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JAKE XIA: This is the second time we are having this class. We had it last year in a smaller version. That was for six units of a credit, and we had it once a week. And mostly practitioners from the industry, from Morgan Stanley, talking about examples how math is applied in modern finance.

And so we got some good response last year. So, with the support of the math department, we decided to expand this class to be 12 units of credit and have twice a week. So, we have every Tuesday and Thursday afternoon from 2:30 to 4:00, as you know, in this classroom.

So last year, Dr. Vasily Strela and I-- by the way, I'm Jake Xia and that's Dr. Vasily, and we were the main instructors last year. Now we doubled it up to four main instructors. That's Dr. Peter Kempthorne and Dr. Choongbum Lee. The reason we doubled up the main instructors is we have newly added math lectures, mostly focusing from linear algebra, probability to statistics, and some stochastic calculus to give you the foundation to understand the math will be used in those examples in the lecture taught by the practitioners from the industry.

And the purpose of this course is really to give you a sampling menu to see how mathematics is applied in modern finance and help you to decide if this is a field that you would be--

RECORDED VOICE: Thank you, for using WebEx. Please visit our website at www.webex.com.

JAKE XIA: OK, you heard that. And so hopefully, this will give you enough information to decide this is a field you would like to peruse in your future career. In fact, last year when we finished the class, we had a few students coming to work in the industry. Some

work at Morgan Stanley, some work at elsewhere.

So that's really the goal. And at the same time, obviously, you will further solidify your math knowledge and learn new content. And we put the prerequisite about the math part a bit later.

So I will use today's first lecture's time to give you an introduction, really, to prepare you some basic background knowledge about the financial markets. Some terminologies will be used, which you may not have heard before. So before I get into the introduction, I always like to know who are actually in the classroom, so let me ask you a few questions. You just need to raise your hands so I know roughly what kind of background and where you are.

So how many undergraduate students are here? So I would say 80% percent. How many graduate students are here, just to verify? Yep, that's about right, 20%. And how many students are in finance and business major? Just one. And how many of you are a math major? Most of you. How many of you are engineering majors? A few.

How many of you actually are from other universities? Great, because last year we had quite a few, so I want to specifically tell you that you're very welcome to attend the classes here. So it's open door. And last year I remember we had a couple of students from Harvard. That's where I actually work right now. I forgot to mention that, but I'm affiliated with both the math department and the Sloan school here. So anyway, thanks for that.

We will be doing a bit more polling along the way, mainly to get feedback of how you feel about the class. Last year we had it online, so if you feel the class is going too fast, or the maths part is going too slow, or the finance part is a bit confusing, the easiest way is really just to send us emails, which you will find from the class website. So anyway, today--

VASILY STRELA: And all of us got MIT emails.

JAKE XIA: Yes. We all have MIT emails, which are listed on the website.

VASILY STRELA: [INAUDIBLE].

JAKE XIA: And obviously, we have offices here. You can easily stop by Peter and Choongbum's offices. And Vasily and I probably will be less often on campus, but we'll be here quite often and definitely love to be more.

So anyway, I will start today's lecture with a story, and a quiz at the end. Don't worry, it's not a real quiz. Just going to ask you some questions you can raise your hand and give your answer. But let me start with my story.

This is actually my personal story. I want to tell you why I tell the story later. But the story actually was in the mid '90s. I just left Salomon Brothers-- that was my first financial industry job-- to go to Morgan Stanley in New York to join the options trading desk.

So the first day, I sat down, I opened the trading book, I found something was missing. So, I turned around, I asked my Desk Quant. I said, where is the Vega report? So, let me show you.

So that's the story. So I'm obviously not going to tell you the story of Pi or "Life of Pi." That's not a financial story. The rest of the story, Alpha, Beta, Delta, Gamma, Theta, which you will learn from Peter and Choongbum and Vasily's classes. So I'm going to talk about Vega. So by the way, before I tell you the story, what's unique about Vega on this list?

AUDIENCE: It's not a Greek letter.

JAKE XIA: It's not a Greek letter. That's right. So I turned around and asked my Desk Quant, I said, where's the Vega report? But how many of you actually know what a Vega is? OK, lot of people know. So anyway, I'm not going to-- just for the people who haven't heard about it before, it's a measurement about a book or portfolio or position's sensitivity to volativity.

