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## ABOUT FISCHER BLACK

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This speech is based on the chapter about Fischer Black in my 2004 book *My Life as a Quant*.



### First Impressions

I first met Fischer in 1986 when I was a new hire working in fixed income. I was trying to produce a model for valuing options on bonds, which were the hot product at that time as interest rates fell from their peak in 1979. As bond mutual funds tried to stretch for yield in this declining environment, they sold call options on bonds they owned to generate income if yields continued to fall. Our trading desk sold these options and hedged them with listed Treasury bond futures. They needed a model, and this is what led to BDT.

The prevailing models in use at that time treated bonds like stocks in a Black–Scholes world. But whereas stocks were perpetuities and the passage of time didn't affect their intrinsic qualities, bonds in contrast aged, moving down the yield curve, so that a longer bond continually transformed into shorter ones. Because of this it became clear to modelers and traders on the Street that you couldn't model one bond or an option on it without modeling all bonds—that is, you had to model the yield curve.

Fischer and Bill Toy, in the equities division, were working on the same problem as me, and so in mid-1986 I was summoned to meet him. I knocked on the door of Fischer's office and entered. Fischer's office was much less glamorous than that of other Goldman partners. He was an anomaly at Goldman and, I guess, an anomaly in all the circles in which he participated in life. He sometimes bragged, if that's the right word, that he was proud to be the partner with the least number of shares at Goldman, and he thought that was right. His office was dominated by a large Nike poster of a long road disappearing into the distance and, below it, the sentence: "The race is not always to the swift, but to those who keep on running." Fischer really thought that way, and when I ran into the usual turf squabbles at Goldman later in my career, he always encouraged me to think long-term, and ignore the politics. He did that himself.

Brought to Goldman Sachs from M.I.T. by Bob Rubin in 1984, Fischer was one of the first finance academics to head for the Street. Unlike many other academics who worked for a while on Wall

Street but maintained their umbilical links to the safe haven of universities, hedging their bets by taking leaves of absence or working as part-time consultants, Fischer abandoned academia wholeheartedly.

After a brief introduction, I began to show him the bond options model I had inherited in the fixed-income division and then cleaned up. It was an enhanced Black–Scholes model for an option on an individual bond. Its stochastic variable was the bond yield, which I correlated with the riskless discount rate, so that they moved together to crudely represent the yield curve. I had built a graphical user interface for the options traders. It ran on a VAX that Fischer logged into through a VT-100 terminal emulator on his PC. Almost as soon as my program started running the VAX itself crashed, and we were left looking at the frozen screen image of my calculator. You couldn't run anything. I offered to come back later but Fischer was quite unperturbed. He spent the next hour examining and commenting on the user interface, 24 lines of 80 characters controlled only by a keyboard. Those were the pre-mice days.

I was surprised at his willingness to spend so much time on the mere interface without learning about the insides. But this was typical of Fischer. Fischer was always a stickler for precision, and clear expression was an invariant devotion of his. Over the years, I became a convert and tried as hard as I could, in anything I subsequently wrote, to be as clear and didactic as possible. (This is not to say that he wasn't equally dedicated to usefulness and accuracy in modeling, in a very pragmatic way, about which more later, but that isn't so surprising.)

In a few days Fischer let me know that I could join his effort to create a new bond options model. It was a singular opportunity that had a large and beneficial effect on my life.

Just as on the first day I visited him, Fischer was always quiet and calm, always in visible equilibrium, reading, or on the telephone, or entering his thoughts into *Thinktank*, a note-keeping program from the 1980s which he loved. He kept up a fierce correspondence with them to add or correct features. *Thinktank* and running models was his main use of the computer. He didn't program though he used programs he developed with others.

Fischer had strange tastes in computers. He didn't like mice, didn't like graphical user interfaces. He liked pure text input, and he liked keyboard shortcuts, redefining a single key to do several successive things, which he thought was more useful than a mouse.

