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Retrospectives
Irving Fisher's *Appreciation and Interest* (1896) and the Fisher Relation

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This feature addresses the history of economic terms and ideas. The hope is to deepen the workaday dialogue of economists, while perhaps also casting new light on ongoing questions. If you have suggestions for future topics or authors, please write to Joseph Persky of the University of Illinois at Chicago at jpersky@uic.edu.

Introduction

From 1886 up until the start of the *American Economic Review* in 1911, the American Economic Association published the proceedings of its annual meetings along with occasional monographs; these *Publications of the American Economic Association* are now freely available at JSTOR (http://jstor.org). In an outstanding contribution to that First Series of AEA publications, Irving Fisher's monograph *Appreciation and Interest* (1896) proposed his famous equation showing expected inflation as the difference between nominal interest and real interest rates. In addition, he drew attention to insightful remarks and numerical examples scattered through the earlier literature, and he derived results ranging from the uncovered interest arbitrage parity condition between currencies to the expectations theory of the term structure of interest rates. As J. Bradford DeLong (2000, pp. 83, 85) wrote in this journal, "The story of 20th century macroeconomics begins with Irving Fisher" and

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specifically with *Appreciation and Interest* because "the transformation of the quantity theory of money into a tool for making quantitative analyses and predictions of the price level, inflation, and interest rates was the creation of Irving Fisher."

In 1896, Irving Fisher was an assistant professor in his 20s, just five years out of graduate school, who had been teaching mathematics rather than economics for the first four of those years. Fisher was not trained as a monetary specialist. His 1891 doctoral dissertation in mathematics and political economy (Yale's first Ph.D. in political economy or economics, see Barber 1986), which was published as *Mathematical Investigations in the Theory of Value and Prices* (1892), brought general equilibrium analysis to North America; it was supervised jointly by the physicist and engineer J. Willard Gibb and the economist and sociologist William Graham Sumner.[1] Paul Samuelson once described Fisher (1892) as the "greatest doctoral dissertation in economics ever written" (quoted by Barber, in Fisher 1997, Vol. 1, p. 4). However, Robert Dorfman (1995, footnote on p. 23) made the point that "[i]f Fisher's examiners had been better versed in European economic literature than they were, a promising career might have been blighted at its inception," because Fisher invented general equilibrium analysis for himself before his last-minute discovery of the writings of Léon Walras and Francis Ysidro Edgeworth. Fisher's thesis went beyond these writings in one striking respect: influenced by Gibbs's work in mechanics, Fisher not only imagined but actually built a hydraulic mechanism to simulate the determination of equilibrium prices and quantities—in effect, a hydraulic computer in the days before electronic computers (Brainard and Scarf 2005; Dimand and Ben-El-Mechaiekh forthcoming). His first academic appointment was in Yale's Department of Mathematics in 1891 (Fisher coauthored an elementary geometry textbook in 1896 and published a brief introduction to calculus the next year), and he did not transfer to the Department of Political Economy until the summer of 1895. Fisher's course in the mathematics department on "The Mathematical Theory of Prices," based on his dissertation, was far ahead of its time in the 1890s. A typical American course in political economy in the 1890s such as that taught by J. Laurence Laughlin at the University of Chicago still used John Stuart Mill's *Principles of Political Economy* (1848 [1871]) as the textbook; it did not use Alfred Marshall's *Principles of Economics* (1890 [1920]), let alone mention general equilibrium.

Edgeworth invited Fisher to apply a simplified version of his hydraulic model to "The Mechanics of Bimetallism" for presentation to the Economics Section of the British Association for the Advancement of Science and then publication, in 1894, in the *Economic Journal,* which Edgeworth edited. Bimetallism was a hot topic at the time. Prices tended to decline under the gold standard from 1873 to 1896 as real demand for money rose faster than the world supply of gold (a situation

[1] Sumner was also one of the two supervisors of Thorstein Veblen's 1884 Yale Ph.D. dissertation on Kant's ethics and so was a mentor to two outstanding young economists, with Veblen's institutionalism and Fisher's formal theorizing and pioneering econometrics offering very different paths for American political economy (Dimand 1998).