So, what is volatility? Which again, you will learn more in rigorous terms what has

defined in mathematics. But the meaning of it is really a measurement or indication of how volatile, or what's the standard deviation of a price can change over time. That's all you need to know right now. I'm not going to ask you questions later.

So my Desk Quant look at me, said-- this is supposed to be options trading desk, so he look at me puzzled. So instead of answering my question, he handed over me a training manual for new employees and new analysts. So I opened the training manual and looked it through. I actually found my answer. So actually, at Morgan Stanley this is not called Vega, it's called Kappa. So now, I remember to call it Kappa. Kappa is actually a Greek letter.

So further, I look on the same page there was actually a footnote, which I copied down. So the footnote about why it's called Kappa at Morgan Stanley. Kappa is also called Vega by some uneducated traders at the Salomon Brothers. That's where I came from. I just joined. They have mistaken Vega as a Greek letter after gambling at Vegas.

So anyway, so that was my first day. So obviously, I learned how to call kappa very quickly, because I came from Salomon Brothers. And I call it Kappa in the last 17 years, but you will hear people calling it Vega. Obviously, I have probably more people calling it the vega. But anyway, so that's my first day at Morgan Stanley.

But why did I tell you the story? What point I try to make? So this story is actually-- when you think about it, mathematical or quantitative finance is a rather new field. A lot of these terms were newly introduced. And the pricing model of options, as you know, was introduced in the black shows in the '70s, or some of the ground work may be done a bit earlier. But it's not like finance was a quantitative profession to start with.

So what we witness in the last 30 years was really a transformation of the trading profession coming from mostly under-educated traders. Some of them typically joined the firms in the mail room and became trader later on. That's typical career path. And to nowadays, if you walk on the trading floor, you talk to the traders, most of them have advanced degrees and quite a few of them have very high training in

mathematics and computer science.

So what has changed over the last 20 or 30 years? I myself, personally, was probably one of the data point experiencing this change. And I certainly didn't expect I would be doing this when I was at MIT, but I did that in the last 20 years.

So the point I'm trying to tell you is, before you dive into any details of mathematics or any concept in finance in this class, just bear in mind, this is a field developed in the last mostly 30 years, or even shorter. And what you really need to ask questions is-- it's not really is the right or wrong in mathematics, is it right or wrong in physics? So, how the concepts are established and defined and verified. Because this is a field the transformation about the participants, products, models, methodology, everything are changing very rapidly. Even nowadays, they're still changing.

So with that, I will give you some background on how the financial markets actually started, and that's really the history part of this industry. So, when we talk about markets, we know in early days people need to exchange goods. You have something I don't have, I have something you don't have, so there's exchanges.

Then it becomes centralized. There are stock exchanges, futures exchanges all over the world where these products will be listed as securities on these exchanges. That's one way of trading, which is centralized. Obviously, in the last 10, 15 years, now we have ECS, electronic platforms. Trade over even larger volume of those trades. So, financial products is really just one form of trading.

There are many other ways of trading aside from exchanges. One of them, which is called OTC, is over-the-counter, meaning two counterparties agree to do a trade without really subject to the exchange rules, or the underlying trading agreement does not have to be a securitized product, or standardized, or whatever ways you define it.

And the different regions have different exchanges and markets, as well. And they typically specialize in local products, local company stocks, local bonds, and local currencies. So, there are many different forms. So again, what's in common? That's

the question you need to ask. Also, you don't know the specifics.

And the currencies, money itself, are also traded. And that's where different currencies issued by different countries. So, when we talk about trading stocks-- there are also people trade baskets of stocks, trade groups of stocks together, and that's stock index or indices. So, there are different types products.

How the stock get listed on the stock exchange? It goes through IPO-- Initial Public Offering process. So, when a company changes from private to public, it goes through this IPO process. It's called primary market, primary listing. And once the stock is listed on the exchange and it becomes traded in the market, we call it secondary trading. So, that's after the primary market.

And equity or stock is one form of trading or one form of financial products. What are other forms? Loans. Actually, debt products are more generic than equity products.

When you started thinking about it, what is really finance is about? It's really about someone has money, someone doesn't. Someone has money to lend out, someone needs to borrow money. So, that's loan. Loan is really a private agreement between two counterparties or multiple counterparties.