In his office, if you said something he found useful, he'd write it down in pencil on a fresh sheet of his ruled white pad, and then tear it off and insert it into a fresh light-brown manila folder which he labeled and then inserted into one of his file drawers. He left behind 6000 files, archived at MIT by Beverly Bell, the editor he employed for all the papers and memos he wrote in those days.

## BDT

When we wrote the first draft of our paper on a one-factor model of interest rates that the trading desk later used, Fischer wanted no equations in it, and I had to struggle long and hard to satisfy his standards: he wanted accuracy and honesty without the technical details, which meant that you had to understand the model viscerally, and then explain that understanding. I think it was the clarity of the mechanics of our model that made it so popular and widely used.

In that regard, we used the CRR binomial model as our modeling framework. Fischer liked binomial trees because traders could easily understand them. I liked them too, and always have. In those

days traders and salespeople didn't know stochastic calculus, were sometimes even relatively innumerate, and getting them to embrace a new model involved getting them to understand its foundation. This was especially true in equities. I once at that time said to my friend Mike Mendelson in equity derivatives, now at AQR, that I thought fixed income people were smarter than equity people, to which he replied: "That's because there's no competitive advantage to being smart in equities!" Not true any more, but it probably was then. Anyhow, I think our model got widely embraced on trading floors because it was easy to understand and explain, and our paper was easy to read. I've always tried to write like that since.

At this time I also witnessed Fischer's pragmatic approach to the world. I was tremendously excited by what we had done. Still at heart a physicist, and still philosophically naive about financial modeling, I half-thought of what we had built as a grand unified theory of interest rates, and imagined we could use it to value every interest-rate-sensitive security in the universe, consistently.

Fischer, however, disliked this view. More practical and much more experienced, he knew that there were financial forces that lay outside our model; it seemed perfectly possible to him that the model might be good for one sector, simple options on Treasury bonds for example, but not for callable bonds or caps or a host of other option-like fixed-income instruments. Now of course that's obvious to me, but then, in my first year in the field, learning on the job, it took me a little while to grasp that. Fischer called what we had created an "as-if" model, by which he meant that we were assuming that the world of bond market investors behaved *as if* only short rates mattered.

I came around to this view myself later. It is impossible to make a correct financial model. Therefore, I like to think of financial models as *gedanken experiments*, like those Einstein carried

out when he pictured himself surfing a light wave or Schrödinger when he pictured a macroscopic cat subject to quantum effects. Models are only models, not the thing in itself. Models are better regarded as a collection of parallel thought universes you can explore. Each universe should be consistent, but the actual financial and human world, unlike the world of matter, is going to be infinitely more complex than any model you make of it. You are always trying to shoe-horn the real world into one of the models to see how useful an approximation that is.

### Fischer's Attributes

Fischer liked clarity but he could be unyielding—if you didn't understand what he said, he often simply repeated it, as though he couldn't do any better than tell you the truth as he saw it, leaving you to come to recognize it. He didn't often try to persuade.

Fischer expected clarity and directness from others too. Though he was generous with his time and didn't care about rank—he would pay equal attention to famous people and to letters from people he didn't know—you had to prepare for an audience with him. If it was evident that you hadn't thought carefully about your question, you quickly discovered that he wasn't going to do your thinking for you. But you had to speak his language to him. He thought about things a certain way, and it was most effective if you could tell him your ideas in his style.

Because he like clarity, and perhaps because he hadn't been trained in economics, Fischer avoided excessive formalization. His papers were the antithesis of the unnecessarily rigorous lemma-filled research papers of financial economics journals. He tried to write as he spoke, in a terse but good-natured conversational style, using clear but casual, unadorned English. There was a touch of jerkiness to his prose because it lacked the

technically superfluous conjunctions—*and*, *but*, *thus*, and *therefore*—people commonly use to link the flow of sentences.

