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Irving Fisher and statistical approaches to risk

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Abstract

Irving Fisher has been recognized as one of the most prominent economists in the US in the first half of the 20th century. His contribution to financial economics has not been well recognized, however. This article describes Fisher's pioneering efforts to apply statistical methods to the analysis of investment risk. In addition, it will argue that Fisher's statistical analysis of risk had a Bayesian philosophy of probability theory. Finally, the highs and lows of Fisher's investment strategy for the 1920s and 1930s will be discussed.

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1. Introduction

Starting in the1950s, statistical methods began to influence thinking about finance and investments. This approach began with the development of what is called modern portfolio theory by Harry Markowitz. Markowitz made the decision of what stocks to include in a portfolio a statistical one. In the Markowitz paradigm, the return of an asset is expressed as a

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mean while the risk of an asset becomes its variance. Correlation analysis tracks the relationships between asset returns to evaluate their likely impact on the total return and risk of the portfolio. Given a group of less than perfectly correlated stocks, the return–risk ratio of a mean/variance optimized portfolio will be higher than the individual return–risk of any of the individual stocks that comprise the portfolio.

With this start, financial researchers began developing theories of how financial markets work that incorporated learning from real-world events. Bayesian statistics, with its emphasis on the value of new information, was a natural for this research. Bayesian statistical approaches assume that the parameters of a distribution, the mean and variance, are randomly changing over time. This approach gives a dynamic estimation of volatility in financial markets that is based on all information available, including new information. When new data become available, the Bayesian approach is to revise the probability distribution of the parameters. This approach then gives a forward-looking estimate of the expected return of an asset or portfolio as well as a revised estimate of its variance.

The traditional and Bayesian statistical methods that Markowitz popularized have been around for over a century, which raises an interesting question of whether any one else had used them before he did. This question does not deny Markowitz's contribution. By asking it, however, we turn up an interesting answer. Irving Fisher (1867–1947) did anticipate features of Markowitz's analysis. This article describes Fisher's early application of Bayesian statistical methods to the problem of investment risk.

2. Fisher's background

Irving Fisher would be included on any list of prominent early economists from the US. He was a pioneer in several technical areas of economic theory, such as the development of index numbers, the mathematical treatment of utility, and the revival and clarification of the quantity theory of money. In the area of investment analysis, he is well known for his use of discounted cash flows as a method for valuing stocks and bonds. These accomplishments have overshadowed his innovative use of statistical theory as part of his risk analysis.

Fisher had the right background for applying quantitative methods to economic problems. He completed a PhD in mathematics at Yale in 1891 by writing a dissertation titled *Mathematical Investigations in the Theory of Value and Prices*. Its mathematical treatment of marginal utility easily qualifies Fisher as the first mathematical economist in the US.

There is nothing in his dissertation that is directly applicable to investment theory because Fisher appreciated that the methods he used in it had limitations for real-world application. Mathematical economics relied on an idealized, static world. Only by adopting this "refined ideal analysis" could economics become scientific. Once the workings of the static ideal were understood, the economist could incorporate the dynamic elements one by one. As a result, he concluded, in theoretical work, "an economist is [unfit] to direct a Wall street speculator" (Fisher, 1926, pp. 101–104).

Despite this disclaimer, Fisher did take up the study of stock market investing in his first major work, *The Nature of Capital and Income*, first published in 1906. He labeled it as his effort to give the concepts of capital and income a rational basis and hoped that it "may supply a link long missing between the ideas and usages underlying practical business transactions and the theories of abstract economics" (Fisher, 1930b, p. vii). The starting point in supplying that link was in Fisher's (1930b) definition of wealth as "material objects owned by human beings" (p. 2). The value of this wealth, Fisher added, equaled its exchange price (pp. 3–13).