When you securitize them, they become bonds. And when you look at bonds, every government will issue large sovereign debt. So, US government has large outstanding US Treasury debt-- bonds, notes, bills. And corporates have issued a lot of debt product, as well. They borrow money when they need to build a new factory or expand. Universities borrow money.

When MIT needs to build a new building, some of the money will come from the endowment support, some will come from some other form of research budget, or some will come from debt financing. Just borrow from the public-- local governments, states, counties, even. So, they have various forms. So, that's product.

Commodities, actually, you know. Metal, energy, agriculture products are traded,

mostly in the futures format and some in physical format, meaning you take deliveries. When you actually buying and sell, you build a warehouse to take them. You ship a tank to store above the ocean.

And the real estate, you're buying and sell houses. 2008 financial crisis, if you read about it, this has a lot to do with the real estate market, the mortgages, and asset-backed securities. So, I'm not trying to give you all the definition, dumping the information on you. But I like you at least hearing it once today, and then you have more interest, you can read on the side.

So asset-backed securities is when you have an asset, you basically issue a debt with the asset backing it. And how do you rate the asset's risk level and what's the income stream, cash flow? And before 2008 financial crisis, as you heard, large amount of CMBS-- basically, it's a commercial real estate backed securities, mortgage securities, and the residential, as well.

And further of all of these, you heard probably a lot about the derivative products. So, that started with swaps, options. And the structure of the products, it become more tailor-made for either investors or borrowers to structure the products in a way to suit their needs. And some of the complexity of those structured products become quite high, and the mathematics involved in pricing them and the risk management become rather challenging.

So coming back to the players in the market, one large type of player is really bank. Essentially, after 1933 Glass-Steagall legislation, there were two main types of banks. One is called commercial bank, the other is investment bank. Commercial bank is supposedly, you're taking deposits and lend out the money, and doing more commercial services. Investment bank supposed to focus on the capital markets, raising capital, trading, and asset management.

But obviously, after 1999, the Glass-Steagall was repealed. There's no longer that. Some people blame that, and probably for a very good reason, for the cause of 2008 financial crisis. But I want to tell you how currently investment banks are organized.

Vasily just mentioned he works in the fixed income. So banks typically organized by institutional business and asset management. So, within the institutional client business, it has typically three main parts. Fixed income, which trade the debt and the derivative products. Equity, trade stocks and the derivative products. And IBD, stands for Investment Banking Division, which really covers corporate finance, raising capital, listing a stock IPO, and merger and acquisition, and advisory.

So that's how banks are organized. Outside banks, other players, basically, the asset managers, are obviously a very big force in the financial markets.

So the question a lot of people ask is, is this a zero sum game? I'm sure you've heard this many times. So, in the financial markets, some people win, some people lose. A lot of times, it depends on the specific products you trade, the market you're in. It is, lot of times, pretty net zero. But why do we need financial markets?

This comes back to what I described before. Because something existed-- actually, there's a need for it. It's really the need to bridge between the lenders and the borrowers. That's really coming down to the essential relationship. So, investors who have money need to have better yield or better return, better interest.

In the current environment, when you have a savings account, you don't really earn much at all. And so you would have to take more risk to generate more return, or you have longer horizon CDs, other type of products, or trade the stocks. So, when somebody has money, when you trade stocks, you're essentially-- you're buying a stock, you give the money somewhere. Supposedly, it will go to the company. Company use the money to generate a better return.

And for the borrowers, whoever needs money, they need to have access to the capital. So obviously, different borrowers have different risks. Some people borrow money, never return. So, never generate any returns, or never even return the principal. And so the trade between lenders and the borrowers, is again, essentially the main driver of the financial markets.

So, a few more words about the market participants. So, banks and so-called

dealers play the role of market making. What is market making? So, when you or some end user go to the market, wants to buy or sell, typically, if there's no market, you don't really find the match. And some of the products you want to buy or sell may not necessarily be liquid.

So, the dealers step in the middle, make you a price. Say, OK, you want to buy or sell. I can tell you the stock. I make you price. $0.99, and that's my bid. $0.95, that's my offer. So, that's the price I'm willing to buy or sell.

