–96), that the "model remains a useful approximation to the world" (p. 487).

7. See Sargent reference in note 4 above.

money or in the conditions determining the nominal quantity of money; by a real disturbance we mean an autonomous change in the conditions of production (the production function), or in the supply of productive resources, or in the conditions of demand for goods and services (including the demand for capital goods and for real balances).

To isolate the effect of a monetary disturbance, we shall first trace the effect of a systematic change in the rate of change of the quantity of money, on the assumptions (1) that the system starts from a position of equilibrium, and (2) that any real disturbances are transitory, not systematic.[8] We shall then consider more briefly the effect of a systematic real disturbance in a stable monetary framework.

10.1.1 Monetary Disturbances

For the monetary analysis we shall, for definiteness, take the initial position at time t_o to be one in which output and the quantity of money have both been increasing at 3 percent per year, velocity and prices have both been stable, and the nominal interest rate is 4 percent. Initial systematic changes in velocity and prices would complicate the exposition but not alter the analysis. We shall take the systematic monetary change to be a shift at time t_o from a steady 3 percent rate of monetary growth to a steady 8 percent rate. We postpone briefly the question of where the additional money comes from.

The effect of such a shift from one rate of monetary growth to another can be usefully classified under three headings: (1) the impact effect, which includes the Keynesian liquidity effect and a first-round loanable funds effect; (2) an intermediate-run effect on real income and the price level; and (3) a long-run price anticipation effect, associated with the name of Irving Fisher, though he analyzed all three sets of effects.[9] These effects depend on whether the change in the quantity of money is anticipated—in which case the first two sets of effects largely disappear—or is unanticipated. We shall assume throughout that initially the change is unanticipated.

Impact Effect

Liquidity effect. Keynes introduced, and the textbooks of the past few decades have popularized, the liquidity preference function as drawn in chart 10.1, showing the quantity of money (M) that the public desires to hold as a function of the interest rate (R). As drawn, the diagram

8. Disturbances range along a continuum from strictly momentary to the longest-lasting; however, it will simplify the analysis to replace the continuum by a dichotomy.

9. Similarly, Henry Thornton, a century earlier, was aware of all three effects. See *An Enquiry into the Nature and Effects of the Paper Credit of Great Britain* [hereafter, *Paper Credit of Great Britain*] [1802], ed. F. A. von Hayek (London: George Allen and Unwin, 1939), appendix 1, pp. 256–57, 296–97; appendix 3, p. 336.

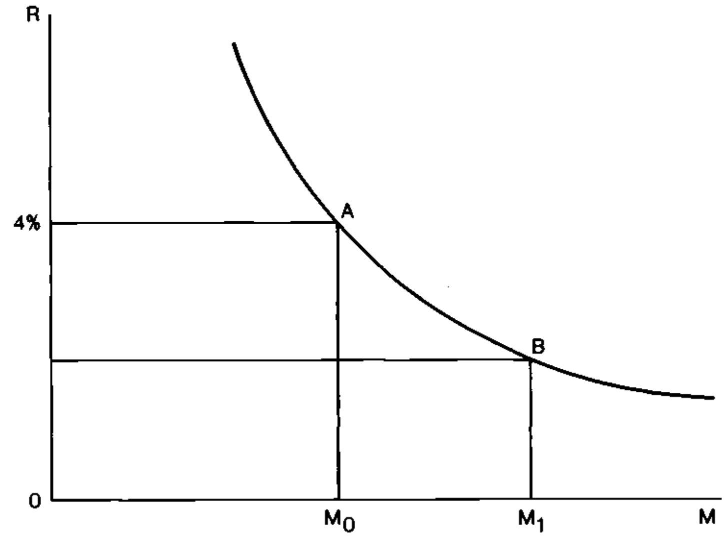


Chart 10.1 Keynesian liquidity preference function.

embodies three crucial simplifications. First, measuring "the" nominal rate of interest on the vertical axis implicitly assumes that the concept of money for which it is drawn pays no interest; otherwise the vertical axis should record the difference between "the" rate of interest and the rate of interest paid on cash balances (either explicitly or implicitly in the form of services rendered without charge). This simplification reflects Keynes's assumption that the financial assets available to be held could be regarded as consisting either of money bearing no interest or long-term bonds.[10] Second, and more important for our purposes, the horizontal axis should be in terms of the real stock of money (*M/P* or *M/Y*), not the nominal stock of money. The failure to distinguish the nominal from the real quantity of money reflects Keynes's assumption that prices could be taken as rigid and that any effects on income would be on real income.[11] We shall relax this assumption in considering the intermediate output and price effect, as well as the long-run price anticipation effect. Third, the diagram neglects, as Keynes did not, the role of the level of income in determining the demand for money. The curve drawn is to be interpreted as holding for a particular level of income (both nominal and real, given the fixed price assumption, or real, if the horizontal axis is interpreted as real money stock). A higher level of income would be associated with a higher curve, a lower level with a lower curve.

10. See section 2.5.3.
11. See section 2.5.2.

The curve as drawn is for a particular time t_o. For our initial assumptions, with M growing at 3 percent a year, the curve is moving over time to the right at 3 percent per year along with output, and the quantity measured on the horizontal axis is doing the same. More simply, we may interpret M as corrected for a 3 percent secular trend.

A shift at time t_o to an 8 percent rate of monetary growth means that cash balances will start to rise at a 5 percent a year rate relative to their previous trend. So far as our present restricted framework is concerned, nothing will happen initially except that the public will hold the excess cash—after all, the rise is unanticipated and cash is held as a shock absorber. But presumably this interval will be brief. As excess cash accumulates, holders of cash, finding the composition of their portfolios disturbed, will try to adjust the portfolios by replacing cash with other assets (including both securities and physical assets). In the process they will bid up the price of other assets and force down the rate of interest. This is the pure liquidity effect.

Note that chart 10.1 gives the demand for a *stock* at a point of time, and the assumed change is a change in a *flow*. Hence this effect would involve not a once-for-all shift from one point to another on the demand curve, but a sliding down the curve from point A toward, say, point B, which we may take to correspond to the (trend-adjusted) quantity of money available at the end of a year. Expressed in terms of a time scale, the behavior of the rate of interest that would be produced by this effect is as described in chart 10.2, namely, an indefinite decline.

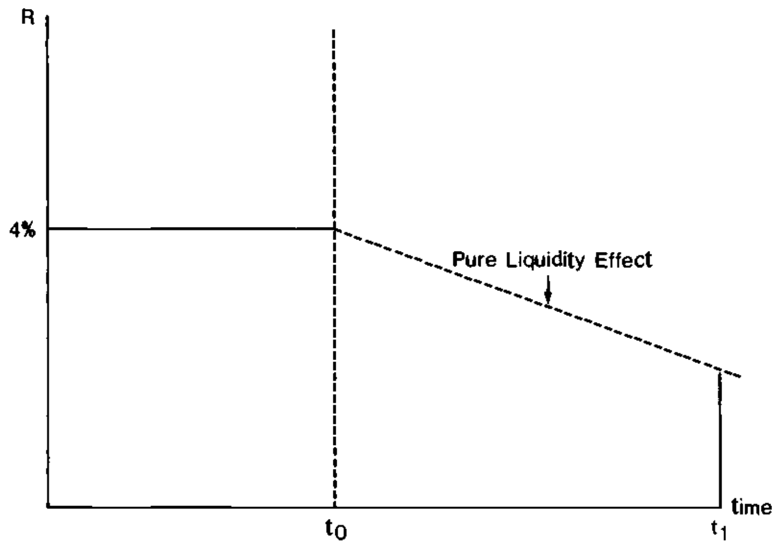


Chart 10.2 Pure liquidity effect on the interest rate of an increase in the rate of monetary growth.

Note also the crucial role of the rigid price assumption. Suppose that we interpret the horizontal axis as referring to M/P, that the shift to an 8 percent rate of monetary growth is announced in advance and fully taken into account and is simultaneously accompanied by a 5 percent rate of price rise. Then, if we neglect the price-anticipation effect on the interest rate considered later, the public would stay at point A in chart 10.1, since real (trend-adjusted) balances would be constant.

The liquidity effect as just described underlay the academic opinion in the Keynesian era that "easy" money could be regarded as equivalent to both lower interest rates and more rapid monetary growth. A rather different effect underlay the corresponding opinion held by bankers, commercial and central, for a far longer period.

The first-round loanable funds effect. Where does the extra money come from? How is it put in circulation? In the present financial system, it is natural to view the increased rate of monetary growth as coming through the banking system, via larger open market purchases by the central bank, which add to reserves of commercial banks, inducing them to expand more rapidly their loans and investments. In the first instance, therefore, the higher rate of monetary growth appears to take the form of an increase in the flow supply of loanable funds. Taken by itself, without allowing for any subsequent effects on ouput or prices of the expenditures financed with the additional funds, or for any liquidity effect, the increase in the supply of loanable funds would produce a once-for-all drop in the interest rate to a new level as in chart 10.3.

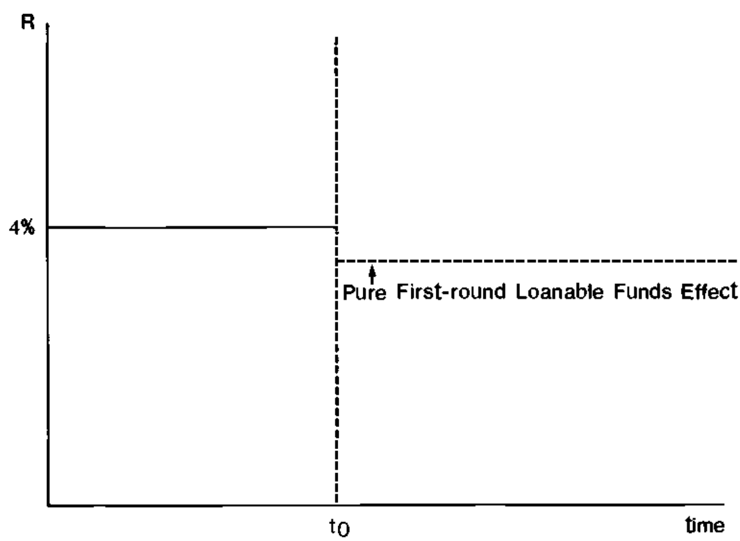


Chart 10.3 Pure first-round lonable funds effect on the interest rate of an increase in the rate of monetary growth.

Note that there are two slips 'twixt the cup and the lip with respect to the first-round effect. The first is that the increase in the quantity of money need not come through an increase in loanable funds. Historically, it has sometimes come through gold discoveries; currently, it is likely to come through government spending. In each case, the first-round effect, as John Stuart Mill stated more than a century ago, will depend on the initial use made of the new money.[12] If, for example, the monetary increase came through gold production, the first-round effect would be not on the flow of loanable funds and interest rates, but on the wages of gold miners and the prices of commodities they bought.[13]

The second slip is that the rise in the supply of loanable funds via money issue may not be a net rise. Whether it is depends on the behavior of the issuers of new money. The new money represents a source of revenue to the issuers, and there is no reason why the issuers would use the whole of the increase in revenue to add to their assets. It seems much more reasonable that they will use revenue from this source in the same way as other revenue. Even if legal or institutional arrangements require the issuers to put the money in circulation by purchasing assets, the issuers can offset the increase in holding of these assets by disposing of other assets, including the equity in the right to issue money. In that case there is no first-round effect on loanable funds at all.

The use of new money to finance government spending can be regarded as a special case of this slip instead of the first. However, this slip has much wider relevance, since it is the key issue in the extensive discussions of forced saving.[14]

On the empirical level, the two components of the impact effect imply different relations. The liquidity effect would produce a relation between the interest rate and the level of the nominal quantity of money or equivalently between the rate of change in the interest rate and the rate of monetary growth; the first-round loanable funds effect, between the

12. "It is perfectly true that . . . an addition to the currency almost always *seems* to have the effect of lowering the rate of interest: because it is almost always accompanied by something which really has that tendency. The currency . . . is all issued in the way of loans, except such part as happens to be employed in the purchase of gold and silver. The same operation, therefore, which adds to the currency, also adds to the loans. . . . Now, though, as currency, these issues have not an effect on interest, as loans, they have." John Stuart Mill, *Principles of Political Economy*, 5th ed. (London: Parker, Son and Bourn, 1862), book 3, chap. 23, par. 4.

13. See J. H. Cairnes, "Essays toward a Solution of the Gold Question," in *Essays in Political Economy* (London: Macmillan, 1873), pp. 1–165.

14. See the discussion by Phillip Cagan, *The Channels of Monetary Effects on Interest Rates* (New York: NBER, 1972), pp. 29–39.

John L. Scadding has examined this issue in greater detail, both theoretically and empirically, and has concluded that the second slip may well eliminate the bulk of any forced saving or first-round loanable funds effect. "Monetary Growth and Aggregate Savings," Ph.D. diss., University of Chicago, 1974, pp. 27–28, 56–58, 61–68.

interest rate and the rate of change of the nominal quantity of money or, equivalently, the rate of change of the interest rate and the acceleration of the quantity of money.[15]

Combined liquidity and loanable funds effects. Of course, the liquidity effect and the loanable funds effect operate together so that charts 10.2 and 10.3 cannot be simultaneously correct—in this simplified analysis there is only one interest rate. The reconciliation is the same as in other problems of capital theory in which demand and supply depend on both levels and rate of change.[16] The liquidity preference curve depicted in chart 10.1 must be treated as a function of the rate of change of the quantity of money—for our present purpose, of the excess of the actual over the anticipated monetary growth rate.

Chart 10.4 shows the demand situation incorporating this effect—the right-hand panel for stocks, the left for flows. The stock demand curve is depicted as a function not only of the level of balances but also of the rate of change (g_M in both panels is to be interpreted as only the unanticipated component of the rate of change). The flow demand is in its turn a function of the level of the stock. A shift of the rate of change of the quantity of money from zero to 5 percent per year produces an immediate decline in the level of interest rates via a downward shift in the stock demand curve to intersect with the vertical monetary supply curve at A'. As the quantity of money grows, the interest rate declines along the new stock demand curve from A' to B', which as before represents the temporary position at the end of a year. In the left-hand panel for flows, the flow demand curve declines as the quantity of money increases, the market interest rate at B' corresponding to a rate of monetary growth of 5 percent. The result is a time pattern of interest rates which reflects simply the super-position of chart 10.2 on chart 10.3, as in chart 10.5.

Intermediate Income Effect

As time passes, the initial impact effects will be superseded by more basic effects. Even though unanticipated, the rising money balances and

15. Cagan in his study of intracycle movements found evidence of the impact effect, in the form of both a negative synchronous correlation between the level of interest rates and short-term monetary growth, and a tendency for the rate of interest to decline for some six months after an acceleration in monetary growth. Cagan interprets his findings as reflecting primarily a portfolio or liquidity effect, with a first-round loanable funds effect playing a definite but secondary role (see Cagan, *op. cit.*, *Channels of Monetary Effects*, chaps. 3, 4, and 7). However, it is not clear that this interpretation is fully satisfactory. See William Poole, *Journal of Political Economy* 82 (May/June 1974): 665–68. Cagan recognizes that the liquidity and loanable-funds effects cannot be distinguished by relating the interest rate to monetary growth, but argues that his analysis distinguishes between them by introducing bank credit as an additional variable.

16. For a full analysis, see Milton Friedman, *Price Theory* (Chicago: Aldine, 1976), chap. 17, pp. 283–322.

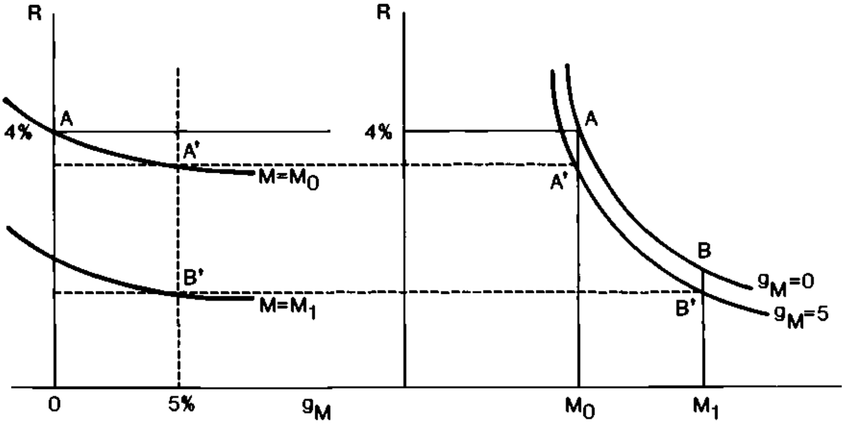


Chart 10.4 Liquidity preference curve as a function of rate of change of quantity of money.

initially lower interest rates will stimulate spending, the spending will affect both prices and output, and these effects will feed back on the demand for money. And sooner or later the increase in the rate of monetary growth will cease to be unanticipated. These effects begin to operate along with the impact effects as soon as the rate of monetary growth changes. However, initially they are negligible and build up only gradually, which is why it is convenient to separate them for purposes of analysis.

The existence and character of the intermediate income effect does not depend on any doctrinal position about the way monetary forces affect the economy. Along strict Keynesian income-expenditure lines, the initial liquidity and loanable funds effects produce lower interest rates, and the lower interest rates stimulate business investment, which in turn has a multiplier effect on spending. Along the broader monetary lines we prefer, the attempt to correct portfolio imbalance raises the prices of sources of service flows relative to the prices of service flows themselves, which leads to an increase in spending on both the service flows and the production of new sources of service flows. Put differently, reported interest rates are only a few of a large set of rates of interest, many implicit and unobservable, that are affected by the changed rate of monetary growth. As a result, higher monetary growth affects a much broader area than on the Keynesian view. In either case, a higher rate of monetary growth will tend, after some lag, to raise the rate of growth of nominal spending and hence nominal income.

For a moment, retain the Keynesian assumption that the whole of the acceleration in nominal income takes the form of an acceleration in output, while prices remain constant. The acceleration in real income will

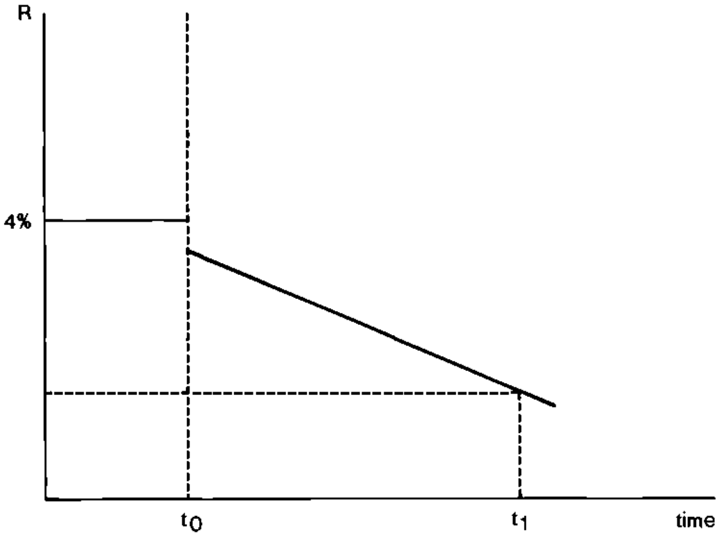


Chart 10.5 Combined impact effect: liquidity plus loanable funds effects on the rate of interest.

shift the liquidity preference curve of chart 10.1 to the right and also raise the demand for loanable funds—that is, it will shift the whole set of curves in the right hand panel of chart 10.4 to the right. These shifts will tend to raise interest rates, counteracting the downward pressure from the liquidity and first-round effects.

Sooner or later the acceleration in nominal income will have to take the form of rising prices, since the initial position was assumed to be one of equilibrium and we have introduced nothing to change the long-run trend of real income. Indeed, the initial acceleration in real income will presumably be followed at some point by a deceleration that brings it below the long-run trend so that the cumulative effect on real income cancels out. However, the qualitative effect on interest rates is the same whether the acceleration in nominal income takes the form of an acceleration in output or in prices. In either case the liquidity preference function, if the horizontal axis is in nominal terms, shifts to the right. If the horizontal axis is in real terms, the rising prices will instead be translated into a slowing or reversal of the right-hand movement of real balances, which also tends to raise interest rates.

The impact and intermediate effects together would, by themselves, ultimately produce a return to the initial rate of interest.[17] The 8 percent

17. As Henry Thornton put it in 1802, "It seems clear . . . that when the augmented quantity of paper shall have been for some time stationary, and shall have produced its full effect in raising the price of goods, the temptation to borrow at five per cent will be exactly the same as before" (*Paper Credit of Great Britain*, pp. 256–57).

rate of rise in money would be matched by an 8 percent rate of rise in nominal income, divided into a 5 percent rate of price inflation and a 3 percent rate of real income growth. Real balances and the real supply of and demand for loanable funds would be at their initial level.

As we know from chapter 2, this is not really a stable long-run equilibrium position because of the price anticipation effect. Even if we continue to abstract from this effect, the time path of interest rates produced by the combination of the impact and income effects would be not the smooth path described by curve *A* in chart 10.6 but the cyclical path involving overshooting described by curve *B*. In the first place, both the initial acceptance of excess balances and the delay between portfolio effects on interest rates and the effect of changes in interest rates on spending will produce an initial lag in the reaction of income. In chart 10.7, similar to chart 2.3 the lag means that, for some time after t_o, nominal income will tend to follow line *C* rather than line *B*. (Note that these lines are not in proper scale; their slopes are exaggerated to make the difference between them more obvious.) This will require a catch-up phase during which nominal income will have to rise more rapidly than 5 percent a year to get to line *B*. The rate of change of nominal income will certainly overshoot, and this may, though it need not, lead to an overshooting of the interest rate as well. Second, the initial unanticipated acceleration in output is likely to be regarded by the public as transitory, as in fact it will prove to be. It will therefore not raise their permanent income proportionately. If, as we have argued, demand for money is related to permanent income,

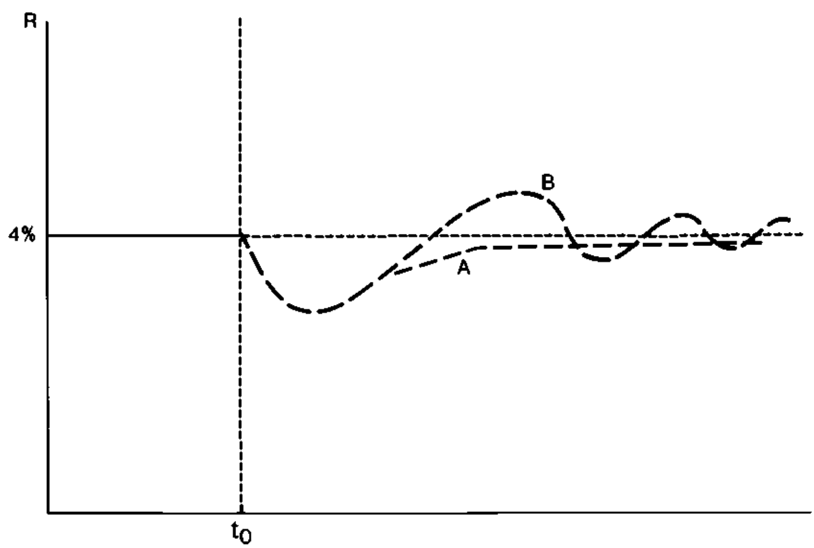


Chart 10.6 Combination of impact and income effects on the rate of interest.

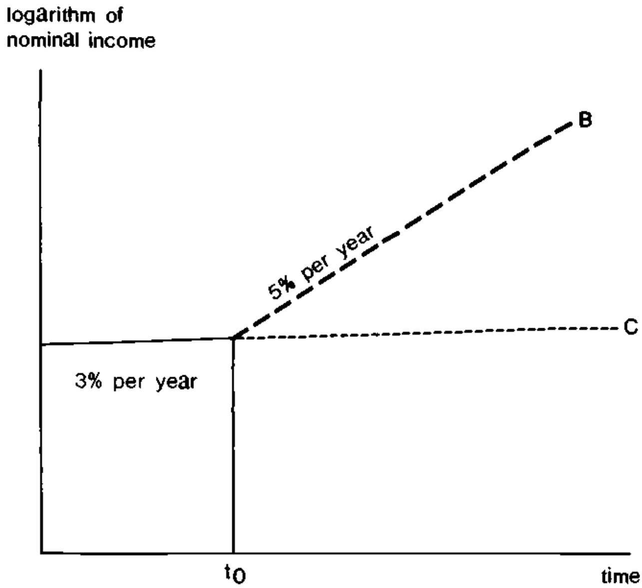


Chart 10.7 Combination of impact and income effects on nominal income.

the liquidity preference curve in charts 10.1 and 10.4 (with the horizontal axis interpreted as the nominal quantity of money adjusted for trend) will initially shift to the right in lesser proportion than the rise in (similarly trend-adjusted) nominal income, though ultimately it will have to shift in full proportion. This will make for a more rapid rise in nominal income and a slower upward effect on interest rates in the initial stages when most of the increase in nominal income is in output.[18] This will contribute to an overshooting in the upward direction of the rate of change of nominal income and subsequently an overshooting in the downward direction. For interest rates, it means a slower recovery from the initial decline and may, though it need not, mean subsequently a rise above the final level.

If, for simplicity, we assume that the reaction pattern of interest rates to a monetary change is independent of the level of interest rates and of past and subsequent monetary change, we can express the composite effect of the impact and intermediate effects in the equation

(1) $$R(T) = R_o + \int_{-\infty}^{T} b(T-T')\, g_M(T')dT',$$

where $R(T)$ is the interest rate at time T and $g_M(T')$, the rate of monetary growth at time T' and where

(2) $$\int_{-\infty}^{T} b(T-T')dT' = 0,$$

18. We are indebted to Michael Darby for this refinement with respect to income.

and

$$(3) \qquad b(T-T') \begin{matrix} < 0 \text{ for } (T-T') < \tau_1 \\ > 0 \text{ for } (T-T') > \tau_1 \end{matrix}$$

if there is no overshooting (curve A in chart 10.6) and

$$(4) \qquad b(T-T') \begin{matrix} < 0 \text{ for } (T-T') < \tau_1 \\ > 0 \text{ for } \tau_1 < (T-T') < \tau_2 \\ < 0 \text{ for } \tau_2 < (T-T') < \tau_3 \\ \cdots\cdots\cdots\cdots \end{matrix}$$

when there is overshooting (curve B in chart 10.6).

Condition (2) assures that the impact and intermediate effects cumulate to bring the interest rate back to its initial position, which so far as we have gone is independent of the rate of monetary growth and is symbolized by R_o. R_o is of course to be regarded not as a numerical constant but as a function of whatever variables other than monetary growth affect the interest rate.

Condition (3) expresses the initial negative influence of the liquidity and first-round effects and the subsequent positive income effect, and condition (4) expresses these plus the subsequent cyclical adaptation mechanisms. τ_1 is the time delay between the acceleration of monetary growth and the subsequent initial trough of the interest rate (or the deceleration and subsequent initial peak).[19]

Price Anticipation Effect

When, in our example, prices are rising at 5 percent a year, the public will sooner or later come to anticipate the price rise. As a result, the 4 percent initial interest rate can no longer be the equilibrium rate. We can no longer neglect the distinction to which Irving Fisher called attention between the nominal rate of interest and the real rate of interest. Initially both equaled 4 percent. If the nominal yield were to stay 4 percent, the real yield would be −1 percent. Nothing has happened in the real sector, in the tentative equilibrium resulting from the impact and income effects alone, to reduce the equilibrium real yield. As the inflation come to be anticipated, lenders will come to demand higher interest rates and borrowers will be willing to pay higher interest rates. The nominal interest rate must rise above its initial level.[20]

19. Cagan in his study has tried to estimate an equation like equation (1) and has concluded that τ_1 is of the order of magnitude of six months and that the sum of the weights first totals zero, that is, the interest rate returns to its initial level, after about fifteen months. Cagan, *Channels of Monetary Effects*, p. 102.

20. As Henry Thornton put it in 1811, "Accordingly, in countries in which the currency was in a rapid course of depreciation, supposing that there were no usury laws, the current rate of interest was often . . . proportionably augmented" (speech, 7 May 1811, in the debate in the House of Commons on the Report of the Bullion Committee, in Thornton, *Paper Credit of Great Britain*, appendix 3, p. 336).

More formally, designate the nominal interest rate on nominal assets by R, the real interest rate on nominal assets by ρ, the rate of change of prices by g_P. Then the real yield actually realized after the event, the ex-post real yield,[21] will be

(5) $$\rho = R - g_P.$$

R is observed directly in the market. It corresponds to the yield to maturity of a security with specified maturity and interest payments if it is purchased at the market price. ρ is not observable in the market at the time the security is purchased. It can be calculated only after the event, when the security has matured and the rate of price rise over its life is known. Hence ρ cannot be a variable that directly influences behavior. What influences behavior is the *anticipated* real yield, or

(6) $$\rho^* = R - g_P^*,$$

where g_P^* is the rate of price change anticipated over the period to the maturity of the security to which R refers.

Note that a whole spectrum of equations like equations (5) and (6) exists at any point in time, one for each possible maturity. For convenience, we can treat these equations as referring to some standard maturity or, alternatively, to a maturity approaching zero as a limit, so they refer to a continuous rate of yield at a moment of time. The important consideration in any calculation of nominal and real yields is that the price change refer to the same period as the holding period for the security. As the term "holding period" suggests, the yield can be calculated for a period less than the stated maturity of a security. However, in that case the price of the security at the end of the holding period will also affect the yield and will, like the price change, generally not be a known quantity at the initial date. It too, like the rate of price change, will have to be determined ex post or treated as an anticipated magnitude.

In our example, initially

$$R = \rho = \rho^* = 4 \text{ percent.}$$

When the public comes to anticipate the 5 percent price rise, R will have to be higher than initially, and R will have to differ from ρ and ρ^* by 5 percentage points. The precise terminal value of R—whether it is 9 percent or higher or lower —depends on what happens to ρ^*. Will it remain 4 percent?

To answer this question we must examine the effect of the higher value of R on cash balance holdings. The higher value of R makes interest-bearing nominal assets more attractive relative to non-interest-bearing money and so will tend to reduce the real value of cash balances held: at the terminal position, velocity will be higher than at the initial position.

21. Equation (5) is exact only for continuous compounding.

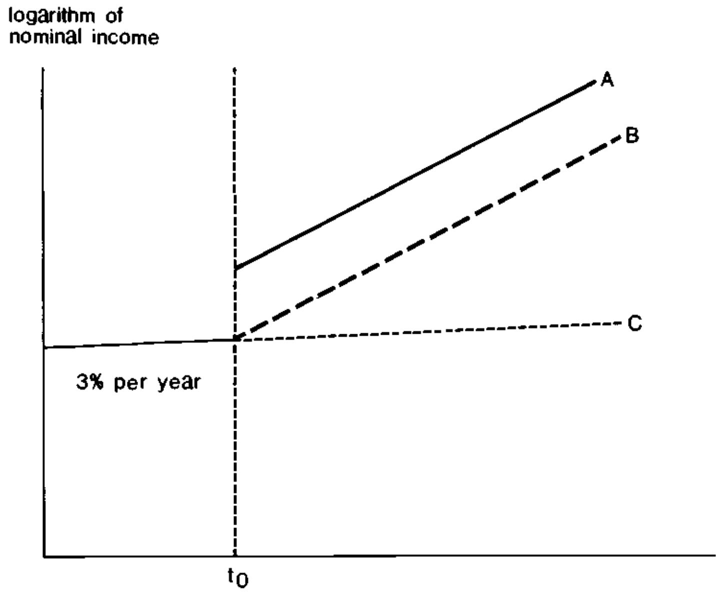


Chart 10.8 Effect of an increase in rate of monetary growth on the equilibrium path of nominal income.

The higher velocity has a number of important effects. In the first place, as we pointed out in chapter 2, the equilibrium path of nominal income will not be line *B* in chart 10.7 but line *A* in chart 10.8, parallel to *B* but higher (like chart 10.7, chart 10.8 is not drawn to scale). This in turn means that income will at some time or other have to overshoot its ultimate equilibrium rate of growth for a more basic reason than those cited earlier.