3. Capital and income

To value the wealth used in business, Fisher (1930b) argued that the best measure was the value of the stock that was the title to it:

> Thus, the value of a railroad operating under normal conditions is found by taking the sum of the values of its stocks and bonds. Railroads are seldom sold as a whole, but their stocks and bonds are constantly on the market, and are often the only means of offering a valuation. (p. 35)

The value of the stock, moreover, reflected the market's valuation of the business' "capitalized earning power," a measure that "fluctuates from day to day in response to a thousand causes" (Fisher, 1930b, p. 71).

To show how the stock market value of capital fluctuated, Fisher explored the relationship between capital and income. He avoided the confusion that often existed regarding the relationship between capital and income by setting forth the capital–income relationship in the form of ratios. Physical productivity was the ratio of the quantity of services per unit of time to the quantity of capital; value return was the ratio of the value of services per unit of time to the value of capital. It was important, however, to get the sequence between the two ratios correctly. To Fisher, the proper sequence was that physical capital produced services. When those services were sold at their market price, they generated income. The value of that income as a flow in the future set the value of capital. His basic premise was that "the value of capital at any instant is derived from the value of the future income which that capital is expected to yield." The future may turn out differently but the current value of capital was based on a current estimate of an expected future flow of income (Fisher, 1930b, pp. 185–188).

4. Stock prices under certainty

To explore the market valuation of the stocks representing capital, Fisher started from conditions of certainty. Given a regular pattern of future income and a fixed and permanent rate of interest, the value of capital was "the present worth of the future income from the specified capital" discounted at the established interest rate (Fisher, 1930b, p. 202). If interest rates fluctuated, the price of the asset, stock, or bond would adjust in a predictable pattern. As income accrued over time, the value of capital earning a fixed income would increase by the

accrued amount until the income was paid, at which time it reverted to the value of the fully discounted future income stream (Fisher, 1930b, pp. 213, 223).

In a later chapter, Fisher presented a graphical version of his theory of asset pricing under conditions of certainty. Because income was paid out only periodically, capital value increased in between the payments of income in line with the accrued income; when the income was paid, capital value returned to its former state. This process created a saw tooth pattern over time, with stock prices rising gradually and falling quickly in response to certain payments of income (Fisher, 1930b, pp. 302–308).

In a certain world, Fisher argued that the annual income from capital consisted only of dividends and retained earnings. This enabled him to judge that capital gains were not income, but a reflection of expectations about future income from dividends. For him, treating capital gains as income amounted to double counting. In a certain world, the price of a stock would increase in line with retained earnings. To count that increase as income would be counting savings as income. If the business were able to use those earnings to undertake profitable projects and grow, that would enhance the prospect for future income. A capital gain thus reflected a change in expectations about future income from dividends, but it would not become income until that future materialized.

5. Stock prices under uncertainty

These results came under conditions of certainty. Fisher then brought in the element of risk. He described the problem of capital value under conditions of risk as follows: "If we take the history of the prices of stocks and bonds, we shall find it chiefly to consist of a record of changing estimates of futurity, due to what is called chance" (Fisher, 1930b, p. 265). When uncertainty entered into the valuation process, the result was to create abrupt discontinuities in the saw tooth pattern "at points where the estimates of future chances are changed." The capital value of a business may shoot up very rapidly, as investors judge that its future income will pay a return that was high enough to compensate them for the risk of buying the stock. Such opportunities were short-lived, Fisher continued, with a hint of what is now called efficient market theory:

> It is not infrequent that when a new enterprise is started, those who have first knowledge of the possibilities, and the first opportunity to exploit them, expect returns out of proportion to the ordinary rate of interest and compensation for risk. The only reason this is not generally true is because of the existence of competition, by which the special advantage of individuals through special knowledge, foresight, etc., is offset by the vigilance of their rivals. (Fisher, 1930b, p. 321)

Whatever the starting point of a capital value, the value would continue along a saw tooth pattern, but under the influence of risk, it would move up or down as investors gained "new information" or their "confidence in the future receives a shock" (Fisher, 1930b, pp. 321–322) The pattern Fisher set forth on his diagram for this case was a random one, suggesting that changes in information and confidence were also random.

