Irving Fisher (1867–1947)

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Irving Fisher was born in Saugerties, New York, on 27 February 1867; he was residing in New Haven, Connecticut at the time of his death in a New York City hospital on 29 April 1947.

Fisher is widely regarded as the greatest economist America has produced. A prolific, versatile and creative scholar, he made seminal and durable contributions across a broad spectrum of economic science. Although several earlier Americans, notably Simon Newcomb, had used some mathematics in their writings, Fisher's dedication to the method and his skill in using it justify calling him America's first mathematical economist. He put his early training in mathematics and physics to work in his doctoral dissertation on the theory of general equilibrium. Throughout his career his example and his teachings advanced the application of quantitative method not only in economic theory but also in statistical inquiry. He, together with Ragnar Frisch and Charles F. Roos, founded the Econometric Society in 1930; and Fisher was its first President. He had been President of the American Economic Association in 1918.

Much of standard neoclassical theory today is Fisherian in origin, style, spirit and substance. In particular, most modern models of

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capital and interest are essentially variations on Fisher's theme, the conjunction of intertemporal choices and opportunities. Likewise, his theory of money and prices is the foundation for much of contemporary monetary economics.

Fisher also developed methodologies of quantitative empirical research. He was the greatest expert of all time on index numbers, on their theoretical and statistical properties and on their use in many countries throughout history. From 1923 to 1936, his own Index Number Institute manufactured and published price indexes of many kinds from data painstakingly collected from all over the world. Indefatigable and innovative in empirical research, Fisher was an early and regular user of correlations, regressions and other statistical and econometric tools that later became routine.

To this day Fisher's successors are often rediscovering, consciously or unconsciously, Fisher's ideas and building upon them. He can be credited with distributed lag regression, life cycle saving theory, the 'Phillips curve', the case for taxing consumption rather than 'income', the modern quantity theory of money, the distinction between real and nominal interest rates, and many more standard tools in economists' kits. Although Fisher was not fully appreciated by his contemporaries, today he leads other old-timers by wide and increasing margins in journal citations. In column inches in the *Social Sciences Citation Index* (1979, 1983) Fisher led his most famous contemporaries, Wesley Mitchell, J. B. Clark, and F. W. Taussig in that order, by rough ratios 5:3:1:1 in 1971–5 and 9:3:1:1 in 1976–80. Much more than the others, moreover, Fisher is cited for substance rather than for history of thought.

For all his scientific prowess and achievement, Fisher was by no means an 'ivory tower' scholar detached from the problems and policy issues of his times. He was a congenital reformer, an inveterate crusader. He was so aggressive and persistent, and so sure he was right, that many of his contemporaries regarded him as a 'crank' and discounted his scientific work accordingly. Science and reform were indeed often combined in Fisher's work. His economic findings, theoretical and empirical, would suggest to him how to better the world; or dissatisfaction with the state of the world would lead him into

scientifically fruitful analysis and research. Fisher's search for conceptual clarity about 'the nature of capital and income' led him not only to lay the foundations of modern social accounting but also to argue that income taxation wrongly puts saving in double jeopardy. Fisher turned his talents to monetary theory because he suspected that economic instability was largely the fault of existing monetary institutions. His 'debt-deflation theory of depression' was motivated by the disasters the Great Depression visited upon the world.

Economics was not the only aspect of human and social life that engaged Fisher's reformist zeal. He was active and prolific in other causes: temperance and Prohibition; vegetarianism, fresh air, exercise and other aspects of personal hygiene; eugenics; and peace through international association of nations.

Fisher was an amazingly prolific and gifted writer. The bibliography compiled by his son lists some 2000 titles authored by Fisher, plus another 400 signed by his associates or written by others about him. Fisher's writings span all his interests and causes. They include scholarly books and papers, articles in popular media, textbooks, handbooks for students, tracts, pamphlets, speeches and letters to editors and statesmen. They include the weekly releases of index numbers, often supplemented by commentary on the economic outlook and policy, issued for thirteen years by Fisher and assistants from the Index Number Institute housed in his New Haven home.

Fisher was the consummate pedagogical expositor, always clear as crystal. He hardly ever wrote just for fellow experts. His mission was to educate and persuade the world. He took the trouble to lead the uninitiated through difficult material in easy stages. Whenever he was teaching or tutoring students, he wrote handbooks or texts for their benefit—in mathematics and science when he was still a student himself, in the principles of economics when he was the professor responsible for the introductory course. Fisher's economics text was published in 1910 and 1911. Its graceful exposition of sophisticated theoretical material will impress a modern connoisseur, but it was too difficult for widespread adoption. Some of it survived in a leading introductory text of the 1920s and 1930s, by the younger Yale economists Fairchild, Furniss and Buck (1926).