In the second place, and more important for our purpose, if terminal real nonhuman wealth held in nonmonetary form were the same as initially, total real nonhuman wealth would be less. The purely monetary disturbance we have assumed which produces a steady anticipated inflation has the *real* effect of lowering the equilibrium real wealth held in the form of money.[22] The reduction in real balances would in turn lead to an increase in other forms of real nonhuman wealth, either as a substitute for some of the cash balances that served as a productive resource or as a replacement for some of the cash balances held by ultimate wealth holders. Robert Mundell has argued that the result would tend to be a lower real yield on capital. However, that is by no means clear on a purely theoretical level. Everything depends critically on the determinants of the wealth/income ratio desired by ultimate wealth holders. For example,

22. See M. Friedman, *Optimum Quantity of Money*, and Robert Mundell, "Inflation and Real Interest," *Journal of Political Economy* 71 (June 1963): 280–83.

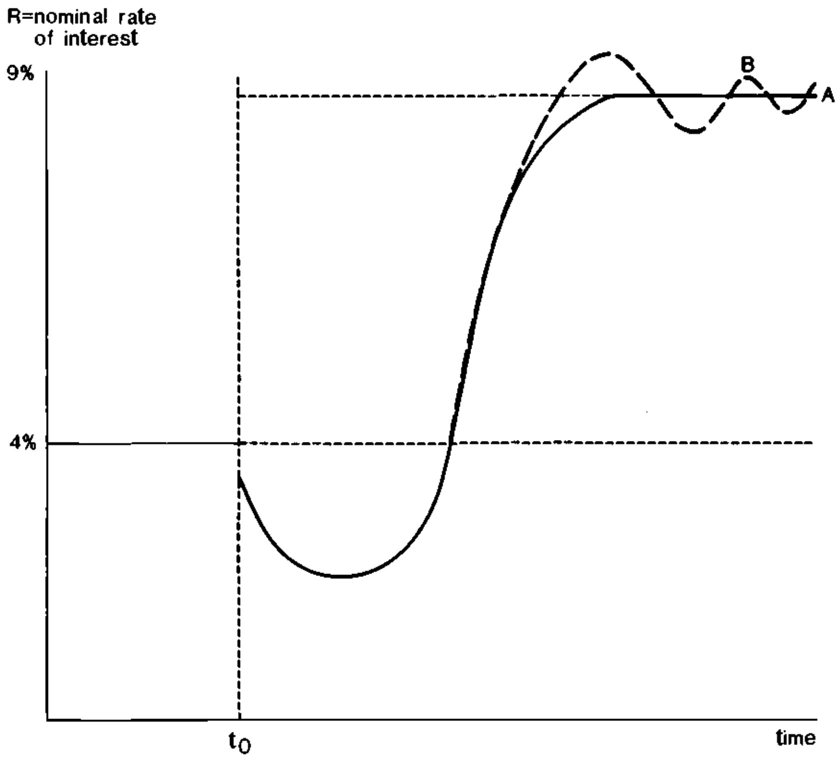


Chart 10.9 Full effect of an increase in monetary growth on the nominal interest rate.

if they have a constant internal rate of discount when in wealth equilibrium, the ultimate result would be a higher real level of nonmoney nonhuman wealth, but a sufficiently lower real level of total nonhuman-wealth that the yield of the smaller amount of now less productive capital would be the same as before.[23]

If the real rate were unaffected by inflation, the final pattern of interest rate behavior for our example would be as depicted in chart 10.9, with curve *A* showing a monotonic ultimate approach to the final equilibrium, curve *B*, a cyclical approach.

Equation (1) could still be used to describe the composite effect of the anticipation effect as well as the impact and intermediate effects, but equation (2) would change, since the integral would equal unity instead of zero, so that a permanent increase in $g_M(T)$ by unity in equation (1) would ultimately raise the interest rate by unity. For some purposes, it

23. An even more bizarre possibility is that nonhuman nonmoney capital is sufficiently complementary with money balances that nonhuman nonmoney capital must decline along with real money balances to keep the yield constant.

might be useful to keep separate the impact and intermediate effects from the price anticipation effects by writing the equation for the interest rate as

(7) $$R(T) = R_o + \int_{-\infty}^{T} b(T - T')\, g_M(T')dT' + \int_{-\infty}^{T} c(T - T')g_M(T')dT',$$

where

(8) $$\int_{-\infty}^{T} b(T - T')dT' = 0$$

and

(9) $$\int_{-\infty}^{T} c(T - T')dT' = 1\ .$$

Conditions (3) or (4) would apply to the b function, but it is not easy to write corresponding conditions for the c function, since that depends on how monetary change is incorporated into price anticipations, a subject yet to be considered. In this form, R_o equals the real interest rate plus the hypothetical rate of inflation when the monetary growth rate is zero.

The terminal value of ρ^* might be less than the initial value, in which case the terminal value of R would be above the initial value by less than the rate of inflation. In that case the final pattern of interest rate behavior for our example would be as depicted in chart 10.9 except that curves A and B would both be lowered somewhat. It is more difficult to alter the equations in any simple way because there is no reason why the shortfall from unity in equation (9) should be the same for all rates of monetary growth.

The effect of moderate rates of anticipated inflation on the real rate is likely in practice to be negligible. Non-interest-bearing money is a small fraction of total wealth.[24] Even a substantial reduction in real balances would amount to a small reduction in total nonhuman wealth. In addition, the real yield on capital is almost surely highly insensitive to the size of the stock of capital, that is, the demand on the part of producing enterprises for the real stock of capital is highly elastic. That is the implication of the rather stable real rate of interest realized on the average over long periods of time. We conclude that the theoretically possible effect of anticipated inflation on the equilibrium real rate of interest can be neglected and the real rate regarded as unaffected by *anticipated inflation*.[25]

24. For the United States, M_2 in 1979 was roughly about six months' national income, M_1 was less than three months' national income, and high-powered money was about two-thirds of one month's national income. Total nonhuman wealth is typically something like three to five years' national income, so at most M_2 would be about one-sixth of total wealth, M_1 about one-twelfth, and high-powered money about one-fortieth.

25. A formal theoretical analysis that presents an explicit model leading to results such as those in chart 10.9 and equations (8) and (9) is developed in Dean G. Taylor, "The Effects of Monetary Growth on the Interest Rate," Ph.D. diss., University of Chicago, 1972.

A more important practical complication is taxation. Currently in the United States, nominal interest payments are taxed to the recipient and deductible in computing taxable income to the borrower. For the real after-tax yield to the lender to be unaffected by anticipated inflation, the differential between the nominal and real yield must exceed anticipated inflation by an amount that depends on the relevant marginal tax rate. If the marginal tax rate is t, the differential must be $1/(1-t)$ times anticipated inflation. If the borrower is subject to the same marginal tax rate as the lender and is permitted to deduct interest payments in computing taxable income, the same differential keeps the net real rate paid unchanged.[26] With the present high marginal rates of tax, the effect is potentially of considerable quantitative significance. For example, at a 50 percent rate, the differential between the real and nominal rate would have to be twice the anticipated rate of inflation to keep the real rate unchanged.[27]

Unanticipated inflation or, even more important, highly variable inflation is a different matter and almost surely is capable of having a major effect on real yields. Unanticipated inflation makes the ex-post real yield differ from the ex-ante real yield and hence makes the real yield obtained from physical capital differ from the real yield to holders of financial securities, particularly fixed interest securities. "The" real yield no longer has any meaning, even if we continue to neglect problems raised by

26. There has been much recent discussion of this issue. See Michael Darby, "The Financial and Tax Effects of Monetary Policy on Interest Rates," *Economic Inquiry* 13 (June 1975): 266–76; Jack Carr, James E. Pesando, and Lawrence B. Smith, "Tax Effects, Price Expectations and the Nominal Rate of Interest," *Economic Inquiry* 14 (June 1976): 259–69; Martin Feldstein, "Inflation, Income Taxes and ihe Raie of Interest: A Theoretical Analysis," *American Economic Review* 66 (December 1976): 809–20; Vito Tanzi, "Inflation, Indexation and Interest Income Taxation," *Banca Nazionale del Lavoro Quarterly Review*, no. 4 (1975), pp. 319–28; Arthur E. Gandolfi, "Taxation and the 'Fisher Effect,'" *Journal of Finance* 31 (December 1976): 1375–86. John A. Carlson, "Expected Inflation and Interest Rates," *Economic Inquiry* 17 (October 1979): 597–608, examines empirical evidence on the tax effect, finding some evidence of its existence during the 1960s, much less evidence for the 1950s and 1970s. In general the existence of the theoretically expected tax effect has evaded the several efforts to isolate it and, as yet, no satisfactory explanation for the failure has been forthcoming.

In an unpublished paper, Arthur E. Gandolfi has examined the effect of different income, capital gains, and depreciation tax arrangements and has concluded that the existence or nonexistence of the tax effect may depend on the specific tax arrangements. This is a matter on which much further work can be expected.

27. Vito Tanzi, "Inflation and the Incidence of Income Taxes on Interest Income: Some Results for the United States, 1972–74," *IMF Staff Papers* 24 (July 1977): 500–513, calculates the interest rates persons in various income brackets would have had to receive in 1972, 1973, and 1974 to have realized a zero net real return after allowing for inflation and taxes, and the net gain or loss because of the tax treatment—gain to debtors, loss to creditors. He concludes that, while actual interest rates in 1972 yielded positive net real returns to creditors in most income brackets, they did not do so for high income groups in 1973 and did so for almost no groups in 1974. He finds that middle-income groups are net debtors and therefore gained from the tax treatment; lower- and upper-income groups are net creditors and therefore lost.

different maturities, different degrees of default risk, and so on. These effects are reinforced if inflation is both high on the average and highly variable, even if the *average* rate is largely anticipated. Highly variable inflation tends to destroy financial intermediation, rendering the capital market both limited and inefficient—a tendency that is in practice strongly reinforced by government controls and restrictions on financial transactions. As a result, not only may the yield to the holder of securities deviate widely from the yield on the physical capital to which the securities are linked, but also the real yield on physical capital may differ widely from one enterprise or industry to another.

Unanticipated inflation has been important for the United States and the United Kingdom for the period we cover, but not highly variable inflation. Highly variable inflation has been much more important for less developed countries, particularly in South America. However, highly variable inflation has more recently plagued the United Kingdom and the United States as well.

The general effect of anticipated inflation on nominal interest rates is apparent from comparisons across countries: nominal interest rates are invariably higher in countries that have experienced substantial inflation for some time than in countries that have not. But the precise relation is much more difficult to pin down. The major problem is the difference between actual and anticipated inflation, so that any analysis requires combining a hypothesis about the formation of anticipations with a hypothesis about the behavior of real rates and the relation between real and nominal interest rates.

If price change were perfectly and instantaneously anticipated, rapid rates of price rise would be associated with high nominal interest rates and low rates of price rise with low nominal interest rates, but there would be no correlation between high prices and high interest rates or between rising prices and rising interest rates; yet the Gibson paradox is the allegation that such a correlation does exist.

Chart 10.10 illustrates this point. Suppose that the historical record of prices were the one plotted, where the ordinate is the logarithm of price so that straight lines correspond to constant rates of price change. If this price pattern were fully anticipated and were the only factor altering the nominal interest rate, the nominal interest rate would be high for periods a and c and low for periods b and d, as shown by the dashed steps. The difference in height between the two steps would be the rate of inflation in steps a and c plus the rate of deflation in steps b and d. There would be no correlation between the level of prices and the level of interest rates: half the time, a high interest rate would be associated with an above-average price level; half the time, with a below-average price level; and similarly for low interest rates. There would be perfect correlation between the level of interest rates and the rate of change of the price level.

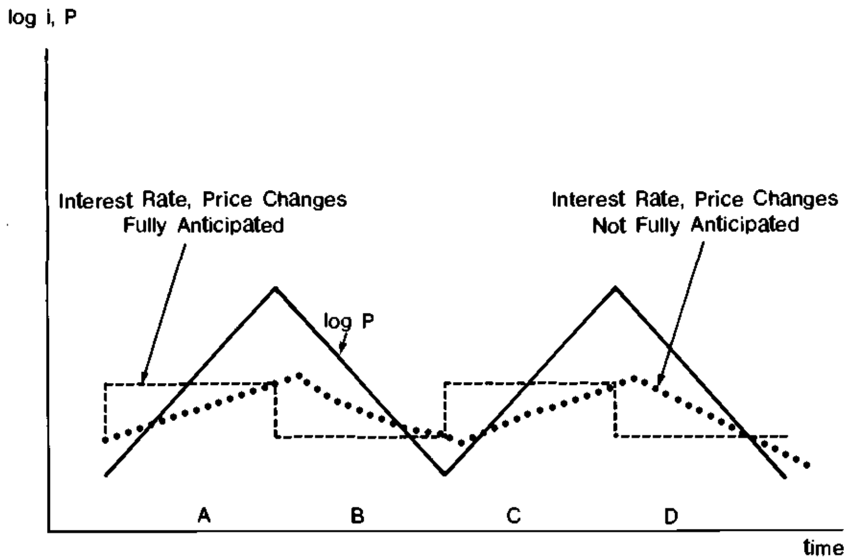


Chart 10.10 The effect of perfectly and imperfectly anticipated price changes on the interest rate.

This description applies rigorously only to the continuous interest rate at a moment of time. For a finite maturity, the interest rate at any point in time would reflect the rate of price change expected over the period from then to maturity. If price changes were correctly anticipated, the interest rate would equal a moving average of the step function in chart 10.10, the length of the average would be equal to the maturity, and the average would be plotted at the *initial* date of the moving average. The result would be to smooth the step function and to shift its turning dates earlier.

The actual relation, as we shall see below, is more like the wavy dotted line in chart 10.10 than like the step function. The turning dates are in practice shifted later, not earlier. To explain this pattern requires introducing discrepancies between actual and anticipated inflation, or movements in real interest rates, or some combination of the two. The particular explanation of this phenomenon, termed the Gibson paradox by J. M. Keynes, that has received most attention is the one offered by Irving Fisher. It combines an assumed rough constancy in the real rate with a lagged adjustment of price anticipations to the actual price movement. We shall discuss his and other explanations in greater detail in section 10.7, after we have first established in sections 10.2 through 10.6, as best we can, the phenomena to be explained.

10.1.2 Real Disturbances

The monetary disturbances analyzed in the preceding section have systematic effects on real interest rates. An unanticipated acceleration in monetary growth to a new steady rate produces at first a decline in the ex-post real instantaneous rate realized by lenders, then a rise, and ultimately a return roughly to its initial level. In the interim the ex-post real rate is likely to fluctuate above and below that level. The ex-ante real rate follows a similar qualitative course, but the timing may be quite different. The ex-post and ex-ante real rates on loans of different durations will tend to be appropriately weighted averages of the instantaneous rates.

It would be gratifying to be able to present a parallel systematic analysis for real disturbances. However, there is no way to do so because the pattern of effects on nominal and real interest rates depends on the character of the real disturbance. For that reason this section will be briefer and vaguer than the preceding and purely illustrative.

Compare for example, two hypothetical real disturbances: first, a Wicksellian or Schumpeterian surge of innovations that raises the real yield on a wide range of physical capital; second, innovations in the use of cash balances of the kind Irving Fisher expected to produce an upward trend in the transactions velocity of circulation of money. Initially, for both, assume given monetary conditions in the sense of a given rate of monetary growth.

A Surge of Innovations Raising the Yield on Physical Capital

An upward shift in the stock demand for capital in response to a surge of innovations will be accompanied by a similar shift in the flow demand curve for investment funds that will tend to raise nominal interest rates, which, in turn, will tend to raise the velocity of circulation of money. As in response to a monetary disturbance, this effect will be spread over time. The higher velocity will mean for a time a more rapid rise in nominal income which, given that it is unanticipated, will initially be reflected primarily in greater output rather than in prices. At this stage the rise in the nominal interest rate will be accompanied by a rise in both the ex-post and the ex-ante real rates. As time passes, the higher nominal income will be translated into higher prices, output will decline to its earlier level and, for a time, below it. Ex-post real rates will decline as the price adjustment occurs and may fall below the initial level. However, the rise in velocity is a once-for-all effect. There is nothing in the process so far considered to produce a continuing rise in velocity. Hence, when velocity has adjusted, prices will resume their prior rate of change, and the differential between nominal and real interest rates will return to its prior level. Both nominal and real interest rates will continue at higher than initial levels until the increased stock demand for physical capital is gradually satisfied by the higher savings called forth by the higher interest rate, possibly reinforced by saving out of the higher income generated by the assumed surge of innovations.[28] Depending on the wealth-holding preferences of the community, interest rates may ultimately return to their initial level or may settle at a higher or, possibly, even a lower level.

For our purpose, the important phenomenon is that the real disturbance produces an initial rise, then a later decline in nominal and real interest rates, with all sorts of possible detours in between.

A different monetary system, of the kind assumed by Wicksell, for example, would alter the results in detail but not in broad outline. In Wicksell's model, the initial rise in the "natural" rate would be resisted by banks, which would lead to a rise in the initially assumed rate of monetary growth, thereby partly reinforcing, partly offsetting the rise in velocity. But this effect too would tend to be a once-for-all phenomenon rather than a continuing process.

A Surge of Innovations in the Use of Cash Balances

The initial effect on interest rates of a surge of innovations in the use of cash balances (e.g., faster computer clearing, reducing average balances required) would be precisely the opposite of the Wicksellian surge of innovations. The innovations would have the same effect as more rapid monetary growth, tending to lower nominal interest rates through the attempt of holders of now-redundant cash to acquire interest yielding assets. Velocity would tend to rise as in the preceding case, but the rising velocity would itself be an autonomous force, not a response to a higher interest rate, and so would tend simultaneously to make for higher prices, as in the preceding case, but lower interest rates. If we assume, with Fisher, an upward *trend* in velocity rather than a once-for-all shift, the effects on interest rates would be precisely the same as that attributed in the preceding section to an increase in the rate of monetary growth, which means that ultimately nominal interest rates would settle at a permanently higher level, though real interest rates would return to their initial level.

The response of interest rates to this surge of innovations is very nearly the reverse of the pattern in response to the Wicksellian surge.

Perhaps this comparison will explain why we do not embark on a detailed analysis of real disturbances comparable to our earlier discussion of the effect of a more precisely specifiable monetary disturbance. We shall consider real disturbances further in section 10.7, which examines alternative explanations of the Gibson paradox.

10.1.3 Conclusion

The preceding general theoretical analysis of this chapter will perhaps prepare readers for a major feature of the empirical findings that follow:

28. The exact process is highly complicated. See M. Friedman, *Price Theory*.

the complexity of the behavior of interest rates and the difficulty of identifying any simple and consistent pattern connecting interest rates with price levels, rates of price change, or rates of monetary growth. Because interest rates connect the future with the present, they are necessarily sensitive to judgments about the future, about the formation of which we have little confirmed knowledge. Because interest rates connect large stocks to relatively small flows, they can display wide variations as a result of apparently trivial changes. Because they connect holders of financial assets to holders of physical assets, they are sensitive to the process whereby nominal and real magnitudes are linked. Finally, the same disturbance can have effects in opposite directions over different periods of time, so the observed behavior of interest rate is sensitive to variations in the reaction time of different groups in the population.

Like prices and money, interest rates are a pervasive and crucial phenomenon entering into every aspect of economic activity. But the special features just mentioned make their empirical behavior an even more challenging subject of scientific study.

10.2 Average Yields

Table 10.1 summarizes the average yields for over a century on various categories of assets. For this purpose we have used three measures of yield: (1) a short-term rate—the rate on commercial paper (sixty to ninety days through 1923, four to six months since) for the United States and the rate on three-month bank bills for the United Kingdom; (2) a long-term rate—the yield to maturity on high-grade corporate bonds for the United States and the consol yield (coupon divided by price) for the United Kingdom; (3) the proxy for the nominal yield on physical assets that we used in chapter 6 (g_Y)—namely, the rate of change of nominal income.[29] We shall, for simplicity, refer to this proxy as "the yield on physical assets."

For the more than a century that our data cover, the several average yields display a relation consistent with expectations from earlier studies.

1. For both the United States and the United Kingdom, the short-term nominal yield is less than the long-term nominal yield—by 0.68 percent-

29. For the United States we have experimented also with the two other interest rates on nominal assets: the call money rate and the basic yield on long-term bonds. The results largely duplicated those for the two in table 10.1: hence we have omitted them.

For the proxy yield, and also the rates of change of prices and money, we have departed from our usual procedure of calculating them from exponential trends fitted to triplets of phases. Instead they are calculated as the average of the annual rates of change within phases. The reason for this departure is to make them as closely comparable as possible to the matching interest rates. Interest rates are initially observed as rates, hence their phase averages are derived solely from rates within the several phases. Our notation for these rates of change is $g_Y.A$, $g_P.A$, and $g_M.A$.

age points for the United States, 0.77 for the United Kingdom. This difference presumably reflects a liquidity premium that various more detailed studies of the term structure of interest rates have shown to exist.[30]

2. For both the United States and the United Kingdom, the nominal yield on physical assets is between the nominal yields on short- and long-term securities—about halfway between for the United States, close to the long yield for the United Kingdom. In that mythical stationary state in which arbitrage between physical and nominal assets is effective, all assets of the same maturity and risk would provide the same return. These results therefore add to our confidence that g_Y can be treated as an approximation to the nominal yield on physical assets, and also that the physical assets for the yield on which it proxies are intermediate in maturity and risk between short- and long-term securities. As we shall see later, this equality does not hold for short periods. Indeed, the difference between the nominal yield on nominal assets and the nominal yield on physical assets is a sensitive index of economic conditions.

3. The nominal yields average about 0.5 percentage points higher for the United States than for the United Kingdom—0.68 points for the short rate, 0.59 points for the long rate, 0.33 points for the yield on physical assets. However, United States and United Kingdom yields are not directly comparable because of changes in the exchange rate. The price of the pound in dollars at the end of the period was lower than at the beginning, the rate of decline averaging 0.94 percent per year. Hence, a hypothetical long-lived Englishman who had purchased United States assets at the beginning of the period, held them throughout the period, and converted them back to pounds at the end of the period would have earned in pounds 0.94 percentage points more than the nominal United States yield given in table 10.1. Alternatively, an American who did the same with United Kingdom assets would have earned in dollars 0.94 percentage points less than the nominal United Kingdom yield. The

30. The literature on the term structure is immense. The most careful examinations of the existence of a liquidity premium are perhaps Reuben Kessel, *The Cyclical Behavior of the Term Structure of Interest Rates*, Occasional Paper 91 (New York: NBER, 1965); Phillip Cagan, "A Study of Liquidity Premiums on Federal and Municipal Government Securities," in *Essays on Interest Rates*, vol. 1, ed. P. Cagan and J. Guttentag (New York: NBER, 1969), pp. 107–42. These authors view the liquidity premium as reflecting the value of the services of short-term securities as substitutes for money balances. An alternative view is that long-term securities carry a yield premium, given an aversion to the risk of capital losses, resulting from a general belief that interest rates return to their "normal" level over the long run, with higher yields on long- relative to short-term securities when interest rates are relatively low because long securities are then especially subject to capital losses, and the converse when rates are high. For this view see J. Van Horne, "Interest-Rate Risk and the Term Structure of Interest Rates," *Journal of Political Economy* 73 (August 1965): 344–51; Franco Modigliani and Richard Sutch, "Innovations in Interest Rate Policy," *American Economic Review* (May 1966): 195–96.

Table 10.1 **Nominal and Real Ex-Post Yields: Averages, Standard Deviations, Correlations for All Phases and All Nonwar Phases**

	Yields							
	All Phases				All Nonwar Phases			
	United States		United Kingdom		United States		United Kingdom	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
Number of Phases	49		37		43		31	
	Means (Percentage Points)							
Nominal assets								
Short-term rate	4.15	2.62	3.47	0.88	4.41	3.83	3.77	2.54
Long-term rate	4.83	3.29	4.24	1.66	5.02	4.43	4.38	3.15
Physical assets								
Yield[a]	4.53	3.00	4.20	1.62	3.48	2.90	3.17	1.94
Rate of price change[a]	1.54		2.58		0.58		1.23	
Rate of monetary growth[a]	4.97		4.10		3.81		2.83	
Rate of change of exchange rate[a]			−0.94				−0.21	
	Standard Deviations (Percentage Points)							
Short-term rate	1.80	4.26	2.15	4.87	1.58	3.20	2.12	3.26
Long-term rate	1.31	4.14	2.14	4.68	1.20	3.23	2.33	3.08
Yield on physical assets	5.82	3.61	5.04	2.63	5.24	3.53	4.61	2.12
Rate of price change	3.72		5.26		2.98		4.16	
Rate of monetary growth	4.79		5.22		3.98		4.50	
	Correlation Coefficients							
Short-term and long-term rates	.908**	.981**	.893**	.979**	.873**	.970**	.926**	.963**
Short-term rate and yield on physical assets	−.136	−.285	.318	.294	−.022	−.336*	.505**	−.052
Long-term rate and yield on physical assets	−.164	−.265	.457**	.355*	−.071	−.301	.604**	.023

[a]See footnote 29 of text for method of calculation of phase rates of change of nominal income (i.e., nominal yield on physical assets), prices, money, and the exchange rate of the pound for dollars.
*Significantly different from zero at .05 level.
**Significantly different from zero at .01 level.

difference between the yields in the two countries measured in comparable terms is therefore roughly 1.27 to 1.62 percentage points rather than 0.33 to 0.68 percentage points. This difference is consistent with the net outflow of capital from the United Kingdom to the United States for much of the period, offset not by private return flow induced by interest rate differentials but by government repatriation of capital during World Wars I and II.

4. The ex-post real yield has been calculated from the nominal yield for all three categories of assets simply by subtracting the rate of change of prices (the implicit price index); hence the relation among the three ex-post real yields is the same as the relation among the nominal yields. However, as between the two countries, the real yields are directly comparable. No further adjustment for exchange rate changes is required because all yields are, as it were, expressed in the prices, and hence exchange rate, of a given base date. The difference between the two countries is 1.74 percentage points for the short rate, 1.63 for the long rate, and 1.38 for the yield on physical assets, somewhat higher than the differentials estimated in the preceding paragraph. The differentials are somewhat higher because the excess rate of rise of prices in the United Kingdom of 1.04 percentage points per year is slightly higher than the 0.94 percentage point per year decline in the exchange rate. The near-identity of these two numbers is to be expected from the theory of purchasing power parity. The United Kingdom's shift from a capital-exporting to a capital-importing country might have been expected to make the excess rate of rise of prices greater than the rate of decline in the exchange rate, and, according to our estimates, this is what happened (see sec. 6.8).

5. The average real yield varies from 2.6 to 3.3 percent for the different categories of assets for the United States, from 0.9 to 1.7 percent for the United Kingdom.

6–9. Excluding the wartime phases, which reduces the period covered from 103 years to 88 for the United States and from 102 to 87 for the United Kingdom, has a minor though systematic effect on the results.

6. The excess of long rates over short rates is reduced slightly, from 0.7 percentage points for the United States and 0.8 for the United Kingdom to 0.6 for both countries.

7. The differential between the two countries remains about 0.5 percentage points for nominal yields unadjusted for the change in the exchange rate and about 1.25 percentage points for real yields. Since exchange rate changes were greatest in wartime phases, the decline in the price of the pound in dollars in nonwar phases was 0.21 percent per year, only about a fifth of the decline over the full period.

8. The major change is that the yield on physical assets is decidedly

lower for the nonwar phases alone than the yield on both short- and long-term nominal assets—roughly one percentage point lower than the short rate. The major reason is that the war phases are inflationary phases. More than half the average rate of inflation for the period as a whole is accounted for by the wartime phases. Prices in the United States rose on the average by 0.58 percent per year during the nonwar phases alone, compared with 1.54 for the period as a whole, and in the United Kingdom by 1.23 percent per year compared with 2.58. As we shall see below, yields on physical assets have tended to be higher than yields on nominal assets during inflationary periods and lower during deflationary periods. A secondary reason is the deliberate government policy of holding down interest rates during World War II, so that the average nominal yields on nominal assets are higher during nonwar phases than during all phases, while our measure of the nominal yield on physical assets is lower.

9. The changed difference between the return on nominal and physical assets reflects primarily a different behavior in war and nonwar phases of the returns on nominal, not on physical assets. The nominal return on physical assets is higher for all phases than for all nonwar phases by roughly the differential rate of inflation, so that the real return on physical assets is about the same for all phases as for nonwar phases only. By contrast, the nominal return on nominal assets is about the same for all phases as for all nonwar phases, so that the real return is appreciably less for all phases. The wartime periods simply highlight a point that we shall examine below for other periods: yields on nominal assets for the most part behave as if price changes up or down were unanticipated.

We have included in the table the average rate of change of the quantity of money, both as something of an alternative proxy for the nominal yield on physical assets and because our major interest is the relation of monetary growth to interest rates. We know from earlier chapters that the rate of monetary growth is closely related to the rate of growth of nominal income, and that is about all these averages show.

Table 10.1 also gives measures of the variability of the yields from phase to phase. The most interesting feature of these standard deviations is that, whereas for nominal assets nominal yields are less variable than real yields, the reverse is true for physical assets. The reason is straightforward. The nominal yields on nominal assets, at least as measured here (see further discussion of holding period yields below), are contracted in advance; they are both ex post and ex ante. They are affected by anticipated price changes but not by unanticipated price changes. The ex-post real yield reflects in full the unanticipated price changes, and the high variability of the ex-post real yield indicates that the actual price changes have been largely unanticipated. For physical assets, on the other hand, neither the nominal nor the real yield, as measured here, is contracted in advance. Both are subject to random variation. However, price changes affect both cost and return on physical assets; there is a measure of automatic indexing, as it were. Hence, the real yield tends to be less variable than the nominal yield.

The bottom section of table 10.1 shows the correlation between the various yields. Short- and long-term yields on nominal assets both real and nominal are highly correlated for both countries. The correlations between yields on nominal and physical assets, both real and nominal, show an interesting difference for the two countries. For the United States they are consistently negative, though generally not significantly different from zero; for the United Kingdom, seven out of eight are positive, and four are sufficiently large to differ significantly from zero. However, all correlations for both the United States and the United Kingdom are lower in size than between short and long nominal rates.[31] However adequate the arbitrage between physical and nominal assets may be over a century, it appears to be weak for periods as short as a phase—which highlights one of the key problems requiring attention.

10.3 A Digression on the Measurement of Yields

The precise time reference of the yields for individual phases and, connected with that, their ex-post or ex-ante character, is not important for averages for long periods but is important for correlations, standard deviations, and the analysis in the rest of this chapter of relations over briefer periods.

Consider, first, *nominal yields on nominal assets*. The basic observations averaged to obtain the rates we have used are the yield to maturity calculated from the market price of a security at a point in time. That is both the ex-ante and the ex-post yield for a purchaser of the security who holds it to maturity. It is neither for a purchaser who intends to hold it or does hold it for a shorter period. For such a purchaser, the yield depends also on the price of the security when it is sold. For our purposes, this difference between holding period yield and yield to maturity can safely be neglected for commercial paper or bank bills, since our basic observations are averages for a year, and we further average these into phase averages, so the timing problem is trivial.[32] For long-term bonds the

31. All correlations between real yields have an upward statistical bias, because the same value of g_P is subtracted from the two yields correlated. Insofar as g_P is incorrectly measured, this introduces a common statistical error into both variables.

32. As a check on this presumption, we calculated for the United States the correlation from 1926 to 1974 for annual data between the annual holding-period yield on Treasury bills, as calculated by Ibbotson and Sinquefield, and the commercial paper rate. Despite the difference between the two securities, the correlation is .988. We do not use the Treasury bill series in our analysis because it is available for only part of the period we study. See Roger C. Ibbotson and Rex A. Sinquefield, "Stocks, Bonds, Bills, and Inflation: Year-by-Year Historical Returns (1926–1974)," *Journal of Business of the University of Chicago* 49, no. 1 (January 1976): 11–47.

In addition, we have experimented for the United States with the use of call money rates, which are one-day rates. The correlation with the commercial paper rate is high.

