Empirical Tests of the Quantity Theory of Money in the United States, 1900–1930

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EMPHASIS on empirical research has long been a hallmark of the American approach to the quantity theory of money. This fact is often overlooked by those economists who contend that the modern Chicago version of the quantity theory is largely unrelated to the earlier Fisherine version.[1] Similar to their modern counterparts who are frequently engaged in statistical testing of monetary hypotheses, earlier American quantity theorists were motivated by a desire to adhere closely to the statistical data and to state the quantity theory in an empirically verifiable form.

J. R. Hicks has argued recently [16, pp. 156–58][2] that monetary economics is unique in the degree to which it is influenced by historical experience. According to Hicks, monetary theory, more than any other area of economics, tends to be stimulated by events and episodes, notably severe monetary disturbances, and structural-institutional changes that alter the character of the monetary system. Hicks' conjecture would seem to apply also to empirical research. On the American scene, at least, developments in monetary research seem to fit the pattern described by Hicks. The bulk of the empirical work on the quantity theory during the period under review was

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1. Allais [1, p. 1125], Friedman [11, pp. 139–40], Laidler [20, p. 56], and Patinkin [28, pp. 47, 61] state explicitly that the origins of the modern Chicago version of the quantity theory are to be found in the Cambridge cash-balance and Keynesian liquidity-preference approaches. None of these authors mention the characteristic empirical orientation of both contemporary and pre-1930 American quantity theorists. Nothing is said about a tradition of empiricism which links the Fisherine and the Chicago approaches.

2. Bracketed references are cited in full in the References listed at the end of the article.

Published by Duke University Press

inspired by doctrinal issues and policy problems arising from particular monetary disturbances, chief among which were (i) the secular price deflation and the agitation for the monetization of silver in the 1880's and 1890's, and (ii) the post-armistice inflationary boom and subsequent sharp depression of 1920–21. Moreover, the direction of empirical research in the United States was strongly influenced by major changes in the monetary system, including the ascendency of bank deposits as the predominant means of payment and, in the 1920's, the replacement of the rules of the gold standard game by Federal Reserve discretionary policy as the chief regulator of the domestic money supply.

The empirical emphasis of American monetarism was stimulated initially by doctrinal issues arising out of the bimetallism controversy of the late nineteenth century. That is, the early statistical researches of Edwin Kemmerer [19] and Irving Fisher [9] were aimed at reestablishing the validity of a theory that had emerged thoroughly discredited from that controversy. During the bimetallism debate the quantity theory had been linked with the inflationist doctrines of various cheap-money forces (debtor farmers, organized labor groups, advocates of "free silver," etc.), thereby tarnishing its reputation among sound-money men, i.e., gold-standard advocates. The theory had also encountered heavy criticism on the grounds that it was tautological, oversimplified, and at variance with the facts. Influential monometallists, including, among others, J. Laurence Laughlin, Horace White, and William A. Scott, had espoused the following anti-quantity-theory views: (i) that the circulating media were endogenously determined by the needs of trade; (ii) that demand deposits and other forms of bank money have no influence on the level of prices; and (iii) that the secular price decline of 1870–96 stemmed largely from technological changes that lowered production costs in the real (non-monetary) sector of the economy.[3] Moreover, studies of price and money-stock movements conducted by Laughlin's graduate students at the University of Chicago seemed to contradict the quantity theory [17, p. 828–34]. Monetarists Kemmerer [17, 2d ed., pp. 12 n., 19, 92] and Fisher [9, pp. vii–viii, 15,

3. Both the monometallists' critique of the quantity theory and Francis Amasa Walker's defense of it have recently been summarized by Hirsch [17]. See also Hegeland, [15, pp. 75–80]. Walker was a leading American bimetallist.

50 n., 242 n.], however, charged that the critics had misinterpreted the theory and had either ignored completely or specified incorrectly the influence exerted by velocity, by trade, and especially by bank deposits on the relation between the money supply and the price level. Kemmerer and Fisher were particularly eager to prove (i) that checking deposits influenced prices no differently than did standard or primary money (gold), and (ii) that the existence of a stable relation between deposits and primary money preserved the stable link between the latter and the price level. Therefore these economists sought to restate correctly the quantity theory, confirm it statistically, and thus refute its critics.

More frequently, however, the empirical work was policy-oriented. Although purely doctrinal issues definitely provided some impetus to the research of the earlier quantity theorists, their chief interest, like that of modern monetarists, was in the policy implications of their empirical findings. Thus earlier American monetarists, notably Fisher, Carl Snyder, and Holbrook Working, attempted (i) to demonstrate the necessity for monetary stabilization and (ii) to provide reliable policy guides. In line with the first objective, monetarists sought to establish empirically that business fluctuations stem from the erratic behavior of the money stock rather than from non-monetary sources. The quantity theorists' view of the origin of fluctuations differed markedly from the dominant non-monetarist conceptions. According to the latter views, fluctuations were either self-generating and self-perpetuating (i.e., the adaptive mechanism of the economy's institutional structure was inherently cyclical), or alternatively, were caused by exogenous disturbances (wars, harvest variations, technological change, etc.) affecting the real economy. Monetarists felt that these non-monetary explanations, prevalent among monometallists in the 1890's and business-cycle analysts in the 1920's, directed public attention away from the need for monetary control.

American quantity theorists also attempted to define policy guidelines in terms of price-index numbers or money-stock growth rate rules and to provide statistical indicators necessary for the implementation of policy. The policy orientation of American monetarism extends back at least to 1911 when Irving Fisher [9, pp. 337–47] proposed that the government stabilize the price level by adjusting the official price of gold whenever the general price index rose or fell. The policy focus did not reach peak intensity, however, until the 1920's when the sharp depression of 1921 generated public clamor for monetary stabilization and when the virtual demise of the gold standard created a need for new policy guides to replace the old rules of the gold-standard game. Quantity theorists generally supported proposals, much discussed in banking circles and the subject of several congressional hearings, to make control of the general level of prices a statutory objective of Federal Reserve policy [14, pp. 199–207]. Consequently much of the research effort of monetarists in the 1920's was devoted to the search for more reliable price index numbers for stabilization purposes. This focus on statistical policy indicators sharply distinguished American quantity theorists from their classical predecessors (Ricardo, Mill), who were largely unaware of the possibility of using index numbers, and from many participants in the bimetallism controversy, who either denied the need for indicators or else specified indicators lacking information content.

Not only did earlier American monetarists adopt an empirical approach, but the quantity theory itself played an active role in the early development of numerical data and statistical methods. Much has been written about the quantity theorists' role in the construction of time series and in the measurement of the economic aggregates comprised in the equation of exchange [12, pp. 262–72; 13, pp. 89–93, 117–32; 25, pp. 117–28]. Less attention, however, has been devoted to their contribution to statistical technique. One of the earliest applications of correlation analysis to economic data in the United States occurred in a test of the quantity theory in 1908. During the period 1909–15, a lively controversy developed around other attempts to test the quantity theory. This controversy helped acquaint economists and statisticians with some special problems or pitfalls peculiar to the analysis of economic time series. In the 1920's, several advances on the statistical front—including new techniques of time-series decomposition, trend and cycle analysis, distributed-lag analysis, and price-index construction—grew out of or were employed in tests of the quantity theory.