A Brief Biography

IRVING FISHER GREW UP AND attended school successively in Peace Dale, Rhode Island; New Haven, Connecticut; and St. Louis, Missouri. His father, a Congregational minister, died of tuberculosis just when Irving had finished high school and was planning to attend Yale College, his father's *alma mater*. Irving was now the principal breadwinner for himself, his mother and his younger brother. He did have a $500 legacy from his father for his college education. The family moved to New Haven, and together managed to make ends meet. Irving tutored fellow students during term and in summers.

Fisher was a great success in Yale College, ranking first in his class and winning prizes and distinctions not only in mathematics but across the board. He was also determined to make good in the extra-curricular college culture so important in those days. His efforts won him election to the most prestigious secret senior society, Skull and Bones, the ultimate reward senior campus leaders bestowed on members of the class behind them.

Awarded a scholarship for graduate study, he stayed on at Yale. Graduate Studies were not departmentalized in those days, and Fisher ranged over mathematics, science, social science and philosophy. His most important teachers were Josiah Willard Gibbs, the mathematical physicist celebrated for his theory of thermodynamics, William Graham Sumner, famous still in sociology but at the time also important in political economy, and Arthur Twining Hadley, a leading economist specializing in what is now known as Industrial Organization.

As the time to write a dissertation approached, Fisher had still not chosen his life work. Young Fisher's interests and talents were universal. In the seven years at Yale before he finished his doctorate, he had written and published poetry, political commentary, book reviews, a geometry text together with tables of logarithms, and voluminous notes on mathematics, mechanics and astronomy for the benefit of students he was teaching or tutoring. If he had specialized in anything in six years at Yale, it was mathematics, but even in his graduate years he had spent half his time elsewhere.

Sumner put him on to mathematical economics, and in his third

year of graduate study, he finished the dissertation that won him worldwide recognition in economic theory. Fisher's 1891 PhD was the first one in pure economics awarded by Yale, albeit by the faculty of mathematics. Although the university, thanks to Sumner, Hadley and Henry W. Farnum, was strong in 'political economy', there was no distinct department for the subject, let alone for 'economics'. This was generally the case in American universities. Venturing into mathematical economic theory, Fisher was very much on his own; and his route into economics was quite different from that of most American economists of his era.

The dominant tradition in American political economy was imported from the English classical economists, mainly Smith, Ricardo and John Stuart Mill; it was just beginning to be updated by Marshall. This tradition Fisher's mentors at Yale had taught him well. But the neoclassical developments on the European continent from 1870 on, the works of Walras and Menger and Böhm-Bawerk, or even those of their English counterparts Jevons and Edgeworth, had been little noticed at Yale or elsewhere in America.

At the time, the main challenge in America to classical political economy was coming from quite a different direction. The American Economic Association was founded in 1886 by young rebels against Ricardian dogma and its *laissez-faire* political and social message. They included Richard T. Ely, J. B. Clark, Edwin R. A. Seligman and other future luminaries of American economics. Many of them had pursued graduate studies in Germany. In the German emphasis on historical, institutional and empirical studies they found welcome relief from implacable classical theory, and in the German faith in the state as an instrument of socially beneficial reform they found a hopeful antidote to the fatalism of economic competition and social Darwinism. Sumner was prominent among several elders who refused to join an Association born of such heresy; he did not relent even though the AEA very soon became sufficiently neutral and catholic to attract his Yale colleagues and other initial holdouts. Fisher, a bit younger than the founding rebels and educated solely at one American university, was not involved. It was his reconstruction, rather than their revolution, that was destined eventually to replace the classical tradition in the mainstream of American economics.

Fisher stayed at Yale throughout his career. He started teach mathematics, evidently even before he received his doctorate and was appointed Tutor in Mathematics. His first economics teaching was under the auspices of the mathematics faculty, an undergraduate course on 'The Mathematical Theory of Prices'. In 1894–5 during his Wanderjahr in Europe, this young American star was welcomed by the leading mathematically inclined theorists in every country. On his return he became Assistant Professor of Political and Social Science and began teaching economics proper. He was appointed full Professor in 1898 and retired in 1935.

Fisher was struck by tuberculosis in 1898. He spent the first three years of his professorship on leave from Yale and from science, recuperating in more salubrious climates. His lifelong crusade for hygienic living dates from this personal struggle to regain health and vigour. The experience powerfully reinforced his determination to gain 'a place among those who have helped along my science' and his ambition 'to be a *great* man', as he wrote to his wife (I. N. Fisher, 1956, pp. 87–8). After his recovery the books and articles began flowing from his pen, never to stop until his death at the age of 80.

Fisher participated actively in teaching and in university affairs until 1920. Thereafter his writings and his myriad outside activities and crusades preoccupied him. He taught only half time and had little impact on students, undergraduate or graduate. Thus Fisher had few personal disciples; there was no Fisherian School. The student to whom Fisher was closest, personally and intellectually, was James Harvey Rogers, a 1916 PhD who returned to Yale as a professor in 1930. His career was prematurely ended by his tragic death in a plane crash in 1939 at the age of 55.