But what the result of the trade-- the dealer actually takes the other side of your trade. So, they take principal risk, in this case. So, that's the difference between dealers and the brokers. So, brokers don't really take principal risks. If you want to buy something or sell something, if I'm a broker, I don't make you a price. I go to the market makers. I actually put two people together, matchmaking, make that trade happen. So, I earn the commission. So, that's a broker's role.

So obviously, there are individual investors, retail investors, same meaning. Mutual funds, who actually manage public investors' money, typically in the long only format. Long means you buy something. So, you don't really short sell a particular security.

Insurance companies has large asset. They need to generate a return, generate cash flow to meet their liability needs. So, they need to invest. And the pension funds, same thing. As inflation goes higher, they need to pay out more to the retirees, so where do you get the return? Sovereign wealth fund, similarly, endowment funds-- they all have this same situation, have capital and needs to deploy and to make better return.

So this other type of players, hedge funds. So, how many of you have heard hedge funds? OK, good. Almost everyone. And Peter mentioned that he used to work at a hedge fund. And so, there are different types of strategies, which I will dive into a bit more, but hedge fund play the role in the market-- they basically find opportunities to profit from inefficient market positioning or pricing, so they have different strategies.

And the private equity is different type of funds. They basically look to invest in companies and either take them private or investing the private equity form to hopefully improve the company's profitability, and then catch up. And governments obviously have a huge impact on the market.

So, we know in the financial crisis, government intervened. And not only that, at the normal market condition, government always have a very large impact on the market, because they are the policymakers. They decide the interest rate and interest rate curve. And the different policies they push out, obviously, will generate different outlook for the future markets, therefore, profitability. Then the corporate hedges and the liabilities. When corporates borrow money, they create some risk, so they need to be sensitive to the market, it changes.

So, to summarize the types of trading. The first type is really just hedging. That means you're not proactively adding risk to what you have. You already have some exposure. Just give you an example.

Let's say you borrow money, you bought a house, so you have mortgage. So, let's say it's a floating rate mortgage payments. And you're worried about interest rates going higher, so you can lock that rate in into the fixed rate format. Or you can find ways to hedge your exposure.

Or your corporate has a large income coming from Europe. So, you have euros coming in, but you're not sure if euro would trade stronger to the US dollar in the future, or trade weaker. If you think it will be stronger, you just leave it. But if you think it will trade weaker, so you may want to hedge it, meaning you want to sell euro and buy US dollars. And so that's the hedging type.

The second type, as I mentioned, is a market maker. So, market maker also takes principal risk, but the main source of profit is really to earn the bid offer. I gave you the example $0.90 bid, $0.95 offer. So, that's what the market maker is trying to profit from. But obviously, they have residual risks sitting on the book. Not every trade is matched.

So, how to optimize those group of trades, that's what market maker is doing. Most of the bank's dealers are market makers. In the new regulation, obviously, proprietary trading is [INAUDIBLE], right?

And so the third type is really the proprietary trader, the risk taker. So, these are the hedge funds or some portfolio managers. They need to focus on generating return and control the risk. So, that's where the beta and alpha, the concept comes in. So, if you're a portfolio manager, some people say, don't worry. Don't go pick any stocks. Just buy S&P 500 index fund. Very cheap. You can pay very little cost to do it. That's true.

But if you want to beat the S&P 500 index-- let's assume we call S&P 500 index fund is asset B. So, the return of that, R of the b. That's a return of that index. Now, you have a portfolio A. Your time series of return of your asset A, obviously, you can do linear regression. Lot of you are math major here, and you can find a correlation between those two time series. So, how the two returns are related in a simplified form.

So you can say, this actually-- somehow it came out. It's supposed to be alpha and a beta, but it turned out to be the letters. So, in a short description, beta is really-- just think as a correlated move with the other asset. Alpha is really the difference in the return. It's a format. You want to beat S&P 500, so you want to basically have certain tracking of this index, but you want to return more on top of that.

So let me just go in bit of details of how each type of trade actually occurs. So, when we talk about hedging, I mentioned the currency example. Let me give you another example. There are a lot of people issue bonds, or issue a debt.