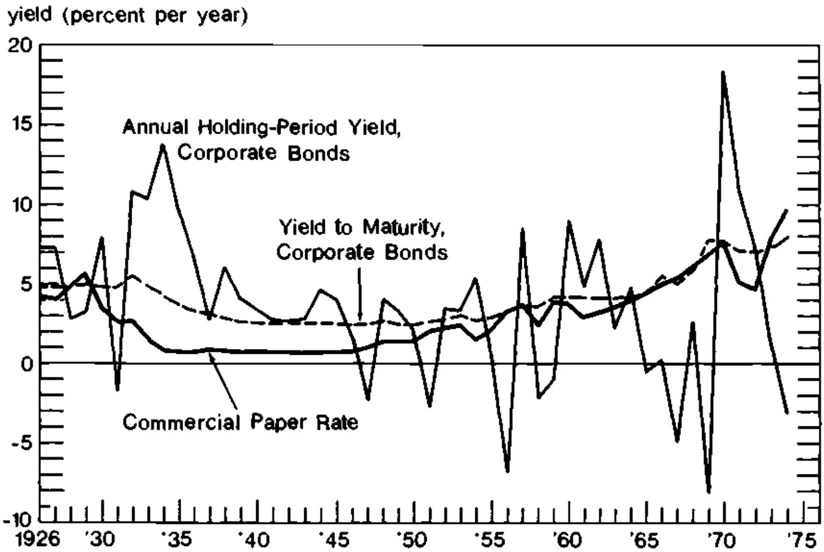


Chart 10.11 Nominal yields on nominal assets for annual holding periods and to maturity, annually, United States, 1926–74.

difference is far from trivial, since the period to maturity is substantial relative to the time units we use in our analysis. Chart 10.11 indicates the difference for annual data for the United States from 1926 to 1974. The yield to maturity of long-term bonds behaves like the commercial paper rate—as the high correlations in table 10.1 foreshadow. But the annual holding-period yield fluctuates widely. The yield to maturity cuts through the annual holding period like a trend series, though the two series are not correctly dated relative to one another.[33]

The annual holding-period yield is strictly an ex-post yield. It cannot be observed or known in advance. Its wide variability reflects this feature plus the large unanticipated element in the market price of the securities.

We have no corresponding direct evidence for the United Kingdom, but none is necessary. The consol yield is never strictly a realized holding-period yield, though obviously it approaches one as the holding period lengthens indefinitely. The annual, or other short-term holding period, yield of the consols fluctuates widely as the price of the consol varies.

For *real yields on nominal assets* there is the additional problem of matching the period for which the price change is calculated with either the period to maturity or the holding period. Again, no significant problem arises for the short-term rate. Our procedure of subtracting the

33. The yield to maturity series is plotted at the initial date whereas, to correspond in timing to the holding period series, it should be plotted later by an interval corresponding to some concept of average effective maturity.

average price change from one calendar year to the next from the average rate during the second of those years is not accurate; the price change should be for a year beginning seven and a half to eight and a half months later than the calendar year, but that error is negligible for our purpose. However, for long-term bonds, our procedure introduces serious error, since the nominal yield is calculated to maturity, but the rate of price change is not.

The real yields on nominal assets are ex-post yields. To get ex-ante yields requires some advance independent estimate of the anticipated rate of price change.

Given the very high correlation between short- and long-term nominal yields to maturity, the computational problems involved in correctly computing real yields to maturity, and the large erratic element in holding-period yields on long-term securities, we have bypassed these problems in the rest of this chapter by using only the short-period rates for our detailed analysis. Our interest is not in the term structure of rates but in the relation of monetary change to interest rates. For that purpose it seems adequate to use the short rate as a proxy for the whole structure of rates. In effect, that is equivalent to taking the average remaining maturity of the short-term instrument whose yield we use as the ex-ante holding period the return for which is being studied. Arbitrage across maturities assures that ex-ante yields for other maturities will differ only by liquidity or risk premiums, and these are not our primary concern.

For nominal yields, we can identify the ex-post with the ex-ante return, neglecting, for the series we use, the default risk. For real yields, even for short-term securities, we cannot do so. True, prices tend to move rather sluggishly; so for short periods it might be supposed that anticipated price movements will not differ much from actual price movements. However, the shorter the period, the smaller the yield, not as an annualized percentage, but as a percentage of the capital value. There is no reason to suppose a priori that the error in estimating price change declines any more rapidly than the yield. The pure measurement error in price change must rise as a fraction of the price change as the period shortens, but this component would tend to average out in our annual and even more phase averages and hence would not by itself be a reason for rejecting the identity of ex-post and ex-ante real yields.

For *nominal and real yields on physical assets*, the timing problem does not arise. Our proxies can be regarded as corresponding to holding-period yields. However, since they are based on differences between the logarithms of calendar year nominal and real income series, they are dated as of the end of the year; that is, they correspond to fiscal years ending 30 June rather than to calendar years. There is therefore a six-month difference in dating between the proxy series and the series on yields on nominal assets. Given that our time unit is generally a phase, this timing difference will generally be of minor significance.[34] Our proxies are necessarily ex post not ex ante, and there seems no way of getting a corresponding ex-ante measure.

The major measurement problem that arises for our proxies is whether they are valid proxies for the nominal and real yield on physical assets. The successful use of the nominal proxy in the demand functions of chapter 6, and the closeness of the averages for a century to the corresponding averages for the yields on nominal assets, is substantial evidence in their favor but can hardly be regarded as conclusive. We have therefore made a number of additional tests by comparing our proxies with two alternative estimates of returns on real assets for the United States for the period 1929 to 1969: (1) the Ibbotson and Sinquefield series of annual holding-period return on common stocks; and (2) the rate of return on capital for the United States private national economy, as estimated by Christensen and Jorgenson.[35] Chart 10.12 plots our proxies against these series, in panel A for nominal yields, in panel B for real yields, and table 10.2 gives means, standard deviations, and correlations for the several series.[36]

Our proxies compare very well with the Christensen and Jorgenson (CJ) rate of return on capital, having roughly similar mean values, a high positive correlation of nominal yields, and a low though statistically significant positive correlation for real yields. The main difference is that the CJ rate of return is much less variable, particularly the CJ real rate of return. Perhaps that means that it is closer to an ex-ante than to an ex-post return, perhaps it simply reflects the large measure of smoothing and interpolation that has gone into the construction of the CJ rate of return measures.

The common stock holding-period yields are much more variable than either of the others—hardly surprising given the volatility of the stock market prices from which they are derived. The high mean yield, double or more than double that shown by the other two measures, may be a return for risk or an artifact of the selective nature of the stock market or period. The correlation between the stock market returns and either of the others is trivial, though it is positive for three out of four comparisons.

So far as this evidence goes, it strengthens our confidence in the proxies as valid measures of returns on physical assets. The disagreement with common stock yields seems more reasonably interpreted as an indication

34. We have tested this proposition by computing phase averages from fiscal year interest-rate observations. The results were sufficiently similar to those derived from calendar year observations that we decided for simplicity to retain the latter.

35. Laurits R. Christensen and Dale W. Jorgenson, "U.S. Income, Saving, and Wealth, 1929–1969," *Review of Income and Wealth*, December 1973, pp. 344–45.

36. Though these charts cover 1926–74 for the proxies and holding-period returns, the Christensen-Jorgenson estimates are available only for 1929 to 1969, which is why table 10.2 is restricted to that period.

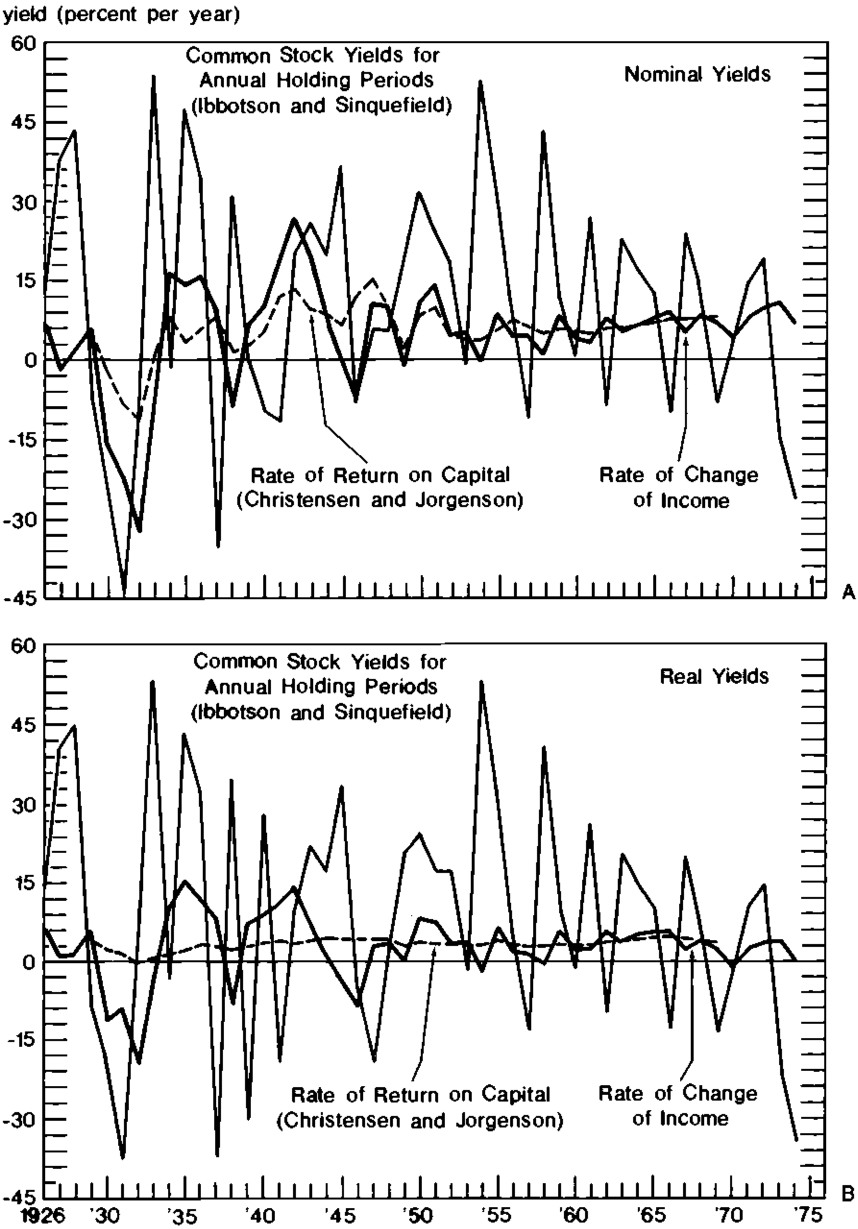


Chart 10.12 Three measures of yields on United States physical assets, 1926–74.

Table 10.2 **Three Measures of Yields on Physical Assets, United States Annual Data, 1929–69**

	Nominal Yields	Real Yields
	Mean (Percentage Points)	
Physical assets (proxy)	5.2	3.1
Common stocks, annual holding period	10.8	8.9
CJ rate of return on capital	5.9	3.5
	Standard Deviation (Percentage Points)	
Physical assets (proxy)	10.8	7.1
Common stocks	22.6	23.1
CJ rate of return	5.0	1.1
	Correlation Coefficient	
Physical assets (proxy) and common stocks	.23	.06
Physical assets (proxy) and CJ rate of return	.82	.44
Common stocks and CJ rate of return	.15	−.06

of the highly special character of the subset of physical assets reflected in stock market securities than as evidence against our proxies for what they purport to be: yields on the broad spectrum of assets, both human and nonhuman, whatever the financial claims, if any, that are their counterpart.

One further minor bit of evidence is that the correlation between the commercial paper rate and the CJ nominal rate of return on capital, as between the commercial paper rate and our proxy, is essentially zero.

10.4 Yields in Subperiods

Table 10.3 repeats table 10.1 for a series of subperiods, except that we have omitted the long rates. We have subdivided the pre–World War I period into the period before 1896, when prices were generally falling, and the subsequent period, when prices were generally rising, have separated out the war periods, and have treated the interwar period as one unit, because of the paucity of observations, even though the behavior of prices varied greatly during these nearly two decades. As the mean rate of change of prices shows, the interwar period was certainly on the average a period of falling prices. The postwar period requires no subdivision. It clearly is a period of generally rising prices.

We therefore have two periods of generally falling prices (pre-1896, interwar), two wartime periods of rising prices, and two peacetime periods of rising prices (1896–1914, post–World War II).

Table 10.3 **Nominal and Real Ex-Post Yields for Subperiods, 1873–1975**

	Yields											
	Pre–World War I											
	Falling Prices (Pre-1896)				Rising Prices				World War I Phases			
	United States		United Kingdom		United States		United Kingdom		United States		United Kingdom	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
Number of Phases	11		6		10		5		3		3	
	Means (Percentage Points)											
Nominal assets												
Short-term rate	5.12	6.77	2.60	3.25	4.70	2.84	3.26	2.58	5.07	−4.33	4.33	−10.80
Physical assets												
Yield[a]	1.60	3.30	1.57	2.22	5.09	3.23	1.95	1.27	12.95	3.55	12.55	−2.58
Rate of price change[a]	−1.65		−0.65		1.86		0.68		9.40		15.12	
Rate of monetary growth[a]	1.80		1.63		5.97		2.22		12.53		14.10	
Rate of change of exchange rate[a]			−0.45[b]				0.07				−4.30	
	Standard Deviations (Percentage Points)											
Short-term rate	0.60	1.71	0.36	1.69	0.42	0.94	0.21	0.43	1.14	3.26	0.61	2.02
Yield on physical assets	3.60	2.86	2.96	1.91	4.18	3.74	1.92	1.73	4.19	3.09	4.00	6.24
Rate of price change	1.69		1.51		0.83		0.36		2.14		2.25	
Rate of monetary growth	3.87		1.27		1.87		1.76		0.83		2.13	
	Correlation Coefficients											
Short-term rate and yield on physical assets	.066	−.183	−.358	−.498	−.499	−.633*	.099	−.321	−.829	−.322	−.616	.938

Table 10.3 (Continued)

	Yields											
	Interwar Phases				World War II Phases				Postwar Phases			
	United States		United Kingdom		United States		United Kingdom		United States		United Kingdom	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
Number of Phases	9		9		3		3		13		11	
	Means (Percentage Points)											
Nominal assets												
Short-term rate	3.54	5.31	3.06	4.76	0.82	−4.70	0.85	−4.02	4.20	1.03	5.70	0.08
Physical assets												
Yield[a]	0.09	1.86	0.03	1.73	9.13	3.61	6.65	1.78	6.23	3.07	7.85	2.22
Rate of price change[a]	−1.76		−1.70		5.52		4.87		3.17		5.62	
Rate of monetary growth[a]	1.11		−0.24		11.30		7.32		5.82		6.73	
Rate of change of exchange rate[a]			0.67				−4.21				−0.84	
	Standard Deviations (Percentage Points)											
Short-term rate	1.92	4.28	1.76	4.77	0.17	0.91	0.22	2.01	2.15	1.12	2.66	2.32
Yield on physical assets	8.37	5.82	4.85	3.48	6.71	5.89	3.49	1.44	1.88	1.73	3.22	1.12
Rate of price change	3.34		4.30		0.90		2.12		1.77		3.40	
Rate of monetary growth	4.87		3.97		4.52		3.69		2.62		5.37	
	Correlation Coefficients											
Short-term rate and yield on physical assets	−.247	−.591	−.411	.037	−.358	−.955	.394	−.950	.443	−.073	.719*	.288

[a]See footnote 29 of text for method of calculation of phase rates of change of income (i.e., yield on physical assets), prices, money, and the exchange rate of the pound for dollars.
[b]Reflects appreciation of the dollar and so shift in the exchange rate of the pound from a premium before United States resumption in 1879 to par thereafter.
*Significant at .05 level.

The division into periods adds to the conclusions derived from the averages for the period as a whole in respect to, first, the differences between the United States and the United Kingdom; and second, the effect of price experience on the differential between the yields on nominal and on physical assets.

10.4.1 United States versus United Kingdom

For the period as a whole, the short rate averaged 0.7 percentage points higher for the United States than for the United Kingdom, or 1.6 percentage points higher if allowance is made for changes in the exchange rate, which is equivalent to allowing for the differential behavior of prices in the two countries.

Table 10.4, which records the United States–United Kingdom differential for the various subperiods and yields, shows that the excess of the United States nominal short rate over the United Kingdom rate declined steadily from period to period, particularly sharply from the first to the second. This sharp and regular decline can in principle be attributed to any of three factors: (1) a decline in the differential real yield available on physical assets in the two countries; (2) a change in the relative behavior of prices, as reflected in the exchange rate; (3) a change in the effectiveness of financial intermediation leading to a relative decline in the United States in the differential between nominal yields on nominal assets and on physical assets.

All three factors apparently played a role, though each at a different time; the first, for the decline from the second prewar period to the

Table 10.4 United States–United Kingdom Yield Differences, Subperiods, 1873–1975

	United States Yield Minus United Kingdom Yield (Percentage Points)			
	Nominal Yields		Real Yields	
Subperiod	Nominal Assets[a]	Physical Assets[b]	Nominal Assets[a]	Physical Assets[b]
Pre–World War I:				
Falling prices (before 1896)	2.52	0.03	3.52	1.10
Rising prices	1.44	3.14	0.26	1.96
World War I	0.74	0.40	6.47	6.13
Interwar	0.48	0.06	0.55	0.13
World War II	−0.03	2.48	−0.68	1.83
Postwar	−1.50	−1.62	0.95	0.85

[a]Commercial paper rate for United States, rate on three-month bank bills for United Kingdom.
[b]Rate of change of income.

interwar period; the second, for the decline from the interwar to the postwar period; and the third, for the decline from the first to the second prewar period.

1. The final column of table 10.4 indicates that, excluding war periods, the excess of the real yield in the United States over that in the United Kingdom was about one percentage point higher before World War I than after.[37] This clearly matches the 0.96 percentage point decline in the United States–United Kingdom nominal short-rate differential from the 1896–World War I period to the interwar period.

2. The sharp further decline of 1.98 percentage points in the nominal short-rate differential from the interwar to the postwar period corresponds fairly closely to the 2.39 percentage point decline in the rate of price rise in the United States relative to that in the United Kingdom.[38] This differential rate of price decline was reflected in the depreciation of the British pound relative to the United States dollar by 1.51 percent per year.

3. Finally, the sharp fall in the nominal short-rate differential from the first period to the second period cannot be attributed to item 1, since there is no corresponding decline in nominal differential yields on physical assets—rather, there is a rise. It cannot be attributed to item 2, because the pound appreciated by 0.52 percent per year between the two periods, reflecting differential behavior of average rates of price change, which would work against the change in the interest differential that actually occurred.[39] Our first impression was that item 3 must have been triggered by the substantial increase in the degree of financial sophistication in the United States relative to that in the United Kingdom that we identified in chapter 6, and to which we attributed much of the differential behavior of velocity in the United States and the United Kingdom up to about 1903. It seemed reasonable that increased financial sophistication would also produce a decline in the market rate of interest on securities like commercial paper traded in active financial markets.

37. As a rough estimate, a simple average of the excess for the two pre–World War I periods is 1.53, for the interwar and post–World War II periods, 0.49, or a difference of 1.04 percentage points. Alternatively, the difference between the prewar and interwar periods of falling prices is 0.97, between the prewar and postwar periods of rising prices, 1.11.

38. As table 10.3 shows, during the interwar period prices fell in the United States by 1.76 percentage points, in the United Kingdom, by 1.70 percentage points, or by .06 percentage points more in the United States. Prices rose in the United States during the postwar period by 3.17 percent; in the United Kingdom, by 5.62 percent, or by 2.45 percentage points less in the United States. Consequently, United States prices fell relative to those in the United Kingdom in both periods, but by 2.39 percentage points more after World War II than in the interwar period.

39. Before 1896 prices fell more rapidly in the United States than in the United Kingdom; after 1896 they rose more rapidly in the United States than in the United Kingdom. The differential changed by 2.18 percentage points. This factor alone should have made for a rise in the United States interest rate relative to the United Kingdom, not a fall.

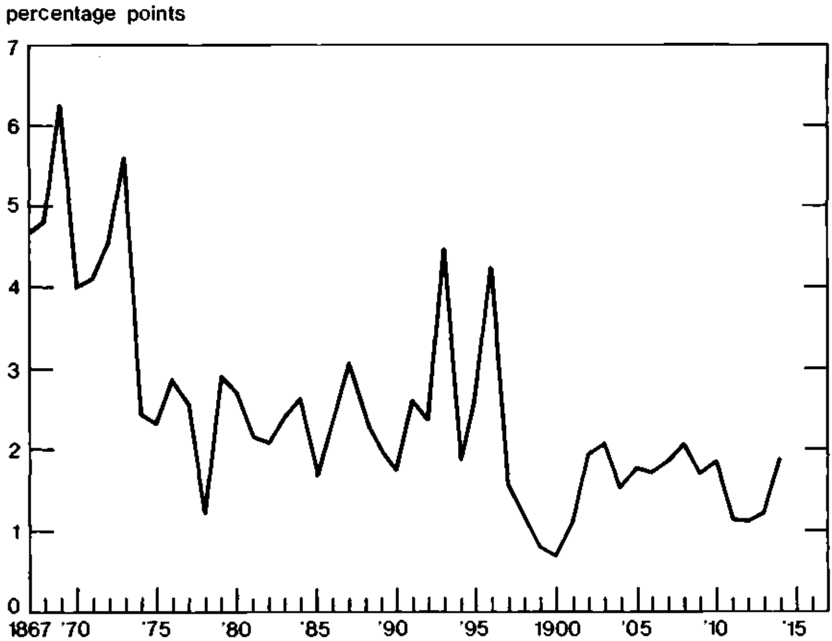


Chart 10.13 Excess of United States commercial paper rate over United Kingdom rate on bank bills, annually, 1867–1914.

However, chart 10.13, which plots the United States–United Kingdom differential year by year, contradicts this interpretation. That chart does not show a gradual reduction in the differential such as might be expected from a gradual growth in financial sophistication. On the contrary, it shows an abrupt drop from one level, 1874 through 1896, to another level, 1897 to 1914, with sizable year-to-year fluctuations about those levels. The peaks in 1893 and 1896 suggest an explanation for the drop in level. The peak in 1893 is connected with the banking panic of that year. The initial banking difficulties reinforced fears, endemic before 1896 because of silver politics, that the United States would go off gold and the dollar would depreciate. The restriction of cash payments by banks after July produced a premium in the market on currency (i.e., it took more than $100 of deposits to buy $100 of currency), which was equivalent to a depreciation of the United States dollar vis-a-vis the British pound, for a time converting the fear into a reality. The peak in 1896 is connected with the capital flight of that year accelerated by Bryan's nomination, which greatly strengthened fears that the United States would leave gold.[40] In both cases, fear of devaluation meant that owners of United Kingdom capital were reluctant to participate in the United States short-term

40. *A Monetary History*, pp. 107–13.

market except at a substantial premium. The election of McKinley changed the situation drastically. It made United States retention of the gold standard secure for the time being, and the subsequent flood of gold from South Africa, Alaska, and Colorado removed all doubts.

The sudden reversal of confidence in the sterling value of the dollar had the effect of an equally sudden improvement in the effectiveness of the financial market. The United States short-term market became linked, as it were, to the United Kingdom market as an equal participant rather than as a poor relative. The gradual improvement in the United States market by itself, which doubtless was proceeding, was overshadowed by the drastic one-time shift to a new level. Hereafter, financial intermediation was available at lower cost and could be expected to reduce the differences in rates charged in different markets.

The United States–United Kingdom nominal short-rate differential for the pre-1896 period in table 10.4 averages 1.08 percentage points higher than for the 1896–World War I period. We shall take this as measuring the magnitude of the shift.

One point about this shift deserves special mention. The fear that the United States would leave gold was equivalent to a fear that the United States would inflate at a faster rate than the United Kingdom (or deflate at a slower rate). The fear of inflation also animated the domestic opponents of free silver. As we pointed out in *A Monetary History*,[41] the paradoxical effect was to produce deflation—or more rapid deflation than would otherwise have occurred. The paradox shows up to the full in interest rates. Before 1896, prices were falling one percentage point per year faster in the United States than in the United Kingdom. That alone should have produced a 1 percent per year appreciation of the United States dollar and a one percentage point *lower* interest rate. However, the fear of inflation more than countered the fact of deflation; it kept the currency in danger of being devalued; and made interest rates in the United States one percentage point higher relative to those in the United Kingdom than they were after the fear was resolved.

The contrast between *fact* and *belief* continued after 1896. In the subsequent eighteen years, prices rose in the United States by roughly one percentage point more per year than in the United Kingdom. The *fact* of inflation by itself should have produced a 1 percent per year depreciation of the United States dollar and a one percentage point higher interest rate in the United States. However, the altered attitudes and the almost complete elimination of the silver issue meant that the exchange value of the dollar was never threatened and that United States interest rates, while higher than those in the United Kingdom, were one percentage point less so than before 1896. Put most simply, the *facts* of

41. Ibid., p. 132.

inflation would have justified a two percentage point rise in the differential from before to after 1896. The *beliefs* about inflation produced a one percentage point decline! We shall revert to this issue later in our discussion of the Gibson paradox.

The two war periods are obviously special. Yet, so far as nominal rates are concerned, the United States–United Kingdom differentials for the war periods are intermediate between the preceding and following periods.

To summarize: We conclude that the decline in the United States–United Kingdom differential for the nominal short rate from before to after 1896 reflects the resolution of fears that the United States would experience inflation and the United States dollar would be devalued; the further decline from pre–World War I to the interwar period reflects a decline in the real yield on physical capital in the United States relative to that in the United Kingdom, and the further decline from the interwar period to the post–World War II period reflects greater inflation in the United Kingdom than in the United States and an accompanying depreciation of the pound sterling.

10.4.2 Yields on Nominal and Physical Assets

If arbitrage had worked as well for each subperiod as it did for the period as a whole, yields on nominal and physical assets would either have been equal or would have differed by a constant reflecting the average preference for nominal versus physical assets (or the reverse). As noted in our earlier comparison between averages for all phases and averages for all nonwar phases, arbitrage did not work as well for the subperiods as for the period as a whole. For the two periods of falling prices, the yield on nominal assets was decidedly higher in both countries than the yield on physical assets. Deflation was not anticipated. Lenders did well. Borrowers did poorly. Since entrepreneurs generally borrow in nominal terms to acquire physical assets, it follows that rentiers did well, entrepreneurs badly—which is of course conventional (which does not always mean correct) wisdom, merely another way of expressing the widely believed generalization that a period of unanticipated deflation is adverse to enterprise and growth.

With one exception (the United Kingdom after 1896), the relation is reversed during periods of inflation, including the war periods: the yield on physical assets was higher than the yield on nominal assets. Apparently inflation too was not anticipated. Entrepreneurs did well, rentiers did poorly; capital was transferred from savers to borrowers—which is of course another way of expressing the widely believed generalization that unanticipated inflation is favorable to enterprise and growth.

As Irving Fisher put this point in 1907: "While *imperfection* of foresight transfers wealth from creditor to debtor or the reverse, *inequality* of foresight produces overinvestment during rising prices and relative stagnation during falling prices."[42]

Yet, like many widely believed generalizations, the generalization that unanticipated inflation is favorable to growth and unanticipated deflation unfavorable may be an illusion—a money illusion that is part and parcel of the same phenomenon as the failure to anticipate inflations and deflations. According to table 10.3, in both the United States and the United Kingdom, real growth (our proxy for the real yield on physical assets) was greater during the pre-1896 period of falling prices than during the post-1896 period of rising prices.[43] But the public perception at the time was clearly the reverse. Alfred Marshall referred to the possible contradiction between perception and reality in 1886 when he wrote, "I think there is much less difference than is generally supposed between the net benefits of periods of rising and falling prices."[44]

The situation is different for the interwar and postwar periods: real growth was greater in both countries during the postwar period of rising prices than during the interwar period of falling prices. However, the emergence of stagflation in both countries at the end of and following the period we cover, plus the special role of the Great Depression, suggests that this is a fragile piece of evidence for the generalization in question.

Table 10.5 brings out more clearly the effect of the rate of change of prices on the difference between the yields on nominal and physical assets. It lists the subperiods by the rate of price change, disregarding both chronology and country—even though, as the preceding section demonstrates, there are systematic differences between the United States and the United Kingdom. If the price change had been fully anticipated and the real yields had been independent of the rate of price change, the nominal yields on nominal assets in column 2 would rise as we go down the table, the real yields on nominal assets in column 4 would stay constant. In fact, the nominal yields in column 2 fluctuate about a roughly constant level, so that the effect of inflation is reflected primarily in a sharp decline in the real yield on nominal assets in column 4.[45] The hypothetical pattern of yields for a fully anticipated inflation comes closer to being realized for physical assets. Their nominal yield rises with inflation and their real yield fluctuates about a more or less constant level. However, this pattern does not reflect anticipations so much as the

42. *The Rate of Interest*, p. 286.

43. We are indebted to Arthur Gandolfi for calling our attention to the contradiction between our table 10.3 and the common belief.

44. Alfred Marshall, *Official Papers* (London: Macmillan, 1926), p. 9.

45. Note that the pre-1896 nominal yield is the most out of line, and that this is the yield that we decided in the preceding section was held up by fears of inflation despite the fact of deflation. Lowering this yield by one to three percentage points would produce a tendency for the nominal yield for peacetime periods to rise slightly along with the rate of inflation.

Table 10.5 **Difference between Yields on Physical and Nominal Assets, Related to Rate of Change of Prices (Percentage Points)**

Period and Country	Rate of Price Change (1)	Nominal Yield: Nominal Assets (2)	Nominal Yield: Physical Assets (3)	Real Yield: Nominal Assets (4)	Real Yield: Physical Assets (5)	Excess of Yield on Physical Assets over Yield on Nominal Assets Col. 3 Minus Col. 2 or Col. 5 Minus Col. 4 (6)
Interwar, United States	−1.76	3.54	0.09	5.31	1.86	−3.45
Interwar, United Kingdom	−1.70	3.06	0.03	4.76	1.73	−3.03
Pre-1896, United States	−1.65	5.12	1.60	6.77	3.30	−3.47
Pre-1896, United Kingdom	−0.65	2.60	1.57	3.25	2.22	−1.03
1896–World War I, United Kingdom	0.68	3.26	1.95	2.58	1.27	−1.31
1896–World War I, United States	1.86	4.70	5.09	2.84	3.23	0.39
Postwar, United States	3.17	4.20	6.23	1.03	3.07	2.03
World War II, United Kingdom	4.87	0.85	6.65	−4.02	1.78	5.80
World War II, United States	5.52	0.82	9.13	−4.70	3.61	8.31
Postwar, United Kingdom	5.62	5.70	7.85	0.08	2.22	2.15
World War I, United States	9.40	5.07	12.95	−4.33	3.55	7.88
World War I, United Kingdom	15.12	4.33	12.55	−10.80	−2.58	8.22

physical character of the assets and the real character of the yields. For nominal assets, investors fix rates in nominal terms and contract for a period ahead: prescience is therefore required if these rates are to reflect future price behavior. For physical assets, investors may fix no rates—certainly not in nominal terms—and generally make no contracts about either real or nominal yields for a period ahead. The yield is generated out of the economic activity in which the asset is employed. It requires no prescience for the nominal yield on physical assets to reflect current price behavior, only that the physical assets participate along with other assets in the nominal income and spending flows.