Fisher was, on top of everything else, an inventor. His most successful and profitable invention was the visible card index system he patented in 1913. In 1925 Fisher's own firm, the Index Visible Company, merged with its principal competitor to form Kardex Rand Co., later Remington Rand, still later Sperry Rand. The merger made him wealthy. However, he subsequently lost a fortune his son estimated to amount to 8 or 10 million dollars, along with savings of his wife and her sister, when he borrowed money to exercise rights to buy additional Rand shares in the bull market of the late 1920s.

More than money was at risk in the market. Fisher had staked his public reputation as an economic pundit by his persistent optimism about the economy and stock prices, even after the 1929 crash. His reputation crashed too, especially among non-economists in New Haven, where the university had to buy his house and rent it to him to save him from eviction. Until the 1950s the name Irving Fisher was without honour in his own university. Except for economic theorists and econometricians, few members of the community appreciated the genius of a man who lived among them for 63 years.

Irving Fisher's marriage to Margaret Hazard in 1893 was a very happy one for 47 years. She died in 1940. They had two daughters and one son, his father's biographer. The death of their daughter Margaret in 1919 after a nervous breakdown was the greatest tragedy of her parents' lives. Their daughter Carol brought them two grandchildren.

General Equilibrium Theory

FISHER'S DOCTORAL DISSERTATION (1892) is a masterly exposition of Walrasian general equilibrium theory. Fisher, who was meticulous about acknowledgements throughout his career, writes in the preface that he was unaware of Walras while writing the dissertation. His personal mentors in the literature of economics were Jevons (1871) and Auspitz and Lieben (1889).

Fisher's inventive ingenuity combined with his training under Gibbs to produce a remarkable hydraulic-mechanical analogue model of a general equilibrium system, replete with cisterns, valves, levers, balances and cams. Thus could he display physically how a shock to demand or supply in one of ten interrelated markets altered prices and quantities in all markets and changed the incomes and consumption bundles of the various consumers. The model is described in detail in the book; unfortunately both the original model and a second one constructed in 1925 have been lost to posterity. Anyway Fisher was a precursor of a current Yale professor, Herbert Scarf (1973) and other practitioners of computing general equilibrium solutions. In his formal mathematical model-building too, Fisher was greatly impressed by the analogies between the thermodynamics of

his mentor Gibbs and economic systems, and he was able to apply Gibb's innovations in vector calculus.

Fisher expounds thoroughly the mathematics of utility functions and their maximization, and he is careful to allow for corner solutions. He uses independent and additive utilities of commodities in his first mathematical approximation and in his physical model; later he was to show how this assumption could be exploited to measure marginal utilities empirically (1927). But the general formulation in his dissertation makes the utility of every commodity depend on the quantities consumed of all commodities. At the same time, he states clearly that neither interpersonally comparable utility nor cardinal utility for each individual is necessary to the determination of equilibrium. Fisher's list of the limitations of his analysis is candid and complete. The supply side of Fisher's model is, as he acknowledges, primitive. Each commodity is produced at increasing marginal cost, but neither factor supplies and prices nor technologies are explicitly modelled.

Finally, Fisher shows his enthusiasm for his discovery of mathematical economics by appending to his dissertation as published an exhaustive survey and bibliography of applications of mathematical method to economics.

General equilibrium with intertemporal choices and opportunities. The distribution of income and wealth, and in particular the sources, determinants and social rationales, of interest and other returns to private property, were obsessive topics in economics, both in Europe and North America, at the turn of the century. One important reason, especially in Europe, was the Marxist challenge to the legitimacy of property income. Answering Marx was a strong motivation for the Austrian school, in particular for the capital theory of Böhm-Bawerk and his followers. Neoclassical economics was in a much better position than its classical precursor to respond to the Marxist challenge. The labour theory of value, which Marx borrowed from the great classical economists themselves, neither explains nor justifies functionally or ethically incomes other than wages.

These topics engaged the two leading American economists of the era, John Bates Clark and Fisher. Clark (1899) set forth his marginal

productivity theory of distribution, arguing that a generalized factor of production, capital, the accumulation of past savings, has like labour a marginal product that explains and justifies the incomes of its owners.

Fisher attacked these problems in a more elegant, abstract, mathematical, general and ethically neutral manner than Clark, and than Böhm-Bawerk. At the same time, his approach was clearer, simpler and more insightful than that of Walras.

The general equilibrium system of Fisher's dissertation was a single-period model. No intertemporal choices entered; hence the theory was silent on the questions of capital and interest. But Fisher took up these subjects soon after.