6. Fisher on risk

Now we come to Fisher's contribution to financial theory—his analysis of risk. When future income was uncertain and its estimates based on changes in information, all owners of stock operated under conditions of risk. Some of them might estimate their risk differently from others. This might lead them to make a distinction between estimates of risk and actual risk. Fisher disagreed:

> A little consideration will show that this distinction is spurious, for, by the nature of the case, *chance is always an estimate*. Chance is subjective. Although one man's estimate may be better than another's through superior knowledge, intuition, or experience, the best estimate is still only an estimate, not a certainty. (Fisher, 1930b, p. 206)

This view of chance, he went on, was not well established among "students of chance" who adhered to an objective theory that defined the chance of an outcome in terms of its relative frequency in a long run of occurrences. Fisher pointed out, however, that no matter how long the run, the relative frequency of an event rarely held exactly with its established probability. Long runs of coin flips seldom came up exactly 50% heads. Long runs of all heads were possible, if improbable. If advocates of objective chance held that it took the proper conditions for chance to be objective, Fisher rejoined that outcomes changed "only as the conditions vary slightly from time to time in the unknown elements." Once unknown elements were allowed, the subjective theory of chance held. To be sure, he continued, the existing statistical data were a significant factor in forming a subjective judgment of chance, but chance remained a "psychological and not an objective magnitude" (Fisher, 1930b, pp. 265–269).

In mathematical terms, chance was defined in terms of probability. Probability theory, however, still relied on human judgment. Fisher explained this distinction as follows:

> The mathematics of probability never establish a probability of itself, but always rest on some human estimate of chances which are equal to start with... By mathematics we seem to discover that the chance of throwing double sixes with two dice is one in thirty-six. But this calculation rests on the hypothesis that, in some person's estimation, each die is equally liable to fall on any one of its six faces.

Given that assumption, the probabilities of all outcomes of the dice can be calculated. To Fisher, the probabilities were contained in the assumption of balanced dice, which had to be based on human judgment. If the assumption was erroneous and the dice were "loaded," the outcomes would have a different set of probabilities (Fisher, 1930b, pp. 269–271). Today, Fisher would be labeled a Bayesian for holding this outlook toward probability.

7. Risk and investment

To use this theory of chance in valuing capital, Fisher pointed out that the two variables used in valuing capital, the future interest rate and future incomes, were uncertain. The problem of changes in the interest rate was handled by using the current rate, but unforeseen

changes in the rate of interest caused changes in the value of capital. Because interest rates did not fluctuate greatly, however, the main use of risk in capital valuation concerned income.

To explain the role of risk of income in capital valuation, Fisher used analogies with gambling. With any gamble, the return on a bet was equal to the prize to be won times the probability, the expected value (Fisher called it mathematical value). As risk takers, professional gamblers might pay more than the expected value to make a bet. Most persons, being risk-averse, would usually not even pay the expected value to make a bet. To them, the possibility of a loss overwhelmed the chance for a gain.

From this analogy, Fisher found three values in an uncertain investment return. The riskless value that would exist if the uncertainty could be eliminated, the expected value of the return, and the commercial value or the amount a person would pay to risk getting the return. Fisher called the ratio of the commercial value to the expected value the ''coefficient of caution'' and indicated that it varied depending on the individual's make-up. This coefficient of caution is comparable to the risk aversion parameter in the objective (utility) function of a portfolio optimization under the Markowitz approach.

To value a security, in theory, an investor started from the riskless amount of expected future income, multiplied it by the probability of the income being received, and then adjusted that by his or her own coefficient of caution. With fixed income securities such as bonds or preferred stocks, the calculation of the expected future income was simply the interest on bonds or the fixed dividend of a preferred stock (Fisher, 1930b, pp. 275–281).