That research on the quantity theory served as a catalytic agent in the development of empirical techniques of economic analysis should not be surprising. After all, the equation of exchange was the chief single-equation macroeconomic model in use up to the 1930's. Nonetheless, the connection between the history of the quantity theory and the development of statistical methods has not been fully recognized or appreciated.[4]

This article examines the relationship that existed between the quantity theory and empirical techniques in the first three decades of the twentieth century. It is divided into three sections. The first section discusses the empirical model used in tests of the quantity theory during the period 1900–1930. The second section reviews tests of the quantity theory with special reference to new statistical techniques used in those tests. The third and concluding section is an evaluation of the contribution made by statistical research to the advance of monetary theory during the period.

The Empirical Model

Throughout the period 1900–1930, the empirical model used in tests of the quantity theory was the equation of exchange, $P = (MV + M'V')/T$, where P is the price level, M and M' are the quantities of currency and deposits respectively, V and V' the velocities of currency and deposits, and T is the physical volume of transactions.

Simon Newcomb [26] in 1885 and John Pease Norton [27] in 1902 had emphasized the feasibility of the equation as a framework for organizing and analyzing data.[5] It was the pioneering investigations of

4. The standard surveys of the quantity theory by Hugo Hegeland [15] and Arthur Marget [23] are largely silent on this issue. Hegeland's text is chiefly devoted to theoretical issues. Marget's monumental treatise contains extensive commentary on the meaning and measurement of the terms in the equation of exchange, but practically nothing on statistical techniques. Wesley Clair Mitchell [25] provides an extended exposition of statistical techniques applied in business cycle analysis during the period 1900–25. But he does not examine specifically the relation between statistical methods and quantity theory research. The same is true of Warren Persons' shorter survey [34] of the development of statistical techniques and their application to economics. Joseph Schumpeter [35, pp. 1080, 1091; 36, pp. 233–35] recognized the connection between the quantity theory and statistical analysis but did not pursue it in detail. George Garvy's valuable monograph [13] examines much of the same literature covered in this article. Garvy's focus, however, is on (i) problems of data collection and consistency and (ii) methods of time-series construction rather than on techniques of statistical analysis used in tests of the quantity theory.

5. Norton [27, pp. 1–12] developed what is perhaps the most elaborate, disaggregated version of the exchange equation to be found in the literature on

monetary economics. On the transactions side of the equation he distinguished between the commodity sector and the banking sector. In addition to the term representing the value of commodity transactions (PT), he included two terms $[-(1-r)M_f + M_s]$ to represent the value of net transactions by the banking sector. The first term, $(1-r)M_f$, shows the banks' loans or purchase of "futures contracts to money" (M_f) valued at their discounted value. Here is a unique case of the rate of interest (or discount rate) appearing in the equation of exchange. The second term (M_s) represents receipts of "spot" money as previous-period borrowers pay off their bank loans. The net difference between the two terms is reflected on the money side as either a change in money in circulation or in reserves.

The money-flow side of Norton's equation was even more detailed than the transactions side. In deriving an expression for the exchange work done by hand-to-hand money, Norton wrote a separate symbol for each of the six types of money in circulation in 1902 and multiplied it by its own velocity:

$$\sum_{i=1}^{6} M_i V_i$$

This simplifies to

$$V \sum_{i=1}^{6} M_i$$

where V, i.e.,

$$\frac{\Sigma M_i V_i}{\Sigma M_i}$$

is the weighted average velocity of the whole stock of circulating money.

Next, Norton derived an expression for the exchange work accomplished by bank reserves. His expression is derived in terms of reserves rather than deposits because he wanted the equation to express analytically how the volume of deposits was determined. Recognizing that the volume of deposits outstanding would depend on the legal reserve ratio, the proportion of required reserves that could be held with correspondent banks, and the desire of banks to hold precautionary balances over and above their legally required reserves, Norton wrote the expression for the money-work of reserves in the form

$$DU = \sum_{j=1}^{4} A_j B_j K_j R_j U_j$$

where A is the reciprocal of the legal minimum reserve ratio, B is the reciprocal of unity minus the proportion of required reserves allowed to be held as deposits with correspondent central reserve city banks, R is required cash reserves, K is the proportion of maximum allowable deposits that banks actually create, U is the velocity of bank deposits, the subscript j refers to the bank category (central reserve city, reserve city, country, state), and D is total deposits.

E. W. Kemmerer [19] in 1907 and Irving Fisher [9] in 1911, however, which established the exchange equation as the standard vehicle for empirical work on the quantity theory.

Kemmerer and Fisher tested the correspondence between a hypothetical price level based upon the exchange equation and an "actual" price level represented by a composite index of prices of commodities, securities, and labor hours. They obtained yearly estimates for each term but P of the exchange equation, $P = (MV + M'V')/T$, and expressed them as ratios or relatives of their base period values, by this means deriving a time series of P $[= (MV + M'V')/T]$. They then compared their estimates of what the hypothetical P would be (derived from the equation) with an index number based on observed commodity prices (the "actual" price level). The relation between the series of hypothetical and actual P appeared to be fairly close whether judged on the basis of visual comparison (Kemmerer) or the value of a correlation coefficient (Fisher). Therefore, they concluded that this rough correspondence between the two series amounted to a confirmation of the quantity theory. Actually, the investigations of Kemmerer and Fisher did not constitute valid tests of the quantity theory.[6]

The complete expression for the exchange work done by money in circulation and reserves is

$$E = T\left[V\sum_{i=1}^{6} M_i + \sum_{j=1}^{4} A_j B_j K_j R_j U_j\right]$$

where i is the type of money in circulation and j is the bank category. Norton multiplied the currencies' velocities (turnover rate per unit of time) by the symbol T, representing the number of time units in the interval of analysis. This procedure is unnecessary, as T equals unity if the interval for which the analysis holds is taken to be the unit time period. He did not apply the T factor to the goods side of the picture, although the exchange of goods is also a flow per time unit.

A good empiricist, Norton discussed sources and availability of data corresponding to the symbols in his equation. Decrying the lack of statistics on the velocities V and U, he advocated government-sponsored research on the behavior of these variables.

6. Kemmerer framed his hypothesis incorrectly and consequently tested the hypothesis that the ratio P/M varies with the state of business confidence. He did not test the quantity theory hypothesis that $P/M = k$. Fisher's test was marred by his use of short-run cyclical data to test a hypothesis of a long-run equilibrium relation between variables. Fisher's hypothesis was $P/M = k(t)$

Of greater significance than Kemmerer's and Fisher's unsuccessful attempts to test the quantity theory was their willingness to abandon the subtle and complex monetary theory that appeared in their writings for a single-equation empirical model. Apparently they felt that the operational virtues of their empirical model outweighed its failure to approximate closely their complete analytical model. Their complete model expressed algebraically would have included several equations in several variables and would have made the task of empirical testing exceedingly difficult.

The willingness to abandon a complex theoretical model for a simple empirical one remains a dominant characteristic in the American approach to the quantity theory. It appears, for example, in the work of Milton Friedman, whose reduced-form regression model is an extreme simplification of his total monetary theory and whose empirical demand for money function contains six fewer independent variables than his theoretical demand function.