His first contribution, one that should not be underestimated, was to set straight the concepts and the accounting. This he did in (1896) and (1906) with clarity and completeness that have scarcely been surpassed. It's all there: continuous and discrete compounding; nominal versus real rates; the distinction between high prices and rising prices, and its implications for observations of interest rates; the inevitable differences among rates computed in different *numéraires*; rates to different maturities and consistency among them; appreciation, expected and unexpected; present values of streams of in-and out-payments; and so on. Schumpeter calls this work 'the first economic theory of accounting' and says 'it is (or should be) the basis of modern income analysis' (1954, p. 872).

Perhaps the most remarkable feature is Fisher's insistence that 'income' is consumption, including of course consumption of the services of durable goods. In principle, he says, income is psychic, the subjective utility yielded by goods and services consumed. More practically, income could be measured as the money value, or value in some other *numéraire*, of the goods and services directly yielding utility, but only of those. Receipts saved and invested, for example in the purchase of new durable goods, are not 'income' for Fisher; they will yield consumption and utility later, and those yields will be income. To include both the initial investment and the later yields as income is, according to Fisher, as absurd as to count both flour and bread in reckoning net output. This view naturally led Fisher to

oppose conventional income taxation as double taxing of saving, and to favour consumption taxation instead. His views on these matters are loudly echoed today.

Fisher published his theory of the determination of interest rates in *The Rate of Interest* (1907). A revised and enlarged version was published in 1930 as *The Theory of Interest*. One motivation for the revision was that Fisher's many critics apparently did not understand the 1907 version. They typically concentrated on the 'impatience' side of Fisher's theory of intertemporal allocation and missed the 'opportunities' side. It was there in 1907 already; the theory is much the same in both versions.

In 1930 Fisher is at pains to label his theory the 'impatience and opportunity' theory. 'Every essential part of it', he acknowledges, 'was at least foreshadowed by John Rae in 1834.' He does claim originality for his concept of 'investment opportunity'. This turns on the 'rate of return over cost, [where] both cost and return are differences between two optional income streams' (1930, p. ix). As Keynes acknowledged, this is the same as his own 'marginal efficiency of capital' (Keynes, 1936, p. 140).

In these books Fisher extended general equilibrium theory to intertemporal choices and relationships. This strategy was different from Walras. Walras tried to extend his multi-commodity multi-agent model of exchange to allow for production, saving and investment. This maintained his stance of full generality but was also difficult to expound and to understand. Fisher saw that intertemporal dependences were tricky enough to justify isolating them from the inter-commodity complexities that had concerned him in his doctoral thesis. Therefore he proceeded as if there were just one aggregate commodity to be produced and consumed at different dates. This simplification enabled him to illuminate the subject more brightly than Walras himself.

The methodology of Fisher's capital theory is very modern. His clarifications of the concepts of capital and income lead him to formulate the problem as determination of the time paths of consumption—that is, income—both for individual agents and for the whole economy. Then he divides the problem into the two sides, tastes and technologies, that are second nature to theorists today. One

need only read Böhm-Bawerk's murky mixture of the two in his list of reasons for the agio of future over present consumption to realize that Fisher's procedure was not instinctive in those times.

Fisher's theory of individual saving is basically the standard model to this day. Undergraduates learn the two-period 'Fisher diagram', where a family of indifference curves in the two commodities consumption now c_1 and consumption later c_2 confront a budget constraint $c_1 + c_2/(1 + r) = y_1 + y_2(1 + r)$, where the y's are exogenous wage incomes in the two periods and r is the (real) market interest rate. From the usual tangency can be read the consumption choices and present saving or dissaving. This is indeed a Fisher diagram, but of course he went much beyond it.

He stated clearly what we now call the 'life cycle' model, explaining why individuals will generally prefer to smooth their consumption over time, whatever the time path of their expected receipts. But he was not dogmatic, and he allowed room for bequests and for precautionary saving. Where Fisher differed from later theorists, and especially from contemporary model-builders, was in his unwillingness to impose any assumed uniformity on the preferences (or expectations of 'endowments'—the latter term was not familiar to him though the concept was) of the agents in his economies, and in his scruples against buying definite results by assuming tractable functional forms. In general, many of the advances claimed in present-day theory appear to depend on greater boldness in these respects.

On the side of technology, Fisher's approach was the natural symmetrical partner of his formulation of preferences, equally simple, abstract and general. He assumed that the 'investment opportunities' available to an individual (not necessarily the same for everybody) and to the society as a whole can be summarized in the terms on which consumption at any date can be traded, with 'nature', for consumptions at other dates. In modern language, we would say that Fisher postulated intertemporal production possibility frontiers, properly convex in their arguments, consumptions at various dates.