With shares of common stock, the problem was more difficult as their dividends varied over time. To calculate the expected income on a stock, Fisher first gave an example that listed previous dividends on a stock in percentage terms. He then argued that the mean of the dividends was the expected return of the stock and the variability (risk) of those returns was the standard deviation. Probability tables of normalized standard deviations existed. From these, it would be possible to calculate the probability that dividends would fall outside of the range set by the standard deviation (Fisher, 1930b, pp. 406–410).

With this approach, the mean of past dividends would be the riskless rate and the expected value would be the riskless rate multiplied by the probability of its being within the range set by the standard deviation. If an investor had a known coefficient of caution, he or she could use it to place a commercial value on a common stock. If the stock's price was below this value, the investor should rate it as a buy. Otherwise, it was too risky. Since the probabilities used in this calculation were subjective, Fisher acknowledged that most investors used a rule-of-thumb approach. Still, he believed that as precise calculations of cost were replacing rule-of-thumb methods in accounting, ''so should the mere guessing about future income conditions be replaced by making use of the modern statistical applications of probability'' (Fisher, 1930b, pp. 281–282, 410).

Fisher's forecast that statistical methods would become widely used for analyzing stocks proved to be one of his best predictions. Modern practitioners of quantitative finance use the statistical measures of mean and standard deviation to calculate the return and risk of stocks, much as Fisher suggested. It is not clear from Fisher's record of investing in the 1920s, however, that even he appreciated what he had accomplished in terms of risk analysis.

8. Fisher and the reality of risk

The decade of the 1920s, to put it mildly, was a period of rapid economic growth combined with a long, rapid upward trend in stock market prices. Large numbers of investors altered, to use Fisher's term, their coefficients of caution and began taking on more risk by buying stocks. Fisher joined them.

The facts of Fisher's investments during this period have been detailed by his son, Irving Norton Fisher, in his biography, *My Father Irving Fisher* (Fisher, 1956). In 1912, Fisher invented a system for filing index cards and formed Index Visible to make and market the system. In 1925, he sold his company to Kardex Rand for US$600,000 in bonds and common and preferred stocks. Later, Kardex Rand would be merged with Remington Rand and Fisher came to own a large block stock in the latter company.

During the next 4 years, he would use that stock as collateral to buy more stock on margin. His biggest investment was in additional shares of Remington Rand, but he also bought shares of small- and mid-sized firms involved with recent inventions or path-breaking products. From 1925 to 1929, his wealth on paper increased by at least 10 times and he became worth nearly US$10 million.

When the stock market crashed in 1929, Fisher predicted that it would be a minor correction and held all of his shares for as long as possible. His brokers called in his margin loans, however, and the value of all his stocks kept falling. By 1933, he had no wealth left and was in debt to his sister-in-law for nearly US$1 million. He remained in that situation until his sister-in-law died in 1945 and forgave his debts in her will. At his death in 1947, he was still in poor financial condition (Fisher, 1956, pp. 160–161, 213–214, 206–207, 235–238, 256–257).

This was not a very good record for a person who had written so astutely about risk management. Had Fisher followed his own advice about using statistics to judge how risky his investments were? Modern theories of risk management emphasize the importance of diversification in risk management. Fisher's portfolio, as much as we know of it, does not seem well diversified. Had he thrown his coefficient of caution to the wind?

In a postmortem of the crash that he rushed into print (he may have been working on it before the crash began), *The Stock Market Crash and After* (Fisher, 1930c), Fisher repeated his long-held view that common stocks had become a sound investment during the 1920s. To him, the fundamentals of the 1920s bull market had been steady throughout the decade. He wrote:

> Since every stock represents a discounted value of the future dividends and earnings of that stock, there are four reasons that may justify a rise in the price level of stocks.
>
> Because the earnings are continually plowed back into business instead of being declared in dividends;
>
> Because the expected earnings will increase on account of technical progress within the industry:
>
> Because less risk is believed to attach to those earnings than formerly;
>
> Because the "basis" by which the discounting is made has been lowered.All four of these causes were at work, tending to raise the prices on the stock market during the years preceding the panic of 1929. (Fisher, 1930c, p. xxii)

To make his case, Fisher first explored the issue of the fundamental value of common stocks to consider whether the bull market had overvalued them. His opinion was that "the market went up principally because of sound, justifiable expectations of earnings" (Fisher, 1930c, p. 53). In support of this, he showed that dividends had remained steady during 1928–1929 and were rising in October and November 1929. The combination of dividends and retained earnings showed a similar pattern. What Fisher (1930c) found was that profits were rising faster than stock prices (pp. 67–73). From Fisher's early theory of stock prices under certainty, this meant that increases in stock prices were justified.