He was uncomfortable with small talk. When he had nothing to say, he said nothing; this could be disconcerting on the telephone, where he often simply kept silent for a minute or two without terminating the conversation. Sometimes, this led you to babble in an attempt to fill the silence, until Fischer simply said an abrupt good-bye and hung up.

This directness and informality characterized his research too. His approach seemed to consist of *ab initio* unafraid hard thinking, intuition, and no great reliance on advanced mathematics. He attacked problems directly, with whatever skills he had at his command, and often they worked. He gave you the sense (perhaps misguided) that you could discover deep truths with whatever skills you had too, if you were willing to think hard. He was guided by his great economic intuition; though his mathematical skills were good but unexceptional, his instinct was strong, and he was tenacious in trying to attain insight before resorting to mathematics.

In modeling he had a taste for the concrete: he liked to describe the financial world with variables that represented observable phenomena rather than hidden statistical or econometric factors. He thought practical usefulness and accuracy were more important than elegance, despite the unquestionable elegance that lends so much appeal to the Black–Scholes–Merton framework he founded. He had a strong pragmatic streak; he was at least as much a practitioner as an academic, willing to devote time and attention to software, trading systems and user interfaces. He thought that these were just as important as the models themselves.

Fischer preferred reality to elegance in modeling. In one of his last published papers, *Equilibrium*

*Exchanges*, he succinctly stated his attitude at the end of his introduction. “In the end,” he wrote, “this entire article amounts to a series of conjectures about the nature of equilibrium, if one exists. I have been unable to provide an exhaustive and precise analysis of the implications of my assumptions, but I would rather guess about what follows from more-relevant assumptions than derive precise conclusions from less-relevant assumptions.” The best, he said, is “to explore a model.”

Fischer had a good grasp of the overwhelming importance of computing in making effective use of models. He didn’t believe in keeping models secret. People have often asked why we made public our research on BDT, given that we worked at a profit-making investment bank. The truth is that models are rarely an unambiguous source of profits. What counts as much or more is the trading system and the discipline it imposes, the operational errors it disallows and the intuition traders gain from being able to experiment with a model. And then there is the reputation gained by getting the larger world to use your model, your insight, the implied parameters your model employs, as valuation and hedging tools.

Fischer had his own way of thinking about markets. He was deeply inspired by the so-called “general equilibrium” approach of the capital asset pricing model, the idea that prices and markets equilibrate when the expected return per unit of risk is the same for all securities. This belief was the source of much of his intuition, and was the method he first used to derive the Black–Scholes differential equation. In late July of 1995, shortly before his death, in response to a question I sent him about these matters, he emailed me: “I view all our work on fixed-income models as resulting from the application of the capital asset pricing model to fixed-income markets.”

I had a touching glimpse of his love for this approach a few years before he died when,

together with a few of my colleagues, I tried to assess the effect of transactions costs and finite hedging frequency on our trading desk's options prices. We built a Monte Carlo simulation program that dynamically replicated each option as the stock price changed, adding the assumed transactions costs as each rebalancing of the hedging portfolio took place. In the long run we intended to use the program to see how much this caused options prices to deviate from the Platonic Black–Scholes value, so that we could estimate the actual cost of our hedging strategy rather than accept the value of the idealized strategy embodied in the Black–Scholes model.

Whenever you write a program to do something new, you should first make sure that it does the old things correctly. In testing the program written by one of my colleagues, we first ran it under the assumption that there were no transactions costs and that you could hedge continuously, in order to ensure that we obtained the exact Black–Scholes replication price. Of course, you cannot really hedge continuously in a computer simulation, so we rehedged very often, several times a day. To our amazement, we discovered that even for 10,000 rehedgings on a one-year option, that is for more than thirty rebalancings in a day, we still couldn't obtain the exact Black–Scholes value. There was always a residual small discrepancy that didn't vanish. This seemed wrong, so I wrote my own version of the program and found a similar small but significant discrepancy. This was very puzzling; it suggested that the Black–Scholes formula was less applicable to the conditions of actual markets than we had expected.