Column 6 gives the excess of the yield on physical assets over that on nominal assets. It is negative for deflation, positive for inflation. This pattern comes out clearly in chart 10-14, which plots the excess yield on physical assets against the rate of price change. If inflations were fully anticipated, the difference between yields on physical and nominal assets might be expected to be roughly a constant, reflecting any preference among asset holders for one category or the other of assets. Clearly the points are very far from clustering around such a horizontal line. If inflations were wholly unanticipated and there were no preference for

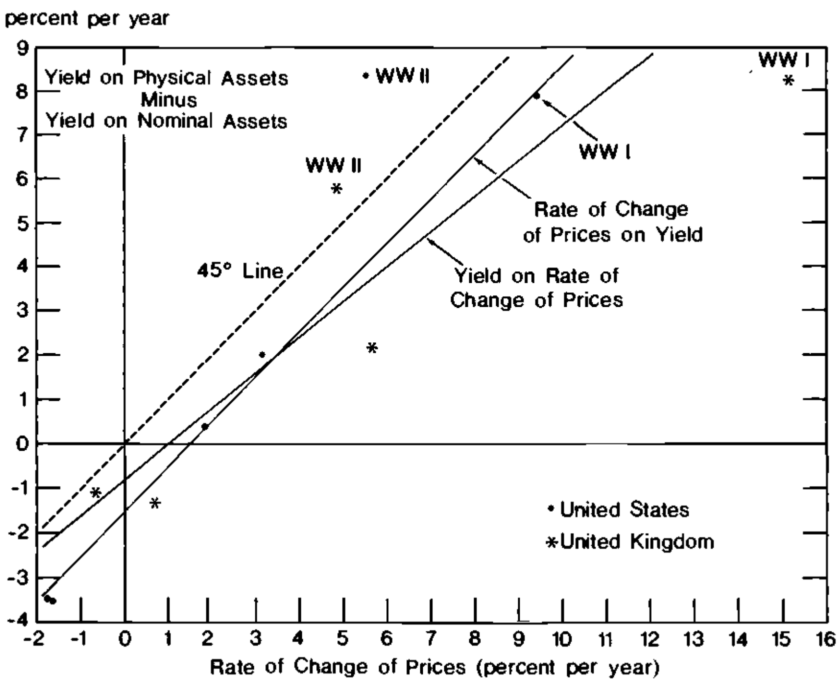


Chart 10.14 Excess of yield on physical over yield on nominal assets versus rate of change of prices.

one or the other category of assets, the points would fall along the dashed forty-five-degree line, since, ex post, the nominal yield on physical assets would reflect the actual rate of inflation, whereas the ex-ante nominal yield on nominal assets would not. In fact the points come rather close to approximating a line with a forty-five-degree slope but displaced downward by about one percentage point, as is indicated by the two regression lines, implying a preference of that amount for physical over nominal assets, that is, a willingness to accept that much less in yield in order to hold a physical rather than a nominal asset.[46]

Chart 10-14 diverges appreciably from the pattern that would be produced by wholly unanticipated inflations only with respect to the points for the final three wartime episodes in table 10.5: both United States wartime episodes and, especially, World War I for the United Kingdom. These lie roughly on a horizontal line, as if they corresponded to anticipated inflations. But interpreting them this way implies a very great preference (about eight percentage points) for nominal assets during wartime periods over physical assets—which seems most implausible. We are inclined therefore to treat the United Kingdom World War I point as an aberration—perhaps statistical, perhaps economic—rather than as an indication of correct anticipation of wartime inflation.[47]

The generalization that these results suggest is that, for the period our data cover, there was a preference of about 1.25 percentage points for physical over nominal assets and both inflation and deflation were wholly unanticipated—which, combined with risk aversion, would justify the preference for physical assets as reflecting a desire to hedge real returns against both unanticipated inflation and unanticipated deflation.

These results are inconsistent with the hypothesis that the ex-ante nominal yields on nominal assets incorporate correctly anticipated rates of inflation—which merely confirms what has long been known, that the public has not in fact been able to form correct anticipations of inflation—at least, until possibly very recently (see section 10.8). They give little evidence on a more interesting proposition: Is there within the periods a gradual recognition of and adjustment to inflation or deflation of the kind that was postulated by Irving Fisher? To answer that question, we need to

46. The simple correlation for the points in chart 10.14 is .89, and the regression equations calculated both ways are

$$\text{Differential yield} = -.84 + .80\, g_P.A$$
$$= -1.54 + 1.01\, g_P.A\ .$$

Note that the second equation is obtained simply by solving the regression of $g_P.A$ on the differential yield for the differential yield.

47. Excluding this point, the correlation is .93 and the two regressions are:

$$\text{Differential yield} = -1.22 + 1.09\, g_P.A$$
$$= -1.62 + 1.27\, g_P.A\ .$$

go beyond the subperiod averages and look at the observations within the periods.

10.5 Relation between Yields on Nominal and Physical Assets

Our proxy for the real return on physical assets was far from being the same in the various periods, ranging for the six periods for the United States from 1.9 to 3.6 and for the United Kingdom from −2.6 to 2.2. Yet these yields varied far less than the ex-post real yield on nominal assets, which ranged from −4.7 to 6.8 for the United States and from −10.8 to 4.8 for the United Kingdom. Moreover, one extreme item accounts for most of the range for the United Kingdom for the real return on physical assets. Omitting World War I which, as we have seen, appears to be an aberration, leaves five observations ranging from 1.3 to 2.2. No remotely comparable reduction in the range can be achieved for the real yield on nominal assets for either the United States or the United Kingdom by omitting the most discrepant observation.

These results suggest that it may not be a bad first approximation—for the purpose of studying monetary influences on interest rates—to follow Irving Fisher and assume that the ex-post real return on *physical assets* can be taken to be roughly constant on the average over time—though at a higher level in the United States than in the United Kingdom—and to accept our proxy as a reasonably accurate measure of that real return.

On these lines, the wide variation among subperiods in the difference between returns on nominal and physical assets reflects primarily the failure of nominal yields on nominal assets to adjust to the actual rate of inflation. As a result, ex-post real returns on *nominal assets* vary widely. The implication of rough constancy of real returns on physical assets is that the variation in ex-post real returns on nominal assets reflects primarily unanticipated changes in inflation.[48]

48. As Fisher says in his chapter "Inductive Verification (Monetary)" in *The Rate of Interest*, "In general the latter factor—unforseen monetary change—is the more important [compared with factors affecting the real rate on physical assets]. . . . It is, of course, not to be assumed that commodity-interest [the real yield] ought to be absolutely invariable; but it is practically certain that its variations would not be three and a half times the variations in money-interest, unless the price movements were inadequately predicted" (pp. 279–80).

In the chapter in his later book, *The Theory of Interest*, in which he presents his statistical calculations relating interest rates to past price change, Fisher does not explicitly discuss the constancy or variability of the real return on physical assets until the final two sentences of the chapter. He writes, "while the main object of this book is to show how the rate of interest would behave if the purchasing power of money were stable, there has never been any long period of time during which this condition has been even approximately fulfilled. When it is not fulfilled, the money rate of interest, and even more the real rate of interest [i.e., the *ex-post* real return on nominal assets] is more affected by the instability of money than by

Suppose now that the nominal yields do not adjust to the actual rate of inflation, but along Fisher's lines do adjust to the anticipated rate of inflation, which in turn adjusts to actual inflation after a considerable lag. We would then expect to find that shortly after a change from, say, falling to rising prices, the yield on physical assets would exceed considerably the yield on nominal assets, reflecting the incorporation in the yield on nominal assets of the lagged anticipations of falling prices. As prices continued to rise, the differential would decline and approach the equilibrium difference reflecting (inversely) any general preference for physical over nominal assets (or the converse).

On this interpretation, real yields on nominal assets would be highly variable within the subperiods, but real yields on physical assets would be relatively stable. The standard deviations of ex-post real returns in table 10.1 for the period as a whole show such a difference. However, those for nonwar phases alone do not for the United States and table 10.3 demonstrates that, for both the United States and the United Kingdom, the higher variability of ex-post real returns on nominal assets reflects largely differences between periods, not within periods. For five out of six within-period comparisons for the United States and three out of six for the United Kingdom, the ex-post real yield on physical assets is more variable than the ex-post real yield on nominal assets. Clearly, there is no systematic tendency the other way.

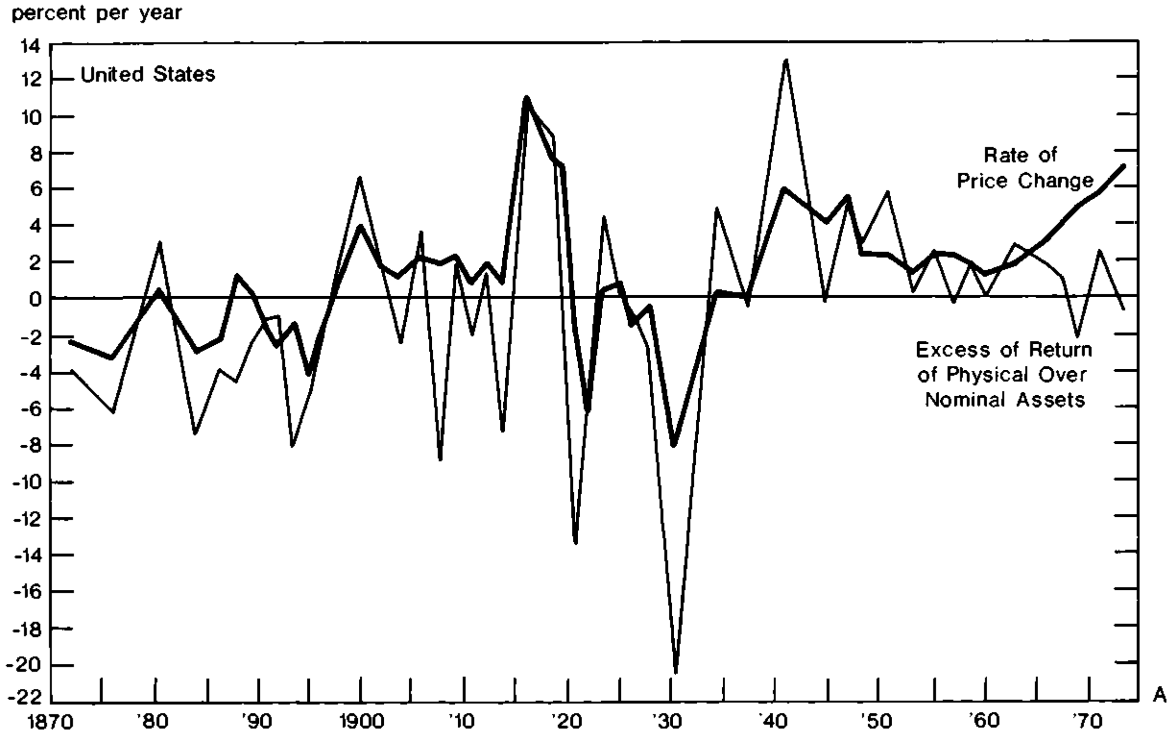
Chart 10.15 permits a more detailed examination of the intraperiod relation. It plots for each phase the excess of the return on physical assets over the return on nominal assets—which we shall refer to for brevity as the "differential"—against the rate of change of prices. The vertical lines separate the subperiods distinguished in table 10.3.

For both countries, the positive correlation between the differential and the rate of price change that we found to hold between periods clearly is present also within periods, though somewhat less consistently. Again, the correlation reflects the failure of yields on nominal assets to be adjusted promptly or at all to the actual course of prices.

For the United States, for the two prewar periods, there is a very clear and distinct shift in the rate of price change from a rate of decline of about 2 percent per year to a rate of rise of about 2 percent (see table 10.5, col. 1), so this pair of periods seems almost ideal for examining the effect of a shift from reasonably steadily falling prices to reasonably steadily rising

those more fundamental and more normal causes connected with income impatience, and opportunity, to which this book is chiefly devoted" (p. 451).

In the earlier part of the chapter, the assumption of a fixed real return on physical assets is imbedded in all of his calculations since they include no variables to adjust for changes in the real return.


percent per year
United States
Rate of Price Change
Excess of Return of Physical Over Nominal Assets
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
1870
'80
'90
1900
'10
'20
'30
'40
'50
'60
'70
A

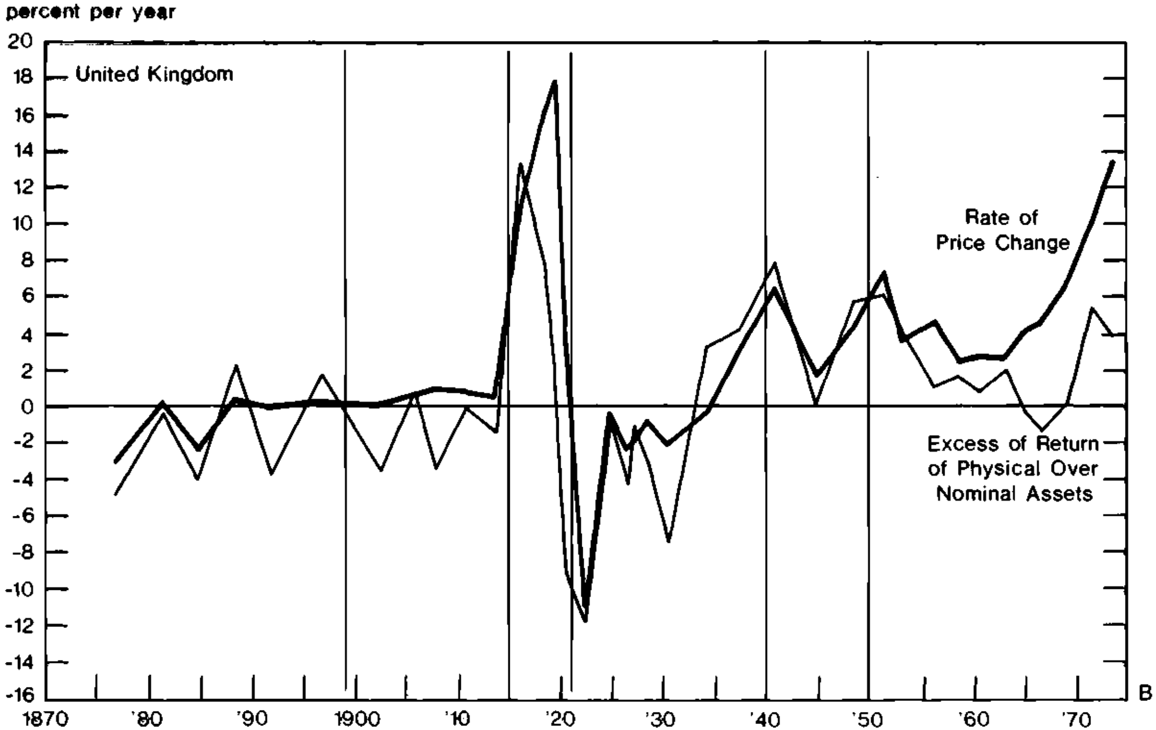


Chart 10.15 Excess of return on physical over nominal assets and the rate of price change, phase averages.

prices. However, we have already seen that this appearance is deceiving: the first period was one in which inflation was anticipated, even though deflation was experienced. Hence, the lower differential in the first period than in the second is consistent with the adjustment of the differential to the anticipated movement in prices, though the magnitude of the difference between the two periods (3.86 percentage points; see table 10.5, col. 6) is larger than can readily be accounted for in this way. With respect to movements within the periods, the differential shows no tendency to rise in the first period as would be expected from a gradual adjustment of anticipations. However, as chart 10.16 shows, the nominal rate on nominal assets does decline during the period. The failure of the differential to decline reflects the decline also in the nominal yield on physical assets. In the second period, the differential starts out sizably positive and then does decline, fluctuating around zero. This second period, therefore, conforms in part to the pattern for the differential sketched earlier. However, a closer examination indicates that this conformity, like the nonconformity for the first period, is partly spurious. As chart 10.16 shows, the decline in the differential in the second period is produced mostly by a decline in the yield on physical assets (both nominal and real), rather than by a rise in the yield on nominal assets, though the latter does rise mildly. These intraperiod patterns are therefore only very loosely consistent with a gradual adjustment of nominal rates to incorporate inflationary expectations.

The United Kingdom data for the pre–World War I period plotted in panel B of chart 10.15 do not show any clearer evidence of the Fisherian pattern than the United States data. The differential in the main fluctuates about a roughly constant level. That level shows at the most a very mild rise during the first period of falling prices but no decline during the later period of rising prices. However, the nominal short-term yield does fall mildly during the first period as if it were adjusting to expectations of deflation and rise mildly during the second as if it were adjusting to expectations of inflation. The United Kingdom was, of course, at the time a much more sophisticated financial market than the United States, so it might have been expected to conform to the Fisherian pattern more closely than the United States. In fact, any difference in this respect is trivial.

For World War I, for both the United States and the United Kingdom, the differential primarily mirrors price changes: nominal yields rose only slightly along with inflation, while our proxy for nominal yields on physical assets reflected the inflation—fully for the United States, largely for the United Kingdom. Clearly, no Fisherian pattern is evident here—nor should it be, given the widespread recognition that war is after all special and not to be extrapolated, plus the extensive government intervention into the financial system.

For the interwar period, for both the United States and the United Kingdom, there is some minor evidence of the Fisherian pattern. Nominal yields fall sharply toward the end of the period, the lowest level being reached after the rate of price change has shifted from negative to positive. The adjustment is sizable in terms of the usual variation in short-term rates but mild compared to the drastic changes in the rate of price change. On the other hand, yields on physical assets fully reflect the change in the rate of price change. As a result, the differential largely mirrors, as during the two wars, price changes. The low level of short-term yields in the succeeding period that we have designated as in World War II, though it begins in 1937, may partly reflect the Fisherian process. However, that lower level owes as much to government controls as to the incorporation of deflationary expectations in the low short-term yields during the highly inflationary war.

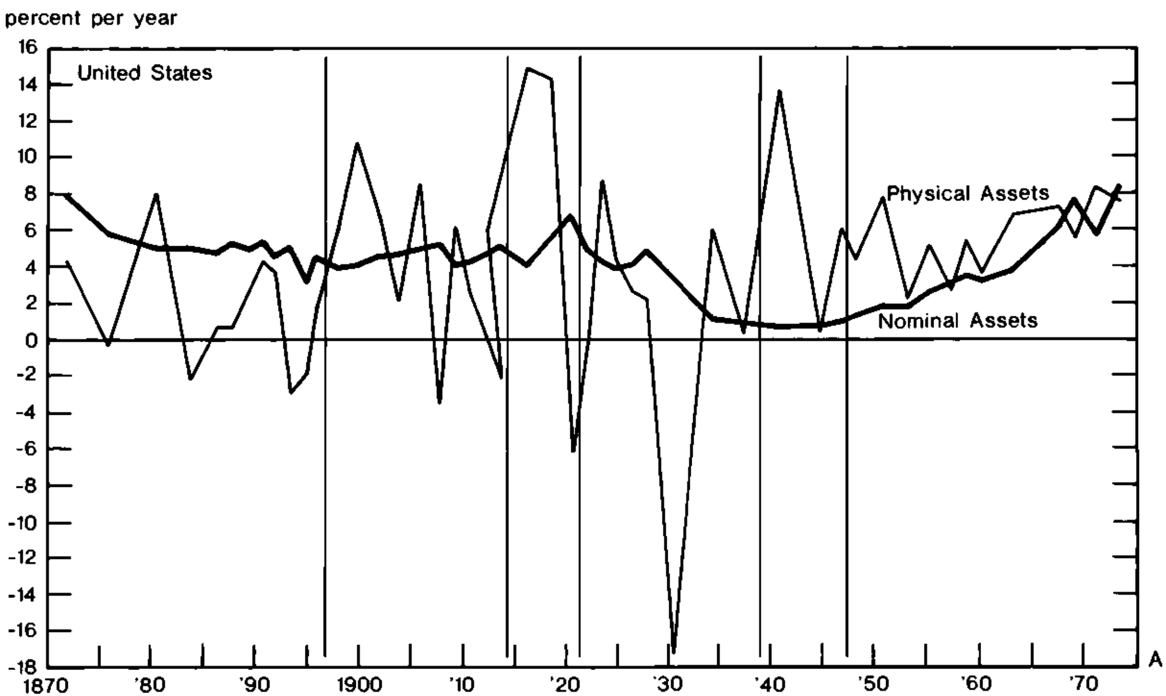
The post–World War II period shows the clearest evidence of the Fisherian pattern. For both the United States and the United Kingdom, the differential falls during most of the postwar period of rising prices, though not continuously so. More important, the differential is mostly inversely rather than positively related to the rate of price change, the nominal short-term yield is as variable as our proxy for the nominal yield on physical assets, the nominal short-term yield rises steadily throughout the period, the ex-post real yield on nominal assets rises sharply in the early part of the period and then fluctuates about a more or less constant level, and our proxy for the real yield on physical assets shows no steady trend.

All in all, this detailed examination of the intraperiod movements of yields supports the Fisherian interpretation at most for the post–World War II period.

10.6 Nominal Yields, Price Levels, and Rates of Change of Prices

The inconclusive results of the preceding section suggest examining more closely the relation between nominal yields and both the level of prices and the rate of change of prices.

On theoretical grounds, there is no reason to expect any direct relation between the nominal rate of interest and the level of prices. The rate of interest is a pure number except for its temporal dimension: dollars per dollars per year. The level of prices is not a pure number; it has the dimensions of dollars. There is a strictly arbitrary element in the price level related to the monetary unit. Clearly, if prices double because of a change in the unit—as happened, for example, in Rhodesia when it shifted in 1965 from the British pound as its currency to the Rhodesian


percent per year
United States
Physical Assets
Nominal Assets
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
1870
'80
'90
1900
'10
'20
'30
'40
'50
'60
'70
A

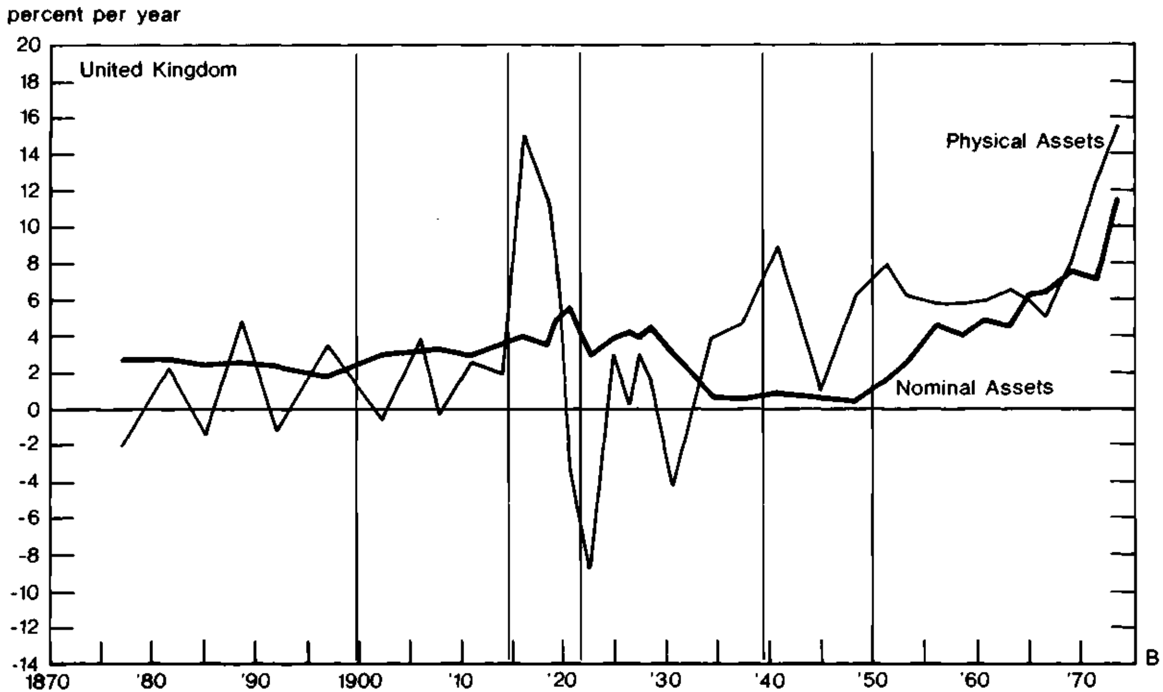


Chart 10.16 Nominal return on physical assets versus nominal return on nominal assets, phase averages.

dollar at an initial exchange rate of $2 to the pound—there is no reason for any interest rate to be affected. If prices double, not because of a change in units, but because of a doubling of the amount of money per unit of output as a result, say, of war finance, there is again no reason to expect the rate of interest to change on this score once the country has adjusted to the new situation.

Dimensionally, the rate of change of prices, not the level of prices, is comparable to the interest rate. It too is dollars per dollar per unit of time and has the dimension of the reciprocal of time. And, as Fisher pointed out, theoretical considerations suggest that the nominal interest rate should be related to the rate of change of prices—either actual or anticipated.

Yet, empirically, the "tendency of prices and interest rates to rise together . . . and to fall together" was described by J. M. Keynes in 1930 as "one of the most completely established empirical facts within the whole field of quantitative economics." He termed it the "Gibson paradox," after a British financial journalist, A. H. Gibson, and this name has stuck despite the fact that the phenomenon had been described and analyzed three decades earlier by Knut Wicksell.[49]

Keynes's unqualified and colorful assertion helped to render the Gibson paradox a largely unchallenged generalization despite Macaulay's subsequent conclusion, in the course of one of the most perceptive examinations of the paradox that has yet been published, that while "it is true that, in various countries and often for long periods of time, the movements of interest rates (or rather bond yields) and commodity prices have been such as to suggest that they might be rationally related to one another in some direct and simple manner . . . the exceptions to this appearance of relationship are so numerous and so glaring that they cannot be overlooked."[50]

We now have data for nearly five decades more than were available to Keynes and nearly four decades more than were available to Macaulay, so it will be well to reexamine how well and with what exceptions Keynes's empirical assertion holds.

49. J. M. Keynes, *A Treatise on Money*, vol. 2 (1930), ed. Royal Economic Society (London: Macmillan, 1971), pp. 177–86. Keynes's failure to refer to Wicksell in connection with the Gibson paradox is curious, since in volume 1 of the *Treatise* he discusses Wicksell's work and refers to Wicksell's analysis as largely coinciding with his own and as deserving "more fame and much more attention than it has received from English-speaking economists" (*Treatise*, 1: 167). Wicksell discussed in English what Keynes called the Gibson paradox in his article "The Influence of the Rate of Interest on Prices," *Economic Journal* 17 (June 1907): 213–20.

50. Frederick R. Macaulay, *The Movements of Interest Rates, Bond Yields and Stock Prices in the United States Since 1856* (New York: NBER, 1938), p. 185. See also his implicit criticism of Keynes's "adjustments" to the data, pp. 163–64.

Chart 10.17 plots phase averages of the short-term nominal rate and of the rate of price change. For the United States, these more detailed data, like the earlier analysis simply in terms of periods of rising and falling prices, show only the loosest relation. Before 1950 there are occasional coincidences, such as the 1896 dip in both commercial paper rates and price change, or lagged relations, such as the World War I price explosion and the subsequent peak in commercial paper rates. But these are more plausibly interpreted in terms of specific historical circumstances than as a Fisherian allowance for anticipated inflation. The first coincidence is very likely the common result of the measures taken to end the threat to the gold standard. The 1921 peak in interest rates is related to the price inflation, not through allowance for anticipated inflation but through monetary policy. The sharp contractionary monetary measures taken by the Federal Reserve to end the postwar inflationary boom had an initial liquidity effect that drove up short-term rates.

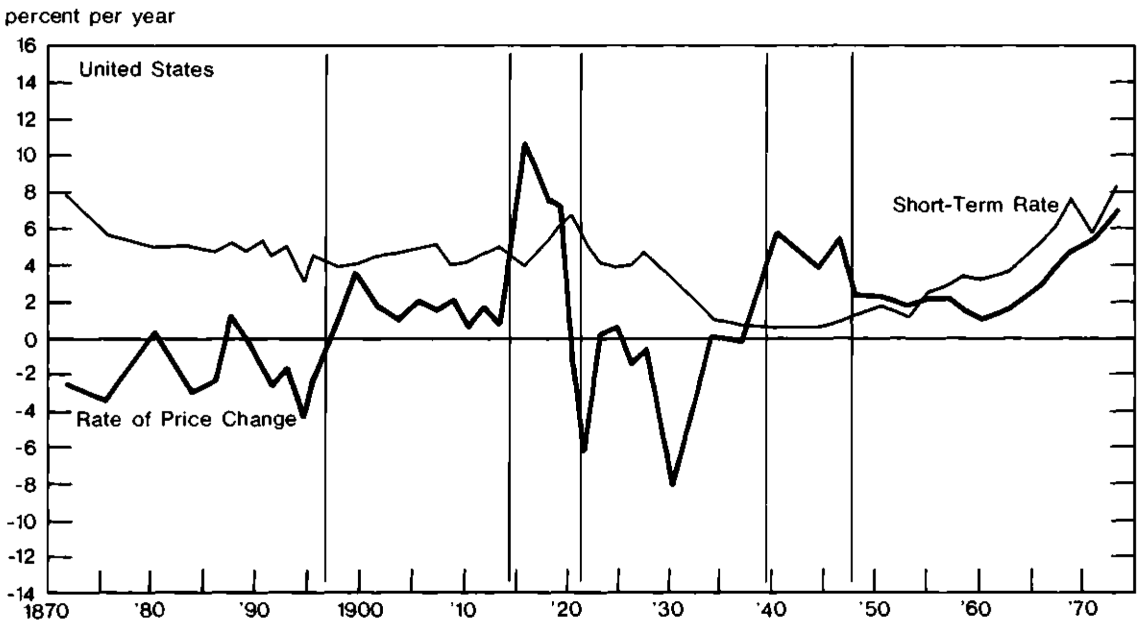
The interesting feature of the United States chart is the striking contrast between the period before and after 1950. For the post–World War II phases there is a close correlation between the rate of interest and the rate of price change.

Fot the United Kingdom, panel B of chart 10.17 again confirms the earlier judgments. Before the early 1950's there is little relation. After World War II, except only for the first two phases, there is a close correlation.

One feature common to both countries is the much wider variability in the rate of price change than in the rate of interest, except for the one post–World War II period. The wider variability in the rate of price change may be simply a statistical artifact, reflecting greater measurement error in the series on price change than in the series on interest rates. A more plausible explanation is economic: before World War II, the wider variability of prices reflects the existence of monetary and other disturbances that were stochastic and could not readily be anticipated. After World War II, variability was large but was attributable to policy, not chance. We shall return to this line of reasoning later.

First, however, let us examine the relation between the short-term rate and the price level. These series are plotted in chart 10.18. The difference in dimensionality makes the association of scales for the two series arbitrary. We have resolved this arbitrariness for the basic price scale by locating it so as to put the mean price level for the pre–World War I period on the same point on the ordinate as the mean interest rate for that period. The interval on the logarithmic price scale was chosen so as to yield about the same amplitude for prices in that period as the arithmetic scale for interest rates yields for interest rates.

The continuous series plotted for a century resolve a major part of the so-called Gibson paradox and support Macaulay's doubts: interest rates


percent per year
United States
Short-Term Rate
Rate of Price Change
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
1870
'80
'90
1900
'10
'20
'30
'40
'50
'60
'70

A

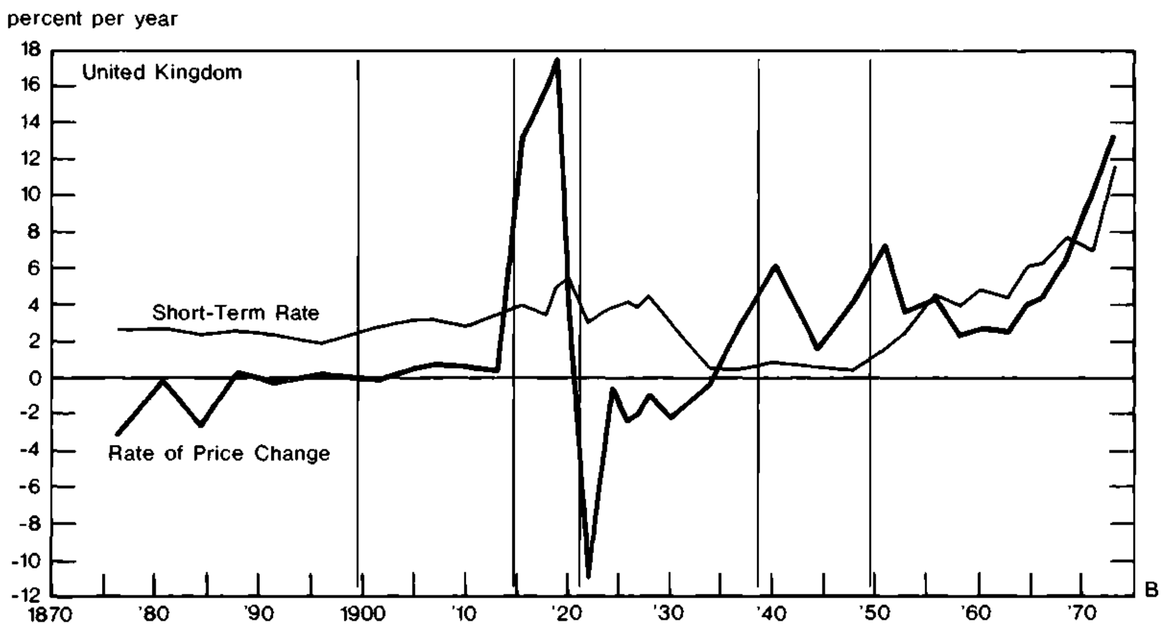


Chart 10.17 Short-term nominal interest rate and rate of price change, phase averages, 1870–1975.