that changed after 1896 with the Witwatersrand and Klondike gold rushes and the cyanide process for extracting gold from low-grade ore). As prices fell, the real value of nominal debts increased. In the United States, Midwestern populists denounced the rising real burden of farm mortgages held by Eastern banks and, together with Western silver miners, demanded "bimetallism"—that is, increasing the money supply by free coinage of silver as well as gold. During the 1896 presidential election campaign, the Democratic and Populist nominee William Jennings Bryan in his speech accepting the Democratic nomination famously condemned the gold standard for crucifying mankind on a "cross of gold." The leading bimetallist tract, William Harvey's *Coin's Financial School* (1894 [1963]), sold perhaps a million copies, vastly exceeding the circulation of any mainstream economics book of the time (see Hofstadter's introduction to the reprint, and Willard Fisher 1896). In the book, Harvey's fictional financier Coin soundly defeated Professor J. Laurence Laughlin of the University of Chicago, a hard-money stalwart, in public debate—although when Laughlin was able to speak for himself in a real public debate with Harvey in 1895, he fared much better (Skaggs 1995; Willard Fisher 1896). The bimetallists followed the quantity theory of money in holding that an increase in the quantity of money would raise prices, but went beyond the quantity theory in insisting that a higher price level would have lasting real benefits. Laughlin and some other academic defenders of the gold standard met such populist use of the quantity theory not just by insisting on the long-run neutrality of money, but also by rejecting the quantity theory's explanation of changes in the purchasing power of money (Skaggs 1995; Gomez Betancourt 2010).

By July 1895, Fisher was writing to a friend that he was "working on an essay which will either be a long article or a short book on bimetallism *against* its expediency or necessity . . . I never was so morally aroused I think as against the 'silver craze'" (Fisher 1997, Vol. 1, p. 7, Fisher's emphasis). Fisher's *Appreciation and Interest* was presented to the American Economic Association in Indianapolis in December 1895 and then published by the association in August 1896.[2] The title featured the appreciation of the purchasing power of money during deflation rather than its depreciation in a period of price inflation. Fisher had two goals in his 1896 monograph: to show the fallacy of bimetallist claims of permanent gains from inflation while rescuing the quantity theory of money from its populist misuses. During his long and productive career, Fisher attempted statistical verification of the relation (making use of correlation analysis and introducing distributed lags into economics) and developed a monetary theory of fluctuations in economic activity based on slow adjustment of inflationary expectations (that is, modeling expected inflation with a form of adaptive expectations). In the 1930s, when propounding his

[2] The other three issues of that year's volume of *Publications of the American Economic Association* were, regrettably, devoted to Frederick L. Hoffman (1896), a work of racist pseudo-science by the statistician to the Prudential Insurance Company of America. Irving Fisher was also a strident eugenicist (Fisher 1997, Vol. 13, pp. 160–207; Cot 2005; Dimand 2005), and Fisher's *The Rate of Interest* (1907) expressed strong views on racial and ethnic differences in rates of time preference, which he considerably toned down in *The Theory of Interest* (1930).

debt-deflation theory of the Great Depression, Fisher came to regret his earlier lack of sympathy with the bimetallists. By then, he viewed them as having raised a real problem—the short-run non-neutrality of deflation—while he continued to reject the soundness of their proposed remedy, which would have required the monetary authority to fix the relative price of two commodities, gold and silver.

The Message of *Appreciation and Interest*

Fisher (1896) stressed that an appreciating value of money redistributed wealth from debtors to creditors only to the extent that the appreciation was a surprise. If the appreciation was expected, it would have been taken into account when the debts were incurred and the interest rates negotiated. A high rate of interest need not harm trade, nor need a low rate of interest encourage activity. What matters is whether the interest rate is high or low relative to the rate of appreciation of some standard. If i is the interest rate expressed in some standard I, and j is the interest rate expressed in some other standard J, and a the rate at which standard I (say, money) is expected appreciate in terms of standard J (say, commodities) over the relevant time period, then the equilibrium condition is $(1 + j) = (1 + i)\ (1 + a)$, which offers no possibility for profitable arbitrage. Falling prices need not harm farmers who owe mortgages as long as expectations of the falling prices were reflected in the interest rates on the mortgages: "It is clear that if the unit of length were changed and its change were foreknown, contracts would be modified accordingly . . . To alter the mode of measurement does not alter the actual quantities involved, but merely the numbers by which they are represented" (Fisher 1896, p. 1). "We thus see that the farmer who contracts a mortgage in gold is, *if the interest is properly adjusted*, no worse off and no better off than if his contract were in a 'wheat' standard or a 'multiple' standard" (Fisher 1896, p. 16, his italics). Appreciation or depreciation of the purchasing power of money only matters if expectations are wrong, and they won't be wrong in the long run, because people learn from experience, gather and process information, and adjust their expectations.[3]