Second, in support of the reasonableness of stock prices during 1929, Fisher turned to an analysis of price/earnings ratios. On average, he found that price/earnings ratios were lower in 1929 than in 1928. Admittedly, price/earnings ratio averages were not a good method for comparison "because of the variability of expected earnings" in different companies and industries. In a traditional industry, a price/earnings ratio of 10:1 was acceptable. With a rapidly expanding company, however, it "might be anywhere up to 100 to 1, or even literally to infinity in the initial stages of investment when earnings are not being realized." Still, he went on, "during 1929 stocks were being selected with respect to their probabilities of future earnings" (Fisher, 1930c, p. 88).

To justify the probability of future earnings, Fisher pointed to several economic trends. Corporate mergers during the 1920s had produced large, more efficient companies with enhanced earnings power. The application of science to industry ushered in a period of innovation that would continue unabated. The acceptance and implementation of Frederick W. Taylor's methods of scientific management enhanced the efficiency of industry and would bring greater future earnings. Unionized labor was becoming more cooperative, which would lead to better earnings. Prohibition was creating a more productive workforce (Fisher, 1930c, pp. 101–181). Well-informed investors knew all of these. That was why they had placed a high probability on future earnings.

9. Diversification and risk

What of risk? Fisher observed, "A potent reason for the long bull market rising to the plateau of stock prices of 1923–1930 is that there has been a material change during this period as to the risk of investing in common stocks" (Fisher, 1930c, p. 198). Previously, bonds had been thought of as safe, but that was because investors had not recognized that inflation eroded the value of bonds and made them risky. In the 1920s, several studies had shown that during certain periods of price fluctuation "bonds are not, as compared with well-selected and diversified stocks, what they have been cracked up to be. . . These findings threw a bombshell into the investing world." They resulted in a new attitude toward common stocks as giving more chance of gain than bonds, as offering steady dividends and a reinvestment of retained earnings that would lead to greater dividends, as being less affected by inflation than bonds, and as allowing investors to diversify and smooth out irregularities of income (Fisher, 1930c, pp. 202–203).

The benefits of diversification were being pointed out by investment experts to show that the risk of stocks could be reduced while that of bonds could not. An investor could spread the risk of investing in common stocks by diversification. When inflation eroded the value of bonds, however, it hit all bonds, so no diversification was possible. After summarizing the work of other investment analysts, Fisher offered his own analysis.

10. Fisher on diversification

By the late 1920s, Fisher had become an advocate for the merit of a new investment vehicle, investment trusts—the forerunners of today's mutual funds. He found their ability to offer diversified portfolios a contribution to investment methods.

In his early writings on risk, Fisher's approach was aimed at evaluating the risk of individual stocks. From his work on index numbers, however, he had an appreciation of some of the methods underlying modern portfolio theory. For example, he understood that individual prices of commodities showed a great deal of variation over time, much as stock prices do, and that these prices did not move together. He advocated the use of a combination of commodity prices into an index that would eliminate much of the variation of individual prices. Use of combination of stocks to reduce variation of individual stock prices is a hallmark of modern portfolio theory.

He also pointed out in his book on index numbers, *The Making of Index Numbers* (Fisher, 1922), that the variation in a price index from the fluctuations of individual prices declined rapidly as the number of prices in the index increased; an index of 20 prices eliminated an acceptable amount of variation and, after 100 prices, the decline in the variation (measured by the standard deviation) was not greatly improved by adding more prices (Fisher, 1922, pp. 20, 336–340). Modern portfolio theory has given us the insight that diversification can eliminate most of the risks of individual stocks with as few as 20 different stocks in a portfolio, with reduction in risk from diversification falling rapidly after.

