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ADVANCES IN MODELING THE MARKETS

BILL JANEWAY VICE CHAIRMAN, WARBURG PINCUS
hosted by Mark Anderson, CEO, Strategic News Service

Mark Anderson, Strategic News Service: Now, for those of you who've never been through this experience [*laughing*], I've now been through it, I think, twice. Get out your legal pads and your Number 2 pencils, because you'll need them to keep track of what we're about to do here, I think.

I'm here with Bill Janeway, and we are now, I think, making a tradition of this conversation. So far, we've talked about looking in general at risk, and then risk aversion, risk and markets, how to invest… You talked one year about venture investing and cycles, and how risk aversion was more important than maybe even knowing what to invest in. Almost.

Bill Janeway, Warburg Pincus: Well, the regime – the capital market regime – the state of the IPO market, had an enormous impact on venture capital returns over time, and that venture capital cannot really be thought of as a separate, autonomous asset class, independent of the valuations that are taking place in the public market.

Anderson: Right; right. So we're kind of building on these annual conversations, and this year we're going to go a little bit further. We'll talk about some different markets, and we're going to talk about modeling, and where modeling has moved from, where it began, and where it's going to end up, maybe, in a few years.

There's a quote I'd like to read back to you, from yourself. You told me recently: "In my own experience as an undergraduate some 40 years ago, the most dismaying consequence was the elevation of the notion of 'equilibrium' to divine status. The purpose of any exercise in economic reasoning was to find an equilibrium solution to a problem, as if we

did not, in fact, live in constant motion, from one state of unsustainable disequilibrium to another." I want you to talk about that for a minute and describe this evolution, this change, from those states of mind.

Janeway: Sure. Well, I guess one way to begin looking at that is to take note of what – anyone here who took Economics 101 and 102 in the last 40, 50 years, and if your kids, or your in some cases *grand*kids, are doing it today – the grand project of economics beginning after World War II came to be the construction, the translation into a formal mathematics, of the principles of economics that had been evolved over the previous 100 years.

Now, this was a very worthy project, to bring a degree of rigor to a discipline which was notorious for having soft and fuzzy concepts bleeding off into each other. And the project was led in an *entirely* nonpartisan way by economists across the political spectrum, from the University of Chicago to MIT – leading Keynesian economists like Paul Samuelson and Robert Solow, as they had become in the States, Kennedy administration leaders, Ken Arrow…

The methodological revolution in economics, however, had consequences; it had side effects. And the first and the most notable side effect, and the one that I'm really going to talk about this morning, came with a kind of contrary wave: if we couldn't construct a formal mathematics about a particular domain, then it wasn't economics. If economics is a formal mathematical structure, then that which is not formal mathematics should not be deemed to be economics.

Anderson: So the tools defined the knowledge.

Janeway: Exactly right; exactly right. And the tools were pretty primitive at first. Now, reflecting on our conversations last year about managing risk and how the management of risk on the trading desks in Wall Street was driving the IT industry towards real-time analytics, new models, new ways of dealing with vast quantities of streaming data, to extract information from data: everybody here did so well on that – on the take-home test, they really did well – so that's why we thought that this year we'd take it a step further and dig down a little further into what is risk and what risk is not; what is *not* risk.

Where I want to begin is, in a sense, what the leaders of that great project in economics – the brain – the work that they were reacting against. Even though they called themselves

Keynesian, to a large extent they were reacting *against* Keynes. At the core of the General Theory, now 70 years old, is a subject of extreme interest to anybody, and that means everyone, who is dependent on how the stock market works and what happens when it doesn't work. At the core of Keynes' economics is the process through which financial assets are valued, are priced; and the relationship between that pricing method and how real assets, physical assets, a plant, equipment, and, for that matter, lines of code, are priced – the cost of them. At this point, you're supposed to say, "Well, why does that matter?"

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Bill Janeway

Anderson: Why does that matter?

Janeway: Why does that matter? Thirty-five years ago, when I came into Wall Street, an old codger said, "Son, you gotta remember that sometimes it's cheaper to drill for oil on the floor of the New York Stock Exchange than in the Gulf of Mexico." So, the ability to buy assets through the medium of their equity securities – they're securities that are traded, versus building them – is right at the core of what drives growth and the behavior of the macroeconomy as well as the microeconomy, made up of a very large number of firms, new firms and old firms.

In other words, we translated this in our own venture capital practice to the notion that you buy what you can; you only build what you have to. Sometimes you have to build it to be innovative, but there are an awful lot of assets that are available because the pricing in the stock market has got them wrong.