So this example I'm going to give you is, let's think about Australian corporate. Because interest rate in Australia is higher than in Japan, so typically, people like to borrow money in Japan, because you pay smaller interest. And they invest it in Australia. You earn higher interest rate.

So let me ask you a question. Who can tell me, why don't people just do that all day

long, just borrow from Japan and invest it in Australia? Then that interest rate, I'm giving you example of a difference is about 3 1/2% for the roughly 10 year swap rates. Yeah, go ahead.

AUDIENCE: [INAUDIBLE].

JAKE XIA: Right. Because you invest in the Australia Ozzie, Australian dollar. The Australian dollar may become weaker to the yen. You may lose all your profit, or even more.

And further, if everybody plays the same game, then when you try to exit, you have the adverse impact of your trade. So, let's say you think that's the right time to do it, but then at one time, you wake up, you said, huh, I think too many people are doing this. I want to hedge myself. So, what do you do?

AUDIENCE: [INAUDIBLE]?

JAKE XIA: Yep. So, you try to lock in, right? So basically, you sell the Australian dollars, buy the Japanese yen. Or on the interest rate terms, you say you'll basically pay the Australian dollar in the swap leg, and the receive yen.

This involves foreign exchange trade, interest rate swap, and the cross-currency swap. So, your answer about currency forward is roughly right, but obviously involves a bit more in actual execution.

So that's just to give you example. Even if you are not a finance guy, you work in the corporate, you just do you import, export, or building a factory, you have to know, actually, what the exposure is. So, risk management, nowadays, becomes pretty widespread responsibility. It's not just the corporate treasury's responsibility. So, that's on the hedging side.

Obviously, if you are Intel, for example, you sell a lot of chips overseas. And your income-- actually, Intel does have lot of overseas income sitting outside the states. So, the exposure to them is if the exchange rate fluctuates, dollar becomes a lot stronger, they actually lose money. So, they need to think about how to hedge the revenue produced overseas.

And obviously, for import exporters, that's even more apparent. And if you're entering in a merger deal, and one company is buying another, you need to hedge your potential currency exposure and your interest rate exposure. And whatever is on the assets, or the liability, or the balance sheet, you need to hedge your exposure.

So we talked about hedging activity. Let's talk about market making. So if it's a simple transparent product, everybody pretty much knows where the price. So, if you buy Apple stock, I think a lot of people know pretty much where it is. You may even have it on your cellphone, know where that stock is.

But if it's not transparent, so what do you do? So, if instead of asking you where Apple is, probably you're going to tell me $495 today.

AUDIENCE: I don't really know.

JAKE XIA: OK. But if I asked you instead, what is the core option on Apple stock in two month's time? I'll give you a strike, let's say, 500. So you're probably less transparent.

So that market maker comes in to provide that liquidity, and then takes the risk. They manage the book by balancing those Greeks, which I mentioned earlier. Delta, which describes the [INAUDIBLE] relationship of this whole book to the underlying stock, or underlying whatever currency. That's called a Delta.

Gamma is really the change of the portfolio. Take the derivative to the delta, or to the underlying spot. So, that's second order derivative. Delta is the first order. So Gamma, now you have curvature or convexity coming in.

And Theta is really-- nothing changes in the market. Nothing changes in your position. How your trading book is carrying or bleeding away money. And we talk about the volatility exposure was Vega.

And on top of that, what are the tail risks? What are the events can actually get you into big trouble? So people use value at risk. So you will hear this "var" concept in some of the lectures, which is also, obviously, a very important concept. I think

Peter will-- or Choongbum will-- probably Peter will teach.

Then capital. How much capital are you using? It becomes a very important issue nowadays. And balance sheet. Again, you have asset, you have liability. How do you leverage? How much leverage you have?

Before the crisis, for example, lot of the banks leverage up 40 times, meaning when you have $1, you had $40 exposure. So when the market moves little, you get wiped out. That's really what amplified in the 2008 financial crisis. And how do you measure the asset in balance sheet when you have derivatives rather than a straightforward notional?

So lot of qualitative type of people like to focus a bit more on the risk taking side, because people heard stories about successful cases of some hedge funds using high math. They generated very impressive returns and they seem to have an edge. So now, people focus on trading strategies.