Quantity Theory Tests and the Development of Statistical Techniques

The equation of exchange continued to serve as the framework for empirical studies throughout the remainder of the period under survey. Although no changes took place in the basic empirical model, new statistical techniques continued to be applied. More refined methods were employed in analyzing data corresponding to the equation. These techniques included correlation analysis, trend and cycle analysis, distributed-lag analysis, and price-index construction.

Emergence of Correlation Analysis in Early Tests of the Quantity Theory

The first decade of the twentieth century saw the initial application of some rudimentary techniques of modern correlation analysis in tests of the quantity theory. Up to that time, the coefficient of

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where t is the composite long-term trend of T, V', V, and M'/M. (Fisher's statement of the theory allowed for historical, evolutionary changes in these variables.) But the yearly data used in testing the hypothesis corresponded to transitional, disequilibrium periods in which the quantity theory did not hold. Fisher, like Kemmerer, ended up testing, not the validity of the quantity theory, but the validity of the exchange equation in which none of the variables were constrained by the *ceteris paribus* condition.

correlation for linear regression, developed in the early 1890's, had been used almost exclusively in the analysis of biological and physical data.

Warren M. Persons [31, pp. 285–89] was the first to use the correlation coefficient in testing the quantity theory. In a 1908 review of Kemmerer's test discussed above, he noted the impressionistic, qualitative nature of Kemmerer's conclusions, which were based on nothing more than a visual comparison of graphed curves of the ''actual'' price index and hypothetical (i.e., derived from the exchange equation) price index. To obtain a more precise measure of the relation between the two price indexes, Persons correlated the two series, using Kemmerer's figures. The correlation coefficient he obtained of .23, with a probable error of .13, denied the validity of Kemmerer's conclusion that the two series move together, thereby upsetting the ''proof'' of the quantity theory.

Persons' correlation analysis used Kemmerer's figures in their original ''raw'' form, no adjustments being made. It did not take long for other economists to express their doubts about the soundness of Persons' procedure. The criticism was directed at Persons' general method and not at his findings with regard to Kemmerer's data. Irving Fisher [9, pp. 279, 294–95] pointed out that, because successive observations appear in a unique (chronological) sequence, economic time series are particularly subject to autocorrelation which might result in spuriously high correlation coefficients. Fisher himself suggested that those problems could be met by correlating *link-relatives* X_t/X_{t-1} instead of the original data. By using the link-relative adjustment on the price-level series that he had derived for his own test of the quantity theory, he showed that it reduced the correlation coefficient from .97 to .57.

Persons [30, pp. 827–28] acknowledged the validity of Fisher's criticism in his 1911 review of Fisher's *The Purchasing Power of Money*. In fact, Persons had been aware of the autocorrelation problem before Fisher called attention to it. In 1909, a British statistician, R. H. Hooker [18], had discussed the problem and had developed the method of first differences $X_t - X_{t-1}$ to deal with it. Persons [29, pp. 312–14] learned of Hooker's study and of the first difference method for eliminating the trend in 1910 and used the method in that year in several correlation analyses. But he did not go back and apply it to his earlier analysis of Kemmerer's study. He [30, pp. 827–28] did, however, apply it to Fisher's data, getting a higher coefficient than Fisher had obtained using the link-relative method (.62 vs. .57).

This exchange between Persons and Fisher helped to resolve the puzzling discrepancy between Kemmerer's and Fisher's test of the quantity theory. As their methods were essentially the same, one would have expected the evidence of their respective time series not to differ markedly. But the coefficient obtained by direct correlation of Kemmerer's series was .48 compared with .97 for Fisher's series.[7] This disparity was too great to be attributed to differences in estimates. For example, Fisher [9, pp. 277–78] showed that even a reduction of estimated velocity of money from 47 to 18 in Kemmerer's series would not materially affect his results.

The discrepancy was due to coverage of two different time periods. Fisher covered the period 1896–1909, when the price level displayed an almost uniformly rising trend. Kemmerer's study covered the longer span 1879–1908 marked by radically dissimilar subperiods. From 1879–96, the price level fluctuated erratically about a gently falling trend, whereas from 1897–1908, the trend was steadily upward. When data from the two studies were compared [9, p. 295] for the years common to both (1896–1908), the correlation coefficients were .83 (Kemmerer) and .95 (Fisher). It was not even necessary to reduce the studies to a comparable period to show their basic agreement when the spurious trend was removed. Using Fisher's link-relative method to remove the trend, Persons [30, pp. 828–29] calculated the (whole-period) correlation coefficient for Kemmerer's series as .52, practically the same as Fisher's whole-period coefficient, .57. Fisher's data were dominated by the trend; Kemmerer's were not. Fisher's series were highly autocorrelated; Kemmerer's were not. Even in the first subperiod, when the trend was slightly downward, fluctuations dominated the trend in Kemmerer's series. Persons [30, pp. 828–29] pointed this out by showing that over the period 1879–95 a correlation of Kemmerer's original data yielded about the same coefficient, .55, as was obtained by correlating link-relatives of his figures, .59.

The discussion was reopened in 1913 by J. D. Magee [22], who

7. The time series appearing in the first edition of Kemmerer's book [19] terminated at 1901. In the revised edition [19] Kemmerer had extended his series to 1908. The adding of seven years to his series raised the correlation coefficient from .23 to .48 [30, p. 828].

referred to certain shortcomings in the use of the correlation coefficient in analysis of economic time series. Magee then suggested that the correlation coefficient be replaced by a measure or statistic which he called the Degree of Correspondence (DC).

There were two versions of Magee's DC concept, the first measuring correspondence of the series in direction of change only and the second purporting to measure correspondence in both direction and amount of change. Under the first version, the year-to-year changes of the two series were observed with the following "scores" being assigned: +1, —1, and 0 respectively for coincident movement, opposite movement, and one series alone exhibiting change. These numbers were then summed and their arithmetic means represented the DC. If the two series were unrelated, one would expect that opposite movements would tend to cancel the coincident movements in the series, with the result being a DC of zero. On the other hand, a positive DC with a value close to 1 would indicate a very strong relationship. This rough method was but a slight elaboration of a simple comparison of the number of times that two series did and did not move together. The latter comparison was one of the ways that Fisher [9, p. 294] had presented the results of his test.

The second version of the DC was arrived at by calculating the percentage increase or decrease $(\Delta X_t/X_{t-1})$ of each series for each year, dividing the smaller by the larger, and finding the arithmetic mean of these quotients.[8]

Calculating the DC (both versions) for Kemmerer's and Fisher's data, Magee obtained

(i) +.48 and (ii) +.20 for Kemmerer, and
(i) +.31 and (ii) +.23 for Fisher.

For some reason not revealed, he chose the measures least favorable to Kemmerer and Fisher (version ii) to infer that their proofs of the quantity theory were far from conclusive.

8. More formally, Magee's Degree of Correspondence statistic for two series X and Y covering n years is

$$DC = (1/n) \sum_{i=1}^{n} Z_i \quad ,$$

$Z_i = (\Delta X_i/X_i)/(\Delta Y_i/Y_i)$ when $(\Delta X_i/X_i) < (\Delta Y_i/Y_i)$ and $(\Delta Y_i/Y_i)/(\Delta X_i/X_i)$ when $(\Delta X_i/X_i) > (\Delta Y_i/Y_i)$.