All that remained for Fisher, then, was to assume complete intertemporal loan markets cleared by real interest rates, count equations, and show that in principle the equalities of saving and investment at every date determine all interest rates and the paths of consumption and

production for all individuals and for the society. Like hundreds of mathematical theorists since, he set the problem up so that it conformed to a paradigm he knew, in this case the Walrasian paradigm of his own doctoral dissertation. A more rigorous proof of the existence of the equilibria Fisher was looking for came much later, from Arrow and Debreu (1954). As we know, the problems of infinity, whether agents are assumed to have infinite or finite horizons, are much more troublesome than Fisher imagined.

In any event, Fisher had an excellent vantage point from which to comment on the controversies over capital and interest raging in his day. His formulation of 'investment opportunities' seems to allow for no factor of production one could call 'capital' and enter as argument in a production function. For that matter, he doesn't explicitly model the role of labour in production either, or of land. Strangely, in Fisher's insistence that interest is *not* a cost of production, he seems to say that labour is the only cost, evidently because labour and labour alone is a source of disutility, the loss of utility from leisure, the opportunity cost of the consumption afforded by work. Proceeding in the same spirit, he postulates that, from a position of equality of present and planned future consumption a typical individual will require more extra future consumption than present consumption as compensation for extra work. The difference, the agio, is interest, whether or not it is a "cost". Fisher attributes the agio to 'impatience', at the same time scorning the notion that interest is the cost of securing the services of a factor of production called 'abstinence' or 'waiting'.

In the 1890s and 1900s Knut Wicksell, discovering marginal productivity independently of Clark, was modeling production as a function of labour and land inputs with the output also depending on the lags between those inputs and the harvests (Wicksell [1911], 1934, vol. I, pp. 144–66). This is an 'Austrian' formulation, akin to Böhm-Barwerk's examples of trees and wine, in which time itself appears to be productive. Fisher rightly objects to any generalization that waiting longer increases output. His own intertemporal frontiers are, to be sure, sufficiently general to encompass such technologies. They can also accommodate Leontief input–output tables and Koopmans–Dantzig activity matrices with lags, Hayekian triangular structures with inventories of intermediate goods in process, Solow technologies with

durable goods and labour jointly yielding output contemporaneously or later. The only common denominator of these and other representations of technology is that they relate consumption opportunities at different dates to one another, though not necessarily always in the convex trade-off terms Fisher assumed. There does not appear to be any summary scalar measure to which the productivity of a process is generally monotonically related, whether roundaboutness, average period of production, or replacement value of existing stocks of goods.

Fisher describes himself as an advocate of 'impatience' as an explanation of interest, although he realizes there are two sides of the saving-investment market, and although he acknowledges that real interest rates can at times be zero or negative. He does appear to believe that in a stationary equilibrium with constant consumption streams, consumers will require positive interest, and that only those technologies and investment opportunities affording a 'rate of return over cost' equal to this pure time preference rate would be used. He does not face up to Schumpeter's argument in 1911 that in such a repetitive and riskless 'circular flow', rational consumers would not care whether a marginal unit of consumption occurs today or tomorrow (Schumpeter [1911], 1934, pp. 34–6). Like Böhm-Bawerk, Fisher appeals to the shortness and uncertainty of life as a reason for time preference. For life-cycle consumers, however, time preferences are entangled with age preferences, and it is hard to defend any generalization as their net direction. Fair annuities take care of the uncertainty.

Monetary Theory: The Equation of Exchange and the Quantity Theory

IRVING FISHER WAS THE MAJOR American monetary economist of the early decades of this century; the subject occupied him until the end of his career. Here especially Fisher combined theorizing with empirical research, both historical and statistical. The problems he encountered led him to invent statistical and econometric methods—index numbers and distributed lags in particular—to apply for the purposes at hand to the data he and his assistants compiled. (He even studied

the turnover of cash and checking accounts of a sample of Yale students, professors and employees.)

Money was a big subject in American economic literature in the 19th century, before Fisher came on the scene. The monetary events of the times—the inconvertible greenbacks issued during the Civil War, their redemption in gold in 1879, the demonetization of silver, the rapidly increasing importance of banks—stimulated research and controversy. Nevertheless, monetary theory was relatively undeveloped and unsystematized, both in Europe and in America. Fisher's treatise (1911a) was an ambitious attempt to organize with the help of theory a large body of historical and institutional information.

Yet for all its theory, statistics and index numbers, *The Purchasing Power of Money* is a tract supporting Fisher's proposal for stabilizing the value of money. This came to be known as the 'compensated dollar', the gold-exchange standard combined with a rule mandating periodic changes in the official buying and selling of gold inverse to changes in a designated commodity price index. In 1911 Fisher proposed that the gold price changes be uniform and synchronous in the currencies of all countries linked by fixed exchange parities, in proportional amounts related to an international price index. Later he was willing to accept as second best that the United States adopt the scheme on its own. Keynes proposed a similar but less formal rule for the United Kingdom (1923).