So that falls into the category of proprietary trading or risk taking. So that you can just simply doing directional trading strategies. Just go long or short the stock. That's very simple. Those so-called the gut traders, gut feeling. Go with your gut. You don't even think. You say, I'm eating curry today, so I go long. I'm eating rice tomorrow, so I go short.

So, this arbitrage. Arbitrage is really to find the relationships between prices, and try to profit from those relationship mis-pricing. This is actually very interesting. Not many people focus on arbitrage, because lot of people are gut traders. You essentially just watch your own market. You don't really care what's going on.

If you trade gold in the states, the gold price happen in Asia and in Europe matters, right, because you're trading the same thing. If they are not priced the same way, you can profit from the difference. And that's just a simple example.

But a spot price versus forward price, that's a deterministic relationship. It's a mathematical relationship. If that relationship breaks down, you can also profit. So

there are many examples mathematical relationship which gives you the arbitrage opportunity.

The other type is called a value trader, or relative value strategies. Think there's a deterministic, temporary mathematical relationship. You look at the longer term in horizon, trying to determine what is really the underlying value of a particular instrument, then trade on the relative value. Obviously, there are successful value investors out there.

And the systematic trader builds computer models. One example is trend following, so just follow the price trend. That used to be an effective strategy for some time, but when lot of people doing the same thing, that becomes much less effective. Or momentum, same thing. Stat op, finding statistical relationship among large number of stocks, then trade at the higher frequency.

And fundamental analysis, you're really trying to understand what's going on in the world. What is the trade balance? What is the earning potential of a company? What's the trade balance of a country? What is a policy change? What does it mean when Federal Reserve announce they're going to taper the quantitative easing? The wide stock market is sold off in the last couple months, especially wide stocks in India, Brazil, Indonesia, sold out more. Why is that?

So it goes through those fundamental analysis. And there are special situations. Some companies are going through particular difficulties, assets are priced very cheaply. So, there are firms out there-- you probably heard Bain Capital and many others-- where they focus on these private equity and special situation opportunities.

So what have all of these to do with mathematics? Where does math come in? How do you use math? So, I want to give you some aspects of that.

So from my personal experience, I joined the market, really start to working on pricing models. So, that's the first area. So, math is very effective, because when you, your bank, your corporate, you want to buy some financial instruments, you

have to know where is the price. It's easy to observe a stock in the market, but when it comes to more complex products, they just take one step forward on the complexity, which is the option. You have to know how to price an option. So, that's where the math comes in.

You actually have to be able to solve differential equations to get a model price, then you obviously adjust to your assumptions to fit into the market. So, pricing model, which Vasily and many of his colleagues can tell you more-- which is very much a very interesting and challenging area. How do you price all these instruments?

And when I say pricing, it's not in the narrow definition of just coming up with the price. When you build a pricing model, you also generate the risk parameters of these instruments, and how do you risk manage them. So, that comes to the second part.

So math is very useful in risk management, which I will give you some not a quiz questions after this slide. You can see that risk management itself is very challenging. It's not a purely mathematical question, but yet, math plays a very important role to quantify how much exposure you have.

Then, the third is trading strategies. Again, I think a lot of people with math background, or in general, people are looking for the so-called holy grail trading strategies. It's almost like perpetual motion machines, people looking for 100 years ago. You just turn and on. It makes money by itself. You go to sleep, you go on vacation, you come back, you'll have more in your bank account. Obviously, that's not going to happen.

The robotrader, a robotic trader, is a dream. It has its place or its use, but it's a fast evolving market. You have to constantly either upgrade your research and adjust your strategies. There's no such thing you can build and leave it alone, it runs for itself forever. But I just want to mention that because maybe towards the end of the term you will feel, hmm, I came up with this brilliant trading strategy. I think it's going to make money forever. Please let me know first.

AUDIENCE: And me second.

PROFESSOR: So, I want to leave some time to Vasily. Actually, he can give you some examples of projects of last year's students who actually came to this class and did some real application at Morgan Stanley. But before I hand it over to Vasily, let me ask you some questions. I just want to-- not really to quiz you, just give you the sense how math and intuition and judgment can come into the same place.

So, let me first give you an example I call risk aversion. So, you are facing two choices, choice A and a choice B. Choice A being you have 80 chance to lose $500. You have 20% chance to win $500. That's pretty clear, right? That's choice A. Or choice B, you basically just lock in you have 100% chance to lose $280.