In a reply to Magee, Warren M. Persons [32, 33] charged that Magee's statistical methods were faulty and that his criticisms of the correlation coefficient were based upon misconceptions. While agreeing that Magee's first measure of DC provided a rough measure of the extent of correlation, Persons felt that the second version of the DC was completely unreliable. Persons demonstrated that perfect correlation in the movements of two series would be compatible with a wide range of values of the DC. The DC, he said, measured the average ratio of percent rates of change, but not the extent of correlation. In addition, he noted that Magee's conception of perfect correspondence ("there is perfect correspondence between two series . . . if they both move in the same direction and the relative amounts of change are the same") was more restrictive than the concept of perfect correlation. Magee's concept implied two necessary conditions: (i) all observations must lie on the regression line, and (ii) the regression line itself must be of the specific form $Y=kX$ (or $dY/Y=dX/X$). The first condition alone would satisfy the concept of perfect correlation, but the second was unnecessary. However, much of Magee's criticism of the correlation coefficient was that it could not distinguish between linear regression equations emanating from the origin and linear equations with a constant term. Magee's concern with the type of regression equation rather than its goodness of fit prompted Persons' remark [33, p. 348] that "Magee has confused the idea of correlation (closeness with which the actual corresponding fluctuations obey any law we may select) and the law [specific regression equation] we select for the test."

Persons pointed out that Magee's two measures give widely different results when applied to the same set of data. He noticed that Magee adhered to the result which offered the least support to the quantity theory. This happened to be the result obtained by version ii which Magee believed was the more refined measure, but which Persons thought was the more unreliable version of Magee's statistic. In summary, Persons felt that Magee's conclusions were unacceptable because his statistical technique was untrustworthy.

This early controversy helped to acquaint economists and statisticians with some special problems or pifalls peculiar to the analysis of economic time series. It did not in itself advance understanding of the money-price-level relationship. In fact, most of the discussion revolved about purely statistical problems instead of monetary theory. But the quantity theory, as the basis of the time-series estimates of Kemmerer and Fisher, had provided the raw material for the controversy. In this case, the quantity theory contributed more to statistical than to monetary analysis.

Subsequent to this controversy economists were careful to adjust their original data, ''eliminating the trend'' prior to conducting correlation tests of the quantity theory. Techniques used in transforming raw data to remove the mutual interdependence of series included first differences, link-relatives, trend ratios, and residuals from trend (this last method being the most widely used). Persons himself became a leading authority on the art of time-series decomposition. In fact, he was largely responsible for developing the famous ''Harvard Barometer'' technique of eliminating trend and seasonal variations from time-series data, thereby isolating cyclical and irregular fluctuations.

Trend and Cycle Analysis

Testing of the quantity theory entered a new phase in the 1920's. As mentioned above, Warren Persons and his colleagues on the Harvard Committee of Economic Research had developed methods of isolating and identifying different types of movements in time series. Using these methods to estimate the trend and cyclical values of the exchange equation variables, researchers analyzed the behavior of short-run deviations of the variables from their trend values—the latter taken to be the equilibrium or ''normal'' values. The studies of Holbrook Working and Carl Snyder were characteristic of this genre.

Working [43] believed that V and T tend to exhibit smooth, continuous growth, the former at a near-zero rate and the latter at a higher, positive rate. That is, he thought that the ratio of T to V tends to grow at a uniform pace with no sharp breaks in its path and only temporary and very minor irregularities about the trend. He wished to test the hypothesis that T/V had a stable trend and that deviations from this trend, resulting from changes in the money supply which temporarily cause actual V (or T) to depart from its desired (equilibrium) magnitude, are quickly corrected through changes in the price level. This hypothesis, he realized, was equivalent to the hypothesis that, except for the T/V trend, the value of money was completely determined by its quantity, i.e., that composite fluctuations about trend of T and V have very little influence on the price level. Treating M/P as a function of time, i.e., $M/P = f(t)$ where t is the year with $t_0 = 1890$, he fitted a third-degree parabola by the least-squares method to the logarithm of annual values of M/P for the period 1890–1916. He treated this curve as the secular trend of T/V. Comparing observed annual values of M/P ("actual" T/V) with the hypothetical, "normal" values lying on the fitted trend line, he found the former to lie very close to the latter, and to display regular year-to-year alternations from one side of the trend line to the other. He concluded that his hypothesis of a smooth, stable (i.e., deviations quickly corrected) growth path of T/V was acceptable.

An alternate means of presenting evidence supporting the hypothesis of a stable trend line would be to show that the observed, "actual" price level follows the "normal" price level, the latter calculated by substituting the trend values of V/T in the equation $P = M(V/T)$. Working did this and found that the actual, observed price level seemed to follow the normal, expected price level closely but with a lag. He tested for strength of the lagged movement [43, p. 243] by regressing first differences of expected and observed price levels with the latter first difference lagged one year behind the former. He obtained a correlation of .57, which he thought too low. He conjectured that the average lag must be *less* than a year and that his coefficient, based on a one-year lag, understated the strength of the relation. But he was prohibited at that time (1923) from testing his conjecture because only annual data on national bank deposits (used to represent M in Working's study) were available.

Three years after his original study, Working derived quarterly estimates of deposits. From these new figures, he found evidence which appeared to support his earlier conjecture. This time he [42, p. 122] obtained the highest correlation (.971) between the two price-level series (unadjusted data, not first differences) when the lag was six months, although he also got very high correlations for lags of three and nine months. Additional supporting evidence was obtained from his comparison [42, p. 127] of the turning points of his deposit and price level series. He found that while upturns in P displayed an average lag of twelve months behind upturns in his trend-corrected M series, the average lag was only nine months for downturns.

Working believed that the evidence he had adduced of the existence of a lag between the actual and expected price levels was sufficient proof of the quantity theory postulate of a unidirectional line of causation running from M to P, something that neither Kemmerer nor Fisher had been able to show. He [42, p. 129] further believed that this lag was sufficiently *uniform* that changes in the volume of bank deposits (M) could be used to *predict* corresponding fluctuations of the price level within nine to twelve months.

Working interpreted his study as showing that cyclical changes in T are largely offset by similar movements of deposit velocity. This conclusion was based on his reasoning that the hypothetical, "normal" price level (P^h) was, except for a trend adjustment factor, equal to deposits, M.[9] Thus, the high correlation between the lagged observed price level($P^o{}_{t+1}$) and hypothetical price level ($P^h{}_t$) was equivalent to a high correlation between $P^o{}_{t+1}$ and M_t. If fluctuations in V and T had not been neutralizing, the correlation between $P^o{}_{t+1}$ and M_t would have been much lower and the residual much higher.

