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ANDREW LO: These are the financial highlights of Lehman Brothers as of the end of 2007. Now, you can get more recent highlights from looking at their SEC filings, their 10-K and 10-Qs which are accounting reports that they provide to the SEC on a quarterly basis. But I just thought we'd take a look at the annual financials of this business.

At the end of 2007, the net revenues for Lehman Brothers was \$19 billion. This is a firm that earned \$19 billion in revenues in 2007. We're not talking about a small little shop here. This is a major financial institution. And if you look at their profits, their net income, \$4 billion of net income in 2007. And 2007 was not a great year, so \$4 billion of income is a pretty impressive number.

And if you look at their long-term capital, the capital base, we're looking at \$145 billion. And if you take a look at their assets under management, the assets under management, in billions, is \$282 billion of assets under management. Now, at the end of 2007, would anybody have forecasted that a company like this could be gone nine months later? Gone-- I mean, just obliterated. 28,500 employees, so we're talking about major disruption to the New York workforce. A number of people are going to be looking for jobs.

Now, a number of jobs are going to be created as a consequence of these dislocations. I'll come to that in a minute. But this is an extraordinary set of events. And one key to what's going on and why this might have happened is this number right here, the net leverage ratio. That net leverage ratio tells you something about how much exposure Lehman Brothers had relative to how much capital they're actually managing.

And let me give you an example of what I mean by that. And I'm going to give you a personal example that we're going to come back to. We talked about mortgages last time, and I told you all that you now have the power to compute mortgage payments.

Well, you know that a mortgage is a loan, right? You're borrowing money from the bank to buy this beautiful home that you want to live in. Does anybody know how much money you typically have to put down when you buy a home? Yeah.

AUDIENCE: [INAUDIBLE]

ANDREW LO: 20% is the typical number, although in recent years, it's much less than that.

For example, when I first bought my home way back in 1988, my first home, when I moved here to Boston, I actually only had to put 5% down because I was able to get a jumbo loan and, in addition, purchase mortgage insurance so that the bank was willing to lend me quite a bit more than they usually would.

Now, let's take the 20% down as the standard number because that is absolutely industry standard. If you put down 20% for, let's say, a \$500,000 home-- which in the Boston area is a little starter home, I'm afraid-- a half a million dollar home you put down \$100,000. And the bank lends you \$400,000.

The value of your total assets is, of course, 500,000, right? You've got 100,000 of your own money, 400,000 of the bank's money, and with that 500,000, you give it to the other party to buy the home. And now you are the happy owners of a \$500,000 home. What kind of leverage ratio do you have in that circumstance? Anybody calculate that quickly?

AUDIENCE: It's 4 to 1?

ANDREW LO: Close, but no cigar. 5 to 1, right? 5 to 1 in the sense that you have five times leverage. Your total exposure is 500. You've got 100. It's 5 to 1. Now, what does that mean, 5 to 1 leverage? That sounds scary. That sounds like you are really levered up.

Well, it's only scary if the value of the assets swings around a lot. For example, let's do a simple back-of-the-envelope calculation. Suppose house prices fall by 10%. That's only 10%, right? That's not a huge number. It's significant, but it's not huge. What's the return on your investment? How much have you invested in the home?

AUDIENCE: 100,000.

ANDREW LO: \$100,000. If the value of the home falls by 10%, how much has the value of your assets fallen by? 50,000, right? Of that 50,000, how much does the bank lose?

AUDIENCE: None.

ANDREW LO: None, right, because they've lent you money, and they expect you to pay it back. They're not equity holders. They're not looking to take on any downside risk. They just want their money back with interest.

So the bank doesn't care what the value is. They still expect you to pay back the \$400,000 that they lent you with interest. So that \$50,000 loss, it's all yours. And you've put down 100,000, and you've lost 50-- half of your assets just got wiped out with only a 10% move in the value of the home.

Now, instead of putting 20% down as a standard, what if you did what I did, which is you put down 5%? So 5% of \$500,000 is \$25,000, right? The bank lends you \$475,000.

So this is not a conforming loan. You've got to buy insurance, and it's subprime, so on and so forth. 5% is your investment, \$25,000. Now, suppose housing prices go down by 10%. What's the return on your capital?

AUDIENCE: Negative.