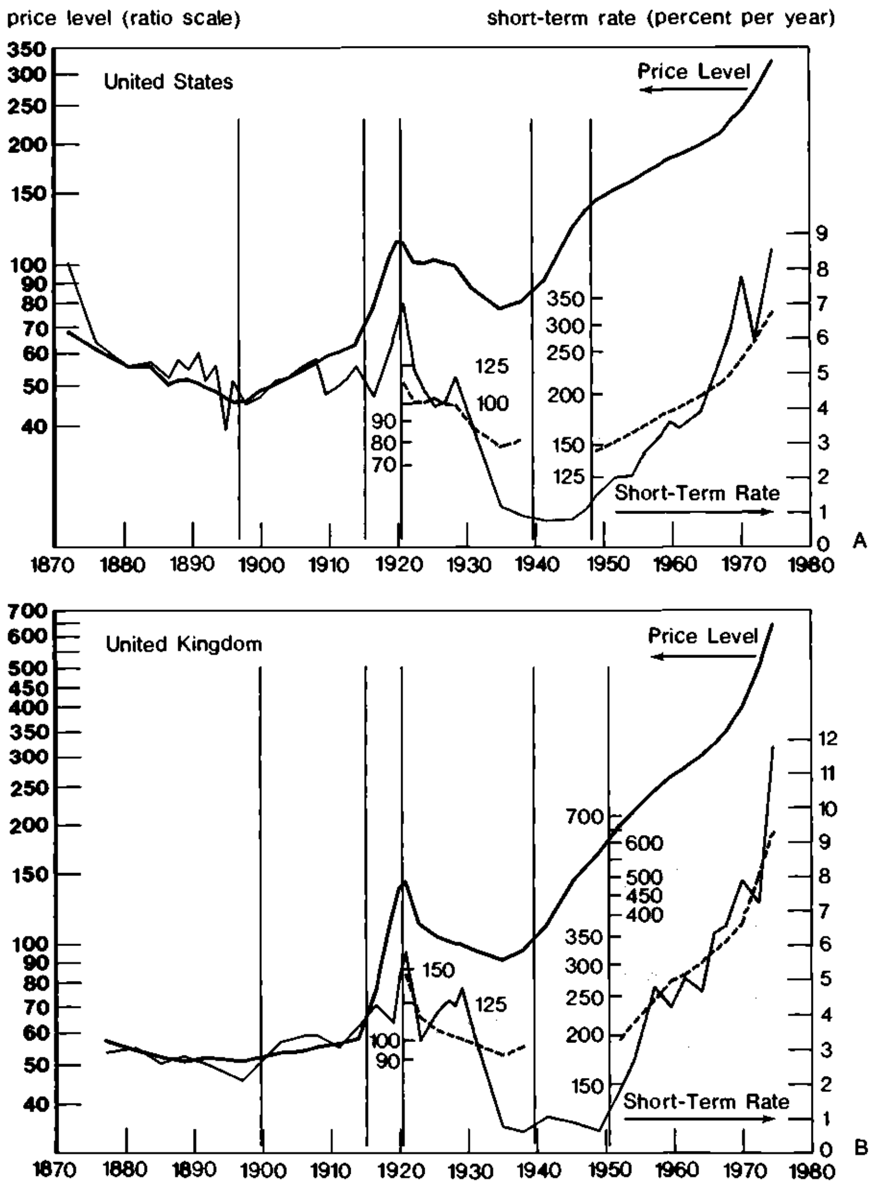


Chart 10.18 Short-term nominal interest rate and price level, 1870–1975.

do *not* follow major changes in price level. The theoretical expectation that jumps in the level of prices should leave no imprint on the rate of interest is fully confirmed. For both countries, the jumps in prices during World Wars I and II are not matched by any corresponding jump in interest rates. That much, at least, is eminently clear.

On the other hand, the close relation between interest rates and the level of prices during the pre–World War I period is striking, the only significant deviations being for the United States in the early years, when interest rates are out of line on the high side, and the final few years, when they are out of line on the low side.

To bring out any similar relation for the interwar and postwar periods, we have replotted the segment of the price series for those periods, shifting the origin of the vertical scale so as to make the average price level for each period coincide with the average rate of interest. For both the United States and the United Kingdom there is a definite correlation for both periods but a less close correlation than for the pre–World War I period, and for the post–World War II period it is not clear that the relation reflects more than common trends. Furthermore, for both countries, but more clearly for the United States, there seems to be a distinct break for the period after 1960 corresponding to the break we found earlier in the relation between the interest rate and the rate of price change. When interest rates start to parallel price *changes*, they start departing from parallelism with the price *level*.

The contrast between the relation of the interest rate to the rate of price change and the price level, as well as between the intraperiod and long-period relations, is brought out clearly in table 10.6. The only significant correlations for individual periods between interest rates and the rate of price change are for the post–World War II period. On the other hand, all the correlations for the three nonwar individual periods between the interest rate and the level of prices are positive and statistically significant.

For the period as a whole, none of the United States correlations with the rate of price change or the price level is statistically significant, either including or excluding wars. Three of the four United Kingdom correlations are significantly positive, both of those for the price level, and the correlation for nonwar phases for the rate of change of prices.

A more detailed description of the Gibson relation for nonwar periods is given in table 10.7. For both the United States and the United Kingdom, the intercepts clearly differ significantly between the periods—as was abundantly clear from chart 10.18. As is obvious from that chart, the slopes differ significantly for the United States, not for the United Kingdom.[51] One remarkable point brought out by the table and not by the charts is the close similarity between the countries. The average slopes for the three periods are almost identical, once allowance is made for differences in intercepts (compare lines 9 and 10); when a single slope is used for the three periods, the intercepts for the United States exceed

51. Herewith a summary analysis of variance (table 10.N.1, following page). Note that the F value for the United States corresponding to the 2 degrees of freedom for the three slopes is 17.2, highly significant.

Table 10.N.1 Significance of Differences among Periods in Regression of Interest Rate on Price Level

	Degrees of Freedom		Mean Square		*F*	
Source of Variation	United States	United Kingdom	United States	United Kingdom	United States	United Kingdom
Slope	1	1	.000001	.007497	0.0	110.2
Differences in intercept	2	2	.004151	.002111	133.9	31.0
Differences in slope	2	2	.000533	.000028	17.2	0.4
Residual	37	25	.000031	.000068		

Critical Values of F

n_1	n_2	.05 Value	.01 Value
1	37	4.10	7.37
1	25	4.24	7.77
2	37	3.26	5.23
2	25	3.38	5.57

Table 10.6 **Relation between Nominal Interest Rate and Rate of Change and Level of Prices**

	Number of Observations		Correlation between Interest Rate and	
Period and Country	Col. 3 (1)	Col. 4 (2)	Rate of Change of Prices (3)	Logarithm of Price Level (4)
Pre–World War I				
United States	20	21	−.339	.538*
United Kingdom	10	11	.120	.719*
World War I				
United States	5	3	−.830	.991
United Kingdom	5	3	−.689	.449
Interwar				
United States	7	9	−.133	.961**
United Kingdom	7	9	−.297	.706*
World War II				
United States	5	3	−.769	.774
United Kingdom	5	3	.335	−.995
Post–World War II				
United States	11	13	.800**	.956**
United Kingdom	9	11	.711*	.955**
All, excluding wars				
United States	38	43	.114	.009
United Kingdom	26	31	.664**	.746**
All				
United States	48	49	−.192	−.032
United Kingdom	36	37	.205	.594**

*Significantly different from zero at .05 level.
**Significantly different from zero at .01 level.

those for the United Kingdom by 2.68, 1.38, and 1.44 percentage points for the three successive periods. More surprising perhaps is the closeness of the residual standard error of estimate, both when a single slope is used (0.0075 versus 0.0081), and when separate slopes are (0.0056 versus 0.0083). This similarity, like the corresponding examples in earlier chapters, is further evidence of how integrated the United States and United Kingdom economies have been. It cannot be taken as further evidence for the reality of the Gibson phenomenon. It is simply a reflection of the tendency for price levels and interest rates in the two countries to move together, though not identically.

The Gibson paradox remains, but cut down to much more manageable size and stripped of its greatest element of mystery.[52]

52. Gerald P. Dwyer, Jr., "An Explanation of the Gibson Paradox," Ph.D. diss., University of Chicago, 1979, explores the relation between interest rates and prices for

Table 10.7 **Equations Relating Nominal Interest Rate to Logarithm of Level of Prices**

Period and Country	Number of Observations	Intercept (Percentage	Slope of Log *P* Points)	Standard Error of Estimate
Pre–World War I				
1. United States	21	6.78	2.94	.0048
2. United Kingdom	11	7.22	7.04	.0033
Interwar				
3. United States	9	4.67	14.08	.0057
4. United Kingdom	9	2.77	9.65	.0133
Post–World War II				
5. United States	13	−1.85	8.86	.0066
6. United Kingdom	11	−2.70	7.29	.0084
All nonwar				
Single equation				
7. United States	43	4.42	0.02	.0160
8. United Kingdom	31	3.61	1.99	.0144
Separate period intercepts		10.20		
9. United States	43	4.22	8.36	.0075
		−1.51		
10 United Kingdom	31	7.52	7.51	.0081
		2.84		
		−2.95		
Separate intercepts and slopes				
11. United States	43	(same as in		.0056
12. United Kingdom	31	lines 1–6)		.0083

Note: Interest rates expressed as decimal (e.g., 5 percent is .05). Price level expressed as ratio to 1929 level (e.g., 1929 = 1.0).

The indication that there may have been a structural change in the relation between interest rates and prices in the post–World War II period is so intriguing that it seems worth exploring this point in more detail by exploiting data for time units shorter than phases. As it happens, monthly data are available from 1913 for the United States and 1915 for the United Kingdom on both consumer prices and interest rates. As background, chart 10.19 duplicates chart 10.17 except that it uses the consumer price index, rather than the price index implicit in the national income estimates, and monthly data, with the rate of price change averaged over six-month intervals to avoid extreme variability, rather than phase average data.[53]

France, Belgium, and Germany, as well as the United States and the United Kingdom. His conclusion parallels ours: "There is no stable relationship between interest rates and prices" (p. 79). He finds periods of positive correlation for the United Kingdom and the United States, especially before 1914 and after World War II, but not for the other countries.

53. It is unclear how best to date the price series matched with the interest rate series. The interest rate recorded for the month of January, for example, refers to a contract that will

The monthly series plotted in chart 10.19 bring out more clearly than our phase averages two respects in which the post–World War II period—or much of it—differs from the earlier period: the first starting in the early or mid-1950s, the second, somewhat later.

The first respect is the drastic decline in the variability of the recorded price series after the mid-1950s in both countries. Before that period the rate of price change is many times more variable than the interest rate; after that date it is still more variable, particularly in the United Kingdom, but the difference is much less. The change in the variability of the price series may be simply a statistical artifact. In both countries the reduction in variability coincides with a comprehensive statistical revision in the price index—in 1953 in the United States, in 1956 in the United Kingdom.[54] It may be that the recorded fluctuations in prices before these dates reflected largely measurement error.[55]

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terminate some months later (for the United States, sixty to ninety days later through 1923, four to six months later thereafter; for the United Kingdom, three months later). The realized real return will depend on what happens to prices in the subsequent period. For that purpose, the January interest rate should be matched with a rate of price change corresponding to the period from January to the termination month. On the other hand, at the time the contract is entered into, data are available only on prices up to that point. To relate the January interest rate only to information available at the time requires using a rate of price change for a period terminating in January. Given that we are using a rate of price change based on a six-month interval, that means matching the January interest rate with the rate of price change from prices in the prior July to January, or a rate centered on October. That is what we have done in chart 10.19.

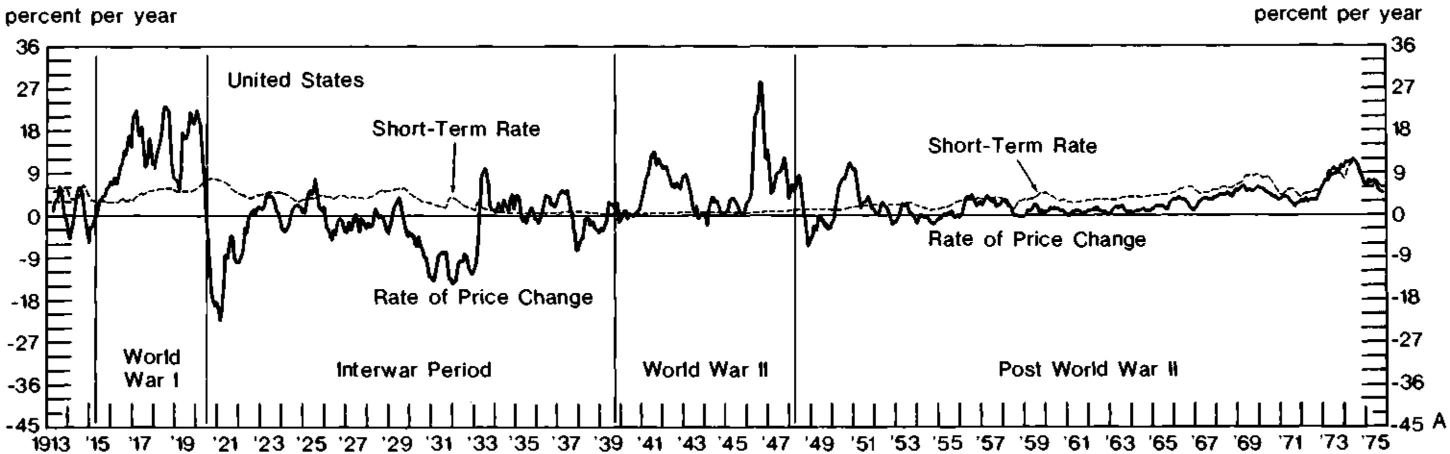
Note that in relating the January interest rate "only to information available at the time" we distinguish between two concepts of information: personal observation over time based on efficient knowledge of the market versus the official statistics of prices released in February for the month of January. Neither concept is right, but we judge the historical one to be better than the official release.

Correlation experiments relating interest rates to price changes subsequently to the date of the interest rate produced no persuasive evidence to justify a different dating.

54. See United States Department of Labor, Bureau of Labor Statistics, *Handbook of Methods of Surveys and Studies*, Bulletin no. 1458, October 1966, chap. 10, on consumer prices, pp. 69–90, for a description of the comprehensive revision of the index in January 1953.

The United Kingdom retail price index was introduced in 1956 as the successor to the cost of living index, the first officially published index of this sort, which started in 1915. The cost of living index was designed to show the effect of price changes on the basic goods consumed by working-class families before August 1914. The retail price index measures changes in prices of a much more comprehensive basket of goods and services reflecting the average spending pattern of the great majority of households, including those of practically all wage earners and most salary earners. See Great Britain, Central Statistical Office, *Method of Construction and Calculation of the Index of Retail Prices*, Studies in Official Statistics, no. 6 (London: HMSO, 1964).

55. In a private communication before his death, Julius Shiskin noted that, for a period of six months after the 1953 revision, the United States Bureau of Labor Statistics continued the old series, using the same samples, weights, and procedures in existence before the revision. There was greater variability in the old series for the overlap period. Phillip Cagan,


percent per year
percent per year
United States
Short-Term Rate
Rate of Price Change
Short-Term Rate
Rate of Price Change
World War I
Interwar Period
World War II
Post World War II
36
27
18
9
0
-9
-18
-27
-36
-45
1913 '15 '17 '19 '21 '23 '25 '27 '29 '31 '33 '35 '37 '39 '41 '43 '45 '47 '49 '51 '53 '55 '57 '59 '61 '63 '65 '67 '69 '71 '73 '75
A

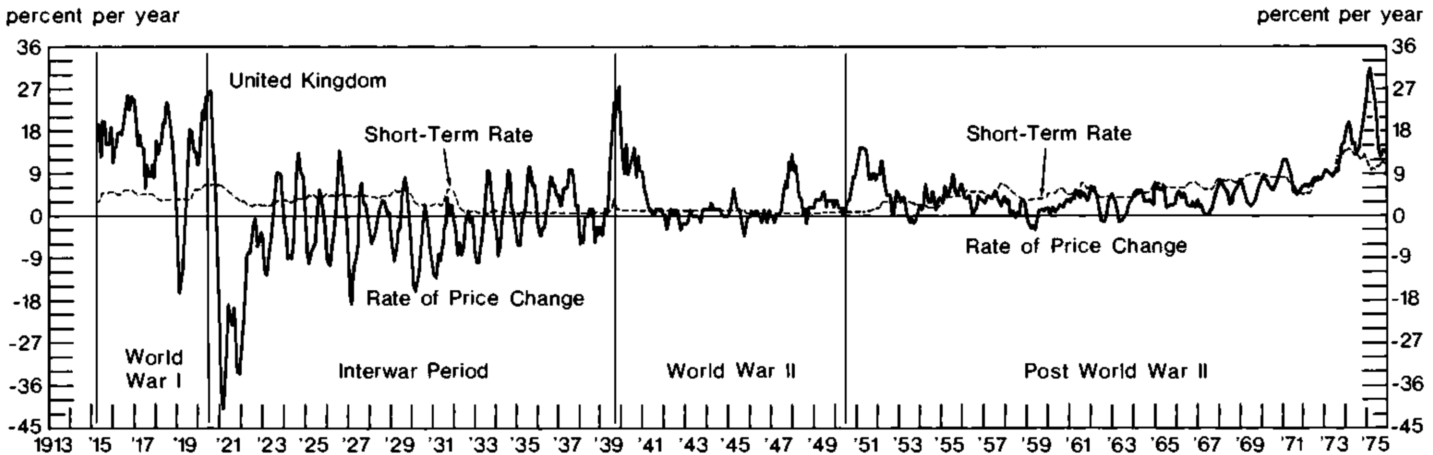


Chart 10.19 Short-term nominal interest rate and the rate of price change, six-month moving averages, 1913–75. Price data are six-month changes centered on the fourth month.

The second respect is the changed relation between the interest rate and the rate of price change. Up to the 1950s at least, there is only the vaguest of hints of any systematic short-term relation in either country between the interest rate and the recorded rate of price change—every once in a while there is a movement in the interest rate that can be connected to a movement in the same direction in the price-change series, but most of the time the two series seem to move independently of one another. This lack of relationship may be a consequence of the large measurement error in the rate of price change—the statistical noise in the recorded price series may have drowned out a systematic relation between interest rates and the "true" rate of price change.

However, the subsequent behavior of the series, particularly in the United States, suggests that statistical noise is at best a partial explanation. For some five to ten years in the United States after the 1953 statistical revision, there is no closer relation between the interest rate and the price series than there was earlier. Then the relation becomes closer and closer, at first in the general movement, then even in the minor ups and downs. The change is gradual so that there is no sharp dividing line, yet after, say, 1965 the relation is clearly very close.

The United Kingdom picture is less clear-cut, partly because the rate of price change retains more variability after the statistical revision, partly because the relation never gets as close as in the United States, partly because of the final spike in the rate of price change unmatched by any movement in the interest rate—a spike that may be connected with changes in price control. Statutory price controls were in effect from November 1972 to February 1974, followed by voluntary controls for the next six months and then by the reimposition of compulsory controls a year later, in August 1975. Nonetheless, with the benefit of the hindsight provided by the United States experience, a very similar pattern can be seen in the United Kingdom data, with 1965 again a convenient dividing line.

The looser relation between the two series for the United Kingdom than for the United States may well reflect statistical defects in both series: for the rate of price change, the more important and frequent use of price controls than in the United States; for the interest rate, its administered character. It is clear from the charts that the rate on bank bills in the United Kingdom is a managed rate, remaining constant for

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however, informs us that he doubts that the decline in variability after 1953 is due to improvement in the United States consumer price index. He bases his judgment on a study of wholesale prices, in which he examined some components of the wholesale price index in the 1920s and post–World War II years and found a considerable decline in the dispersion of price changes for cycles of roughly the same severity. He attributes the decline to changed market behavior or a changed composition of markets and products ("Changes in the Recession Behavior of Wholesale Prices in the 1920s and Post-World War II," *Explorations in Economic Research* 2 [winter, 1975]: 54–104).

months at a time, while the United States commercial paper rate is an effective market rate.[56]

Chart 10.20 provides a closer look at the relation between the interest rate and the rate of price change for the period after 1965 ending in 1979, rather than 1975, the final cyclical turning point of our trend period. It differs from Chart 10.19 both in an enlarged time scale and in a different time reference of the rate of price change. Chart 10.19 plotted the price change retrospectively; that is, the price change associated with, say, a January interest rate is the change during the prior six months, or the information that could have been available to the lenders and borrowers when they entered into their contract. Chart 10.20 plots the price change prospectively; that is, the price change associated with, say, a January interest rate, is the change that is estimated to occur during the period of the loan contract. Hence the vertical difference is the realized real rate of return, and the price change is the one that the transactors would, if they had perfect foresight, take into account.[57]

For the United States the relation is very close indeed throughout the period. The shifting of dates does not improve the relation as judged by simple correlations, though visually it appears to do so at a number of points.[58] These results leave very much open the question whether partici-

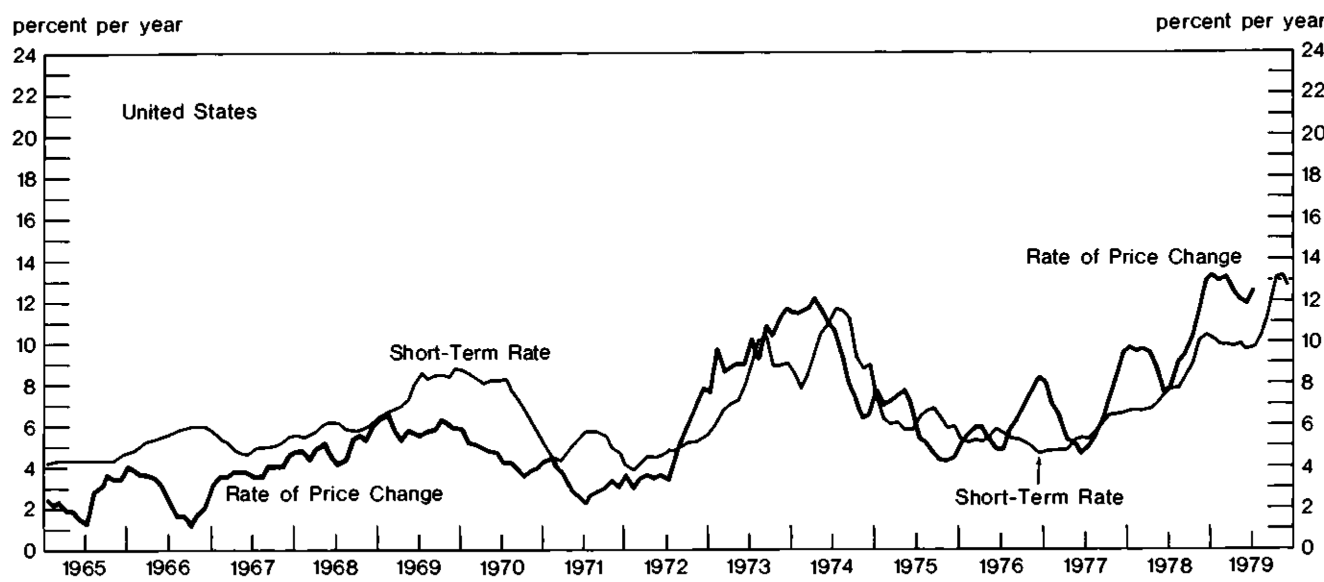
56. John Foster, "Interest Rates and Inflation Expectations: The British Experience," *Oxford Bulletin of Economics and Statistics* 41 (May 1979): 145–64, comments (p. 152, n. 24): "It is worth emphasizing that short-term securities in the United Kingdom differ from those in the United States in that the latter are generally viewed as market determined whereas the former have been administered through Bank Rate policy and, more recently, through alterations in the Minimum Lending Rate [introduced in 1972]."

57. The actual matching is approximate. For the United States, we treated the four-to-six month commercial paper rate as if it always referred to six-month paper, which makes the six-month price change the relevant change, and gives the simple dating of matching the January interest rate (which for six-month paper refers to a contract terminating in July) with the January to July rate of price change.

For the United Kingdom, the interest rate is for a three-month bill, and the correct matching would be with a three-month price change. However, both for consistency with the United States and to reduce variability, we decided to retain a six-month price change and simply match as closely as possible the central dates of the interest rate contract and the price change. A January interest rate refers to a contract terminating in April; its central date is midway between February and March. The price change from November to May is centered in February, the price change from December to June, in March, so either one differs in dating by one-half month. We arbitrarily chose to match the December to June price change with the January interest rate.

58. Herewith the simple correlation coefficients for 1965–79:

Interest Rate Matched with Price Span Terminating	*Correlation Coefficient*
Same month	0.835
One month later	0.833
Two months later	0.823
Three months later	0.804
Four months later	0.782



percent per year
percent per year
United States
Short-Term Rate
Rate of Price Change
Rate of Price Change
Short-Term Rate
24
22
20
18
16
14
12
10
8
6
4
2
0
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

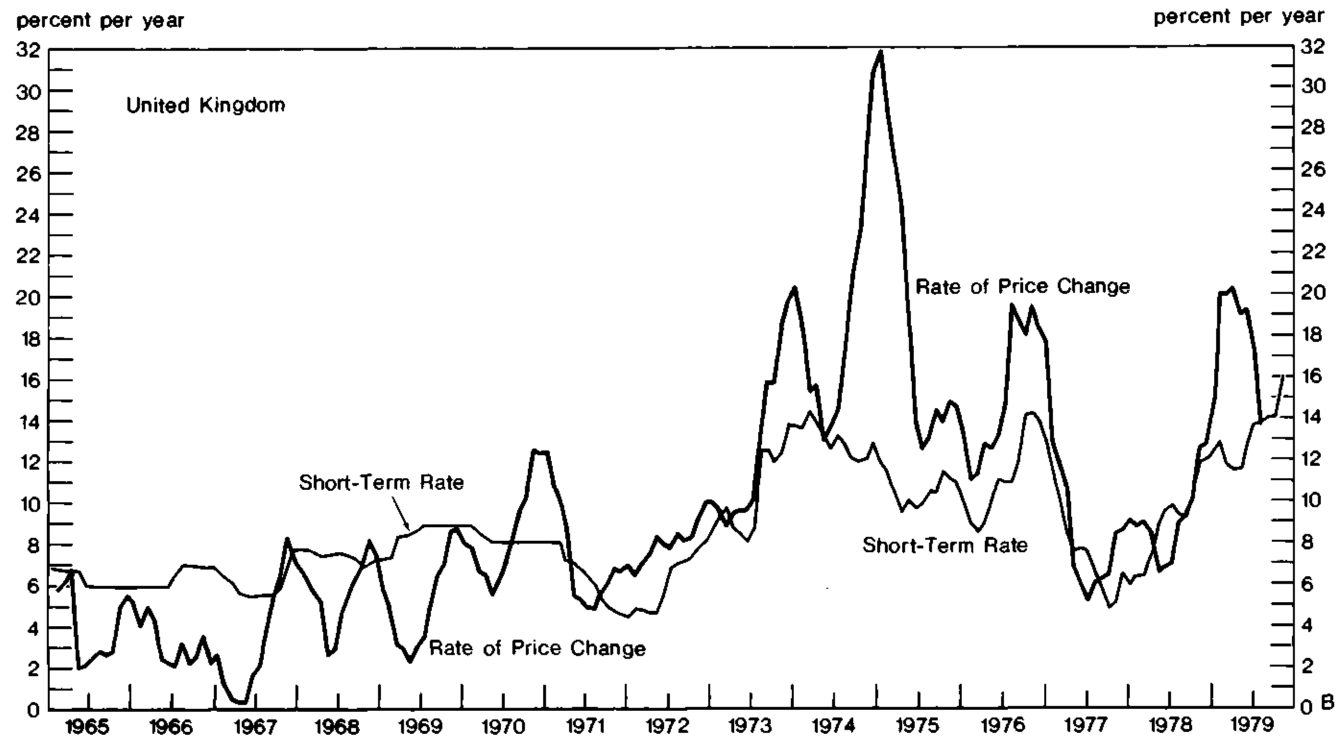


Chart 10.20 Relation between interest rates and price change, United States and United Kingdom, monthly, 1965–79.

pants in the market can successfully predict the movement of prices for a few months ahead.

For the United Kingdom the relation is far looser. As we noted earlier, this difference may reflect the statistical defects of the United Kingdom series rather than a basic economic difference between the two countries.

10.7 Alternative Explanations of the Gihson Paradox

The preceding sections narrow more than has hitherto been done the Gibson phenomenon to be explained: first, the alleged relation does not hold over periods witnessing a substantial shift in the price level, but only within briefer periods; second, the markets may have learned their Fisher and so have made Gibson obsolete. But this narrowing of the paradox does not eliminate it; it still represents a striking empirical regularity in search of an explanation.

The most famous and most fully explored explanations that have been proposed are the monetary explanation suggested by Irving Fisher and the real explanation suggested first by Knut Wicksell and later by J. M. Keynes.

10.7.1 The Fisher Explanation

As already noted, Fisher's proposed explanation hinges on a lag between a change in the direction of price movements and the public's perception of that change. In his 1907 *Rate of Interest*, which largely overlaps his 1896 *Appreciation and Interest*, he expresses this explanation in very general terms:

> Three general facts have now been established: (1) Rising and falling prices and wages are directly correlated with high and low rates of interest; (2) The adjustment of interest to price-movements is inadequate; (3) This adjustment is more nearly adequate for long than for short periods.
>
> These facts are capable of a common explanation expressing the manner in which the adjustment referred to takes place. Suppose an upward movement of prices begins. Business profits (measured in *money*) will rise. . . . Borrowers can now afford to pay higher "money-interest." If, however, only a few persons at first see this, the interest will not be fully adjusted, and borrowers will realize an extra margin of profit after deducting interest charges. This raises an expectation of a similar profit in the future and this expectation, acting on the demand for loans, will raise the rate of interest. If the rise is still inadequate, the process is repeated, and thus by continual trial and error the rate approaches the true adjustment. . . .
>
> Since at the beginning of an upward price-movement the rate of interest is too low, and at the beginning of a downward movement it is too high, we can understand not only that the averages for the whole

> periods are imperfectly adjusted, but that the delay in the adjustment leaves a relatively low interest at the beginning of an ascent of prices, and a relatively high interest at the beginning of a descent. And this is what we found to be true. That the adjustment is more perfect for long periods than for short periods seems to be because, in short periods, the years of non-adjustment at the beginning occupy a larger relative part of the whole period.[59]

When Fisher returned to the problem some two decades later, he converted this general hypothesis into a much more rigid and formal one—and one, incidentally, with less economics. In the interim he had developed distributed lags, and he applied them to this problem. He expressed the nominal interest rate as the sum of a real interest rate, implicitly assumed constant, and an anticipated rate of price change, and then approximated the anticipated rate of price change by a weighted average of prior price change, with the weights declining linearly and summing to unity—that is, a triangular weighting pattern.[60] Whereas in 1907 he had explained the changes in interest rates as produced by shifts in the demand for loans arising from the result of unanticipated inflation on profits, a process that requires no explicit formation of inflationary anticipations, here the anticipations take center stage.