The view that cyclical variations in V and T are equal and canceling was, however, most closely associated with Carl Snyder [38, 39, 40], who was instrumental in establishing the idea of a rigidly constant T/V ratio. Snyder, a statistician with the Federal Reserve Bank of New York during the 1920's, constructed monthly series of P, T, and V'. He examined first the long-term behavior of these series and found that (i) his trade series (T) displayed an almost constant 4 percent average annual growth rate, (ii) the price level (P) and the ratio (M/T) had remarkably similar (almost identical) trends, and (iii) his deposit velocity series exhibited no discernible trend. These findings convinced him that velocity played no role in determining long-term movements of the price level. The latter, he thought, was determined by the growth of trade relative to the growth of the stock of (deposit) money. Turning to examine the short-run, cyclical behavior of his series, he again found a very close correspondence between the general price level and the ratio of bank money to trade, M/T. This

9. The hypothetical, normal price level was calculated as follows. The equation for the trend or normal value of M/P ($\equiv T/V$) is $M/P = f(t)$ where $f(t)$ is the fitted third-degree trend line. Multiplying both sides of the equation by P and dividing by $f(t)$ gives $P = [1/f(t)]M$. Substituting any given value of M in the equation gives the normal level of P corresponding to that value of M.

seemed to suggest that, in the short run as well as the long, velocity played no role in price-level movements. But the highly volatile behavior of his short-run velocity figures appeared to contradict this interpretation until he [39, pp. 699, 708] noticed a strong correspondence, both in timing and amplitude, between his velocity series and the series of monthly deviations of trade from its secular trend. On the basis of the synchronous behavior of his two series (deposit velocity and trade expressed as deviations from trend) Snyder drew the following conclusion:

> Does the velocity of circulation of money or bank deposits ordinarily affect the price level . . . ? The answer is that it does not . . . . The variations in velocity and the variations in the volume of trade . . . run remarkably close together. Thus, their effects tend to cancel each other. Their effect on the price level is therefore slight . . . . [V]elocity [is] not an important factor in the determination of the price level, according to Newcomb's formula [37, pp. 26, 387].

Nowadays it is customary to attribute the crude version of the quantity theory prevalent in the 1930's—that version which Friedman [11, p. 51] has described as "the atrophied and rigid caricature . . . so frequently described by the proponents of the new income-expenditure approach"—to textbook writers and perhaps to commentators who argued that, even in the midst of the depression, expansion of M would have no effect other than inflating P. But the origins of this version are to be found almost a decade earlier, for the conclusions which Working and Snyder drew from their studies in the 1920's were influential in the propagation and acceptance of that version. The Snyder-Working doctrine was a steppingstone to the rigid, extreme version. Of the two, Working and Snyder, the latter was the more dogmatic and extreme. Working at least admitted that the T/V ratio fluctuated about its (estimated) trend, although he believed the amplitude and period of those fluctuations to be small. Snyder looked upon his data as offering proof that V has *no* cyclical influence on P, always being offset by identical cyclical changes in T. It was a matter of degree—Snyder holding V's influence on P to be nonexistent; Working holding it to be slight. Working looked upon price movements as a sensitive equilibrating mechanism, quickly adjusting T/V back to normal after it had been temporarily displaced by changes in M. Snyder, on the other hand, largely ignored the equilibrating role of price movements. In his view, P would *always* be proportional to M: "If . . . variations in national trade . . . and of deposit velocity are synchronous and compensatory, and the ratio of the two replaceable by a constant, K, then we should be able to write the equation: $P/K = M$" [39, p. 708].

Notice how Snyder and Working, while appearing to be achieving a rapprochement between Irving Fisher and his critics, were actually forging a more rigid version of the theory than Fisher had ever held. Fisher's comparative-statics version of the quantity theory had been criticized for its inability to analyze variability of both (i) velocity and (ii) the cash-deposit ratio over the cycle. Snyder and Working settled the problem of the cyclical variability of the cash-deposit ratio by excising it. They extended their definition of money to cover deposits and then worked only with deposit data, arguing that the cash component of the money supply was insignificant enough to justify this treatment. That is to say, they implicitly assumed the cash-deposit ratio to be constant. The second problem, the cyclical variability of (deposit) velocity was neatly solved. Fisher's comparative-statics assumption of constant velocity was replaced by the doctrine of a fluctuating velocity which nevertheless has no influence on price. Fisher's comparative-statics quantity theory had been transformed into a cyclical (transition period) theory.

In showing that Fisher's comparative statics conclusion, $P = kM$, could be extended to transition periods, Working and Snyder made it respectable for authors to enshrine the equiproportionality theorem as *the* quantity theory in their textbooks. Careful qualification was thought to be unnecessary, for had not Working and Snyder shown that $P = kM$ at all times? Only one more extension was necessary to reach the naive version of the theory, namely, a reinterpretation of the constancy of $k (\equiv V/T)$ in the formula. The Snyder-Working doctrine of neutralizing *fluctuations* of V and T was replaced by the doctrine of *constancy* of both V and T.

The striking generalizations of Working and Snyder should have stimulated critical scrutiny of their investigations. Surprisingly, however, there was little critical appraisal of the Snyder-Working studies. Morris Copeland [6] was one of the few to reexamine the evidence.

Copeland criticized Working's test because of its incomplete measure of M and because it correlated P "not with M, but with M multiplied by a trend-correction factor." Copeland held that selection of trend "involves an arbitrary element" and that Working's results may have been affected by the arbitrary element in his trend-adjustment factor. When he correlated monthly first differences of three-month moving averages of M and P for lags of various lengths, Copeland found evidence, contrary to Working's, that the lag was far from uniform and that in some cases movements in P preceded movements in M. He also observed that cyclical movements in trade and deposit velocity were not so similar as to warrant the Working-Snyder conclusion of a practically constant T/V ratio. Copeland further pointed out that Working's theory of a uniform lead of M over P would be true only if (i) T led V and (ii) the ratio T/V oscillated and continually preceded M at turning points. The sequence of leads, $T \rightarrow V \rightarrow M$, he noted, was at variance with the Working-Snyder doctrine of a constant T/V ratio, and with the quantity-theory hypothesis of a channel of influence running from M to real economic activity. Copeland thought that the evidence offered little support to the quantity theory.

Distributed Lag Analysis

The application of correlation analysis to lagged data which appeared in Working's studies had become a common statistical practice by the mid-1920's. But researchers worked solely with lags of fixed length, i.e., they assumed that a change in one variable in period t would exert its full impact on another variable in period $t+n$. The usual procedure was to run separate correlations of two series for lags of different duration. That lag which resulted in the highest correlation coefficient would be selected as the most useful one in predicting the behavior of one time series from another.

In 1925 Irving Fisher [7, pp. 185–87] became the first economist to use *distributed lags*. Fisher had correlated the percentage rates of change of the price level $\Delta P_t/P_t$ with an index of trade for fixed lags of various lengths, and he had found a seven-month lag to give the highest correlation coefficient (.727). He then proceeded to demonstrate that by distributing the lag over several periods he could increase the correlation to .941. He defended his procedure by arguing that the assumption of a distributed lag was more realistic than assuming a fixed lag. Fisher's discussion suggests that the relation between trade in period t (T_t) and prior-period price-level rates of change $\Delta P_{t-i}/P_{t-i}$ could be described by the expression

$$T_t = T_0 + \sum_{i=0}^{\infty} w(i)\,(\Delta P_{t-i}/P_{t-i})$$

where the weighting function $w(i)$ is distributed according to a variant of the logarithmic normal probability density function,

$$w(i) = (1/i)\ \exp\,[-(\log i - \log \alpha)^2/2\beta^2]$$

Estimation of the best-fit weighting function required specification of its parameters (mean and standard deviation). Fisher's method was to try different values of the parameters until he found the pair of parameter values which resulted in the highest correlation coefficient between T and lagged P. Using this estimating technique, he found the mean lag (the time elapsing until half of the total effect of a change in the price level is reflected in T) to be about 9½ months.