If that was all Fisher (1896) had to say, it would have undermined the bimetallist argument for long-run non-neutrality and drawn attention to a crucial factor overlooked in monetary discussions by many leading economists. Fisher (1896, pp. 67–70) gleefully cited unsound passages written by luminaries of that time like William Stanley Jevons, Thomas Tooke, William Newmarch, and by Oxford

[3] A number of modern authors have cited Fisher's (1930) *The Theory of Interest* as the source for the Fisher relationship (for example, Crowder 1997, pp. 1124, 1127). But the Fisher equation does not appear in that work. Fisher presented the equation in *Appreciation and Interest* (1896) and in an appendix to *The Rate of Interest* (1907), but his discussion of the relation in chapters 2 and 19 of *The Theory of Interest* (1930) is verbal, supplemented with diagrams but no equation (Dimand 1999). Similarly, the famous Fisher two-period diagram of optimal consumption-smoothing, often attributed to *The Theory of Interest* (1930), does not appear in that book, where the discussion of intertemporal optimization is largely verbal. Instead, the diagram is in Fisher (1907, p. 409), as discussed in Humphrey (2010).

professor Bonamy Price, and could have provided many more examples. He noted (p. ix): "The views here put forward . . . differ radically from those expressed by Mr. Giffen and many other eminent economists." But, except for writing the relation as an equation, he would simply have been drawing attention to a relation already understood by such well-known figures as John Stuart Mill, Alfred Marshall, and John Bates Clark, as Fisher acknowledged.

However, Fisher did much more. Viewing Marshall's terms "real" and "nominal" interest as inadequate, Fisher applied his formula to any two standards: gold and silver; money and goods; two national currencies; or two commodities (like wheat and barley). From the principle that asset prices and returns will move to eliminate any profitable opportunity for arbitrage, he derived what is now called the uncovered interest parity condition: that is, the difference between interest in any two currencies (say, dollar interest rates in New York and pound sterling interest rates in London) is due to the expected rate of change of the exchange rate between the two currencies.[4] To show this empirically, and to show that money interest reflects the rise or fall of prices, Fisher (1896) assembled and published a wide variety of tables: on interest rates on India silver and gold bonds; Berlin, Paris, Calcutta, Tokyo, and Shanghai interest rates in relation to falling and rising prices; New York interest rates in relation to rising and falling prices and wages; London interest rates in relation to rising and falling prices, wages, and incomes; and U.S. interest rates on "coin" bonds (payable in gold coin) and "currency" bonds (payable in greenbacks) before the U.S. economy returned to the gold standard. He also examined interest rates in the same standard for loans of differing duration, explaining the term structure of interest rates by expectations of what would happen to the purchasing power of money.

Having shown that, with perfect foresight, appreciation or depreciation of the purchasing power of money would not affect real interest rates, Fisher based his monetary theory of economic fluctuations on the slow adjustment of expectations and money interest to monetary shocks in a world of imperfect foresight, which implied that monetary shocks would affect real interest in the short run. To be explicit, Irving Fisher did not believe that the Fisher relation held fully in the short run. Alfred Marshall had mentioned this insight in three sentences in his "Note on the Purchasing Power of Money in Relation to the Real Rate of Interest" in the first edition of his *Principles of Economics* in 1890 (quoted by Irving Fisher 1896, p. 79), but Fisher developed it into a full-blown theory of fluctuations (Fisher 1896, 1907, 1926; Fisher with Brown 1911, chap. 4), declaring the "so-called 'business cycle'" to be a "dance of the dollar."