For the delayed formation of anticipations to explain Gibson's paradox empirically, the time it takes people to form their anticipations must have a particular relation to the duration of the long swing in prices. If people formed their anticipations very rapidly—much more rapidly than the duration of a price rise or a price fall—interest rates would rise only briefly when prices started to rise and soon would be high but constant; and similarly when prices started to fall. Interest rates would look more like the steps in chart 10.10 than like the wavy dotted line. A close correlation between rising prices and rising rates requires that the time it takes for people to adjust their anticipations must be roughly comparable to the duration of the long swings in prices. It is not surprising, therefore, that when Fisher estimated the lag in forming anticipations by using observed interest rates and prices he found that the average period of the distributed lag of anticipations behind prices was 7.3 years (i.e., triangular weights covering twenty years) for United States long rates computed from annual data from 1900 to 1927; 10.7 years (i.e., triangular weights covering thirty years) for United States short rates computed from quarterly data from 1915 to 1927; 10.0 years (triangular weights covering twenty-eight years) for United Kingdom long rates computed from annual data from 1898 to 1924.[61]

59. *The Rate of Interest*, pp. 284–85.

60. Irving Fisher, *The Theory of Interest* (New York: Macmillan, 1930), pp. 407–44.

61. Ibid., pp. 421, 422, 427. The mean period of continuous triangular weights is one-third the total period of the weights. For discontinuous weights, for which the initial

Frederick Macaulay, in his 1938 book, was highly critical of Fisher's analysis, partly on purely statistical grounds. He pointed out serious errors in Fisher's appendix tables, correction of which substantially reduced the already low correlation between levels of interest rates and the rate of change of prices. He noted that "rates and yields were usually more highly correlated with 'the weighted average of sundry successive' price changes than they were with the individual price changes; *but not so highly correlated as they were with the raw prices*."[62] He then pointed out, as did others many years later when there was a resumption of interest in the subject, that "as the number of [past rates of change of prices] included in the [triangularly weighted average of price change] is increased, the configuration of [the weighted average] usually approximates more and more closely the configuration of [the price level]."[63] In consequence, he argued that Fisher's correlations were only a disguised reflection of the Gibson phenomenon, not an explanation thereof. He stressed also the difference in results for different periods, a point to which we shall recur. Macaulay admitted the existence of a real puzzle but believed that Fisher had not provided a satisfactory resolution.

In recent years a number of scholars have repeated and extended Fisher's calculations, with only slight modifications. The results have been highly consistent. For periods including World War I or World War II and some ways beyond, the results reproduce Fisher's finding that long lags yield the highest correlations.[64] However, for recent years that is not the case. Yohe and Karnosky and Robert Gordon find that, for the later years of the postwar period, a shorter weighted average of past price changes yields price anticipations that best explain interest rate movements.[65]

This finding, plus the understandable skepticism about the plausibility of such long lags that has all along hindered the acceptance of Fisher's conclusions, stimulated efforts to find other tests of Fisher's hypothesis. For the period since 1947, an independent series of price forecasts for the

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weight is taken as dated minus one time unit, the mean period is one-third the total period plus either two-thirds or one-third of a time unit, depending on whether a total period of T units is interpreted as corresponding to discontinuous weights $1, 2, \ldots, T$, or to discontinuous weights $0, 1, 2, \ldots, T-1$. Fisher is inconsistent in converting total periods into mean periods. He sometimes converts by dividing by three, sometimes by dividing by three and adding two-thirds. We have used means obtained by dividing by three and adding two-thirds, since this corresponds to a change that Fisher made in listing errata for page 423.

62. Macaulay, *Movements of Interest Rates*, p. 171 (italics in original).

63. Ibid., p. 174.

64. See Suraj Gupta, "Expected Rates of Change in Prices and Rates of Interest," Ph.D. diss., University of Chicago, 1964.

65. W. P. Yohe and D. S. Karnosky, "Interest Rates and Price Level Changes" (note 3, above); Robert J. Gordon, "Inflation in Recession and Recovery," *Brookings Papers on Economic Activity*, no. 1, (1971), pp. 145–48.

United States has been compiled by Joseph Livingston from responses by a panel of business economists. Several studies have correlated this series with interest rates and used it to test hypotheses about the formation of expectations. The major findings relevant to our present purpose are that expectations are highly correlated with interest rates but that a short rather than a long weighted average of past price behavior gives the best fit to inflation forecasts.[66]

66. John A. Carlson, "A Study of Price Forecasts," *Annals of Economic and Social Measurement* 6, no. 1 (1977): 27–56, contains the most thorough description and presentation of these data that we have seen.

For analyses of these data see William E. Gibson, "Interest Rates and Inflationary Expectations"; Kajal Lahiri, "Inflationary Expectations: Their Formation and Interest Rate Effects," *American Economic Review* 66 (March 1976): 124–31; James E. Pesando, "A Note on the Rationality of the Livingston Price Expectations," *Journal of Political Economy* 83 (August 1975): 849–58; David H. Pyle, "Observed Price Expectations and Interest Rates," *Review of Economics and Statistics* 54 (August 1972): 275–81; Stephen J. Turnovsky, "Some Empirical Evidence on the Formation of Price Expectations," *Journal of the American Statistical Association* 65 (December 1970): 1441–54; Stephen J. Turnovsky and Michael L. Wachter, "A Test of the 'Expectations Hypothesis' Using Directly Observed Wage and Price Expectations," *Review of Economics and Statistics* 54 (February 1972): 47–54; Lahiri and Lee, "Tests of Rational Expectations."

Gibson does not test the relation between the Livingston expectations and prior price behavior but solely between them and interest rates, finding a good correlation, but suggesting that there is evidence of a break in the relation around 1965. Turnovsky is more directly concerned with expectations formation. He too finds a break in the data during the early 1960s and finds a good relation between the expectations and prior price behavior only after the early 1960s. A similar finding is reported in A. B. Holmes and M. L. Kwast, "Interest Rates and Inflationary Expectations: Tests for Structural Changes, 1952–1976," *Journal of Finance* 34 (June 1979): 733–41.

Quarterly interpolations of the Livingston expectations series and also of a series based on Survey Research Center surveys have been published by F. Juster and P. Wachtel, "Inflation and the Consumer," *Brookings Papers on Economic Activity*, no. 1 (1972), pp. 71–114. These series were updated in P. Wachtel, "Survey Measures of Expected Inflation and Their Potential Usefulness," *Analysis of Inflation, 1965–1974*, ed. Joel Popkin, Studies in Income and Wealth, vol. 42 (Cambridge, Mass.: Ballinger, 1977), pp. 361–94. G. de Menil and S. S. Bhalla, "Direct Measurement of Popular Price Expectations," *American Economic Review* 65 (March 1975): 169–80, used the Survey Research Center series to explain wage changes. S. J. Feldman has used both expectations series to examine their relation to interest rates from 1955 to 1971 and to various weighted averages of past price changes. He concludes, as did Gibson, that there is a close relation between price expectations and interest rates but finds no evidence of any change in the relation. Like Turnovsky, he does find a break in the 1960s in the relation between directly observed price expectations and the weighted averages of past price changes. He concludes that "distributed lag hypotheses are poor proxies for anticipated inflation" and that "how the market forecasted inflation has altered." "The Formation of Price Expectations and the Nominal Rate of Interest: Is Fisher Right?" unpublished Federal Reserve Bank of New York Research Paper no. 7416, July 1974.

Cukierman and Wachtel relate the variance of the two expectations series to the variance of nominal income change and of the inflation rate. They find that periods with large variances of nominal income change and of the inflation rate are also periods of close

Unfortunately, no similar independent estimates of price expectations are available for the earlier period, so there is no way of knowing whether this finding simply is another reflection of a major break in recent decades or is evidence against the long lags for the earlier period as well.[67]

association between the level of interest rates and the variability of expectations, and they suggest "the need to reformulate Fisher's theory of interest for the case of heterogeneous expectations" (p. 607). A. Cukierman and P. Wachtel, "Differential Inflationary Expectations and the Variability of the Rate of Inflation: Theory and Evidence," *American Economic Review* 69 (September 1979): 595–609.

For the United Kingdom, see J. A. Carlson and M. Parkin, "Inflation Expectations," *Economica* 42 (May 1975): 123–38; and D. Demery and N. Duck, "The Behavior of Nominal Interest Rates in the United Kingdom, 1961–73," *Economica* 45 (February 1978): 23–27. Demery's and Duck's finding that there is a great deal of evidence that inflation expectations have some role in determining nominal interest rates is disputed by John Foster, "Interest Rates and Inflation Expectations: The British Experience," *Oxford Bulletin of Economics and Statistics* 41 (May 1979): 145–64, who reports only limited evidence, "certainly from 1961–66 and probably from 1966–77" (p. 162). See also K. Holden and D. A. Peel, "An Empirical Investigation of Inflationary Expectations," *Oxford Bulletin of Economics and Statistics* 39 (November 1977): 291–99.

Australian data on price expectations of consumers reported quarterly for a five-year period are analyzed by L. V. Defris and R. A. Williams, "Quantitative versus Qualitative Measures of Price Expectations," *Economic Letters* 2, no. 2, (1979): 169–73. They conclude that the quantitative level of expected price change was "about right" and that "prediction of quarter-to-quarter fluctuations was moderately successful" (p. 173), but that qualitative forecasts were of little value. The paper was concerned solely with the price expectations.

67. One approach that has been attempted to obtain an independent series of anticipations is to derive them from futures prices of commodities as recorded on futures markets. Unfortunately this approach has foundered on the highly special composition of the commodities traded on active futures markets so that anticipations about changes in the relative price of these commodities appear to have swamped anticipations about changes in the general price level.

A more successful experiment is contained in an interesting paper by Jacob A. Frenkel, in which he used the forward exchange rate to estimate price anticipations during the German hyperinflation ("The Forward Exchange Rate, Expectations, and the Demand for Money: The German Hyperinflation," *American Economic Review* 57 [September 1977]: 653–70). However, this approach is available only during periods of floating exchange rates and even then gives expectations of changes in relative prices in two countries—limitations of no importance for the German hyperinflation, but of great importance for most periods.

Another approach is used by Cukierman with Israeli data, where the coexistence of indexed and nonindexed bonds provides a reasonably direct measure of the anticipated rate of inflation (not exact because of differences in the time duration and risk elements of the two categories of securities). In an interesting and important paper, he uses such a measure to test various assumed expectational processes, concluding that what he calls a "generalized linear process" gives the best approximation. The process, a modified version of a process presented by J. A. Frenkel ("Inflation and the Formation of Expectations," *Journal of Monetary Economics* 1 [October 1975]: 403–21), is one in which the anticipated rate of inflation is a weighted average of past rates, the set of weights being decomposable into two components, one, extending over a few months only, which is extrapolative, the other, extending over thirty months, which is regressive. The process is dominated by the regressive component, the weights for which first rise and then decline. Cukierman concludes that "the generalized linear expectational process is not inconsistent with the concept of rational

A more indirect approach that has been increasingly adopted in recent studies of the Gibson paradox and Fisher's hypothesis has been to ask whether it would have been rational for people to form their anticipations by such a long weighted average of past price experience. The answer is by no means clear or simple. The question, stated differently, is dual: first, insofar as past prices give information on future rates of inflation, does the long weighting pattern required to explain interest rate behavior extract that information efficiently? Second, was there information readily available to participants in the relevant markets, other than past prices, which would have enabled them to improve their prediction of future rates of inflation? If the answer to the first question were no, or the answer to the second yes then participants would have overlooked profit-making opportunities if they had neglected such information and had insisted on using the long weighted averages Fisher attributed to them: markets would have been inefficient. If the answer to the first question were yes, but the answer to the second no, Fisher's procedure would encapsulate the entire anticipatory process. Finally, if the answer to both questions were yes, Fisher's procedure would be incomplete, but not necessarily invalid, since it would correspond to the extraction from the price data of the information that it contains.

If Fisher's explanation of the Gibson paradox is not valid, that does not of course mean that markets are inefficient. It may rather reflect a lack of constancy in the ex-ante real rate or a different process of forming anticipations.

This indirect approach, like the calculations along Fisher's lines, has yielded very different results for recent and earlier decades. For the post–World War II period for the United States, Shiller and Fama conclude that short and long interest rates are consistent with both a constant real rate and rational expectations.[68] Two more recent papers question Fama's finding of a constant real rate, but not of an efficient market.[69] Rutledge finds that, for recent decades, information other than

expectations" (p. 749). Alex Cukierman, "A Test of Expectational Processes Using Information from the Capital Market—the Israeli Case," *International Economic Review* 18 (October 1977): 737–53.

68. Shiller, "Rational Expectations and the Structure of Interest Rates" Fama, "Short-Term Interest Rates as Predictors of Inflation." See note 6 above.

69. Hess and Bicksler, "Capital Asset Prices versus Time Series Models"; Nelson and Schwert, "Short-Term Interest Rates as Predictors of Inflation." See note 6 above. Both pairs of authors find Fama's procedure defective in allowing only for a single monthly autocorrelation of interest rates rather than a longer series. In a later article that makes no reference to either of these papers, Fama finds evidence of variation in the real rate but concludes that "only a trivial fraction of the sample variance" of the ex-post real return on one-month Treasury bills "can be attributed to the measured variation" in the ex-ante expected real rate. Eugene F. Fama, "Inflation Uncertainty and Expected Returns on Treasury Bills," *Journal of Political Economy* 84 (June 1976): 427–48; quotation from p. 444.

past price movements, namely, past monetary growth rates, can be used to improve predictions of future inflation. However, Feige and Pearce reach the opposite conclusion for roughly the same period and price data but by a different set of statistical procedures.[70] Dwyer concludes, along with Rutledge, that "Fisher's hypothesis is able to explain the upward movement of interest rates and price levels since the early 1950's."[71]

While the results for recent decades confirm the broad outlines of Fisher's approach, they reject his particular empirical hypothesis about the formation of expectations. Indeed, they come close to denying the existence of the Gibson paradox, which was the occasion for his hypothesis.

The situation is very different for earlier decades. For the United States for 1870–1940, Sargent finds that the weighted average of past price changes that gives the best predictions of future inflation has a much shorter average lag than the weighted average that Fisher used—an average much more like that which Yohe and Karnosky found for the 1960s. Sargent concludes that "it is difficult *both* to accept Fisher's explanation of the Gibson paradox *and* to maintain that the extraordinarily long lags in expectations are 'rational.'" However, this conclusion is based on calculations that include World War I, when, as we have seen, there was no Gibson paradox to explain. Siegel and Shiller conclude for both the United States and the United Kingdom for a much longer pre–World War II period that the data are not consistent with a constant real rate plus rational anticipations of inflation.[72] In a highly perceptive comment on Sargent's paper, Gordon points out that, through World War II, the major instances of significant inflation and deflation were concentrated in time and connected with episodes that were widely

70. John Rutledge, *A Monetarist Model of Inflationary Expectations* (Cambridge, Mass.: Lexington, 1974); Edgar L. Feige and Douglas K. Pearce, "Economically Rational Expectations: Are Innovations in the Rate of Inflation Independent of Innovations in Measures of Monetary and Fiscal Policy?" *Journal of Political Economy* 84 (June 1976): 499–522. Rutledge uses multiple correlation and relates an interest rate to other series; Feige and Pearce use Box-Jenkins techniques and do not use interest rates, instead investigating whether the residuals from ARIMA models fitted to time series of prices are correlated with residuals from ARIMA models fitted to time series of various monetary aggregates and the full employment surplus. They find no correlation. This procedure is eminently sensible for investigating the best way to forecast short-term movements in prices. However, it provides only limited evidence on the very different question of the effect of monetary or fiscal forces on the course of prices, since for the most part the important question about those effects has to do with the longer-term systematic movements that are expressly abstracted from in the ARIMA models.

71. Dwyer, "Explanation of the Gibson Paradox," p. 112.

72. Sargent, "Interest Rates and Prices in the Long Run," quotation from p. 402; Shiller and Siegel, "Gibson Paradox." See also Thomas J. Sargent, "Interest Rates and Expected Inflation: A Selective Summary of Recent Research," *Explorations in Economic Research* 3 no. 3 (summer 1976): 303–25.

recognized as special (World Wars I and II, post–World War I contraction, and the Great Depression). Hence, he argues, it would have been irrational to extrapolate them mechanically to the future. He interprets post–World War II experience as more favorable to a mechanical extrapolation, though with a short lag, because inflation has become a part of a standard political-economic response mechanism.[73]

Any shortcoming of Fisher's explanation of the Gibson paradox does not, of course, in any way diminish the importance of his distinction between real and nominal interest rates, or his distinction between ex-post and ex-ante real rates, or his emphasis on the anticipated rate of inflation as affecting both the demand for and supply of loanable funds. But it does put in serious doubt his highly special composite hypothesis that for the purpose of studying monetary influences on interest rates the ex-ante real rate can be treated as constant, and that interest rates follow the level of prices because borrowers and lenders estimate future inflation by a long weighted average of past rates of inflation.

Gordon's comment brings out a key limitation of all the empirical work covering long periods, including not only that of Sargent and of Siegel and Shiller, but also that of Fisher himself. With one minor exception for Sargent, to which we shall return, and more extensive exceptions for Fisher, all the calculations on which they base their conclusions span the World War I period. But we have seen that there was no Gibson phenomenon from before to after World War I. Their results may simply reflect the attempt to explain a nonexistent phenomenon and may be entirely consistent with a very different verdict on the Fisher hypothesis for the pre–World War I period alone, or for the interwar period alone.

It is noteworthy that while in the text Fisher stressed the periods including World War I, he systematically got lower correlations and shorter mean lags for periods excluding World War I: for United States short rates, only 10.2 quarters or two and one-half years for 1890–1914, compared with over ten years for 1915–1927; for United Kingdom long rates, 7.1 years for 1820–64, and 8.2 years for 1865–97, compared with ten years for 1898–1924.

The one exception in Sargent's paper is a calculation for 1880–1914 of the optimum prediction of the change in the annual wholesale price index on the basis of an exponentially weighted average of past price changes. He estimates that the optimum mean lag is very short (one quarter).[74]

73. Robert J. Gordon, "Interest Rates and Prices in the Long Run: A Comment," *Journal of Money, Credit and Banking* 5, no. 1, part 2 (February 1973): 460–65.

74. Sargent, "Interest Rates and Prices in the Long Run," table 2.1, p. 398. Let g_P refer to the continuous rate of price change (first difference of the natural log of price), and let

$$g_P^*(t+1) = b \sum_{i=0}^{\infty} (1-b)^i g_P(t-i),$$

where b is the weight given $g_P(t)$.

However, that optimum gives essentially no information on future price changes, since the weighted average computed from weights adding to unity is to be multiplied by 0.06. In effect, his formula reduces to a weighted average of a zero price change and an exponentially weighted average of prior price changes, with the zero price change receiving 94 percent of the weight. Moreover, the correlation between his exponentially weighted average and the actual subsequent price change is close to zero (for thirty-five observations, it is .062),[75] which is, of course, why it receives so little weight. Taken at its face value, Sargent's conclusion is that a zero price change was the optimum prediction for each year 1880–1914 based solely on past price data.

Sargent's result cannot, however, be accepted at face value. In the first place, it is disproportionately influenced by the one year 1880, in which wholesale prices averaged more than 11 percent higher than in 1879 as a result of the reaction to resumption—again, one of those special events that participants were surely aware of at the time and would not have regarded as simply another year to be extrapolated. Omit 1880, and Sargent would have come out with a much longer optimum lag (probably averaging about six to nine years) and would have given it greater weight in averaging it with a zero price change prediction.[76]

In the second place, the correlation between the interest rate and the actual annual price change, though low, is higher than between the interest rate and Sargent's predicted price change both including 1880 and excluding 1880.[77] The implication is that market participants had information in addition to price changes ending a year earlier. And of course they did. They not only knew about such events as resumption, the silver agitation, the defeat of free silver in 1896, and the like, but also had more current price information. Except at the very outset of a calendar year, the participants had price information for the earlier part of that calendar year itself.

Then the average period of the weights is $b \, \Sigma \, i(1 - b)^i = \frac{1-b}{b}$.

Given that the result is to be used for the next calendar year, the average period of the lag can be described as $1 + \frac{1-b}{b}$.

Sargent's estimate of b is .79, or a mean period of weights of roughly one quarter, or prediction lag of one and one-quarter years.

In this formula the weights are for discrete time units. The version for continuous time is given in note 83.

75. We have calculated this and all later correlations for annual data using the implicit price index as well as wholesale prices. The results differ only in detail.

76. Omitting 1880 raises the correlation between price change a year later and the weighted average from .06 to .24 for $b = .79$ but from .14 to .35 for $b = .14$, that is, a mean weight lag of about six years; and from .16 to .32 for $b = .10$, that is, a mean weight lag of about nine years.

77. The correlations are .24 and .02 including 1880; and .29 and .04 excluding 1880.

In the third place, our comparison of United States and United Kingdom interest rates led us to conclude that anticipated inflation in the United States was systematically above the actual before 1896 and perhaps the reverse after because of abatement of the fears of devaluation engendered by the free silver movement. We assessed the United Kingdom–United States difference on this account as one percentage point, which may well be a decided underestimate of the effect of the resolution of the free silver issue on anticipations.[78] If the interest rate before 1896 is adjusted for this effect by subtracting one percentage point, the correlation of the adjusted interest rate with the actual rate of price change (excluding 1880) is raised from .29 to .46, the correlation of the adjusted interest rate with Sargent's predicted price change, from .04 to .31; and with a predicted price change using a longer lag averaging six or nine years, from .03 or .06 to .45.[79] It also raises the Gibson paradox correlation of the interest rate with the price level from .23 to .57.

Using the annual data solely for 1880–1914, instead of, as Sargent does in most of his calculations, for 1880–1940 and allowing for the effect of other information than prior price change, thus gives a rather different impression. Fisher's explanation of the Gibson phenomenon is by no means confirmed, but, at the very least, it cannot be ruled out.

Similar calculations for the United Kingdom for annual data for 1880–1914 show a higher Gibson correlation of the interest rate with the price level for the United Kingdom than for the United States (.60 versus .30 for the United States unadjusted interest rate and .45 for the United States adjusted interest rate), and also a higher correlation with the rate of price change than for the United States unadjusted interest rate (.44 versus .24), but a slightly lower correlation with the rate of price change than for the United States adjusted interest rate (.44 versus .49). However, for the United Kingdom, an estimate of anticipated inflation using Sargent's weights gives a higher correlation with interest rates than estimates using the weights extending over a longer period.[80] This result reflects the higher contemporaneous correlation with the rate of price change and presumably also a higher serial correlation of the rate of price change in the United Kingdom than in the United States. In any event, all the correlations with anticipated inflation are higher than for the United States, so that United Kingdom data in no way contradict the tentative conclusion for the United States stated in the preceding paragraph.

78. The 1 percent estimate relies on the same exchange rate throughout, but we have seen that purchasing power party would have called for 1 percent per year appreciation of the United States dollar before 1896 and 1 percent per year depreciation of the United States dollar thereafter. Adding these effects would give an estimate of three percentage points as the effect of the resolution of the free silver issue on anticipations.

79. A larger adjusment equal to the three percentage points of the preceding footnote would make all these effects considerably greater.

80. Correlations of .42 for Sargent's weight for $b = .79$, .37 for $b = .14$, .40 for $b = .10$.

Dwyer reaches essentially the same conclusion for the pre-1914 period for the United States and the United Kingdom on the basis of a more complex test of the consistency of the price and interest rate series with rational expectations plus a random real rate with a constant expected value.[81]

Similarly, Harley, in a recent careful study of British pre–World War I experience concludes "that during periods of sustained price movement, the money market adjusted to price expectations and there was little effect on real interest rates." He thus supports Fisher's interpretation and our own finding. He estimates that the mean lag in formulating expectations of future price changes from past price changes was about seven years for short-term rates, about ten to thirteen years for long-term rates. These are even longer lags than Fisher got for the pre–World War I data for both the United States and the United Kingdom. Hence, though Harley's results seem strongly to support Fisher's interpretation of the United Kingdom Gibson phenomenon, they must share the doubt that attaches to such long estimated lags.[82]

One incidental by-product of our analysis is to illustrate a limitation of much recent work on rational expectations. One way that concept has been made operational is by regarding rationality of expectations as requiring that on the average the expectations are correct and hence by testing rationality of expectations by direct or indirect comparison of expectations with the actual subsequent values of the variables about which expectations were formed. But consider the period from 1880 to 1896. It was surely not irrational according to a commonsense interpretation of that term for participants in the financial markets to fear that growing political support for free silver would lead the United States to depart from the gold standard and to experience subsequent inflation—and this despite actual deflation during the period. Indeed, the longer the deflation proceeded, the more pressure built up for free silver, and the higher an intelligent observer might well have set his personal probability of inflation within, say, three years.

As it happened, the departure from gold was avoided. That does not prove that the persons who bet the other way were wrong—any more than losing a two to one wager that a fair coin will turn up heads proves that it was wrong to take the short end of that wager. Given a sufficiently long sequence of observations, of course, it could be maintained that all such events will ultimately average out, that in the century of experience our data cover, for example, there are enough independent episodes so that it is appropriate to test rationality of expectations by their average

81. Dwyer, "Explanation of the Gibson Paradox," pp. 106, 112.

82. C. Knick Harley, "The Interest Rate and Prices in Britain, 1873–1913: A Study of the Gibson Paradox," *Explorations in Economic History* 14 (February 1977): 69–89, quotation from p. 73.

accuracy. But that is cold comfort, since few studies cover so long a period, and our aim is surely to derive propositions that can be applied to shorter periods. Moreover, even one hundred years contain only six periods as long as that from 1880 to 1896, hardly a sufficiently large sample to assure "averaging out." Beyond these practical considerations there is a tantalizing intellectual question—What meaning, if any, can be given to the assertion: "Mr X's personal probability about a specified event was correct [or wrong]"?

To return to our main theme, our analysis of the annual data for 1880 to 1914 confirms the tentative indications of our earlier examination of charts 10.15, 10.16, and 10.17. There is some muted evidence of the Fisher effect, but it is clearly not the only, or even the most important effect at work—which still leaves the possibility that it may well be the feature that explains the Gibson phenomenon, since that too turns out, in a longer context, to be a much more limited relation than it is often represented as being.

We can use our phase average data to explore further the Fisher explanation for the subperiods excluding wars, in order to estimate the mean periods over which expectations would have had to be formed to explain the observed relation between the price level and interest rates, and to compare these mean periods for the two countries and the three nonwar subperiods.

We start with equation (6) rearranged and renumbered for convenience:

$$(10) \qquad R = \rho^* + g_P^*.$$

This is simply a definitional equation, defining the ex-ante anticipated real yield, ρ^*, as a function of the observed interest rate R and the anticipated price change. To give equation (10) content, assume that ρ^* can be treated as a constant except for random disturbances, and that $g_P{}^*$, aside from any special adjustments such as we have made above for the period 1880–96, can be regarded as determined by a simple adaptive expectational model:

$$(11) \qquad D(g_P^*) = \beta(g_P - g_P^*),$$

where $D(g_P^*)$ is the time derivative of g_P^*. This, of course, gives the usual exponentially weighted average of past price changes as an estimate of g_P^*, that is

$$(12) \qquad g_P^*(T) = \beta \int_{-\infty}^{T} e^{-\beta(T-T')} g_P^*(T')dT' ,$$

with a mean lag $= \dfrac{1}{\beta}$.[83]

83. This is the continuous version of the discontinuous form of footnote 74 above. The b of that footnote is equal to $1 - e^{-\beta}$, which, for small β, is approximately equal to β.

Differentiating equation (10) with these assumptions and adding a random disturbance term, we have

$$(13) \qquad D(R) = D(g_P^*) + \epsilon = \beta(g_P - g_P^*) + \epsilon.$$

Now let β be small, so anticipations are formed only gradually; that is, in the long moving average of imperfectly correlated terms that defines $g_P{}^*$, a long period of prior price change receives an appreciable weight. Such a moving average will tend to vary less than its elements, and the longer the moving average, the less variable it will be. As β approaches zero, $g_P{}^*$ approaches the price level, which is nearly a constant by comparison with the rates of price change. Hence, the smaller β, the more will equation (13) be dominated by the term in g_P.[84]

84. The relative importance of the two terms in equation (13) depends on the relative variance of g_P and g_P^*. Assume that g_P^* has been expressed as a deviation from its expected value, so we can take it as having a mean of zero (this is equivalent to adding a constant to equation 11), then from equation 12,

$$\text{(a)} \qquad \sigma^2_{g_P^*} = E[\beta \int_{-\infty}^{T} e^{-\beta(T-T')} g_P(T')dT'] [\beta \int_{-\infty}^{T} e^{-\beta(T-T'')} g_P(T'')\, dT'']$$
$$= \beta^2 \int_{-\infty}^{T}\int_{-\infty}^{T} e^{-\beta(T-T')-\beta(T-T'')} E[g_P(T')g_P(T'')]\, dT' dT'',$$

where E stands for expected value.

$E[g_P(T')g_P(T'')]$ is the covariance function. If $g_P(T')$ is a stationary time series, we can for $T' > T''$ write the covariance function as

$$\text{(b)} \qquad E[g_P(T')\, g_P(T'')\,] = \sigma^2{}_{g_P} r(T' - T''),$$

where $r(T' - T'')$ is the correlogram giving the correlation coefficient between $g_P(T')$ and $g_P(T'')$ as a function of the interval between T' and T''. Note further that the double integral in equation (a), with limits running from $-\infty$ to T for both T' and T'' equals twice the integral over the half phase from $T' = -\infty$ to T, $T'' = -\infty$ to T,' thanks to the symmetry of the integral around $T' = T''$. Converting the double integral to twice the integral over the half phase, replacing $(T - T'')$ in the exponent of e by $(T - T' + T' - T'')$ and substituting equation (b) into equation (a) gives:

$$\text{(c)} \qquad \sigma^2_{g_P^*} = 2\sigma^2_{g_P}\beta^2 \int_{-\infty}^{T}\int_{-\infty}^{T} e^{-2\beta(T-T') - \beta(T'-T'')} r(T' - T'')\, dT'' dT'.$$

Make the transformation:

$$T' = T'$$
$$\hat{T} = T' - T''$$
$$dT'\, dT'' = -dT'\, d\hat{T},$$

noting that $\hat{T}$ goes from $+\infty$ to 0 as T'' goes from $-\infty$ to T'. This gives

$$\text{(d)} \qquad \sigma^2_{g_P^*} = 2\sigma^2_{g_P}\, \beta^2 \int_{-\infty}^{T} \int_{0}^{\infty} e^{-2\beta(T-T') - \beta\hat{T}} r(\hat{T})\, d\hat{T}\, dT',$$

or

$$\text{(e)} \qquad \sigma^2_{g_P^*} = \sigma^2_{g_P} [\beta \int_0^\infty e^{-\beta\hat{T}} r(\hat{T})\, d\hat{T}][2\beta \int_{-\infty}^{T} e^{-2\beta(T-T')} dT'].$$

The second bracket is equal to unity. The first is a weighted average of the correlogram with exponentially declining weights summing to unity. Call this $\bar{r}(\beta)$. We then have

$$\text{(f)} \qquad \sigma^2{}_{g_P^*} = \bar{r}(\beta)\sigma^2{}_{g_P},$$

Since $r(\hat{T})$ is less than unity, so is $\bar{r}(\beta)$, hence $\sigma^2{}_{g_P^*}$ is less than $\sigma^2{}_{g_P}$ for all β. Moreover, so

At the extreme, if we suppose g_P^* to be roughly a constant, equation (13) is a linear relation between the rate of change of interest rates and the rate of change of prices. This is the mathematical translation, for a special case, of Fisher's explanation of the Gibson paradox.

Without going to this extreme, we can use equation (13) to construct an estimate of β. If the disturbance term ϵ is uncorrelated with g_P and g_P^*, the least-squares regressions of $D(R)$ on g_P and of g_P on $D(R)$ give upper and lower limits for β.[85]

These limits have some rather interesting properties. As β approaches zero, the percentage difference between β and the lower limit approaches zero, while both the percentage and the absolute difference between β

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long as $r(\hat{T})$ declines on the average with $\hat{T}$ and approaches zero as $\hat{T}$ approaches infinity, $\bar{r}(\beta)$ will decline as β declines and approach zero as β approaches zero.