The reader may object that discussion of Fisher's contribution does not belong in a paper devoted to tests of the quantity theory. Fisher was investigating the lagged relation between $\Delta P/P$ and T and not the relation between M and P. Yet in a broader sense he probably conceived of this investigation as being at least a partial test of the theory. Fisher thought that all business-cycle phenomena could be explained with his quantity theory *cum* transition-period framework and that the cycle would be practically eliminated by proper monetary control, thereby making the neutrality postulate of the quantity theory a reality. Only two propositions, he thought, needed to be established to prove the validity of his beliefs: first, that changes in the money supply (M or M') caused price-level changes; and second, that business fluctuations were caused by changes in the price level. The first proposition he accepted without question, citing Holbrook Working's research in support. "Professor Holbrook Working has already pointed out that, conformably to the quantity theory, the price level follows bank deposits with a few months lag" [7, p. 199]. The second, he felt, had been established by the high correlations he obtained, using his distributed-lag concept, between $\Delta P/P$ and T. Thus, his "test" had demonstrated the possibility of practically eliminating the cycle via monetary control, that is, of establishing the conditions under which money would be neutral in accordance with the quantity theory. Fisher's innovation, which now plays an important role in econometric studies, was not utilized by other economists during the 1920's.

Price Level Indexes

Quantity theory tests also exerted some influence on work in the field of price-index numbers. A primary objective of empirical research in the 1920's was the construction of a price index that would accurately measure changes in the purchasing power of money. Such an index was supposed to be sufficiently comprehensive to correspond to the omnibus T variable in the equation of exchange. At first it was thought that the Bureau of Labor Statistics' wholesale price index (composed of the prices of 404 commodities) would adequately measure the value of money. However, when the wholesale price index failed to correspond closely with the hypothetical price level derived from the equation of exchange, quantity theorists began to search for more inclusive indexes. The search culminated in Carl Snyder's composite general price index which contained, in addition to wholesale prices, the prices of stocks and bonds, wages, rents, and real estate values.[10] It is indicative of the quantity theorists' strong adherence to their empirical model that they did not question the usefulness of such a broad price index.

At the opposite extreme of the general price index advocates were several economists [4, 21] who complained that the aggregate price-level indexes tended to conceal the behavior of prices of individual commodities. These economists, who were generally critical of global price-level concepts, also rejected the monetarist explanation of inflation and deflation. Instead, they chose explanations that

10. Benjamin M. Anderson, a critic of the quantity theory, had compared observed P with hypothetical P (estimated from the exchange equation) for the period 1919–28. Anderson [3] found a considerable discrepancy between the two series, the discrepancy being 82.5 percent in 1928 and 40 percent or greater in all but three of the other years covered. But Arthur Burns [5] showed that when the BLS wholesale index (which Anderson had used) was replaced with Snyder's index, the average disparity between the observed and hypothetical price series of Anderson's study was reduced by almost three-fourths.

stressed non-monetary factors operating in particular sectors of the real economy, e.g., disruption of international trade, structural maladjustments between agricultural and manufacturing sectors, bottlenecks, transportation difficulties, changes in confidence, technological change, and wage-cost push forces [2, 3, 10]. Other writers, though not explicitly critical of the general price index, implied skepticism of its usefulness by explaining price upheavals in terms of relative-price concepts more appropriate for microeconomic than macroeconomic analysis.[11]

The statistical evidence on this issue of the price level vs. individual prices was conflicting. A 1927 study by F. C. Mills [24] appeared to support the non-monetarist hypothesis of a shifting structure of individual prices. Mills found that the internal structure of the price system displayed significant instability as measured by an index of *price dispersion* (derived from standard deviations of price relatives) and an index of *price displacement* (derived from the coefficient of rank correlation of price relatives and indicating shifts of position of individual prices within the price structure). However, another study by Carl Snyder [40] served to support the quantity theory. Snyder found that over long periods of time prices tend to move together, thus maintaining secular stability of price relationships. He concluded from his findings that movements in the whole set of commodity prices could not be attributed to "random changes in the relationships of individual prices" but must be attributed to changes in the money supply which affected prices as a whole.

The Impact of Empirical Research on the Quantity Theory

Was the relation between the quantity theory and empirical research a mutually beneficial one? The answer to this question depends on the time frame chosen. If the evaluation is limited to the interval 1900–1930, one would have to conclude that testing of the quantity theory contributed more to statistical than to monetary an-

11. Irving Fisher listed forty-one frequently cited causes of inflation and noted that "while some of them are important factors in raising particular prices, none of them . . . has been important in raising the *general* scale of prices" [8, p. 11]. Fisher pointed out that "no explanation of a general rise in prices is sufficient which merely explains one price in terms of another price" [8, p. 14].

alysis throughout the entire period and that in the 1920's empirical work probably retarded the rate of progress of monetary theory. In the 1920's, monetary economists in the United States were preoccupied with time-series estimates, price indexes, and new statistical techniques. As already mentioned, the dominant objective of monetarists was to find a single indicator that would (i) reveal the causal role of money in the business cycle and (ii) serve as a reliable forecasting tool and infallible policy guide for the monetary authority. Engaged in the search for the key indicator, American monetarists devoted a disproportionate amount of effort to empirical rather than theoretical research. Advances in statistical technique were matched by a neglect of monetary theory. Instead of devising more subtle models for testing purposes, economists were content to use the same exchange-equation empirical model employed by Edwin Kemmerer and Irving Fisher a decade and a half earlier. American economists, preoccupied with the task of measurement, devoted less time than their continental and British counterparts to developing fresh approaches to monetary theory which would allow a more direct understanding of the behavior of money holders and money suppliers than that revealed in the market data on *M, V, P,* and *T*.

The ultra-empirical slant of monetary research in the United States was typical of the "measurement without theory" approach to business-conditions analysis that reached epidemic proportions in the 1920's. So-called quantitative economics was in vogue. Its apostles were many and its practitioners included prestigious research organizations as well as numerous private forecasting services. Some of the more fanatical devotees of empiricism even came perilously close to prophesying that it would shortly become the sole means of inquiry on economic questions.

A few observers, however, expressed misgivings about the apparent trend toward rampant empiricism unaccompanied by corresponding advances in economic theory. Allyn A. Young, although characterizing the growing use of quantitative methods as a "most promising development," warned that "it will prove relatively sterile if it does not lead to a renaissance of theory" [44, p. 244]. Jacob Viner was even more emphatic in his denunciation of ultra-empiricism. He detected "ominous signs" that economists were becoming infected with the same enthusiasm displayed by certain educators, who, having discovered the correlation coefficient, "began correlating furiously and indiscriminately and with an inverse correlation between zeal and discretion which . . . approached . . . perfection. As might have been anticipated in a world full of nonsense correlations, the results were grotesque" [41, p. 45].

Additional comments by Viner, while not directed specifically at monetarists, nevertheless implied criticism both of their simplistic empirical model and of their search for infallible indicators:

> I am completely skeptical as to the value of any purely empirical results of statistical analysis in economics, especially when by the mechanical application of statistical devices laws of striking simplicity and of fundamental importance are discovered to be ruling in the economic universe. Where the mind unaided by statistical analysis sees complexity everywhere, and statistical analysis unaided by the mind finds beautiful simplicity, I am reactionary enough to place my faith in [deductive theory].