This is where we get back to that discussion of risk, and where a notion got dropped out somewhere in the last 50 years. This takes us back from Keynes to before Keynes. In 1916, 20 years before the General Theory, there was a really bright young guy at Cornell who wrote a Ph.D. thesis called "Risk, Uncertainty, and Profit." His name was Frank Knight, he went on to found the Chicago School of Economics. One of the great economists of the 20th century, who is in the process of being rediscovered.

"Natural scientists make theories about things; social scientists make theories about things that make theories."

Bill Janeway

Knight, like Keynes, whose first book had been called *A Treatise on Probability*, had a very deep understanding, beyond the kind of conventional wordsmithing, of the nature of risk. What he saw was that you could look at risk in two different ways and get a solid definition on which you could lean. One was a kind of *a priori* physical probability of which – in an honest die, which face is going to come up? So, there are systems where you've got a *physical* definition of probability. And then there are systems which are sufficiently reliably repetitive that you can measure the statistics of those

systems and calculate the moments of the distribution and rely on that statistical definition. And these, of course, are very largely *natural* systems. At this point –

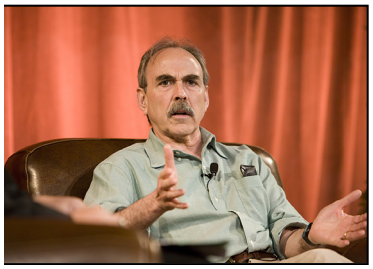
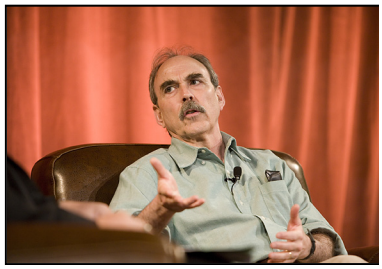
Anderson: Not the business cycle.

Janeway: Well, exactly. You're dealing with the natural world with what technically – here's something to write down – are called *ergodic* systems. Now, there's a great quote for which I've been seeking a source for four years now, and I've given up. I've looked everywhere and no search engine helps me. I finally decided that I have to be the source of this quote. You're all welcome to it. "Natural scientists make theories about things, social scientists make theories about things that make theories."

Anderson: I remember when you said that – last year, I think.

Janeway: Right. Remember that. Write that down. Because when the economists began to deal with their formal mathematical modeling of economic systems, they took over from the natural scientists the notion of ergodic systems, of looking at the behavior of economic social systems constructed by people who were reflecting and wondering and trying to decide what is actually information, what is actionable, what is noise, as *if* they were natural systems.

So, risk came to be defined as volatility, as variance. And why does *that* matter? Well, let's take a look at the Black-Scholes equation for pricing options. If you have a stock at $20 a share, and you issue an option to buy that stock at $20 a share, and the stock moves from $20 to $22 to $18 to $20, you can define the variance; it's around 0.5. If you have the same stock – it starts out at $20, and you issue an option at $20 – and the stock goes to $16, $12, $8, $4…


Anderson: Sun. Sun Microsystems. No…

Janeway. The variance… That's right, except it was $60. The variance is a lot greater. Plug that variance into Black-Scholes. Which option is worth more? Which option issued at $20 a share is worth more? The second one is worth more, obviously; the variance is greater. Black-Scholes will tell you that it's worth more.

Anderson: There you go.

Janeway: Now, economists kind of ran up against the capital markets – this goes back 30, 40 years ago – and you might argue in a very clever way they threw up their hands in dismay and said, "We're not going to deal with that." And that was the creation of the *rational expectations hypothesis*, which we chatted a little bit about – you know, the notion that rational behavior in the markets is a function of the fact that all of us have access to the same information. We all share the same model about what that information means, whether you buy or sell, and…

Anderson: We all have the same IQ equipment.

Janeway: And that model that we have happens to be truth. Right?

Anderson: Correct.

Janeway: So, if that were the case, of course, nobody would ever trade. Everybody would already agree, so there would be no reason to trade. The only reason the stock price would ever move would be because of an external shock.

Anderson: Natural disasters, or...

Janeway: Yeah, or you know, economic, macroeconomic disturbance. Now, the problem with this is that when you run the statistics, and look at the behavior of stock prices over long periods of time, and the behavior of the macroeconomy, you wind up with the notion that common stock should be priced to yield about 1 to 2 percent more than the risk-free rate, than just investing in treasury bills and rolling the bills. The problem is that over the last 100, 150 years, common stocks have actually yielded about 6 or 7 percent more than the risk-free rate. This is called the *equity premium puzzle*. Where does all that extra risk come from?