The proposal is an early example of a policy *rule*, another Fisherian idea ahead of its time, more likely to be popular among economists today than it was with Fisher's contemporaries. Indeed, some rules recently proposed are quite Fisherian, for example Hall (1985).

The 'compensated dollar' is but one of several proposals Fisher advanced over the years for stabilizing price levels or mitigating the effects of their unforeseen variation. In the 1911 book he also writes favourably of the 'tabular standard', which meant no more operationally than facilitating price-indexed contracts. In the 1920s he launched a crusade for 100 per cent reserves against checkable deposits, culminating in *100% Money* (1935). This idea is also beginning to resurface in the 1980s as a preventive defence against the monetary hazards of bank failures. In Schumpeter's view, Fisher's zeal

for monetary reforms lost him some of the attention and respect his scientific contributions to monetary economics deserved, and made him come across as more monetarist than his own analysis and evidence justified (Schumpeter, 1954, pp. 872–3).

The Purchasing Power of Money is a monetarist book. Fisher asserts the quantity theory as earnestly and persuasively as Milton Friedman. There are two species of quantity theories. One is a simple implication of the 'classical dichotomy': since only relative prices and real endowments enter commodity and factor demand and supply functions, the solution values for real variables in a general equilibrium are independent of scalar variations of exogenous nominal quantities. While Fisher mentions this implication of general equilibrium theory, he does not dwell upon it as one might expect. Anyway, it does not quite apply to a commodity money system like the gold standard, which Fisher was analysing. Fisher's theory is mainly of the second kind, based on the demand for and supply of the particular nominal assets serving as media of exchange.

Fisher is usually given credit for the Equation of Exchange, although Simon Newcomb, a celebrated figure in American astronomy as well as an economist, had anticipated him (1886, pp. 315–47). The Equation is the identity $MV = PT$, where M is the stock of money; V its velocity, the average number of times per year a dollar of the stock changes hands; P is the average price of the considerations traded for money in such transactions; and T is the physical volume per year of those considerations. It is an identity because it is in principle true by definition. Actually Fisher, of course, recognized the heterogeneity of transactions by writing also $MV = \Sigma p_i Q_i$, where the p_i and Q_i are individual prices and quantities. His interest in index numbers was substantially a quest for aggregate indexes P and T derived from the individual p_i and Q_i in such a way that the two forms of the equation would be consistent. Much of the book (1911a), both text and technical appendices, is devoted to this quest.

Here and in later writings, particularly (1921) and (1922), Fisher was looking for the 'best' index number formula. He postulated certain criteria and evaluated a host of formulas, investigating their properties both *a priori* and from applications to data. Since the criteria inevitably conflict, there can be no formula that excels on all

counts. Although Fisher was mainly interested in measuring movements of the aggregate price level, naturally he wanted a price index P and a quantity index T to have the property that $P_1T_1/P_0T_0 = (\Sigma p_1Q_1)/(\Sigma p_0Q_0)$, where the subscripts represent two time periods at which observations of p's and Q's are available.

This and various other desirable consistency properties are not hard to meet. The difficult question is the choice of weights in the two indexes, especially when a whole series of consistent period-to-period comparisons is desired, not just one isolated comparison. For a price index, should the quantity weights be those of a fixed base year, yielding what we now call a 'Laspeyres' index $(\Sigma p_1Q_0)/(\Sigma p_0Q_0)$? Or should the weights be those of the ever-changing current period, yielding a 'Paasche' index $(\Sigma p_1Q_1)/(\Sigma p_0Q_1)$? The indicated correlate quantity indexes would be the opposites, respectively 'Paasche' and 'Laspeyres'. In 1911 Fisher opted for the Paasche price index. He also seemed to approve the idea of chain indexes, in which the period 0 of the above formulas is not fixed in calendar time but is always the prior period, even though these violate one possible desideratum, that the relative change between two periods should be independent of the base used. He also wrote favourably of the practical advantages of an entirely different procedure, namely taking the median of an expenditure-weighted distribution of percentage price changes from one period to the next.

In 1920, however, Fisher proposed as the 'Ideal Index' a candidate he had not ranked high in 1911, namely the geometric mean of the Laspeyres and Paasche formulas. This formula has the pleasant property that the correlate of an Ideal price index is an Ideal quantity index. Correa Walsh, another index number expert, on whose comprehensive treatise (1901) Fisher relied heavily from the beginning of his own investigations, reached the same conclusion independently at about the same time (Walsh, 1921).

These index number issues do not seem as important to present-day economists as they did to Fisher. Knowing that they are intrinsically insoluble, we finesse them and use uncritically the indexes that government statisticians provide. But Fisher's explorations have been important to those practitioners.