Viner contended that an ultra-empiricist research agenda would involve a gross misallocation of research resources. That is, only the restricted set of problems that were capable of being investigated with quantitative techniques would be studied. Moreover, research effort would be diverted from important pursuits to the relatively unproductive task of accumulating supplementary data to support spurious empirical relationships. Consequently, an ascendant empiricism, he warned, would lead to a retrogression of economic analysis.[12]

Viner's strictures, although directed at quantitative empiricism in general, seem particularly applicable to monetary research in the 1920's. In some respects, the statistical work of the 1920's probably resulted in a short-run deterioration in the quality of monetary analysis. For example, the already mentioned Snyder-Working doctrine of the cyclical invariability of the V/T ratio contributed to the propagation of the crude version of the quantity theory much criticized by Keynesian economists in the 1930's and 1940's.

12. Incidentally, Viner's—and also Frank Knight's—aversion to empirical testing would appear to weaken Friedman's claim that those economists were among the founders of the modern Chicago tradition. They certainly cannot be considered the founders of the strong empirical orientation so prominent in monetary research currently emanating from Chicago.

On a longer-run basis, however, one would have to give a favorable evaluation of the contribution made by statistical research to the development of the quantity theory. The recent revival of the quantity theory owes much to the empirical tradition established in the first third of the century and to the empirical techniques developed then. The "reduced-form" models used by modern monetarists in regression tests of the predictive power of the quantity theory are similar to the single-equation models used earlier by Working and Fisher in their correlation analyses. Modern monetarists study the timing evidence on the lead-lag relationship between money stock changes and economic activity just as avidly as Working, Copeland, and Fisher once did. Moreover, many of the same techniques developed in the earlier period—correlation analysis, comparison of turning points in time series, distributed lags—are employed today in efforts to establish the timing patterns between M and national income. Finally, modern quantity theorists recently have turned their attention to a problem investigated by Snyder and Working in the 1920's, namely, the reconciliation of the secular and cyclical behavior of quantity-theory variables within the framework of a single empirical model.

ANNEX: SUMMARY OF EMPIRICAL TESTS OF THE QUANTITY THEORY, 1900–1930

The tests are listed below in chronological order. The reader will note the conspicuous absence of regression equations, r^2's, standard errors of estimates, and t-statistics for regression coefficients. Economists of the period relied almost solely on the *correlation coefficient* (r) as a measure of the statistical association among economic variables. Regression equations, although frequently used by monetary economists in correlation analysis, seldom were stated explicitly in published work. A now obsolete statistic, the *probable error* (P.E.), was employed as the chief index of the reliability of r. The probable error equals .6745 of the standard deviation of a normal sampling distribution of r. The reader will also note that many of the tests of the quantity theory came perilously close to being tests of the validity of the equation of exchange.

1907
AUTHOR: E. W. Kemmerer
HYPOTHESIS: Equiproportional relation between M (narrowly defined) and P not upset by existence of a large stock of money substitutes (checking deposits, in this case).
TECHNIQUE USED: Visual comparison of pairs of charted time series.

Time Series Charted

1. a. Money stock
   b. Bank reserves
2. a. Business distrust index
   b. Bank reserves/check circulation $(M'V')$ ratio
3. a. General price index
   b. $(MV + M'V'/T)$

All index numbers of yearly data, 1879–1904.

RESULTS: Roughly parallel movements in the charted pairs of series. Deviations in pairs 1 and 3 in years of low business confidence.

CONCLUSIONS: 1. "Close relation between M and reserves, when due allowance is made for fluctuations in business confidence." 2. "Ratio of bank reserves to check circulation is a function of business confidence." 3. "*Cet. par.,* a change in P can only take place through proportionate changes in the relative money supply. Inasmuch as the check circulation is a function of reserves which are a function of the money supply, the extensive use of checks does not alter the truth of the old quantity theory."

1908

AUTHOR: W. M. Persons

TECHNIQUE USED: Correlation analysis of Kemmerer's time series. Calculated correlation coefficients.

RESULTS:

Series correlated	r	Probable error
(1) M and bank reserves.	.979	±.006
(2) Business distrust index and reserves/$M'V'$ ratio.	.53	±.095
(3) Same as (2) except reserves/$M'V'$ ratio lagged one year.	.723	±.064
(4) General price index and $(MV + M'V'/T)$.	.23	±.13

CONCLUSION: "The statistics presented by Kemmerer do not demonstrate that general prices move in sympathy with relative circulation."

1911

AUTHOR: I. Fisher

TECHNIQUE USED: Correlated yearly estimates of $(MV + M'V'/T)$ and general price index. Also correlated M and P. Thought correlation coefficients too high, indicating serial correlation of the variables. Removed serial correlation by correlating link relatives (year-to-year ratios).

RESULTS:

Series correlated	r	Probable error
(1) $(MV + M'V'/T)$ and P:		
(a) Fisher's series, 1896–1909	.97	
(b) Fisher's series, 1896–1908	.95	Not
(c) Kemmerers' series, 1896–1908	.83	reported
(2) M and P, 1896–1909	.97	
(3) Link relatives of $(MV + M'V'/T)$ and P		
(a) Fisher's series, 1896–1909	.57	.10
(b) Fisher's series, 1896–1908	.54	.11
(c) Kemmerer's series, 1897–1908	.37	.14
(4) M_t/M_{t-1} and P_t/P_{t-1}, 1896–1909	.43	.13

CONCLUSION: "This figure, 57% [see (3a) above] is a moderately high correlation coefficient. We may conclude that the quantity theory is statistically verified to a high degree of correlation." Referring to (4), the gross association between M and P, "even this (.43) is a moderately high degree of correlation."

1911
AUTHOR: W. M. Persons
TECHNIQUE USED: Correlated first difference of Fisher's series to remove serial correlation. Compared correlation coefficients for Kemmerer's and Fisher's series, each series having been detrended via link-relative method.

RESULTS: *Series correlated*	r
(1) $(MV + M'V'/T)$ and P:	
(a) First differences, Fisher's series, 1896–1910	.62
(b) Link relatives, Fisher's series, 1896–1908	.54
(c) Link relatives, Kemmerer's series, 1879–1895	.59
(d) Link relatives, Kemmerer's series, 1879–1908	.52

CONCLUSION: Kemmerer's and Fisher's estimates are in agreement when serial correlation is removed from the latter.

1913
AUTHOR: J. D. Magee
TESTING FOR: (1) Extent of association between changes in P and changes in $(MV + M'V'/T)$. (2) Direction of causation between M and P.
TECHNIQUE USED: Computed statistic called the Degree of Correspondence for the following pairs of series:

(1) P and $(MV + M'V'/T)$:
  (a) Kemmerer's series
  (b) Fisher's series
(2) Wholesale price index and money in circulation, current and lagged values.
  (a) Monthly estimates, 1900–1911
  (b) Yearly estimates, 1867–1911
  (c) Yearly estimates, 1879–1911
(3) Wholesale price index and M per capita, current and lagged values.
  (a) Yearly estimates, 1867–1911
  (b) Yearly estimates, 1879–1911

CONCLUSIONS: (1) Kemmerer's and Fisher's "proof" of quantity theory not conclusive. (2) Magee unable to establish dominant direction of causation between M and P.