Well, this is where the new modeling of the market starts to get interesting and useful. There's a guy at Stanford named Mordechai Kurz, kind of a prophet without honor, at a great university, who took this notion, took it seriously, that yes, if it's economics, you do need rigorous formal models, because you've got to be able to test them. If they're not mathematically rigorous and you try to run econometric tests, the answer is going to be ambiguous. So if you want to really run a test, you have to do the mathematics, and he's a very fine mathematician.

And what he did was take this notion of – well, let's say that rationality means that you're not denying observed history – so you have statistics that describe the overall behavior of the market, of the economy. But then, you're going to have a whole variety of different beliefs as to *why* and *how* that behavior came to be. He calls this theory the Theory of Rational Beliefs. What is built into it is this notion, this observable notion, that all of us who live in markets know: that participants in markets have different beliefs about what's going to happen. That's what makes horse races; that's what makes stock prices: heterogeneous beliefs. Well, when you build that in –

Anderson: So that creates the premium.

Janeway: Exactly. Because when you build that in, what you start out with… Frank Knight called it "uncertainty." He said that you've got this whole array of human behavior – systems populated by people who are making theories about the systems. He didn't use that term; I wish he'd been the source.

Anderson: Another quote we could use –

Janeway: Right. He called it "uncertainty"; you and I might just call it ignorance. The statistics aren't there. In the case of – he actually said that in business life you just don't have enough events that are so like each other, that are so similar, that you can draw meaningful statistical inference from them. You're on your own. And, similarly, when an event happens, as the market evolves you've got these radically different points of view. And people – there's a natural phenomenon known as herding behavior: maybe if the stock starts to move, momentum investment… follow it. Play it out. At the grand scale, of course, this is what drives bubbles –

"Frank Knight said that you've got this whole array of human behavior – systems populated by people who are making theories about the systems."

Bill Janeway

Anderson: [*Coughs*] Google! Sorry.

Janeway: [*Laughing*] Search on Google, you get bubbles, is that it?

So, the ability… This is the first step toward new methods for modeling the markets: to incorporate heterogeneous beliefs, differing points of view and opinions, into understanding why markets overshoot and undershoot, why we move through equilibrium at a rate of speed, and why we see radical reversals at the individual stock level, at the sector level, at the overall market level. And consequently, why that relationship between the price of oil on the New York Stock Exchange and the price or the cost of extracting oil from the Gulf of Mexico can vary so enormously over relatively short periods of time. That's one of the really great steps forward.

Now, there's another one…

Anderson: So you're saying that's the source of the whole idea that disequilibrium is, in fact, the natural state.

Janeway: It is certainly one of the sources. Well, the endogenous risk – that is, the risk that is endogenous *within* the market, not the risk that a –

Anderson: Hurricanes, or…

Janeway: – a Hurricane Katrina, or a meteor, or –

Anderson: Hugo Chavez…

Janeway: – or an idiot at the Federal Reserve raises rates in 1931 instead of cutting rates in '31. So, that's one whole area of innovation, of development, which is actually very promising.

There's another one. Back when the economists turned their backs on the capital markets, as you well know, there were a number of what you might call "failed physicists" – guys with the mathematical tools but without the physical intuition – who wandered across Cambridge in particular, Cambridge, Massachusetts, into the business schools with their armamentarium of mathematics, and their – Larry Smarr is laughing there – and set about…

Anderson: And Goldman, Sachs was born.

Janeway: Well, first actually… Goldman, Sachs was relatively late into this, but Goldman, Sachs was one of the first to get it when Fischer Black moved from Cambridge, Massachusetts, down to Goldman, Sachs. That's absolutely right.

Going back to what I was saying about sort of doing a forklift import from the natural sciences into the social sciences: the original, sort of the mathematics that were embedded in the Black-Scholes option-pricing model came out of the work of a guy at Yorktown Heights named Scott Kirkpatrick – happened to be a classmate of mine at Princeton – who developed a technique known, God save us, as "simulated annealing." It's a mathematics of looking at the process through which a vat of steel cools down. If you have lots and lots and lots of vats of steel, you can see the relaxation curve through which it cools down gradually, and that's the mathematics that says that the price of an option will cool down, will revert to a mean, on a predictable basis. Right?

Anderson: No kidding?

Janeway: Absolutely.

Anderson: That's interesting.