I was perturbed enough to want to speak to Fischer about this, and went over to his office. When I explained what I had found, he briefly became quite excited at the apparent inability of Merton's replication method to produce the exact

Black–Scholes value, and said something like, "You know, I always thought there was something wrong with the replication method."

To cut a long story short, both my colleague and I had independent small programming errors, and of course the result did converge to Black–Scholes.

Fischer had some strange tastes. You couldn't easily guess his attitude to one question by knowing his opinion about another, though what he said was always thoughtful and sensible. But over subsequent years I learned that he was a rarity, one of those people you only occasionally meet, someone whose character is a coherent whole even though its parts seem uncorrelated. At bottom, he simply liked to think through everything for himself. This didn't make him a great rebel, but rather an outsider whose work had vast impact on the world of insiders. It was impressive to watch.

Fischer's independent thinking led him to unorthodox but well-thought-out ideas, many of which sounded obvious once he articulated them. He voiced some of them in speeches, and others in a collection of brief and pointed notes that he circulated informally at Goldman in the early Nineties.

In one note he struck at the foundation of financial economics, writing that "certain economic quantities are so hard to estimate that I call them 'unobservables.'" One unobservable, he pointed out, is expected return, the amount by which people expect to profit when buying a security. So much of finance, from Markowitz on, deals with this quantity unquestioningly. Yet, wrote Fischer, "Our estimates of expected return are so poor they are almost laughable."

In another essay entitled *Managing Traders*, he argued that a trader should be judged on the rationale behind his methods and paid if it is sound, irrespective of whether or not he made money

in the most recent period. “It’s crucial to judge the stories they trade on,” he wrote about traders. “Stories can be wrong, but I’m uncomfortable trading without one . . . Looking only or primarily at their profit and loss statements is a recipe for disaster.” He wanted to reward intelligence and thinking over the long run rather than the vagaries of markets over the short.

In his speech on being named the Financial Engineer of the Year by the IAFE in 1994, Fischer said that he had always preferred applied to academic research. University professors, he claimed, should be paid and hired for their teaching, not their research. He believed that their desire to teach well would then lead them to do good research. It’s ironic and sad that he didn’t get the Nobel prize before he died for work which was clearly going to get a prize, but I think he wouldn’t have cared. What is true though is that the problems of finance arise in the business world, and having people with academic inclinations in the center of the business world is the best way to notice and solve them. When I ran the QS group that I inherited from Fischer, starting 1990 to 2000, I was very careful to situate us with one foot in the academic world, so we published, and one foot in the trading and sales world, where we used our models for the trading desk and our papers for sales. I think that doesn’t exist any more.

When Fischer became terminally ill, he neither hid it nor announced it, but told the people that needed to know, and spoke about it in a detached, objective way that I found admirable. I never heard him complain.

He had a massive operation, and was full of genuine praise for the surgeon, who he said was “a genius;” it made me briefly envious of people who help others rather than work on theories. After the operation, he had a temporary recovery, and worked again, assiduously. For a while we sometimes spoke on the telephone about building

models of options valuation that included jumps in the underlying index.

He was always frank if you asked about his health, but never volunteered any information if you didn’t. Later, when one could sense from occasional remarks and rumors that his condition had worsened, I summoned the courage to ask how he was doing. He said simply that things “look pretty iffy right now.”

When he finally stopped coming to work, he communicated with anyone who wrote to him via email. I liked to keep in contact, and would send him comments or short bits of news from work. If my emails were insubstantial, consisting of small talk or complaints, then, true to his style, he seldom replied. But if you wrote to him about some genuine issue in finance, you received a prompt answer. I asked him once if these email questions were bothering him, and he immediately replied to say no, and then stressed in a post script that he liked to receive these questions.

At his memorial service in Cambridge, I heard a moving speech by Jack Treynor, former editor of the *Financial Analysts Journal* and, in many respects, Fischer’s mentor, who concluded by saying that as regards death, “Fischer wasn’t afraid at all,” and that’s the way I saw it too. He rarely seemed to delude himself about the way the world really worked.