With this understanding, Fisher was on track of discovering modern portfolio theory, but he did not quite get there. Still, it should come as no surprise that Fisher recognized the value of diversification. He wrote:

> If we can, by sufficient diversification in investments, get a greater certainty and thus run less risk from our speculation, then the more unsafe the investments are, taken individually, the safer they are taken collectively... provided that the diversification in sufficiently increased. (Fisher, 1930c, p. 204)

To explain this seeming paradox, Fisher returned to the risk analysis he first set forth in *The Nature of Capital and Income* (Fisher, 1930b).

Because most investors were risk-averse, they avoided common stocks unless their prices were below their "mathematical value," the "prize multiplied by the chance of winning it." Because of their coefficient of caution, investors were not willing to take a risk on a fair bet, but needed better than even odds. The greater the risk, the greater the coefficient of caution.

As a result, investors would not buy a risky stock unless its price was low in terms of its probable income.

By combining investments in an investment trust, however, investors could reduce the risk of individual stocks through diversification. As a result, they were able to buy more risky stocks than they would have otherwise by buying shares of an investment trust. In this way, "the investment trust has proved that speculation can be turned into investment which is much safer than many individual investments in so-called 'gilt edge' securities." Because individual investors were too cautious to buy risky stocks except at a large discount from their expected return, the prices of risky stocks languished. Thanks to diversification, investment trusts had "managed to get a higher average return from investments which individually would have proved quite risky, while at the same time they have extracted from them largely their elements of risk" (Fisher, 1930c, p. 206).

Here we have the principle of modern portfolio theory in a nutshell. A well-diversified portfolio has a risk–return level that is less than the combined individual risks and returns of its components. "This principle," Fisher went on, "so far as I know, never has been definitely formulated in the investment market." Investors acted on it intuitively, however, with the result that investment trusts were causing an increased demand for stocks, especially risky stocks, and thereby added to the growth in stock prices of the late 1920s (Fisher, 1930c, pp. 206–207).

11. Credit and risk

A short time later, Fisher wrote a second book, *Booms and Depressions* (Fisher, 1932), which added to his analysis of risk. Many investors, including Fisher, had not realized how much more risky the stock market had become.

In general, Fisher set forth a theory of the depression and the stock market crash that was based on what he called debt deflation. Regarding the stock market, Fisher's analysis of debt deflation replicated his own experiences. As stock prices fell, investors' assets declined while their debts stayed constant. By trying to sell stocks to pay off some debt, investors as a group made matters worse. In a period of decline, the market became very risky. Fisher had discovered that the use of credit added to the to the risk of the stock market.

The increased risk came from the use of margin accounts. Every upward trend in the stock market started from legitimate growth of earnings by innovative companies. Investment bankers and stockbrokers, however, begin to induce investors to borrow to increase their holdings. That method was safe until some investors became speculators, "buying in order soon to sell again to others who want to invest or to other speculators" (Fisher, 1932, p. 48).

This climate of margin buying was bolstered by a decline in the coefficient of caution due to the idea that stocks were not as risky as had been thought. Consequently, investors were willing to borrow to buy them. Moreover, investment trusts also purchased stocks on margin, taking on more risk than their stated policies of diversification might indicate (Fisher, 1932, p. 75).

Practitioners of modern investment methods recognize that borrowing increases the risk of a portfolio. One of the insights of the capital asset pricing model is that an investor can purchase an index fund and adjust its risk by lending (adding bonds to the portfolio) or borrowing and buying more shares of the index fund. Fisher appreciated, with hindsight, that "anxiety is always present, or should be, in the person who has a margin account" (Fisher, 1932, p. 87). Had he kept track of the volume of broker call loans in 1929, as he did in his 1932 book (Fisher, 1932, p. 81), he might have assessed the riskiness of stocks in 1929 with more acumen.