85. The expected value of the slope of the least-squares regression of $D(R)$ on g_P is given, to a first approximation, by

(g) $$E\, b_{D(R)g_P} = \frac{E[D(R)\, g_P]}{E(g_P)^2} = \frac{\beta\, E[g_P - g_P^*]\, g_P + E\epsilon g_P}{\sigma^2_{g_P}},$$

where $D(R)$, g_P, and g_P^* are expressed as deviations from their mean values. If we assume that ϵ is uncorrelated with g_P, equation (g) reduces to

(h) $$E\, b_{D(R)g_P} = \beta\,(1 - \frac{E g_P\, g_P^*}{\sigma^2_{g_P}}).$$

If we multiply g_p^* as given by equation (12) by g_P, take expected values, and replace $E\, g_P\, g_P^*$ by $r(T' - T'')\sigma^2_{g_p}$ from equation (b) of footnote 83, we have

(i) $$E g_P\, g_P^* = \bar{r}(\beta)\, \sigma^2_{g_P} = \sigma^2_{g_P^*}$$

by equation (f). Substituting in equation (h)

(j) $$E\, b_{D(R)g_P} = \beta[1 - \bar{r}(\beta)].$$

Since $\bar{r}(\beta)$ is necessarily less than unity,

(k) $$E\, b_{D(R)g_P} < \beta.$$

Similarly, the expected value of the reciprocal of the slope of the least-squares regression of g_P on $D(R)$ is given to a first approximation by

(l) $$E(\frac{1}{b_{g_P}D(R)}) = \frac{E[D\,(R)]^2}{E[\,D(R)\, g_P]} = \frac{\beta^2\, E[g_P - g_P^*]^2 + \sigma^2_\epsilon}{\beta\, \sigma^2{}_{g_P}\,[1 - \bar{r}(\beta)]},$$

where σ^2_ϵ is the variance of the random disturbance. Also

(m) $$\begin{aligned} E[g_P - g_P^*]^2 &= \sigma^2_{g_P} + \boxed{\sigma^2_{g_P^*}} - 2E(g_P g_P^*) \\ &= \sigma^2_{g_P} + \bar{r}(\beta)\sigma^2_{g_P} - 2\bar{r}(\beta)\sigma^2_{g_P} \\ &= \sigma^2_{g_P}\,[1 - \bar{r}(\beta)], \end{aligned}$$

from equations (f) and (l). It follows that

(n) $$E\,\frac{1}{b_{g_P}D(R)} = \beta[1 + \frac{\sigma^2_\epsilon}{\beta^2\sigma^2_{g_P}[1 - \bar{r}(\beta)\,]}\,] > \beta,$$

since both numerator and denominator of the fraction in the brackets are positive.

and the upper limit increase without limit. Hence, the lower β, the better the lower limit and the worse the upper limit as approximations. Another interesting property is that the lower limit is not affected by the size of the random disturbances in $D(R)$, while the upper limit is. The upper limit is a better approximation the smaller such random variation in R relative to the random variation in g_P, and it approaches β as the variance of R approaches zero relative to the variance of g_P.[86] From the earlier calculations in this chapter, it seems clear that recorded values of g_P have a much higher variance than recorded values of $D(R)$, which strongly suggests that the upper limit may prove a pretty good approximation to β.[87] Note that the upper limit for β gives the lower limit for the mean lag.

Table 10.8 gives the limits on β computed from the regressions of g_P on $D(R)$ and $D(R)$ on g_P. The results are reasonably satisfactory for the pre–World War I period, for which the Gibson phenomenon is most marked.[88] The limits are both farther apart and lower for the United States than for the United Kingdom. However, given the small number of degrees of freedom for the United Kingdom, the United States and United Kingdom limits do not differ significantly. Moreover, adding additional values of price change in the multiple correlation has almost no effect on the standard error of estimate for the United States—which is as it should be, since their only role is as proxies for g_P^* which, on the interpretation under discussion, is contributing little to the relation. The sharp reduction for the United Kingdom is meaningless, since including all the additional variables leaves only one degree of freedom.

The implied mean period of averaging of past price behavior is between five and twenty-five years for the United States, three and five

86. These statements follow directly from equations (j) and (n) of the preceding footnote, plus the fact that $\bar{r}(\beta)$ approaches zero as β approaches zero.

One other factor affecting the closeness of the limits to β is the serial correlation of g_P. The lower that correlation for each time interval between the items correlated, the lower is $\bar{r}(\beta)$ for each β and hence the closer the limits to one another and to β.

87. The standard deviations of $D(R)$ and g_P (in percentage points) are as follows for the three nonwar periods:

	United States		*United Kingdom*	
	$D(R)$	g_P	$D(R)$	g_P
Pre–World War I	0.18	1.87	0.10	0.37
Interwar	0.24	1.51	0.32	2.02
Post–World War II	0.21	1.44	0.26	2.58

Of course these standard deviations include systematic as well as random variation, and measurement error as well as random variation in the magnitude being measured, so they are only suggestive rather than conclusive. But the differences are so large and so consistent as to establish a strong presumption that the random variation in g_P as measured is very large compared with that in $D(R)$ as measured.

88. For the United States, the pre–World War I limits without adjusment for the free silver effect are .04 to .019. so that the adjustment has little effect.

Table 10.8 **Estimates of β: Upper and Lower Estimates Based on Regressions between Rate of Change in Interest Rates and in Prices; Standard Errors of Estimate from Simple and Multiple Correlations (Percentage Points)**

Period and Country	Number of Observations (1)	Limits on β: Lower (2)	Limits on β: Upper (3)	Standard Deviation of $D(R)$ (4)	Standard Error of Estimate of $D(R)$ from: Simple Regression $D(R)$ on g_P (5)	Standard Error of Estimate of $D(R)$ from: $D(R)$ on $g_P(t), g_P(t-1), g_P(t-2), g_P(t-3)$ (6)
Pre–World War I						
United States [a]	18	0.04	0.22	.181	.167	.162
United Kingdom	6	0.21	0.37	.103	.076	.016
Interwar						
United States	7	0.10	0.25	.242	.201	.114
United Kingdom	7	(negative)		.319	.336	.123
Postwar						
United States	11	0.01	2.78	.206	.217	.188
United Kingdom	9	0.06	0.18	.255	.227	.289

[a] All calculations based on interest rate series adjusted for effect of free silver campaign on expectations by subtracting one percentage point from recorded interest rate, 1867 through 1896.

years for the United Kingdom. These intervals differ from Fisher's own estimates, which are shorter for the pre-1914 period for the United States (2.5 years), longer for the United Kingdom long rates for the pre-1914 period (7.3 for 1820–64, and 8.7 for 1865–97).

As we noted earlier, the lower relative variation in $D(R)$ than in g_P suggests that the upper estimate of β—which corresponds to the lower mean period—is the closer approximation to the true β. If so, that would suggest a mean period of about three years for the United Kingdom, five years for the United States, which is somewhat shorter than the mean period obtained earlier in our reanalysis of the annual data for the United States, 1881 to 1914. Certainly, periods of this length seem more plausible than the periods running two or three times as long that Fisher and others estimate for data spanning World War I.

For the interwar period, the United States results are very similar, again consistent with a mean period of four to ten years. However, for the United Kingdom, the slope of the regression is negative, which gives unacceptable results. For the postwar period, we again see the break we have repeatedly encountered in this chapter: for the United States, zero correlation between $D(R)$ and g_P; for the United Kingdom, a mild correlation, but one which gives a mean period of five to sixteen years.

For the pre–World War I period we have also used the phase averages to duplicate the calculations made earlier for the annual data from 1880 to 1914 for different weighting patterns. In these calculations, we have used the phase as the time unit and have converted the values of b equal to 0.10, 0.14, and 0.79 to corresponding values for phases by allowing for the average length of a phase.[89] The results are again that the longer average weighting patterns, corresponding to annual b's equal to 0.10 and 0.14, give higher correlations for the United States than the shorter weighting pattern derived by Sargent. For the United States it is striking also that for annual b's equal to 0.10 and 0.14 the correlation of the adjusted commercial paper rate with the expected rate of price change is higher than with the price level, thereby meeting one of Macaulay's objections. That is not true for the United Kingdom.[90]

89. Our procedure was first to calculate the value of β equivalent to each value of b, multiply the resultant values of β by the average length of a phase, and then convert back to b's. The resulting values of b are .186, .255, and .952 for the United States, .318, .422, and .997 for the United Kingdom.

In making these calculations, we used $g_P.A$ instead of g_P.

90. The correlations are as follows:

Correlation		*Annual b*	
	0.10	*0.14*	*0.79*
R and g_P^*			
United States (unadjusted)	.14	.11	−.32
United States (adjusted)	.72	.73	.43
United Kingdom	.42	.44	.47

All in all, the net result of these additional calculations is to reinforce our earlier suggestion that Fisher's hypothesis is plausible for the pre–World War I period, somewhat plausible for the interwar period, but not at all plausible for the post–World War II period.

10.7.2 The Wicksell-Keynes Explanation

Writing at the turn of the century, Knut Wicksell suggested that the parallel movement of prices and interest rates reflected long swings in the real yield on capital mediated through the commercial banking system. A rise, for example, in the productivity of capital would produce a rise in the demand for credit and in the "natural" rate of interest—the rate that would equate desired saving with desired investment in a situation of "monetary neutrality" or "monetary equilibrium," that is, without monetary creation. Faced with an increase in the demand for loanable funds, Wicksell argued, banks would expand their loans by creating money, letting the ratio of their liabilities to their reserves rise, and would only belatedly and sluggishly raise the rate of interest they charge. The "market" rate would respond to the increased demand, but too little and too late. The monetary expansion would raise prices; the reaction of banks would slow the rise in market interest rates but not prevent a rise from occurring, so that prices and interest rates would rise together. Some three decades later, Keynes suggested essentially the same explanation.[91]

Cagan has examined this hypothesis in detail for the United States. He found that changes in monetary growth primarily reflected changes in high-powered money rather than in bank-created money, as required by the Wicksell hypothesis. Lars Jonung has since carried out a similar analysis for Sweden. His conclusion is the same as Cagan's: the sources of changes in monetary growth are inconsistent with the Wicksell hypothesis.[92]

A different test of the Wicksell hypothesis can be made using our proxy for the real yield on capital. On the Wicksell hypothesis, the moving force in the whole process is the real yield on capital. Its fluctuations produce

R and P	
United States (unadjusted)	.54
United States (adjusted)	.64
United Kingdom	.72

91. For an excellent summary statement of this hypothesis, see Wicksell, "The Influence of the Rate of Interest on Prices." For Keynes's later presentation, see *A Treatise on Money*, 2: 182–84.

92. Phillip Cagan, *Determinants and Effects of Changes in the Stock of Money, 1875–1960* (New York: NBER, 1965), pp. 252–55; Lars Jonung, "Money and Prices in Sweden, 1732–1972," in *Inflation in the World Economy*, ed. J. M. Parkin and George Zis (Manchester: Manchester University Press, 1976), pp. 295–325.

parallel fluctuations in the price level and the nominal market rate. Accordingly, the Wicksell hypothesis implies a Gibson phenomenon for real and not merely nominal yields. Chart 10.21 and table 10.9 demonstrate that no such phenomenon exists either for our proxy for the real yield or for the ex-post real yield on short-term securities: with minor exceptions, there is a negligible correlation between the level of prices and the real yields, not only for the long periods for which, as we have seen, no nominal Gibson phenomenon exists, but also for the shorter subperiods. This test too therefore rejects the Wicksell hypothesis.

10.7.3 Other Real Explanations

The Wicksell hypothesis is a special case of a broader class of hypotheses that postulate common real disturbances that affect the price level and nominal interest rates in the same direction. Among others, Sargent has suggested an explanation of this class in the form of a specific hypothetical model of the economy.[93]

To illustrate such an explanation, consider the brief business cycles during which there is clearly a tendency for prices and interest rates to rise and fall together—indeed, in his discussion of the Gibson paradox Keynes referred to his initial belief, subsequently rejected, "that Mr. Gibson's surprising results were to be attributed to nothing more than the well-established and easily explained tendency of prices and interest to rise together on the upward phase of the credit cycle, and to fall together on the downward phase *plus* a gracious allowance of mere coincidence."[94]

Any theory of business cycles, be it a "real" theory relying on waves of optimism and pessimism à la Pigou, or bunchings of innovation à la Schumpeter, or an unstable investment function à la Keynes, or even Jevonian sunspots, or be it a monetary theory relying on fluctuations in monetary growth, could produce (1) a cyclical rise and fall in the demand for loanable funds relative to the supply of loanable funds and so a cyclical rise and fall in real and nominal interest rates; (2) a cyclical rise and fall in nominal income relative to permanent income and so a procyclical movement in measured velocity; (3) reinforcement of the movement in measured velocity by a reaction of the quantity of money demanded to the cyclical movement in interest rates; (4) a procyclical movement in monetary growth in reaction to the cyclical movement in the demand for loanable funds and in interest rates, which would reinforce the cyclical movement in nominal income, while damping somewhat the movement in interest rates and in velocity; and (5) a cyclical rise and fall in prices (or in prices relative to trend) as a result of the changes in

93. "Interest Rates and Prices in the Long Run." Sargent's model could indeed almost be regarded as a formal translation of Wicksell.

94. *Treatise*, 2: 177.

Table 10.9 Tests of a Gibson Phenomenon for Real Yields

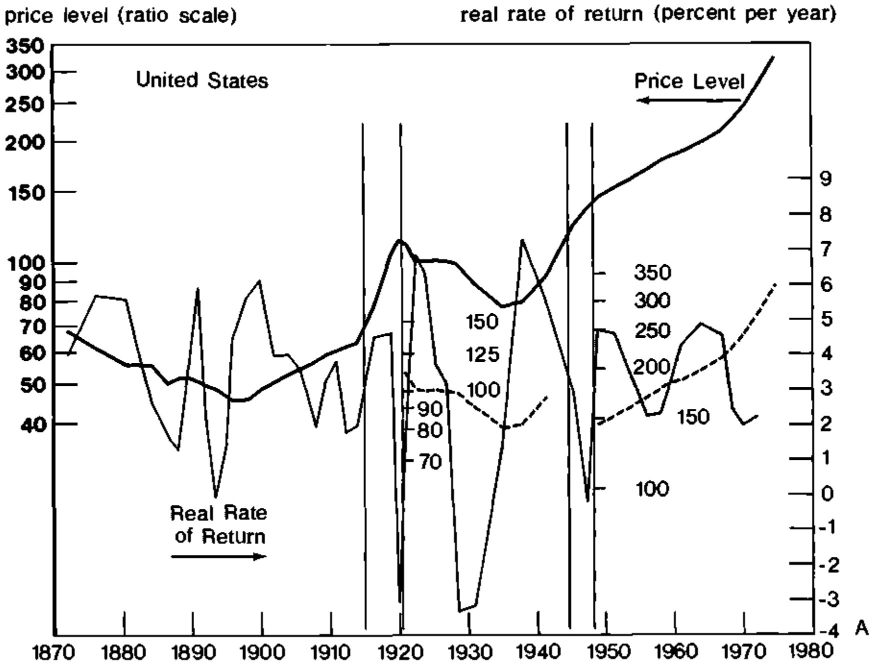
Period and Country	Number of Observations: Col. 3 (1)	Number of Observations: Col. 4 (2)	Correlation between Price Level and Real Yields: Proxy Real Yield on Physical Assets[a] (3)	Correlation between Price Level and Real Yields: Ex-Post Real Yield on Nominal Assets (4)
Pre–World War I				
United States	21	21	−0.20	0.13
United Kingdom	11	11	−0.36	0.47
Interwar				
United States	9	9	−0.08	0.52
United Kingdom	9	9	−0.68	0.33
Postwar				
United States	13	13	−0.36	0.45
United Kingdom	11	11	−0.04	−0.03
All excluding wars				
United States	43	43	−0.06	−0.42
United Kingdom	31	31	0.02	−0.37
All				
United States	49	49	−0.09	−0.32
United Kingdom	37	37	−0.02	−0.25

[a] $g_{y^{\cdot}}.A$.

nominal income. Items 1 and 5 together would produce the Gibson phenomenon of a positive correlation of interest rates and price levels, and it would produce it for both nominal and real rates—in sharp contrast to the Fisher interpretation, which posits such a correlation solely for nominal rates.

Actual experience during business cycles differs in important respects from this hypothetical sequence—notably in the empirical timing patterns of interest rates, monetary growth, and measured velocity, as well as in the apparent independence of monetary growth from interest rates—but it also has many similarities. In any event, the hypothetical sequence illustrates the kind of alternative hypothesis that Sargent and others suggest.

For the longer-period swings that are our concern, as for the cyclical fluctuations, there is no need for there to be a single source of real disturbances. All that is required is that real disturbances that tend to raise nominal interest rates should also tend to raise prices; and real disturbances that tend to raise prices should also tend to raise interest rates; or at least that one of these be correct and the other not reversed. The real forces could operate on prices and interest rates through any of a number of possible channels: on prices, through velocity or high-powered money or bank-created money or volume of output; on interest rates,



through the equilibrium real interest rate or preferences for nominal versus physical assets or preferences for nonhuman assets or the relative quantities of various kinds of assets.

However, the finding that there is apparently no real Gibson phenomenon for the longer swings (our correlations of phase bases give no evidence on the intracycle movement) rules out any such explanation that involves higher real returns along with prices. The real disturbances would have to operate by affecting the relation between nominal and real returns or in some other way be consistent with nominal but not real returns moving in the same direction as prices.

The only explicitly spelled-out hypothesis of this kind that we are aware of is one that was suggested by Macaulay some three decades ago and that has recently been formally developed by Siegel as reflecting distributional effects.[95] Siegel suggests that, if price rises are unanticipated they will tend to produce a transfer of wealth from lenders on fixed interest terms to borrowers on such terms—a phenomenon that we have certainly documented. He goes on to argue that this is a wealth transfer from risk-averse persons to risk-takers, which would tend to raise the

95. Macaulay, *Movements of Interest Rates*, pp. 206–8; Jeremy J. Siegel, "The Correlation between Interest and Prices: Explanations of the Gibson Paradox" (unpublished manuscript, University of Pennsylvania, 1975).

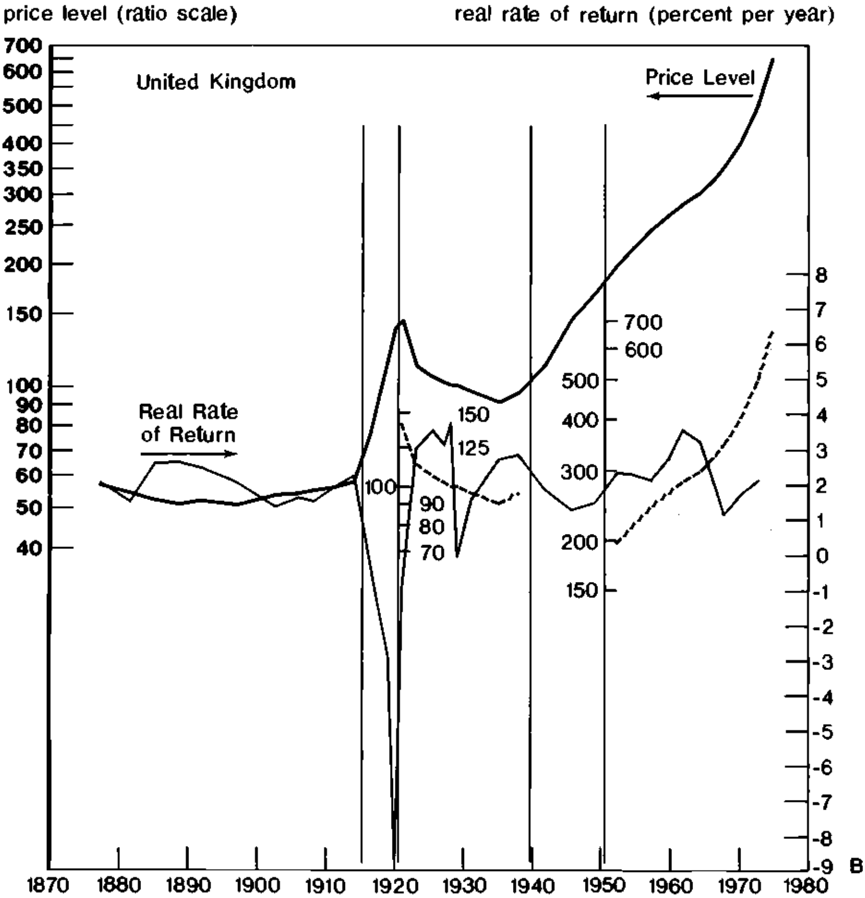


Chart 10.21 Price level and real rate of return on physical assets, United States and United Kingdom, 1870–1975.

differential between yields on securities attractive to the risk-averse and those attractive to risk-takers. If recorded nominal rates are rates on securities attractive to the risk-averse, the transfer could account for rising nominal interest rates along with rising prices.

This ingenious explanation is, however, not satisfactory without additional highly special assumptions. Why would this effect not simply produce an initial rise in the interest rate as the holders of nominal securities lose wealth and then a fall as they seek to restore their wealth and succeed in doing so? After all, the initial distribution of wealth is itself the result of an equilibrating process, not an accidental position. As in the Fisher explanation, there must be a coordination of various adjustments to produce the result to be explained. Throughout most of a price rise, it must continue to be unexpected, it must continue to transfer wealth cumulatively (in order that rates of interest keep on rising), and this cumulative transfer must not be offset by the saving adjustments of the risk-averse or the risk-takers or by the adjustment of interest rates to actual inflation.

A good deal more elaboration of this hypothesis and testing of its implications is required before it can be treated as more than an ingenious speculation.

10.7.4 Other Nominal Explanations

A more promising approach is to proceed along Fisher's lines of stressing the role of inflationary expectations but to alter his particular hypothesis about the formation of expectations and possibly to include an allowance for changing real returns on physical assets as well.[96] In effect, this is what we have done in our examination of the pre–World War I period for the United States by taking into account the effect of the free silver movement on expectations and in our treating World War I and World War II as special cases to be analyzed separately. It may be, however, that such a largely episodic interpretation can be replaced, or at least more fully supplemented, by a more formal model of the formation of expectations. The extensive studies along these lines of the post–World War II period may yet yield results that can be applied to the much longer pre–World War II period, though as yet they have not done so.

One feature of the strict Fisher expectations hypothesis that seems particularly objectionable in light of our empirical results—especially the failure of the Gibson phenomenon to hold over major wars—is the use of a single chronological time scale in converting past price experience to an estimate for the future. We have already had occasion to refer to Maurice Allais's perceptive distinction between chronological and psychological time to explain why it might be more appropriate to use the cycle phase rather than the year as our basic unit of time.[97] This is what we have done in using our phase average data to analyze the pre–World War I relations.

In the present context, however, a wider-ranging interpretation is called for. In judging the future, participants look back for past evidence

96. John Rutledge, "Irving Fisher and Autoregressive Expectations" (*American Economic Review Proceedings* 67 [February 1977]: 200–205) argues that Fisher included changes in real rates as part of his analysis, and Sargent makes a similar point (*Quarterly Journal of Economics* 86 [May 1972]: 224–25). Both are correct but the role is played primarily by changes in the ex-post real yield on nominal assets rather than by changes in either the ex-ante real yield on nominal assets or the ex-ante or ex-post real yield on physical assets. The latter do play a minor role in Fisher's analysis, but primarily in his analysis of cyclical fluctuations rather than of Gibson swings, which are the real puzzle. Of course he makes qualitative remarks that indicate his recognition of the existence of variability in real returns of all kinds, and he stresses over and over the variability of ex-post real returns on nominal assets, since they play, explicitly or implicitly, a crucial role in his analysis both of the cycle and of the Gibson swings. See note 48 above.

97. See chap. 8, n. 17.

that they regard most relevant to the current situation. That may involve a very different retrospective time span at different times. Much of the time it may involve looking back at a comparable stage of the business cycle—that is the rationalization for using the cycle phase as a basic time unit. But on some occasions that will not be relevant. For example, consider the situation in the United States after World War II. According to the first available Livingston forecasts, dated June 1947, the average forecast for the succeeding eighteen months was for declining prices at the rate of 5.8 percent per year for the consumer price index and of 8.7 percent per year for the wholesale price index, and the eighteen-month forecasts stayed negative, though smaller in magnitude, until the Korean War broke out in 1950.[98] Actual prices dipped briefly in 1949 and early 1950, but at nothing like the forecast rate. This expectation of deflation, which was surely widespread, was obviously not based on any simple weighted average of immediately prior rates of inflation—any such average would have led to a forecast of inflation. And it would have been most unreasonable to use any such average. Wars are highly unusual events known to be episodic. It was natural for participants to look back at what had occurred after past wars: the war of 1812, the Civil War, and the First World War. In each case the wartime inflation had been followed by a postwar deflation that ultimately brought the level of prices back to roughly its prewar level. It was not unreasonable to extrapolate that experience, even though that involved averaging experience covering roughly 150 years.

This example involves a process of formation of anticipations that is in the spirit of Fisher's model but cannot be confined within its fixed mechanical structure. Similarly, in allowing for the Great Depression it would have been reasonable for participants to revert back to other major cyclical contractions rather than to use an unchanging past time scale.

10.8 The Structural Change in the 1960s

Whether or not a more adequate explanation is developed for the Gibson paradox than Fisher's supplemented by episodic events, there remains the problem of accounting for the apparent difference between pre–World War II relations and postwar relations, particularly after the mid-1960s, when the Gibson relation largely disappears and is replaced by a close relation between interest rates and the rate of change of prices.

An extremely appealing explanation of the difference has been offered in an important paper by Benjamin Klein.[99]

98. Carlson, "A Study of Price Forecasts," table 1, p. 33, table 2, p. 35.

99. "Our New Monetary Standard: The Measurement and Effects of Price Uncertainty, 1880–1973," *Economic Inquiry* 13 (December 1975): 461–83. Klein has recalculated his measures of short- and long-term price unpredictability in "The Measurement of Long- and

Klein argues that there has been a fundamental change in the character of the monetary system since World War II, that before World War II, and to a lesser extent to the end of World War II, the United States and the United Kingdom were regarded as being on specie standards which limited the price *level*. Prices might rise or fall over short periods, but the price level was widely expected to revert to a roughly constant level, and it did. The price level in the United Kingdom in 1912 was roughly the same as in 1729—so far as it can be measured over such long periods. After the World War I rise, it again reverted to its prewar level by 1931 or 1932 and was lower than it had been during most of the nineteenth century.[100] In the United States wholesale prices were at roughly the same level in 1914 and in 1790 and, again after more than doubling during World War I, had reverted to their 1790 level by 1932.[101] Under this system, Klein argues, there was considerable short-term unpredictability of prices but much less long-term unpredictability. Current rates of price change contained little information about future rates of price change. On the other hand, the level of prices did contain such information. A price level that was high relative to "normal" implied a subsequent decline in prices and conversely.

In the post–World War II period, short-term unpredictability of price change, Klein points out, has been less than earlier. However, there is no longer a specie anchor to the price system. The monetary system is strictly fiduciary. There is no widespread anticipation that the price level will revert to any "normal" level; it (or perhaps its derivative) is now nearly of the nature of a random walk, perhaps with drift. Current rates of price change contain information about future rates of price change. It is rational to take this information into account, and interest rates now respond to recent rates of price change as they did not do before.

This analysis is highly plausible as an explanation for the change after World War II. Before World War I, and to a lesser extent in most of the interwar period, the government's role in the economy in both the United States and the United Kingdom was relatively minor and certainly did not include, and was not perceived to include, the kind of attempt at fine-tuning the economy that we have become so familiar with in recent decades. At most, government's role was to step in at time of crisis or panic and to administer a specie system. The sources of inflation or deflation were largely international and were mostly acts of God rather

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Short-Term Price Uncertainty: A Moving Regression Analysis," *Economic Inquiry* 16 (July 1978): 438–52; see also I. B. Ibrahim and R. M. Williams, "The Fisher Relationship under Different Monetary Standards," *Journal of Money, Credit and Banking* 10 (August 1978): 363–70.

100. For a long-term United Kingdom price series, see Shiller and Siegel, "The Gibson Paradox," fig. 1.

101. Based on Warren and Pearson and BLS index numbers.

than deliberate acts of men. The basic institutions were highly stable, so it made sense to take a long view, and there was no easy way to predict the short-run or intermediate-run fluctuations of the price level. Given the physical or at least nondeliberate character of most of the forces producing such fluctuations, it made sense for participants to extrapolate the past along Fisher's lines. And, given the large degree of random fluctuation and the meagerness and inaccuracy of the available data, it made sense to base extrapolations on a fairly long past period.[102] The Fisher hypothesis, or some variation of it, plus allowance for special events—such as the free silver campaign in the United States or the Boer War in the United Kingdom—plus a good deal of random perturbation plus confidence in the long-run stability of the monetary system and the price level could explain reasonably well the greater short-run stability in the nominal yield than in the ex-post real yield, as well as the systematic covariation of the nominal yield with the longer swings in the price level.

Beginning with the Great Depression, the situation changed drastically. Government began to accept responsibility for the short-term movements in the economy. World War II interrupted the process and doubtless postponed the incorporation of the new role of government into the performance of financial markets. After the war there was a transitional period of adjustment to wartime distortions. In addition, there was widespread anticipation of a repetition of prior postwar experience, namely, a sharp decline in the price level and a severe recession or depression. These anticipations dominated the market for more than a decade after the war, producing the expectation of price decline despite the experience of gradual inflation. The result was low nominal interest rates and negative ex-post real yields—the mirror image of the situation in the decade preceding 1896, when expectations of inflation coincided with the actuality of deflation and produced high nominal rates and ex-post real yields.

By the mid- or late 1950s, the participants in the market were adjusting to the new circumstances, along the lines outlined by Klein. They came to regard the price level and the level of economic activity as largely affected by government authorities, and they saw the specie standard as a histori-

102. We should note that we are here departing from Klein's specific formulation because it is not consistent with the Gibson phenomenon. If the public based its anticipation of price movements on the relation between the current level of prices and some independently estimated "normal" level, as Klein implies, then it should have interpreted high prices as implying a subsequent decline. But this would mean low nominal interest rates when prices were high and high nominal rates when prices were low—precisely the reverse of the observed positive Gibson correlation. Alternatively, if the public took the current price level as its best estimate of the "normal" level, that would imply that it took the anticipated rate of price change as equal to zero at all times. Such anticipations would produce a zero correlation between prices and interest rates, not the observed positive Gibson correlation.

cal relic. The final explicit step in this transformation did not occur until the formal severing of the United States link with gold in 1971 and the explicit adoption of a floating exchange rate system in 1973 and thereafter. But the postwar devaluations and revaluations of many currencies, together with the obvious primacy of domestic considerations in the formulation of government economic policy in essentially all countries, affected attitudes long before this final step.

These changes in institutional arrangements made it easier to predict short-term movements at the same time that, as Klein emphasizes, they increased long-term uncertainty. They were also accompanied by improvements in statistics and in methods of analyzing data—as evidenced particularly by the explosive growth of the short-term economic forecasting industry—and in the sophistication and breadth of financial markets. All this appreciably shortened the horizon of market participants and increased their ability to make short-term projections. Simultaneously, the incentive to make such projections and to embody them in financial decisions was increased by the rise in the rate of inflation to levels seldom experienced before in the peacetime experience of the United States and the United Kingdom and by the considerable variation in the rate of inflation over periods of several years. The net result has apparently been to replace the long-term Gibson phenomenon with the short-term direct Fisher relation between nominal rates and price change. Whether this is a permanent or a temporary change is hard to judge. Presumably that depends in part on whether high rates of inflation, and substantial variation in rates of inflation, persist.