In the 1920s, Fisher began to use distributed lags of past price level changes as a proxy for expectations of future price changes in his correlation analyses (Rutledge 1977). To carry out these empirical studies, Fisher (1922) proposed the Fisher ideal

[4] More than a quarter of a century later, John Maynard Keynes (1923) added the covered interest parity condition: that the spread between forward and spot exchange rates equals the difference between interest rates in two currencies.

index (the geometric mean of the Paasche and Laspeyres price indexes), and, in the absence of a government-produced price index, Fisher created and published his own weekly price index. While Fisher (1896) used statistical tables to show that money interest rates were high in periods of rising prices, Fisher (1930) correlated money interest rates with distributed lags of price changes to demonstrate both that higher expected inflation raises money interest rates and that the adjustment is slow and incomplete. In a series of articles, Fisher correlated distributed lags of price level changes with economic activity and unemployment. His article "A Statistical Relationship between Unemployment and Price Level Changes" (1926 [1973]), little noticed when first published by the International Labour Office, attracted rather more attention when reprinted almost 50 years later in the *Journal of Political Economy* as "Lost and Found: I Discovered the Phillips Curve—Irving Fisher."

How Original was Fisher (1896)?

It is a commonplace observation among researchers in many disciplines that as statistics professor Stephen Stigler (1999, p. 277) put it: "No scientific discovery is named after its original discoverer." (Naturally, Stigler attributed the insight to Robert K. Merton.) In this spirit, Humphrey (1983 [1986], p. 158) wrote: "The real/nominal rate distinction is of 18th rather than 20th century vintage. Irving Fisher, now generally regarded as the father of real/nominal interest rate analysis, originated none of the concepts now bearing his name. Neither the so-called *Fisher relationship* (according to which the nominal rate equals the real rate plus expected inflation), nor the *Fisher effect* (according to which the nominal rate fully adjusts for inflation leaving the real rate intact), nor the *Fisher neutrality proposition* (according to which equilibrium nominal rate adjustments entail no real effects) originated with him. Rather they long predate him, having been enunciated by earlier generations of writers."

But on the subject of appreciation and interest, there appear to be just three brief, isolated insights in this area that predate the work of Jacob de Haas (1889) (discussed below), and Fisher (1896) managed to uncover two of those examples. Fisher (p. 3) wrote, "It is an astonishing fact that the connection between the rate of interest and appreciation has been almost completely overlooked, both in economic theory and in its bearing upon the bimetallist controversy. Of the few writers who have conceived this connection, apparently the earliest was the anonymous author of the remarkable pamphlet entitled: 'A Discourse Concerning the Currencies of the British Plantations in America.' Boston, 1740 (Reprinted in the 'Overstone Tracts' 1857)." Following up on Fisher, Charles J. Bullock of Harvard identified the Scottish-born physician William Douglass as the author of the "remarkable pamphlet" (Douglass 1740 [1897]), which Bullock republished in the *Publications of the American Economic Association* the year after Fisher's monograph (see also Bumsted 1964). Although, as Fisher stated, Lord Overstone had included Douglass's discourse in a collection of reprints of early monetary tracts, Fisher was the first to

notice and quote the relevant paragraphs, including the argument that "*the larger the Emissions* [of colonial paper currency], *natural Interest becomes the higher;* therefore the Advocates for Paper Money (who are generally indigent Men, and Borrowers) ought not to complain, when they hire Money at a dear nominal Rate" (quoted by Fisher 1896, p. 4, Douglass's italics). A later work by Douglass (1760) was cited by Adam Smith (*Wealth of Nations*) for information about the British colonies in North America, but not the 1740 pamphlet.

A second example, discussed by Humphrey (1983 [1986]) but unknown to Fisher, is from a speech in the British House of Commons speech in 1811 about the Bullion Report, in which Henry Thornton remarked that "in countries in which the currency was in a rapid course of depreciation . . . the current rate of interest was often . . . proportionately augmented" as "partly compensation for an expected increase of depreciation of the currency" (Thornton 1811 [1939], p. 336). Humphrey (1983 [1986], p. 153) notes that this passage of Thornton's speech went beyond Douglass in explicitly stating that the premium refers to expected future inflation, not actual past inflation, but observes that "it conflicts with that part of [Thornton's] analysis that ignores anticipated inflation." Thornton's speech was overlooked until 1939 when Friedrich Hayek reprinted it in an appendix to his edition of Thornton's 1802 *Paper Credit*.