In Fisher's Equation of Exchange (1911a) the T and the Q_t are measures of all transactions involving the tender of money, intermediate goods and services as well as final goods and services, old goods as well as newly produced commodities, financial assets as well as goods. The corresponding velocity is likewise comprehensive, much more so than the 'income' or 'circuit' velocity preferred by some monetary theorists, notably Alfred Marshall and his followers in Cambridge (England), who count only transactions for final goods, for example for Gross National Product.

Fisher elaborated the equation to distinguish the quantities M and M' of the two media currency and checking deposits and their separate velocities V *and* V': $MV + M'V' = PT$. This was a bow to the rising importance of bank deposits relative to currency as transactions media. Previous practice counted only government-issued currency as money, in modern parlance high-powered or base money, and regarded bank operations as increasing its velocity rather than adding to a money stock.

How does the quantity theory come out of the Equation of Exchange? Fisher argues that the real volume of money-using transactions T is exogenous; that the velocities are determined by institutions and habits and are independent of the other variables in the equation; that the division of the currency supply, the monetary base in current terminology, between currency and bank reserves is stable and independent of the variables in the equation; that banks are fully 'loaned up' so that deposits M' are a stable multiple of reserves, determined by the prudence of banks and by regulation; that exogenous changes in currency supply itself are the principal source of shocks, which, given the preceding propositions, move price level P proportionately. The many qualifications for transitional adjustments are conscientiously presented, but the monetarist message is loud and clear.

The argument is familiar to modern readers, but certain features deserve notice:

(1) Fisher gives the most illuminating account available of the institutions and habits that generate the society's demand for transactions

media relative to the volume of transactions. He rightly emphasizes the fact that, and the degree to which, receipts and payments are imperfectly synchronized. He seeks the determinants of velocity in such features of social and economic structure as the frequency of wage and bill payments and the degree of vertical integration of firms. His belief that these institutions change only slowly supports his contention that velocities are exogenous constants.

(2) Much ink has been spilled on the difference between Fisher's velocity approach to money demand and the Cambridge (England) 'k' formulation. The latter, like Walras's *encaisse desiré*, directs attention to agents' portfolio decisions. To Fisher's critics that seems behavioural, while velocity is mechanical. The issue is overblown; the same phenomena can be described in either language. If the other variables in the equation are defined and measured the same way, then V and k are just reciprocals each of the other. Fisher himself discusses hoarding. Fisher's explicit attention, in discussing economy-wide demand for circulating media in distinction to other stores of value, to the fact that money 'at rest' soon takes 'wing' to fly from one agent to another seems to be a merit of his approach.

(3) As already noted, Fisher resolved a question current in his day, whether banks' creation of deposit substitutes for currency should be regarded as increasing the velocity of basic money or as enlarging the supply of money. His choice of the latter course compels attention to the structure, behaviour and regulation of banks. He could not be expected to foresee that the proliferation of future candidates for designation as 'money' would create the monetarist ambiguities we see today.

(4) For the most part later writers have not followed Fisher in his preference for a comprehensive concept and measure of transactions volume. It is hard to attach meaning to the *real* volume of financial transactions, and therefore to see why a T that includes them should be a constant or exogenous term in the equation. On the other hand, modern students of money demand tend simply to forget transactions other than those on final payments.

(5) Fisher ignores the possibility that other liquid assets can serve as imperfect substitutes for money holdings because they can be converted into means of payment as needed, though at some cost. Partly

for this reason, he ignores interest rate effects on demand for transactions media. In his day there may have been more excuse for these omissions than there was later. But they are still surprising for an author who elsewhere pays so much attention to the effects of interest rates and opportunity costs on behaviour.

(6) When Fisher was writing, the United States was on the gold standard; the exchange parities of the dollar with sterling and other gold-standard currencies were fixed. Fisher discusses in detail the implications of foreign transactions for the elements of the Equation of Exchange and for the quantity theory. He recognizes that tendencies towards purchasing-power parity, even though imperfect, make money supplies in any one country endogenous, tie prices to those of other countries and enhance quantity adjustments to monetary shocks in the short run. Much of the 1911 book applies, therefore, to the gold standard economies in aggregate. Indeed, Fisher finds the increase in gold production after 1896 to be the main cause of price increases throughout the world.

Macroeconomics: Business Fluctuations and the Great Depression

THE QUANTITY THEORY BY NO MEANS exhausts Fisher's ideas on macroeconomics. His views were much more subtle then straightforward monetarism, but they are scattered through his writings and not systematically integrated. Consider the following non-neutralities emphasized by Fisher:

(1) Probably Fisher's principal source of fame, especially among non-economists, is his equation connecting nominal interest i, real interest r and inflation π: $i = r + \pi$. It is frequently misused. Like the Equation of Exchange, it is first of all an identity, from which, for example, an unobservable value of r can be calculated from observations of the other two variables. More interesting, certainly to Fisher, is its use as a condition of equilibrium in financial markets; for this purpose π must be replaced by expected inflation π^e, another unobservable. In a longer run, as Fisher recognized, steady-state equilibrium would also be characterized by equality of actual and expected inflation: $\pi = \pi^e$.