One further element has encouraged the switch to the short-term Fisher relation and perhaps has made it seem more complete than it really is. That element is the high marginal tax rates levied on nominal yields. As we saw in section 10.1.1 under "Price Anticipation Effect," the effect of such taxation is to widen substantially the margin between the nominal rate and the real rate required to keep unchanged the net real after-tax yield to the lender. Some studies of the relation between nominal and real rates that have concluded that nominal rates have fully adjusted to inflation have neglected this tax effect.[103] What they take to be a full adjustment is therefore less than full. For the United States, most long-term bonds are apparently held by institutions not subject to tax on the interest return (e.g., pension funds, insurance companies, tax-exempt institutions). However, an appreciable fraction appears to be held by taxable individuals. To judge from the differential return on taxable and tax-exempt securities, the relevant marginal tax rate is over one-third.[104] If such a tax rate had applied in the United States during all nonwar

103. E.g., Fama, "Short-term Interest Rates as Predictors of Inflation."

104. In December 1979 the yield on corporate triple Aaa bonds was 10.74, on long-term Treasury securities, 10.07, both taxable; on state and local Aaa bonds, exempt from federal taxes, 6.50, equivalent to a marginal tax rate of 35 percent compared with Treasury

Table 10.10 **Nominal Rates of Interest Required, at Inflations of 6 or 10 Percent, to Yield Average Ex-Post after-Tax Real Yields Recorded in Table 10.1**

	Rate of Inflation			
	6 Percent		10 Percent	
	All Phases	All Nonwar Phases	All Phases	All Nonwar Phases
United States				
Commercial paper	12.9	14.7	18.9	20.7
Corporate bonds	13.9	15.6	19.9	21.6
United Kingdom				
Banker bills	10.3	12.8	16.3	18.8
Consols	11.5	13.7	17.5	19.7

phases averaged in table 10.1, the ex-post after-tax real short-term yield would have been 2.3 percent instead of the 3.8 percent recorded there without allowing for the effect of taxation, and the ex-post real long-term yield would have been 2.7 instead of 4.4.To obtain the ex-post after-tax real yields in table 10.1 with a 6 percent inflation and with a 10 percent inflation for a hypothetical marginal tax rate of one-third would require the nominal rates shown in table 10.10.

Actual commercial paper rates in the United States exceeded 11 percent only briefly in 1974 when the contemporaneous recorded inflation rate was running over 10 percent for consumer prices. At about the same time corporate bond rates hit a peak of only a bit over 9 percent. In the United Kingdom the short-term rate hit a peak of a bit over 14 percent in early 1974, a year in which the average rate of inflation was over 20 percent for consumer prices and the long-term rate a peak of 17.4 percent. Clearly, interest rates did not adjust anything like fully to recent rates of inflation, once the tax effect is taken into account. As in earlier periods, much of the inflation must be regarded as unanticipated, so that lenders have received real returns lower than the real yield on capital. The difference from earlier periods is twofold. There has apparently been a greater relative adjustment to inflation than in earlier periods. And governments in their capacities as borrowers have benefited to a larger extent than in earlier episodes from the transfer of wealth from lenders to borrowers.

We are still clearly in a transition that has not yet been completed and may never be.[105]

securities, of 39 percent compared with corporate securities. These differentials are not atypical for recent years.

105. Even in 1980, after the end of our period, interest rates did not adjust anything like fully to inflation, if taxes at a marginal rate of one-third are allowed for. In the United States, the commercial paper rate hit a peak of over 16 percent, when inflation, as measured by the Consumer Price Index, averaged 13 percent; in the United Kingdom, the short-term rate hit

10.9 Correlations with Money

This long detour through price effects may seem a digression from the explicit subject of this chapter—money and interest rates. It is not. The impact effects via liquidity and loanable funds, and the intermediate effects via income, described in the initial theoretical analysis, can be expected to be most important within cycles and largely to average out for our cycle phases. That leaves the price effect as the major one for our purpose. The long-term effect of money on interest rates can therefore be analyzed best by considering the effect of money on prices—as we did in chapter 9—and then of prices on interest rates, as we have done in this chapter.

10.9.1 Impact and Intermediate Effects

Something of a check on these statements is provided by tables 10.11 and 10.12, which give correlations between money and interest rates relevant to the impact and intermediate effects, and table 10.13, which gives correlations relevant to the price effect.

The liquidity impact effect would tend to produce a negative correlation between R (the interest rate) and M (the stock of money) or between $D(R)$ (the rate of change of the interest rate) and g_M (the rate of change of the stock of money). The simple correlations in column 3 between R and M (table 10.11) and $D(R)$ and g_M (table 10.12) give little evidence of any liquidity effect. Only two of the ten correlations between R and M, and also between $D(R)$ and g_M, are negative, and the largest absolute correlations are all positive. Clearly the Gibson effect—which would produce positive correlations—has overwhelmed any liquidity effect for periods as long as our phases.[106]

The loanable funds impact effect would produce negative correlations between R and g_M, and between $D(R)$ and $D(g_M)$ (the acceleration of the stock of money). The simple correlations in column 4 show only a little stronger evidence of the loanable funds effect than those in column 3 do of the liquidity effect: three of the ten correlations between R and g_M, and also between $D(R)$ and $D(g_M)$ are negative, but this time one of the negative correlations is numerically the largest.[107]

a peak of a trifle over 18 percent when retail prices were rising at a rate in excess of 20 percent.

106. For the United States, for the pre–World War I period, we have computed all the correlations in tables 10.11 and 10.12 also for interest rates not adjusted for the effect of free silver. The results differ only trivially from those in the tables.

107. In an interesting paper that analyzes the relation between monetary policy and long-term interest rates using United States quarterly data for 1954–76, Frederic S. Mishkin finds little or no evidence of the impact effect, which suggests that, for that period, our failure to uncover it may not simply reflect our use of phase averages but may correspond to the impact effect's small or negligible size even for periods as short as a quarter. That

Table 10.11 **Measures of Impact and Intermediate Income Effects: Correlations of Levels of Interest Rates with Money and Trend**

	Number of Observations		Simple Correlation		Multiple Correlation with M and g_M					Multiple Correlation with M, g_M, and Trend						
					M		g_M			M		g_M		Trend		
Period and Country	Col. 3 (1)	Other Cols. (2)	M (3)	g_M (4)	Coefficient (5)	t Value (6)	Coefficient (7)	t Value (8)	Corrected R^2 (9)	Coefficient (10)	t Value (11)	Coefficient (12)	t Value (13)	Coefficient (14)	t Value (15)	Corrected R^2 (16)
Pre–World War I																
United States[a]	21	21	.40	.48	0.002	0.7	0.078	1.5	.17	0.030	3.4	0.089	2.0	−0.001	−3.3	.46
United Kingdom	11	10	.39	.20	0.011	1.2	−0.042	−0.3	−.01	−0.051	−0.7	−0.012	−0.1	0.001	0.9	−.05
Interwar																
United States	9	9	.44	−.13	0.065	1.3	−0.079	−0.5	−.03	0.028	2.0	−0.099	−2.6	−0.003	−9.2	.93
United Kingdom	9	9	−.24	−.69	−0.035	−0.8	−0.374	−2.4	.36	0.034	1.0	0.831	2.3	−0.008	−3.4	.77
Postwar																
United States	13	12	.95	.59	0.036	6.5	0.056	0.4	.86	0.021	0.5	0.048	0.3	0.001	0.3	.84
United Kingdom	11	10	.96	.56	0.056	5.9	−0.090	−1.0	.85	0.026	0.6	−0.066	−0.6	0.002	0.8	.84
All, excluding wars																
United States	43	42	.09	.18	−0.001	−0.6	0.082	1.3	−.01	0.035	4.2	0.077	1.4	−0.002	−4.3	.30
United Kingdom	31	29	.70	.39	0.009	3.6	0.014	0.2	.39	0.038	3.5	0.006	0.8	−0.001	−2.7	.51
All																
United States	49	48	−.02	−.15	−0.001	−0.6	−0.043	−0.8	−.01	0.042	4.8	−0.026	−0.6	−0.002	−4.9	.33
United Kingdom	37	35	.52	.14	0.008	2.6	−0.019	−0.3	.13	0.042	3.4	−0.019	−0.3	−0.001	−2.8	.29

[a]For the pre–World War I period, the United States rate of interest was adjusted for the effect of free silver by subtracting one percentage point from the recorded rates, 1879–96.

Table 10.12 **Measures of Impact and Intermediate Income Effects: Correlations of Rates of Change of Interest Rates with Rate of Change of Money and Trend**

	Number of Observations		Simple Correlation		Multiple Correlation with g_M and $D(g_M)$, Nonzero Intercept				
					g_M		$D(g_M)$		
Period and Country	Col. 3 (1)	Other Cols. (2)	g_M (3)	$D(g_M)$ (4)	Coefficient (5)	t Value (6)	Coefficient (7)	t Value (8)	Corrected R^2 (9)
Pre–World War I									
United States[a]	19	19	.56	.42	0.037	2.5	0.046	1.6	.33
United Kingdom	9	8	−.13	−.79	−0.045	−1.1	−0.302	2.6	.56
Interwar									
United States	7	7	.51	−.26	0.051	2.7	−0.088	−2.3	.51
United Kingdom	7	7	−.51	.32	−0.063	−1.0	0.109	0.4	−.06
Postwar									
United States	11	11	.23	−.26	0.052	1.1	−0.148	−1.2	−.01
United Kingdom	9	9	.62	.49	0.068	1.4	−0.128	−0.6	.23
All, excluding wars									
United States	37	37	.77	.13	0.066	7.5	−0.053	−1.9	.61
United Kingdom	25	24	.51	.13	0.069	2.9	−0.130	−1.1	.23
All									
United States	47	47	.57	.04	0.038	5.2	−0.041	−1.8	.35
United Kingdom	35	34	.35	.20	0.022	1.7	0.015	0.4	.06

[a]For the pre–World War I period, the United States rate of interest was adjusted for the effect of free silver by subtracting one percentage point from the recorded rates, 1879–96.

The intermediate-term income effect would produce positive correlations between R and g_M, and $D(R)$ and $D(g_M)$, thus offsetting the negative impact of the loanable funds impact effect. Clearly, the intermediate income effect too is not strongly reflected in the contemporaneous correlations of tables 10.11 and 10.12. Neither is it strongly reflected in other correlations (not shown in the table) that allow for a lag in effect. The most one can say is that perhaps the intermediate income effect and the loanable funds impact effect are largely offsetting one another in our phase average data, with sometimes one and sometimes the other dominating, thereby producing mixed signs and small correlations. But there is no direct support for that interpretation.

The multiple correlations are an attempt to allow simultaneously for the various effects, instead of considering them one at a time. The coefficient of M in the correlation with R reflects the liquidity effect, and the coefficient of g_M reflects the loanable funds effect, as perhaps offset by the intermediate income effect. Similarly in the correlation with $D(R)$, the coefficient of g_M reflects the liquidity effect, the coefficient of $D(g_M)$, the mixed loanable funds and income effects. These multiple correlations, like the simple correlations, show only muted reflections of the impact and intermediate effects, though there are more negative coefficients—three out of ten for M and six out of ten for g_M in the correlations with R; two out of ten for g_M and seven out of ten for $D(g_M)$ in the correlations with $D(R)$—and several of the negative coefficients differ significantly from zero.

As a further bit of evidence, in the correlations with R for the subperiods, we have also included a time term to correct for trend. These correlations give little evidence of an appreciable liquidity or loanable funds effect—only one of the ten coefficients of M is negative, and only five of the ten coefficients of g_M, and only one of these six negative coefficients differs significantly from zero. The generally positive coefficients presumably reflect the long-term price effect. Only the correlations with $D(R)$ give any appreciable evidence of any other effect, and those support only a loanable funds effect.

All in all, these results suggest that our phases are long enough so that averages for them show at most strongly damped impact and intermediate effects and are dominated by the price effects.

conclusion fits in well with the emergence of the Fisher effect as dominating the Gibson effect in the later post–World War II period, that is, with the importance of the effect of monetary changes on anticipations. However, for that very reason, Mishkin's result cannot confidently be generalized to earlier periods when the Gibson effect was more important than the Fisher effect ("Monetary Policy and Long-Term Interest Rates: An Efficient Markets Approach," *Journal of Monetary Economics* 7 [January 1981]: 29–55).

Table 10.13 Relation of Interest Rates to Current and Prior Monetary and Price Change

Period and Country	Number of Observations (1)	Standard Deviation of Interest Rate (Percentage Points): Total (2)	Residual Multiple Correlation: g_M (3)	Residual Multiple Correlation: g_P (4)
Pre–World War I				
United States (unadjusted)	19	0.494	0.538	0.540
United States (adjusted)	19	0.592	0.377	0.449
United Kingdom	6	0.561	0.458	0.615
Interwar				
United States	7	1.575	0.592	1.340
United Kingdom	7	1.533	1.060	0.994
Postwar				
United States	11	1.765	1.080	0.831
United Kingdom	9	1.733	0.983	0.950
All, excluding wars, Dummies for subperiods				
United States (unadjusted)	37	1.332	1.160	1.270
United States (adjusted)	37	1.273	1.050	1.170
United Kingdom	22	1.786	1.180	1.280
All, excluding wars				
United States (unadjusted)	37	1.332	1.220	1.350
United States (adjusted)	37	1.273	1.070	1.230
United Kingdom	22	1.786	1.540	1.340
All Dummies for subperiods				
United States (unadjusted)	47	1.707	1.110	1.180
United States (adjusted)	47	1.638	1.070	1.140
United Kingdom	32	1.916	1.250	1.280
All				
United States (unadjusted)	47	1.707	1.670	1.700
United States (adjusted)	47	1.638	1.580	1.600
United Kingdom	32	1.916	2.010	1.910

10.9.2 Price Effects

To supplement our earlier analysis of price effects we have calculated the correlation between the level of interest rates and current and prior rates of change of both money and prices (table 10.13). It is not at all clear a priori which of these correlations should give a better relation. If the secular movement of interest rates is dominated by the price effect of

Money					Prices				
Constant Term (Percentage Points)	Coefficient				Constant Term (Percentage Points)	Coefficient			
	$g_{M(t)}$	$g_{M(t-1)}$	$g_{M(t-2)}$	$g_{M(t-3)}$		$g_{P(t)}$	$g_{P(t-1)}$	$g_{P(t-2)}$	$g_{P(t-3)}$
(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
4.726	−0.001	−0.030	0.064	−0.000	4.854	−0.049	−0.038	0.021	0.059
3.431	0.117	−0.017	0.110	0.017	4.301	0.108	0.044	0.046	0.073
1.836	0.608	−0.987	0.594	0.368	3.133	−0.779	0.682	−0.057	0.592
2.361	−0.046	0.298	0.011	0.244	5.655	0.054	0.860	0.023	0.383
4.546	−0.934	−0.047	0.054	−0.334	1.104	−2.585	1.287	−0.509	0.042
−0.819	1.190	−1.155	1.169	−0.345	2.981	0.831	0.513	−0.974	−0.065
7.240	0.435	−0.401	0.136	−0.639	7.851	1.275	−2.173	1.420	−1.299
4.028	0.090	−0.029	0.245	0.093	4.815	0.206	−0.107	0.194	−0.086
3.087	0.152	−0.040	0.297	−0.090	4.283	0.298	−0.048	0.222	−0.056
3.629	0.535	−0.950	0.294	−0.301	2.640	0.867	−0.994	0.111	−0.149
3.887	0.065	−0.019	0.235	−0.145	4.326	0.157	−0.135	0.203	−0.174
3.244	0.113	−0.052	0.287	−0.121	3.986	0.211	−0.125	0.213	−0.129
2.744	0.504	−0.393	0.253	−0.065	2.982	0.796	−0.503	0.074	0.019
4.388	0.038	−0.031	0.201	−0.088	4.865	0.024	−0.051	0.227	−0.088
3.547	0.085	−0.036	0.232	−0.082	4.339	0.096	−0.050	0.272	−0.074
2.781	0.114	−0.242	0.285	−0.146	2.790	−0.004	0.112	−0.056	0.066
3.915	−0.122	0.078	0.041	0.041	4.042	−0.171	0.126	0.029	0.052
3.353	−0.075	0.061	0.067	0.060	3.717	−0.115	0.108	0.053	0.081
2.852	0.018	−0.110	0.071	0.046	2.866	0.028	0.118	−0.066	0.148

monetary changes and if some version of Fisher's interpretation of how price anticipations are formed is accepted, then one might expect the price correlations to be closer, on the argument that factors other than money affect price movements and that such price movements should have the same effect on interest rates as price movements reflecting monetary change. On the other hand, the price series very likely are subject to greater measurement errors than the monetary series, and monetary changes can be expected to affect interest rates through the impact and intermediate effects, not only the price effects. On these grounds one might expect the monetary correlations to be higher.

The empirical comparison of the two multiple correlations in table 10.13 is hindered by the small number of degrees of freedom available for many of the computations for subperiods. Given that five constants are fitted, only one degree of freedom remains for the United Kingdom for the prewar period, only two for the interwar period for both countries and four for the post–World War II period for the United Kingdom, and only six for the United States for the post–World War II period. The period as a whole, both excluding and including war phases, provides more degrees of freedom but is unsatisfactory because of the significant differences among the periods. Accordingly, we have computed additional correlations for the period as a whole including dummies to allow for differences in the level of the interest rate in different periods.

For the three key nonwar periods separately, four of the money correlations (including all three for the pre–World War I period) are superior to the price correlations and three are inferior, as shown by the residual standard errors in columns 3 and 4.

All the results for the combined periods for both the United States and the United Kingdom, when dummies are included, yield a lower residual standard error for the money than for the price correlations, though some of the differences are small. When dummies are not included, that is also the result for the United States; but for the United Kingdom the residual standard error is lower for the price correlations.

For the prewar period we have given correlations for the United States for the original interest rate and also for the interest rate adjusted for the free silver effect by subtracting one percentage point from values for years before 1897. The adjusted results are markedly superior, and we may concentrate our attention on them.

Given the small number of degrees of freedom and the paucity of individual regression coefficients that differ significantly from zero, little confidence can be attached to the time pattern of coefficients. Somewhat, though not much, more can be attached to their sum. Moreover, theory indicates that in principle their sum, if enough terms are included, should approximate unity: that is, an indefinitely continued increase of one percentage point per year in the rate of monetary growth will tend ultimately to add one percentage point to the rate of price increase; and a one percentage point higher rate of price increase will tend to widen the difference between the nominal and real interest rates by one percentage point and, if the real interest rate is unaffected (the qualification that accounts for the "approximate" before unity), to raise the nominal interest rate by unity.

Table 10.14 **Combined Effect of Current and Past Price and Monetary Changes and Estimate of Real Interest Rate**

	Estimate of Real Interest Rate from Correlation with		Sum of Coefficients of Current and Past	
Period and Country	Money (1)	Prices (2)	Money (3)	Prices (4)
Pre–World War I				
United States (unadjusted)	4.73	4.85	0.03	−0.01
United States (adjusted)	3.44	4.30	0.23	0.27
United Kingdom	1.85	3.13	0.58	0.44
Interwar				
United States	2.37	5.66	0.51	1.32
United Kingdom	4.51	1.10	−1.26	−1.76
Postwar				
United States	−0.79	2.98	0.86	0.31
United Kingdom	7.23	7.85	−0.47	−0.78
All, excluding wars, dummies				
United States (unadjusted)	4.03	4.82	0.21	0.21
United States (adjusted)	3.10	4.28	0.32	0.42
United Kingdom	3.62	2.64	−0.42	−0.16
All, excluding wars				
United States (unadjusted)	3.89	4.33	0.14	0.05
United States (adjusted)	3.25	3.99	0.23	0.17
United Kingdom	2.75	2.98	0.30	0.39
All, dummies				
United States (unadjusted)	4.39	4.86	0.12	0.11
United States (adjusted)	3.55	4.34	0.20	0.24
United Kingdom	2.78	2.79	0.01	0.12
All				
United States (unadjusted)	3.92	4.04	0.04	0.04
United States (adjusted)	3.36	3.72	0.11	0.13
United Kingdom	2.85	2.87	0.13	0.23

As table 10.14 shows, the sum of the coefficients for money is between zero and unity for the United States throughout, but for the United Kingdom this is true only before World War I. However, these sums are decidedly short of unity.[108] For the three nonwar periods combined, and for the adjusted United States interest rate, the sum is less than one-third; for the United Kingdom for the pre–World War I period alone it is less than .6. The shortfall from unity may reflect the inability to include more terms. More likely, it reflects our inability to allow for many other factors affecting interest rates, which produce a downward bias in the regression coefficients arising from error in the estimates of both monetary change

108. This contrasts sharply with Harley's results. He finds the effect to be unity for the United Kingdom before World War I ("Interest Rate and Prices in Britain," p. 77).

and interest rates and from correlated disturbances. For prices the results are even less satisfactory.

We can also use the equations to estimate the interest rate that would result if price change were zero: the ex-ante "real" interest rate implied by these equations. For the price equations, this estimate is given directly by the constant term, because that is the value corresponding to all rates of price change being zero. For the money equations, the estimate requires inserting in the equations the rate of monetary change that could be expected to produce a zero price rise. We have estimated this for each period and country by assuming a real per capita income elasticity of 1.1 for the United States and 0.9 for the United Kingdom, which are roughly the values suggested by the results of chapter 6.[109] Inserting the resultant value of monetary change in the multiple regression provides the estimates in column 1 of table 10.14.

The estimates for the subperiods are highly erratic, a reflection of the small number of observations. In particular, the drastic rise from period to period in the real return for the United Kingdom, as estimated from the money equations, seems implausible. For all nonwar periods, as a whole, the results seem much more reasonable and much more in line with the ex-post real returns as recorded in table 10.1, as the summary in table 10.15 indicates.

For the three periods combined, the estimated ex-ante real returns are generally a bit higher than the average realized real rates, implying that on the average the realized rates were affected more by unanticipated inflation than by unanticipated deflation.

10.10 Conclusion

A well-developed theory reveals the complexity of the relation between monetary change and nominal interest rates. In the first place, the impact effect of unanticipated accelerations or decelerations of monetary growth is in the opposite direction from the intermediate and long-range effects. Second, part of the impact effect produces an abrupt shift in the interest rate (the loanable funds effect) while another produces a continuing movement (the liquidity effect). Third, the magnitude and time span of both impact effects depend critically on how rapidly anticipations adjust, and on the extent to which changes in nominal income take the form of changes in output and in prices—about which, as we saw in

109. That is, we have multiplied the rate of change of per capita real income by 1.1 or 0.9, then added the rate of population growth to get the rate of monetary change consistent with zero price rise. For the United States, the monetary figures used in computing the multiple correlations were already adjusted for the period before 1903 for increasing financial sophistication. For both the United States and the United Kingdom the money figures have been adjusted for dummy variables, as explained in chapter 8.

Table 10.15 **Estimated Real Return on Nominal and Physical Assets, Ex-Post and Ex-Ante, All Nonwar Periods**

	Estimated Real Return			
	Ex-Post (Table 10.1)		Ex-Ante (Table 10.14)	
Period and Country	Nominal Assets	Physical Assets	Money Equation	Price Equation
All nonwar				
United States (unadjusted)	3.83	2.90	3.89	4.33
United States (adjusted)			3.25	3.99
United Kingdom	2.54	1.94	2.75	2.98

chapters 2 and 9, we have neither a well-developed, agreed-on theory nor any soundly based and simple empirical generalizations. Such changes in output and prices are the prime source of the intermediate and long-range effects. Fourth, although the intermediate effects tend to offset and ultimately completely cancel the impact effects, in the process there are good grounds for expecting overshooting that produces a cyclical reaction pattern of interest rates to monetary disturbances. Finally, the long-range effect operates through price expectations, and these in turn are affected by monetary disturbances that raise or lower the rate of monetary growth for long periods at a time and so leave their impress on price movements, or monetary disturbances that it is widely believed will have this effect even if they do not in fact—a case that is well exemplified by United States experience during the free silver movement of the nineteenth century. Anticipations of inflation will, perhaps later rather than sooner, make for high nominal interest rates, and anticipations of deflation, for lower ones.

Unfortunately, there is no equally well developed theory of the effect of real disturbances on nominal interest rates. We know of course that changes that raise the real yield on capital will tend to raise nominal rates and conversely. But beyond this we have no satisfactory analysis of the time pattern or magnitude of their likely impact on the relation between nominal and real rates.

In view of the complexity of the effect of monetary disturbances, and the absence of a well-developed theory of the impact of real disturbances, it is not surprising that the empirical part of this chapter has produced no simple generalizations, independent of time and place, that would enable an observer to predict the effects on nominal interest rates of monetary change. Our theoretical framework provides important insight into the empirical behavior of interest rates, but that insight is far richer in understanding particular episodes than in producing a simple empirical generalization covering a wide range of such episodes.

Our empirical analysis has been devoted largely to two related themes: the relation between yields on nominal and on physical assets, and the effect of the level and rate of change of prices on interest rates. Money enters as a factor producing short-term effects, a large part of which averages out within the cycle phases that are our unit of analysis, and as a source of price changes. In principle, price changes arising from other sources should have the same effects on interest rates as those arising from monetary change. Yet it turns out that though nominal interest rates are not very closely connected with current and prior monetary change, they are more closely connected with such monetary changes than with current and prior price changes. We conjecture that this result reflects partly the greater statistical accuracy of our monetary series and partly the impact and intermediate effects that remain in our phase bases.

10.10.1 Yields on Nominal and Physical Assets

The capital markets that determine the interest rates we study serve the economic function of mediating between the suppliers of capital, who prefer to hold assets denominated in nominal terms, and the demanders of capital, who in the main use the capital to acquire physical assets. Financial intermediaries, such as banks, insurance companies, and the like, which have both assets and liabilities denominated in nominal terms, complicate and hide but do not invalidate this fundamental function of the markets in nominal assets. In order to study the relation between the yields on nominal assets and on physical assets, we have employed the rate of change of income as a proxy for the yield on physical assets: that of nominal income as a proxy for the nominal yield on physical assets, and that of real income as a proxy for the real yield on physical assets. Such evidence as we could assemble indicates that our proxy, which we initially used in the analysis of the demand for money, serves its purpose reasonably well, certainly far better than any available alternative.

For the century that our data cover, the average yield on nominal assets was roughly equal to the average yield on physical assets in both the United States and the United Kingdom—itself one of the bits of evidence on the validity of our proxy. The nominal yield on short-term assets averaged 4.2 percent for the United States, 3.5 percent for the United Kingdom; on long-term assets it averaged 4.8 percent for the United States, 4.2 percent for the United Kingdom. The real yield, after subtracting the rate of inflation from the nominal yield, averaged roughly 2.6 percent and 3.3 percent for the United States for short- and long-term assets, 0.9 and 1.7 percent for the United Kingdom. The difference in real yields is wider than in nominal yields because British prices rose on the average more rapidly than United States prices, a difference that was reflected almost precisely in the average behavior of the exchange rate.

The excess of the United States over the United Kingdom yield varies greatly over the century. Before 1914, the United Kingdom was a capital exporter, the United States mainly a capital importer. This situation implies that the yield on capital would be expected to be higher in the United States than in the United Kingdom, and that the difference would be greater than it was after World War I, and this is the case—the excess of United States over United Kingdom real yields being about one percentage point higher before 1914 than in subsequent peacetime periods. Before 1896, the differential between the nominal yields in the two countries was widened, and from 1896 to 1914 it was narrowed by the shift from expectations of devaluation and inflation before 1896 arising out of the free silver campaign, despite the fact of exchange rate stability and deflation, to confidence in the stability of the dollar-pound exchange rate and the avoidance of inflation, despite the fact of inflation. This shift was of course produced by the election of McKinley in 1896 and confirmed by a flood of gold, mostly from South Africa. While the United States–United Kingdom differential in real yields was roughly the same in the interwar and post–World War II periods, the differential in nominal rates shifted from higher United States nominal rates to higher United Kingdom nominal rates as a result of the depreciation of the pound relative to the dollar.

Like the United Kingdom–United States differential, the relation between yields on nominal and physical assets varies greatly from period to period. Equality of yields on nominal and physical assets holds only for the century as a whole. From phase to phase there was essentially no relation between the movements in yields on nominal and physical assets. Over longer periods, the relation depended critically on price movements—in periods of rising prices, the yield on physical assets tended to exceed the yield on nominal assets; in periods of falling prices, the yield on physical assets tended to be less than the yield on nominal assets. Clearly, a large part of the price movement was not anticipated, so that lenders did not succeed in advance in protecting the yield on their nominal assets from being eroded by rising prices, and borrowers did not succeed in advance in protecting their payments from being raised, in real terms, by declining prices. These failures to adjust for price movements had their effect through nominal yields. Between periods displaying different price movements, the real yields on physical assets were far more alike than the real yields on nominal assets, but a similar phenomenon does not hold within periods.

10.10.2 Interest Rates and Prices

Perhaps the most important single conclusion from our examination of the relation between interest rates and prices is to confirm the doubts expressed by Frederick Macaulay in the late 1930s about the validity of Keynes's unqualified assertion that the "tendency of prices and interest rates to rise together . . . and to fall together" is "one of the most completely established empirical facts within the whole field of quantitative economics." This alleged fact, which Keynes properly regarded as inconsistent with theoretical expectations and so dubbed the "Gibson paradox," simply is not a fact, at least since 1914. As Macaulay said, "the exceptions . . . are so numerous and so glaring that they cannot be overlooked" (p. 185). The relation holds over neither World War I nor World War II. It is dubious whether it holds for the post–World War II period, particularly since the middle 1960s. For the period our data cover, it holds clearly and unambiguously for the United States and the United Kingdom only for the period from 1880 to 1914, and less clearly for the interwar period. Dwyer has examined the relation for France, Germany, and Belgium, as well as for the United States and the United Kingdom, and finds no clear-cut Gibson phenomenon for the other countries.

The failure of the relation to hold over wartime price changes—which means over the major price changes—eliminates the major element of paradox but nonetheless leaves a striking empirical phenomenon demanding an explanation. One of two principal explanations that have been offered is Fisher's, that the relation between interest rates and *price level* reflects a relation between interest rates and the anticipated *rate of price change* plus the delayed formation of anticipations by extrapolating past price changes. The other is Wicksell's, also later in a variant suggested by Keynes, that the relation reflects fluctuations in the real yield on capital that are transmitted to both prices and nominal interest rates through commercial banks, which delay the impact of changes in real yields on nominal rates by altering the quantity of money.

Investigators of the Gibson paradox have increasingly come to reject both explanations. Our analysis supports the rejection of the Wicksell-Keynes explanation, partly on the basis of earlier studies by others, partly because we cannot detect in our data the Gibson phenomenon for *real* yields, as well as nominal yields, that is implied by the Wicksell-Keynes explanation. Our analysis does not, however, support the rejection of the Fisher explanation. We found that earlier investigators have been misled because they tested the explanation largely for periods over which the Gibson phenomenon is nonexistent. The Fisher explanation, plus allowance for such episodic phenomena as the free silver movement in the United States, seems to us to remain a highly plausible explanation for the observed relations. However, we are led by this reexamination to regard the period of past price change entering into the formation of price anticipations as being distinctly shorter than the period estimated by Fisher and some others—weights on past price change extending over a period covering something like six to nine years, instead of Fisher's longer periods.

Our data confirm a sharp break in the relation between interest rates and prices in both the United States and the United Kingdom in the mid- or late 1960s that has been reported by other investigators. From then on there is a much closer relation between interest rates and contemporaneous rates of inflation than existed earlier. Gibson disappears and the original Fisher emerges. Apparently lenders and borrowers have been better able than earlier to protect themselves against price changes.

We are inclined to accept an explanation offered by Benjamin Klein for this shift: a drastic change in the character of the monetary system from a largely specie standard to a fiduciary standard and a belated and gradual recognition of this shift by market participants. At an earlier date changes in the quantity of money and in price levels in the connected economies of the United States and the United Kingdom were perceived to be largely the result of such autonomous events as gold discoveries, banking developments, including occasional crises, and the like. They were not, and were not perceived to be, the deliberate consequence of government policy—though obviously measures by government were among the autonomous events that affected the quantity of money. The government was regarded, and regarded itself, as constrained by the requirement to maintain convertibility of the national money into specie, directly or indirectly. In recent decades the situation has changed drastically. Deliberate government management of the quantity of money as part of a policy of steering or tuning or controlling the economy has taken the place of the specie standard.

The change in the monetary standard altered the information relevant to predicting the future course of prices. In addition, it has been accompanied by less short-term but more long-term variability in rates of inflation and by much higher levels of inflation than had been experienced in peacetime in the United States and the United Kingdom during the period we cover. The result was to provide a greater incentive for participants in the market to seek to allow for future price movements, along with a greater possibility of doing so.

The extent of the change may have been exaggerated by the failure of many investigators to allow for the effect of taxes on the difference between nominal and real yields on nominal assets. Even a modest allowance on this score means that borrowers have not succeeded in protecting themselves at all fully from the effect of inflation on real yields. Moreover, the apparent shift may prove temporary. Whether it does, or whether it is carried even further, may very well depend on whether future rates of inflation remain as high and as variable as in the past decade (or even higher and more variable) or whether rates of inflation resume their peacetime behavior.