The third prior example is from John Stuart Mill's *Principles of Political Economy* (1848 [1871], Book 3, Chapter 23, Section 4, p. 656), where he remarked in a single sentence: "We thus see that depreciation, merely as such, while in the process of taking place, tends to raise the rate of interest: and the expectation of further depreciation adds to this effect; because lenders who expect that their interest will be paid, and the principal perhaps redeemed, in a less valuable currency than they lent, of course require a rate of interest sufficient to cover this contingent loss" (quoted by de Haas 1889, pp. 115–116).

As Fisher (1896, footnote on p. 5) noted, Mill's devoted only a single paragraph (and that of only one sentence) to the subject. De Haas (1889) doubted that Mill understood the full significance of the point, since he made no other mention or use of the insight. Mill's paragraph was overlooked before de Haas and Fisher. Of the three discussions that constitute these "earlier generations of writers," only that in Douglass's long forgotten tract is longer than a paragraph, and Humphrey (1983 [1986], p. 153, 158) acknowledges that Thornton's remark was inconsistent with other parts of Thornton's analysis and that Douglass and Mill did not distinguish between complete and incomplete adjustment of the nominal rate to inflation. Douglass's work became known only because of Fisher's experience with his dissertation: he had been shocked to discover Walras and Edgeworth when his own thesis on general equilibrium was almost finished, and this taught him to search carefully for forerunners before publishing ideas that he had developed independently.

Much more substantial contributions were made by three of Fisher's contemporaries, and were, together with Douglass (1740 [1897]), warmly acknowledged by Fisher: "The idea on which this theory is founded appears to have occurred independently to several writers, of whom Mr. Jacob de Haas, Jr., of Amsterdam, seems

most fully to have realized its importance . . . A principle which apparently has been independently discovered by each of these economists and quite possibly by others, is likely to be of some importance. It is the object of the present essay to develop the theory in a quantitative form, to bring it to a statistical test, and to apply it to current problems, and to the theory of interest" (1896, pp. ix, 5).[5] The Dutch economist Jacob de Haas, Jr. (1889) devoted an article in the *Journal of the Royal Statistical Society* to arguing that "the expected rate of change in the purchasing power of money" is "A Third Element in the Rate of Interest," the other two being "the remuneration for abstinence, i.e., the hire of capital" and "the insurance against loss or remuneration for risk" (de Haas 1889, pp. 107, 110–111; Fisher 1896, pp. ix, 5). Ever-skeptical Humphrey (1983 [1986], p. 154) writes: "All in all, de Haas contributed little new to the analysis of real and nominal interest rates. His work, despite its apparent originality, contains nothing that cannot be found in Thornton, although Fisher, being unaware of this, thought highly of him. Marshall too knew of his work and cited it in the first edition of the *Principles*."[6] This seems too generous a reading of a passing remark in Thornton's speech (acknowledged to be inconsistent with other writings by Thornton) and too severe a critique of de Haas, who recognized the importance of the topic sufficiently to make it the subject of his article, which caught the attention of Marshall and Fisher. John Bates Clark (1895) was the first to bring the relationship between nominal interest and expected deflation into the debates over bimetallism. Reviewing Fisher (1896) in the *Economic Journal*, Clark (1896, p. 568) held: "The reader who attaches to Dr. Fisher's statistics and theories their true significance will probably conclude that, in a time of such steady and prolonged appreciation of money, the rate of interest on loans would be so reduced as fully to neutralise the increasing costliness of the money."

Given the real but limited contributions of his predecessors in this area, Fisher's originality is highlighted rather than eclipsed. He stated the relation between interest in two standards as $(1 + j) = (1 + i)\ (1 + a)$ or, equivalently, $j = i + a + ia$. The other writers discussed the relation verbally without writing out the equation. Fisher (1896, footnote on p. 9) pointed out that, except for Marshall, they failed to compound, omitting the cross-product term and equating j to $(i + \mathrm{a})$, so that the numerical examples in Douglass (1740 [1897]) and Clark (1895) were wrong, or at least only approximately correct.[7] Fisher (1896, footnotes on pages 78, 79,

[5] But Fisher (1896, p. 56, his italics) also pointed out some misstatements in the de Haas essay: "The relation of high or low prices to the rate of interest must not be confused with the relation of *rising* or *falling* prices to the rate of interest . . . de Haas appears to have fallen into this confusion both in his criticism of Jevons and in his treatment of statistics."

[6] In later editions of Marshall's *Principles*, references to Fisher (1896, 1907) replaced mention of de Haas (Marshall 1890 [1920], footnote on p. 493).