The Fisher equation is frequently cited nowadays in support of

complete and prompt pass-through of inflation into nominal interest rates. Fisher's view throughout his career was quite different. For one thing, neither Fisher's theory of interest nor his reading of historical experience suggested to him that equilibrium real rates of interest should be constant. Moreover, from (1896) on he believed that adjustment of nominal interest rates to inflation takes a very long time. This he confirmed by sophisticated empirical investigations, regressions in which the formation of inflation expectations was modelled by distributed lags in actual inflation. During the transition, inflation would lower real rates; nominal rates would adjust incompletely. The effect was symmetrical; he attributed the severity of the Great Depression to the high real rates resulting from price deflation.

Moreover, Fisher was quite explicit about the effects of these movements of real interest rates on real economic variables, including aggregate production and employment. In *The Purchasing Power of Money* these transitional effects are mentioned, but minimized in the author's zeal to convince readers of the importance of stabilizing money stocks. But in Fisher's writing on interest rates, the transitions turn out to be long. In his accounts of cyclical fluctuations in business activity, and especially of the Great Depression, they play the key role.

(2) An assiduous student of price data, Fisher knew that some prices were more flexible than others, that money wages were on the sticky side of the spectrum, and that the imperfect flexibility of the price level meant that the T on the right-hand side of his Equation of Exchange would absorb some of the variations of the left-hand side.

In the early 1930s he came to a very modern position. Real variables like production and employment are independent of the level of prices, once the economy has adjusted to the level. But they are not independent of the rate of change of prices; they depend positively on the rate of inflation. He even calculated a 'Phillips' correlation between employment and inflation (1926). He was just one derivative short of the accelerationist position (Friedman, 1968); in a little more time he would have made that step, aware as he was of the difference between actual and expected inflation. Anyway, his

policy conclusion was that stabilizing the price level would also stabilize the real economy.

(3) During the Great Depression, observing the catastrophes of the world around him, which he shared personally, Fisher came to quite a different theory of the business cycle from the simple monetarist version he had espoused earlier. This was his 'debt-deflation theory of depression' (1932), summarized in the first volume of *Econometrica,* the organ of the international society he helped to found (1933). The essential features are that debt-financed Schumpeterian innovations fuel a boom, followed by a recession which can turn into depression via an unstable interaction between excessive real debt burdens and deflation. Note the contrast to the Pigou real balance effect, according to which price declines are the benign mechanism that restores full-employment equilibrium. The realism is all on Fisher's side. This theory of Fisher's has room for the monetary and credit cycles of which he earlier complained, and for the perversely pro-cyclical real interest rate movements mentioned above.

Fisher did not provide a formal model of his latter-day cycle theory, as he probably would have done at a younger age. The point here is that he came to recognize important non-monetary sources of disturbance. These insights contain the makings of a theory of a determination of economic activity, prices, and interest rates in short and medium runs. Moreover, in his neoclassical writings on capital and interest Fisher had laid the basis for the investment and saving equations central to modern macroeconomic models. Had Fisher pulled these strands together into a coherent theory, he could have been an American Keynes. Indeed the 'neoclassical synthesis' would not have had to wait until after World War II. Fisher would have done it all himself.

His practical message in the early 1930s was 'Reflation!' When his Yale colleagues and orthodox economists throughout the country protested against public-works spending proposals and denounced Roosevelt's gold policies, Fisher was a conspicuous dissenter. He was right. Characteristically, he crusaded vigorously for his cause—in speeches, pamphlets, letters and personal talks with President Roosevelt and other powerful policy-makers. Characteristically too, as his

letters home (I. N. Fisher, 1956, p. 275) disclose, he saw clearly and unapologetically that in lobbying for what was good for the country he was also hoping to rescue the Fisher family finances.

Addressing the President of Yale shortly after Fisher's death, Joseph Schumpeter and eighteen colleagues in the Harvard economics department wrote, 'No American has contributed more to the advancement of his chosen subject . . . The name of that great economist and American has a secure place in the history of his subject and of his country.' According to his son, this is the eulogy that would have pleased Irving Fisher the most (I. N. Fisher, 1956, pp. 337–8) Today, four decades later, economics can confirm the judgement and prediction of that eulogy.

James Tobin

Author's Note: Fortunately Fisher's son, Irving Norton Fisher, preserved the memory of his father in two indispensable publications, a biography and a comprehensive bibliography (1956, 1961). I have also relied extensively on John Perry Miller's biographical essay (1967) and Professor William Barber's account (1986) of political economy at Yale before 1900. My review of Fisher's contributions to general equilibrium theory, the theory of capital and interest, monetary theory and macroeconomics draws heavily and often literally on a recent essay of my own (Tobin, 1985).

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