12. Fisher and Bayesian statistics

In 1930, Fisher published a revised version of an earlier book on interest, *The Theory of Interest* (Fisher, 1930a). In it, he repeated his warning, made in the early version of the book, that the laws of economics regarding interest were mathematically precise only in a certain world. In an uncertain world, there was always risk, and he referred readers back to his section on risk in *The Nature of Capital and Income* for an explanation. He then repeated his message that the changes in investment risk due to the dynamics of the real world "pertain to statistics rather than to pure economics" (Fisher, 1930a, pp. 316, 320).

That was an important lesson for Fisher to have taught. Just as important, he took the view that any statistical approach to investment was subjective. Human judgment in the form of the coefficient of caution determined the ultimate price of stocks, and since human judgment was based on random information and shocks of confidence, so were the prices of stocks. Humans continually adjusted their estimates of risk as they gained new information and so should statistical techniques. With this approach, Fisher's view corresponds with the Bayesian approach now being introduced to the study of finance.

A central point of Bayesian statistics is that probability is subjective. Bayesians hold that the probability of an event taking place will depend on the assumptions made about the conditions under which the event will take place. Where the event to be studied is a social phenomenon, human judgment about the conditions surrounding the event becomes especially crucial to determining the probability of the event. Given that humans do not have identical judgment about social conditions, they will differ regarding the likelihood of an event taking place.

Evidence of Fisher's adherence to this Bayesian approach can be detected in his 1933 presidential address to the American Statistical Society. To Fisher, science proceeded by making conditional statements along the lines, "if A is true, then B is true." History and statistics made unconditional statements of fact, "A is true." As a science, economics had to combine the two. Mathematical theory could give precise conditional statements about events and statistics would verify when they took place. He wrote:

> We shall then know our phenomena—that A is true. We shall know, both by a priori reasoning and by a posteriori testing, our laws—that if A is true, then B must also be true. And finally, from these two sorts of knowledge—namely knowledge of the scientific law that if A is true, then B is true—we can predict in advance that B will be true.

Fisher recognized a strong criticism against this method. Society was not like nature. Statements such as "if A is true then B is true" held only under the right conditions. If conditions changed, the statement might no longer be true. To him, that type of problem was exactly what science was intended to correct. Scientists had the function of determining "under what set of circumstances one set of phenomena will occur, and under what circumstances another set will occur." This was not easy to do in economics, however, and Fisher gave as evidence his own failure to predict the extent of the great depression. As economic theory and statistical data improved, so, too, should economic forecasts (Fisher, 1933a, 1993b, pp. 8–12).

In holding this view of science, Fisher recognized that human judgment still mattered in economics. Theory and statistics could provide conditional statements. A scientist's judgment told whether or not the right conditions held. Fisher received prominence in economics for his work on the quantity theory of money—the theory that changes in the supply of money cause changes in prices. His version was qualified, however. He wrote, "This 'quantity theory' does not assert that prices do rise after every increase in the quantity of money, and those who thus interpret it are guilty of the confusion already noted between conditional and unconditional truth" (Fisher, 1933a, 1993b, p. 7). Yet, how was an economist (or anyone else) to know what conditions were necessary for an increase in the quantity of money to cause a price increase without some form of judgment? If judgment had to be part of science, did it not raise the issue of subjectivity?

13. Conclusion

Irving Fisher stands out as a financial economist of the first rank. His work on defining and valuing capital had many elements of modern financial methods. To name two important ones, he established that the value of capital was based on the discounted value of its future earnings and that an investor should use statistical methods to estimate those future methods. The statistical methods he set forth used mean/variance analysis to calculate return and risk, and they had a Bayesian perspective regarding the subjective nature of the probabilities being calculated. Had Fisher devoted more of his time to developing his investment theories, the revolution brought about by the theory of modern finance might have come sooner. Instead, Fisher has not yet been fully recognized for his innovations. This article has remedied that oversight.

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