[7] Although Fisher (1896) reproved Clark (1895) and others for "erroneous" results due to omitting the cross-product term, in *The Rate of Interest* (1907) and later works Fisher used $j = i + a$ as an acceptable continuous-time approximation, and it is in that additive form that the Fisher relation is now usually written. Reviewing Fisher (1896), Fabian Franklin (1897, p. 341) remarked: "The formula reduces approximately to $i = j - a$, which is quite accurate enough for most purposes; and Professor Fisher lays too much stress on the deviation from this simple equation."

86, and 90) also cited Marshall's evidence in the 1886 *Report on Depression of Trade* and 1888 *Report of the Gold and Silver Commission* (both reprinted in Marshall 1926), and Marshall (1926) referred favorably to Fisher (1896) in testimony to the Indian Currency Committee in 1899.

Fisher (1896, p. ix) complained: "The connection between monetary appreciation and the rate of interest has received very scant attention from economists. The writer has been led to believe that this neglect has somewhat retarded the progress of economic science and the successful interpretation of economic history—in particular the monetary history of the last twenty years." He warmly acknowledged de Haas (1889), Marshall (1890 [1920]), and Clark (1895) as contemporary exceptions to this neglect, and hailed Douglass's 1740 tract and Mill's paragraph as overlooked forerunners. But it was Fisher, not these contemporaries and forerunners, who ended the neglect. He expressed what is now called the Fisher relation as an equation (including the cross-product term), undertook a substantial statistical verification of the theory, and extended the analysis from real and nominal interest to interest rates in two currencies (uncovered interest parity), interest rates over different durations of loans (the expectations theory of the term structure of interest rates), and interest rates in pairs of commodities (own rates of interest). While upholding the long-run neutrality of money against the populist advocates of bimetallism, Fisher argued that money interest and expected inflation or deflation adjust slowly and, in the short run, incompletely to monetary shocks, so that fluctuations in real economic activity and employment are a "dance of dollar" driven by fluctuations in real interest. A year after *Appreciation and Interest*, Fisher (1897) first presented his version of the equation of exchange $MV + M'V' = PT$, extending Simon Newcomb's version of that equation to allow currency (M) and bank deposits (M') to have different velocities of circulation (V and V', respectively), where P is the price level and T the volume of transactions. This approach was to be central to Edwin Kemmerer's *Money and Credit Instruments in Their Relation to General Prices* (1907, a revision of his 1903 Cornell dissertation[8]) and to Fisher's *The Purchasing Power of Money* (Fisher with Brown 1911).

In 1898, Fisher was promoted from assistant professor to full professor of political economy at Yale, and shortly afterwards was told that he had tuberculosis and only six months to live. If he had died then, he would have been known primarily to the very small community of mathematical economists. *Appreciation and Interest* was received warmly by its handful of reviewers within the profession (Clark 1896, Powers 1897, Franklin 1897), but even they lamented "the use of complicated mathematical formulae. . . they deter the uninitiated. The readers who will labor through this part of the work can be counted on one's fingers" (Powers 1897, p. 124).[9] Fisher

[8] See Kemmerer (1907, pp. 11, 75, 115, 133, 153) for citations of Fisher, primarily of Fisher (1897), and Fisher with Brown (1911, pp. 14, 25, 45, 139–40, 213, 226, 276–79, 282, 331, 430–32, 487) for citations of Kemmerer.

[9] In this context "complicated mathematical formulae" means $(1 + a)\ (1 + i) = 1 + j$, not the system of equations for general equilibrium in Fisher (1892).

became widely known through the economics profession as a whole after *The Rate of Interest* (Fisher 1907). With *The Purchasing Power of Money* (Fisher with Brown 1911), he became not only a leader within the discipline but also a prominent public intellectual, consulted by policymakers and writing extensively for the popular press. But Fisher (1896, 1897) had already laid the foundations for the approach to monetary economics that he was to pursue after his recovery from tuberculosis: an operational, quantitatively-grounded revival of the quantity theory of money, combining long-run neutrality of money with a monetary theory of economic fluctuations driven by incomplete short-run adjustment of nominal interest to monetary shocks. His contributions in *Appreciation and Interest* concerning expected appreciation or depreciation as the wedge between interest rates in different standards remain fundamental to financial, monetary, and international economics.

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