1923
AUTHOR: H. Working
TESTING FOR: Direction of causation between M and P.
TECHNIQUE USED: Correlated yearly first differences of two time series for period 1890–1916. The series were

(1) BLS wholesale price index.
(2) Demand deposits multiplied by a trend correction factor, or $M_t(\overline{P/M})_t$, where M_t is an index number of total bank deposits and $(\overline{P/M})_t$ is the predicted value of the reciprocal of the real

money stock estimated from the least squares trend equation

$$\log (M/P) = 9.796 + .0222t - .000179t^2 - .00000322t^3 - 10$$

First differences of the price index series were lagged one year behind first differences of the trend-adjusted money stock series.

RESULTS: $r = .57$ with P.E. of $\pm.09$, but graphical analysis suggests that correlation would have been much higher if the lag between the two series could have been shortened to eight months.

CONCLUSION: "Changes in P follow changes in M by a period averaging slightly less than one year. The contention that changes in P are not the result but the causes of changes in M are disproved. Changes in P and other business cycle phenomena can be controlled by regulating M."

1925

AUTHOR: I. Fisher

TESTING FOR: Strength of relationship between fluctuations in P and lagged T.

TECHNIQUES USED: Correlated month-to-month percentage change in BLS wholesale price index and lagged index of trade. Used fixed lags and distributed lags. Used lognormal distribution formula as the weighting function, $w(t)$, to distribute the lagged effect of a price-level change:

$$w(t) = \{\exp [-.6745(\log t - M)/2(\text{P.E.})]\}/t$$

where the two parameters M and P.E. are the mean and probable error of the lognormal distribution.

RESULTS (1) Fixed lag:

	r
(a) T lagged 8 months	.715
(b) T lagged 7 months	.727
(c) T lagged 6 months	.719

(2) Distributed lag:

Mean lag, monthly	*Probable error*	r
(a) 10	.53	.9386
(b) 9½	.52	.9410
(c) 9½	.53	.9404
(d) 9½	.54	.9398
(e) 9	.53	.9405
(f) 9	.52	.9410

CONCLUSION: "Distributed lag correlations so high as to leave little doubt that changes in the price level afford an almost complete explanation of fluctuations in the volume of trade."

1926

AUTHOR: H. Working

TESTING FOR: Direction of causation between M and P.

TECHNIQUES USED

(1) Correlation analysis of two quarterly series, 1890–1916.

(i) Demand Deposits (M) multiplied by a trend correction factor (P/M). (P/M) is calculated from the least-squares trend equation used by Working in 1923 (see under 1923, above).

(ii) Wholesale price index (Faulkner and BLS).

(2) Examination of timing relationship between the turning points of the two series *P* and *M* ($\overline{P/M}$), 1890–1922.

RESULTS

Correlation analysis between P and M (P/M)	*r*
Contemporaneous	.958
P lagged 3 months	.967
P lagged 6 months	.971
P lagged 9 months	.958

Timing relations at turning points

Turning points of trend-adjusted *M* led turning points of *P* in 19 of 19 cases. Average lag of *P* was approximately 12 months at lower turning points and 9 months at upper turning points.

CONCLUSIONS: The uniformity of the lag of P behind trend-adjusted *M* makes the latter a good predictor of price fluctuations.

1929

AUTHOR: M. A. Copeland

TESTING FOR: Direction of causation. Does influence run from money to business or from business to money?

TECHNIQUES USED:

(1) Compared lead-lag relationships at turning points of the following seasonally adjusted series of monthly data 1919–27. All expressed as index numbers:
(a) *M* (cash and checking accounts) and *P*
(b) Velocity and trade
(c) Money side (*MV*) and commodity side ($PT + R$, where *R* represents obligations incurred to make money payments which cannot be expressed conveniently as $P \times T$) of equation of exchange

(2) Correlated contemporaneous and lagged values of monthly first differences of three-month moving averages of the following series (index numbers) 1919–1927.
(a) *M* and *P*
(b) *V* and *T*

RESULTS: (1) Lead-lag relationships at turning points

Series	*Number of leads*	*Simultaneous movements*
(a) *M* and *P*	*M*:4 *P*:3	*M* and *P*:3
(b) *V* and *T*	*V*:6 *T*:6	*V* and *T*:6
(c) Money side and commodity side of equation of exchange	Money side:2 Commodity side:5	Money and commodity sides:5

(2) Correlation analysis

Series	*Lag relationship*	*r*
(a) ΔM and ΔP	Contemporaneous	.651
	ΔM lagged 1 month	.628
	ΔP lagged 1 month	.637
	ΔP lagged 2 months	.631
(b) ΔV and ΔT	Contemporaneous	.609
	ΔT lagged 1 month	.310
	ΔV lagged 1 month	.477
	ΔV lagged 2 months	.217

CONCLUSIONS: Lead-lag relationships between M and P are neither consistent in direction nor uniform in length. Movements in V and T are not synchronous. Data on the behavior of the money and commodity sides of the equation of exchange offer more support to the reverse causation hypothesis than to the monetarist hypothesis of a direct causal role for money.

1929
AUTHOR: B. M. Anderson
TECHNIQUE USED: Compared yearly figures of BLS wholsale price index (P) with Anderson's own estimates of $(MV + M'V'/T)$, 1919–28.
RESULTS: Disparity between the two series exceeded 38 percent in 8 of the 10 years.
CONCLUSION: Quantity theory invalid.

1929
AUTHOR: Arthur F. Burns
TECHNIQUE USED: Compared yearly figures of C. Snyder's general price index with estimates of $(MV + M'V'/T)$, 1919–28.
RESULTS: Using more appropriate and reliable estimates of P and $(MV + M'V'/T)$, Burns showed that the disparity between the two series was much less than B. M. Anderson claimed.
CONCLUSION: If Anderson had used the best available data he would have found little discrepancy between the two series.

1924–30
AUTHOR: C. Snyder
TECHNIQUE USED: Visual comparison of the following charted time series:
(1) Monthly estimates of the velocity of bank deposits (V) and the deviation of business (T) from its trend, 1890–1924.
(2) Trend of business, bank credit, and general price level 1890–1924.
(3) General price level and demand deposits, monthly data 1909–1924.
(4) General price level (P) and estimates of MV/T, monthly data 1919–1924.
CONCLUSIONS: In the short run, fluctuations in V and T are offsetting. Thus fluctuations of M are the sole determinants of fluctuations of P. In the long run, the percent change in P equals the percent change in M minus the percent change in T.

1930–34
AUTHOR: C. Snyder
TESTING FOR: Source of fluctuations in the general price level. Are changes

in P attributable to real factors operating in commodity and labor markets or are they attributable to changes in the money supply?

TECHNIQUE USED: Divided annual average price indexes of individual basic commodities by the composite price index of all commodities, 1820–1915.

RESULTS: Ratios of prices of individual commodities to composite index showed "strikingly general long-time stability."

CONCLUSION: Individual prices "in a broad way swing pretty much together, even under conditions of radical general change." Relative prices remain unchanged. Real factors (e.g., technological progress) "have spread with singular evenness over a wide range of industries, with the result of little change in the *relative* costs of production." Movements in the general price level depend upon exogenous changes in M which affect commodities as a whole.

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