Janeway: It came right out of the physics of melting hot steel. Now, the difference between where the economists were with their ludicrous notion of rational expectation, and where the finance guys were, is exactly what you said: it's Goldman, Sachs. Because these new models, beginning 30-odd years ago, came to Wall Street and were subject to the most intense imaginable Darwinian processes of natural selection. If you stayed with Black-Scholes, and if you stayed, say, with the normal distribution when it became perfectly clear that the tails are too fat, that there's skew… you're cleaned out.

Anderson: You're fired.

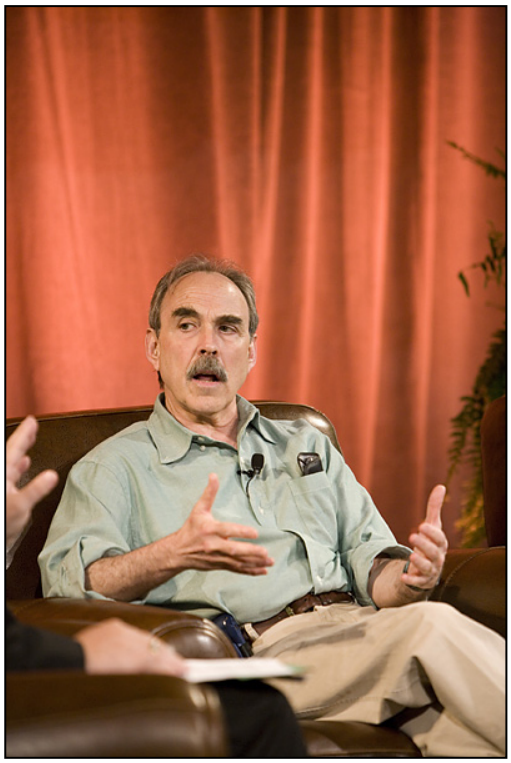
Janeway: You're gone. You're absolutely right. So the models of what Bob Merton insists on calling "finance science" – he won't use the term "economics" – have evolved very, very rapidly. And they've evolved rapidly particularly through the increasing incorporation of Game Theory. And this is the other great methodological introduction. So, as recently as three, five, six years ago, pick up a random paper on finance, on behavior – pricing behavior, trading behavior – and you'd see it begins with the establishment of a *representative agent*. One representative agent who has a set of attributes –

Anderson: A profile of…

Janeway: Risk aversion – exactly – something deemed to be rational according to these criteria. Well, you know, when you think about it, if the rational agent isn't a fully functional schizophrenic, where does the trading come from? Again, it only comes from those external shocks. And we know that external shocks aren't enough.

Anderson: That's right.

Janeway: So what we're beginning to see – there's a guy at Princeton who's not alone, but he's one of the most brilliant, named José A. Scheinkman – are building game theoretic models of traders trading against each other, trying to work out who's got a better notion of what the flow of information actually means. And you know, it begins to sound a little bit like what we actually *do*.



Anderson: Yeah. The actual trading process.

Janeway: The actual trading process. Now, this is becoming *really* important, because of what we've lived through in the last 10 years. And what we've lived through in the last 10 years is what's driving all of this continuing conversation we've been having. Because if you start, say, with the Asian flu, long-term capital management, and unlike the Enron guys – those really *were* the smartest guys in the room – when LTCM almost brought down the financial system, then the NASDAQ bubble and the famous, you know, $6 trillion creation of wealth and liquidation of wealth –

Anderson: House fire.

Janeway: – all done in five years. Clearly, the degree of volatility of risk, quote-unquote, in the market, is enormous. Consequently, there has

been this enormous push, both from regulators and from – internally, for risk management systems. Now, here's the problem.

Anderson: Well, creating the entire derivatives market.

Janeway: Yeah, very much so. And the continuous attempt to extend the derivatives markets. And this is where we're going to start circling back to games a little bit. The problem is – and this really is a problem – most of the conventional techniques for estimating risk still have at their heart those notions of well-defined, statistical, normal distributions of possible outcomes. And they're conducted in a formal mathematics that has not absorbed the frontier work that begins by recognizing that markets are about pricing ignorance.

Anderson: We're still using Poisson curves.

Janeway: Exactly. So when Keynes, as I said, put at the heart of his economics the process through which financial assets are priced – obviously you're going to ask me, "Well, what was that process?"

Anderson: What was that process?

Janeway: Well, what it was *not* was what would be taught at MIT, or CalTech, or Stanford, or Princeton, today, in an undergraduate class. They would teach it in graduate school, but you've got to get brainwashed first.

Anderson: Then they're going to deprogram you later.

Janeway: That's right; then you get deprogrammed. What Keynes talked about was – what you're really trying to work out – is what does average opinion, the wealth-weighted opinion, of market participants expect that the wealth-weighted *average* opinion of market participants is going to be about the price of Google. Right? So you've got a kind of second- and third-order game.