Whenever I think of Fischer I think of him as a consummately unsentimental realist, unafraid to see and take the world for what it is. Once, in 1994, when I was about to travel to Vienna to speak at a conference at which Robert Merton would be present, I called Fischer (already ill but more than a year before his death) and left him voicemail asking the appropriate way to refer to “the model” - should I call it “Black–Scholes” or “Black–Scholes–Merton?” Fischer replied with a message saying it was OK to call

it the Black–Scholes–Merton model, because it was Merton who had come up with the replication argument for valuing the option. Then he added, quite imperturbably, that “that’s the part that many people think is the most important.”

On a professional and personal level, Fischer always seemed more free of artifice than anyone I knew, though this sometimes made him less than easy to deal with. He didn’t soft-pedal in giving you his opinion of work you had done or actions you had taken, but just told you what he thought. He had a strong sense of what was important, and he always took the long view, in corporate politics as well as in research. For that reason, he was the perfect person to call when you needed a clear view about an issue. In the midst of corporate politics, he told you to concentrate on quality even if people around you sometimes didn’t appreciate it. He kept your eye on the goal, which was to help the business in the best way you could, to try to keep breaking new ground. He didn’t sympathize with holding on to turf; instead, he always encouraged the search for new opportunities.

Fischer’s last paper, written but not fully completed while he was dying, was submitted to the *Financial Analysts Journal*. He called the paper *Interest Rates as Options*, and cleverly pointed out that short-term interest rates themselves resemble call options, a consequence he then elaborated on.

In a footnote to the article, the managing editor of the journal explained the circumstances behind the paper’s publication:

Fischer Black submitted this paper on May 1, 1995. His submission letter stated: “I would like to publish this, though I may not be around to make any changes the referee may suggest. If I’m not, and if it seems roughly acceptable, could you publish it as is with a note explaining the circumstances?” Fischer received a revise and resubmit letter on May 22 with a detailed referee’s report.

He worked on the paper during the Summer and started to think about how to address the comments of the referee. He died on August 31 without completing the revision.

Let me say a few words about what the Black–Scholes–Merton model brought us.

The model opened up the world of derivatives structuring. Without replication and the confidence it gave people, without an understanding of volatility, it would have been impossible to create the products that drive the financial world today. But it may have gone too far in some cases. The world needs friction, perhaps even a Tobin tax. It’s not good when things run too smoothly. Before the creation of credit derivatives, you had to understand how to hedge a corporate bond with treasuries if you wanted to trade credit. Similarly, before the creation of the VIX, trading volatility required careful continuous hedging of options, with a model, often imperfect. After the creation of options on the VIX, or VIX futures, trading volatility became a breeze, or perhaps even an ill wind. It’s too easy for what should be a ripple on the market sea to become a tidal wave, as happened with the 1987 Portfolio Insurance crash.

The great joy of Black–Scholes–Merton is both its depth and simplicity: Its depth because of the subtlety of the idea of riskless hedging to replicate a riskless bond—its simplicity because all you need to know is an estimate of the future volatility to value and hedge an option. Of course this is too simple—there are jumps, stochastic volatility, rough volatility, volatility jumps, etc. . . but often, adding these wrinkles does not take you closer to the truth. With just one volatility you can put all your intuition and expectation about the future into the effective volatility, the one unknown parameter which subsumes everything important and uncertain. More is often less when you build models, something that Fischer understood well.

**IN CONCLUSION:**

One of the great qualities I admire is to be able to look at every thing in the world as the thing in itself, and then decide what to do about it. One notices this particularly now, when people on the

left have to adopt the left agenda no matter what it involves, and similarly so for people on the right. I read recently a sentence by Lionel Shriver that said: *In politics one should dine only à la carte.* Fischer did this with everything and I admire it.