Let me ask you, for whoever likes to choose choice A, please raise your hand. One, two, three, four. About six out of say, let's call it 50. So, can I ask you why you think choice A makes sense?

AUDIENCE: So, I know it's a lower expected value, but I enjoy gambling and I would rather take the chance of--

JAKE XIA: Right, because you don't want to lock in that $280 loss, right? That, or you still have 20% chance to win. For the ones raised their hand for choice A, are there any other reasons? Same reason.

AUDIENCE: [INAUDIBLE]

JAKE XIA: I assume the rest of you would choose choice B, unless you neither. how? Many of you chose choice B? Choice B. And are there anybody think neither is right? You have to choose. No, you have to choose. So, either choice A or choice B.

So, let me just talk a little bit about this. Again, I'm not trying to tell you which one is right, but I just share my thoughts how we look at these. Why it called risk aversion? So, this is very common human behavior.

When you go to the market, you buy a stock. When the stock goes up, makes bit of

money, the natural tendency for especially someone is new to the market is to let's take profit. Let's sell. Oh, I made $1000. I made $500. Let's go have a nice meal or whatever. Buy an iPad.

But when the stock loses money, what's the natural tendency?

AUDIENCE: [INAUDIBLE]

JAKE XIA: That's--

AUDIENCE: [INAUDIBLE]

JAKE XIA: I think natural tendency, lot of people will keep it. I think if you have the discipline to get out, that's great. Trading is really all about how do you risk manage, have a discipline, and how to manage your losses. The natural tendency of a lot of people is, well, I think there's a 20% chance to come back, and I'm going to make $500 more. Why do I want to lock in to stop myself out at 280?

So even though the expected value-- I think lot of people said, you lose expected value, which is $300 in choice A, but you would still not to choose choice B, because you don't want to lock in the $280 loss. Again, I'm not trying to inject the idea to you of which one is right or wrong, but think about it. So, that's really the common behavior, which mathematically may not make sense, but lot of people still would like to do.

And also, really, when you think about it, depends on your situation. And let's say, you think the market-- I'm giving you the stock example again. If you're not purely following the discipline of stop loss, but you just think the fundamental picture has changed. You really don't think the stock should go up anymore. Obviously, at whatever level you should get out, regardless how much loss you lock in.

But if you think the fundamental story is still very sound, you should think about as if you don't have a position what you want to do next. But anyway, mathematically, I just want to see-- I guess this is MIT, so many people think mathematically where you would actually choose choice B, because that's low expectation, which makes

sense. But I think if you ask a larger audience, I think a lot of people don't really want to choose choice B, because they don't want to lock in the loss.

Now, let me change the question a little bit. So, choice A becomes instead of the 80% chance to lose, now you have 80% chance to win $500 and 20% chance to lose $500. Choice B, you have 100% chance to win $280.

Who would choose choice A? Again, minority of this audience. Let's say less than 10%. Who would choose choice B? The rest of you. All right.

Can someone choose choice A give me an argument why would you?

AUDIENCE: [INAUDIBLE]

JAKE XIA: Yep. Anyone want to give me a reason for choice B?

AUDIENCE: How you shop. How you shop.

JAKE XIA: How I shop? Mm-hm. Yup. Well, let me just leave it here. Again, I think we can talk a bit more along in the class. I mean, the last day of the class, hopefully we'll have much deeper discussion on this. It's not unique.

The answer, I think it can go you either way, as you said. If your bank account balance is-- let's say you are a freshman student. Your bank account is $800. Your choice will be very different from someone has $100,000 in his bank account. And also, your risk tolerance, how much you can tolerate.

I'm not going to give you say, this is right or wrong. But with that, let me move on and give you some homework. So, before I give you the homework, I want to make a few more comments. Do people always learn from their experiences? In science, we collect evidence, we build models. We first understand the physics. We build mathematical models, then we verify in physics, doing experiments.

But is that the same investigation process in finance? Market cycles are typically very long, but people tend to have short memories. So, how do people really learn from their experiences? A very interesting question.

And very natural tendency is to extrapolate historical experience. What happened in 2008? People still remember. What happened in 1970s? Maybe some people still remember. What happened 100 years ago? So, people tend to extrapolate, drawing conclusions from very recent experience.