Anderson: Which is, the more it goes up, the more it goes up

Janeway: Until it goes down. You've got a multi-player game. Now, Keynes didn't have the formal mathematics to make this, if you like, respectable, in today's world. But the underlying intuition, what he called the "beauty contest"… The British newspapers used to have this contest where your task was not to pick the prettiest girl; it was to pick the girl whom the average opinion of the newspaper readers would judge to be the prettiest girl.

So this process, which is, you know, very natural when you think about how you're trying to evaluate uncertainty by working through how other people are going to evaluate uncertainty, because that's what's going to run the market. Bringing that into the risk-

management models hasn't happened yet. Hasn't happened yet. The good news is that there's really a lot of concern about the fact that it hasn't happened yet.

> "The only rational way to be in the [1999] market was to be doing what, if you stood back, you knew had to be irrational."
>
> *Bill Janeway*

Anderson: Yeah, at least that people are… This reminds me of the definition, the proper definition, of what Darwin said, which is not that the strong survive; it's that the *fit* survive. The most fit. And the most *fit*, in his mind, were those animals or plants which were most quickly able to adapt.

Janeway: To an environment that is continuously changing –

Anderson: Life is made of disequilibrium.

Janeway: – and changing in *part* – the change, in part, is driven by the adaptations, so that the continuous feedback process that sometimes – maybe with global warming – sometimes goes into a positive-feedback mode and drives the system further and further away from equilibrium, which is just what happened in the NASDAQ, telecom, dot-com bubble in 1999. The only rational way to be in the market was to be doing what, if you stood back, you knew had to be irrational. You didn't have to be in the market. But if you were in the market, that's how you had to behave, in a profoundly irrational way.

Anderson: Right; right.

Alright, I think we've done it. We've done it again, which is amazing to me. If we have questions, we have about two and a half minutes left. Are there questions for Bill Janeway?

Peter Biddle, Microsoft: Hi; Peter Biddle. I'm curious: as someone who runs an engineering team, as opposed to someone who invests in the market, how would you – I'm having a hard time thinking about how to sort of bridge the gap between economic theory and sort of building theory.

Janeway: Hey, that's a very good question, and I actually, almost totally by coincidence – I don't have an answer for you, but I have a reference for you. It turns out – as Mark knows, I spend a lot of time at Cambridge University in England, where they've just hired a dean of the business school, a fellow who was the number two at INSEAD for a number of years. His name is Arnoud de Meyer. His whole focus of work and research has been on managing uncertainty at the project level: dissecting it, looking at the different sources of uncertainty, and looking at how you create processes that will kill or fix, in timely fashion, as you are engaged in – whether it's designing and building a bridge, or whether it's back to *The Mythical Man-Month*. So I urge you to look up – Google him, and you'll find some articles. He is very good, and he's absorbed a lot of this literature that I've been talking about.

Anderson: You know, in programming there is a conflict, I guess, between methods of management, and one of the techniques came out of McDonnell Douglas. When I first learned about it, it was called "the wall." This was for software. So, the idea was, you specify whatever you're going to specify, then let the other guys throw in more stuff, more stuff, more stuff – which is typical of what happens – and then you hit a certain date, and on that key date, you begin taking things away.

Janeway: It's like at Sun, they called it the train. The train was on a schedule, and you could put stuff on the train up to the point at which it left the station.

Anderson: Ah, but it gets better. Because the point of the wall is, there is a wall, the train is going to hit a wall, and so you hit the next date, and if they haven't done all those things, you pull 10 percent of them out. You keep withdrawing things – instead of adding more, withdrawing things, all the way up to the ship date.

"There's not a lot of gain in trying to game Goldman, Sachs on Goldman, Sachs' turf."

Bill Janeway

Dan Rosen: Hi, Bill; Dan Rosen. The markets are changing in a couple of ways. One is that the time to make a trade is getting much, much shorter. Are we approaching something that looks like a quantum singularity there [*laughter*], where it gets so short that the ability to control stuff becomes impossible?

Janeway: Well, I'll tell you… You know, clearly the sheer volume, I mean that what's coming off the ticker plants, the ability to interpret it and to react in real time – it almost forces most investors, the vast majority of investors, like it or not, to start thinking strategically. There's not a lot of gain in trying to game Goldman, Sachs on Goldman, Sachs' turf

Anderson: Absolutely.

Janeway: Good!

Anderson: Thank you. Perfect timing. We're done.

[*Applause*]