And deterministic relationship versus statistical relationship is very interesting, as well. When you try to trade on those, how do you really build models? Is the market really efficient? What part is efficient? How do you really apply those theories in your day-to-day risk management or trading activities?

And sometimes, people tend to oversimplify. Just say, oh, I can model this. This is one important parameter. I just take that.

So I just give you all the warnings that the-- again, very young, new field and largely often, this is art, than science. So keep that in mind, even though we're talking about mathematics in finance. Math is very powerful and useful in finance. So learn the math, learn the finance first, but keep those questions along the way when you are learning during this class.

So suggested homework, optional. I mentioned a lot of terminologies today. Go to the course website, read what we have put up for the financial glossary. So if you still have things you don't understand, compile your own list of financial concepts, which you can search on the web or even ask us. But I encourage you to do that. It will prepare you well. So, that's really-- and read other materials on the course work.

So we got maybe-- how about this? We still got about 15 minutes or 12 minutes left, so I'll pass it to Vasily, then maybe we can leave five minutes for some questions.

VASILY STRELA: Yeah.

JAKE XIA: Yeah, OK.

VASILY STRELA: [INAUDIBLE] mentioned that, Apple trades, that now it's [INAUDIBLE]. Yeah, just a couple of [INAUDIBLE]. Well, first of all, no offense to people who were [INAUDIBLE], but I just wanted to give an example of

[INAUDIBLE].

AUDIENCE: [INAUDIBLE].

VASILY STRELA: --because he was working in our group, and it just will give you a little bit of an idea what we will be talking about and what actually we do in the daily life, or what an intern or somebody who comes to work in this industry could do.

And one project is [INAUDIBLE] I worked was on estimating the noisy derivative. Derivative is called delta. Delta is usually the first derivative to a function. And as we will see in the class, quite often, to obtain a price, you do it through Monte Carlo, meaning running a lot of paths and then averaging along them. So, it's a statistical methods. So obviously, there is a noise to your answer every time.

So, if you want to differentiate this functions and get a derivative, then this derivative will be quite noisy. And so, instead of getting the true derivative, you might obtain something quite different from two derivative just because there is a confidence interval around any point. And obviously, there is a trade off here, as well, because you can run more paths, throw more computational power, which will reduce your confidence interval. You will know better where you are, more precise.

Or the other solution could be, if you know that your function is not too concave and reasonably flat, you might do the numerical differentiation on wider interval. Basically, reducing the significance of the error, and you will hope to arrive to a better approximation. So obviously, there is somewhere balance, and the question was, is there an optimal shift size to get the derivative? And that's what-- uh oh, the slide got corrupted.

So, there was quite a bit of mathematics involved and minimization and optimization. There was an answer. And that's actually what we finally arrived at. And that's some toy example, but still, it shows you that if you use constant size and not optimal size, that would be your numerical derivative of this blue function.

While if you use an optimal shift size, which [INAUDIBLE] computed, it would be much smoother and much better. So, that's one of example, and that's what he did.

And we actually are implementing it in our systems and plan to use it in practice.

Another project was actually quite different. And it was about electronic trading and basically how to better predict prices of currencies and exchange rate. And funny enough, it was on ruble US dollar, because it was actually aimed for our Moscow office.

And basically, what we had, we had the noisy observation of broker data and it was coming out at different non-uniform times. Basically, at random times. So, we decided to use Kalman filter and to study how it can predict. And that's one of the nice graphs [INAUDIBLE] produced, which again, we will use this strategy and the Kalman filters which he constructed in our e-trading platform in Moscow.

So, that's just a couple of examples, which I wanted to give you as a preview of what we will be talking in the class. Just to remind, the website is fully functional. We put syllables there, a short list of literature. We will be posting a lot of materials there. Probably most lecturers will be published there. Jake's slides are there already.

So, any questions?

JAKE XIA: Please hand back the sign up sheets. We like to get your emails so we can put you on the website for further announcements, but you can also add yourselves. [INAUDIBLE]. But it's probably easier if you put your email on the sign up sheet, so we can [INAUDIBLE].

VASILY STRELA: Yeah, but please visit and sign up here, because there will be announcements to the class. Thank you very much.