ANDREW LO: Well, you've lost everything, right? The \$50,000 loss is still there, but you only put in 25. So you've now lost all of your capital, and on top of that, you're in the hole for another 25. So you've actually lost not only all of your wealth, but actually, you've lost more than all of it. You've lost minus 100% of your wealth or your total return. Your net return is minus 200%.

So, if you're a major financial institution, and you're leveraged 16 to 1, and the value of that portfolio declines by 10% or 20%, you can go through capital very, very quickly. Now let's do a back of the envelope. The amount of capital that they have-- let's go up and take a look at this. The amount of capital that Lehman had is something like-- total long-term capital \$145 billion, OK?

If you leverage that 16 to 1, and then you ask the question, with that leverage amount of capital, if it drops by, I don't know, 10%, 5%, 7% of that total asset base, you can see how you can go through \$145 billion of capital pretty quickly with leverage.

Now, you might ask, why on earth would anybody do this? Why would you leverage 16 to 1? Well, why would anybody buy a house in New England with 5% down? That's just as crazy. What's the leverage ratio if you put 5% down?

AUDIENCE: 20 to 1.

ANDREW LO: 20 to 1, exactly, so I was a proud leveraged investor that had 20 to 1 leverage. I beat Lehman Brothers. Why would I do that? Is that insane? Well, yeah.

AUDIENCE: So you don't [? tie ?] up too much capital.

ANDREW LO: Well, yes. That's a very polite way of saying it. Yes, I would tie up too much capital if I didn't do that. The fact is, I didn't have the capital. So thank you for being kind. But why wasn't it nuts? Yeah.

AUDIENCE: [INAUDIBLE]

ANDREW LO: Exactly. If the value goes up, then I earn that kind of money, the same kind of money. So if housing prices go up by 10%, then at 20 to 1 leverage, I look like a hedge fund manager, right? Make a ton of money, but that's not the only reason that I'm willing to do that because you're saying that I want to take that risk. Why would I do that? Yeah, Michael.

AUDIENCE: Well, your risk seems very low.

ANDREW LO: Why?

AUDIENCE: Well, in the past, there's nothing to indicate that prices would go down.

ANDREW LO: Exactly. The risk of 20 to 1 leverage is only a risk if the amount of housing price fluctuation is such that it could actually wipe me out. But up until very recently, housing prices have done nothing but this. They've gone up. And not only have they gone up, they've gone up in a very smooth and orderly fashion.

You know, if house prices went up by 15% a year every year, you might be thrilled, but also a bit scared. That's not what happened. Housing prices have gone up, maybe, I don't know-- 8%, 10%, 7%, 5%, 6%. It's been relatively smooth. And so the volatility, the volatility of those kinds of investments were low enough that the leverage didn't scare me at all. And in fact, I didn't lose money. I held that house for about five or six years and bought another one, and it was fine. It was fine because that kind of leverage is not a problem as long as the volatility of the overall investment wasn't out of hand.

What happened over the last two or three years is that the volatility has gotten out of hand. And we're going to talk about that Wednesday at that pro seminar. I'm going to give you a concrete illustration not only of how it got out of hand, but how financial engineering and the design of derivative securities to expand the housing market and provide people with these loans exacerbated the problem on the downside. But of course, the purpose of it was to help people on the upside. It's exactly looking at the investments going up and thinking that, gee,

they could never come down. Yeah, question.

AUDIENCE: What about the fact that at the end of the day, you can live in your house? And the total valuation of your house, if it goes down \$100,000, it's still a [INAUDIBLE].

ANDREW LO: Right.

AUDIENCE: So you only have to deal with the mark to market [? up and down. ?]

ANDREW LO: That's a very important point. The mark to market. What does mark to market mean? Anybody know? We've never used that term in class so far. Yeah.

AUDIENCE: It's something that book value gets [? matched ?] [? together with ?] reality.

ANDREW LO: That's right. When something that may have a book value gets marked to a reality check in terms of market price. So for example, the first lecture, where I auctioned off that little tiny box that you had no idea what was in there, it had no market value beforehand, at least not to any of you. But we marked it to market. We marked it to market at 45 bucks. And so it established a market price.

Now, the question is, who cares what the value of the house is? You're living in it, you're enjoying it, so what's the big deal? Well, that's right. It's not a big deal if you enjoy living in the house, and you can afford to pay the mortgage, and you're OK. And millions of homeowners are exactly in that situation. So we can't forget that.

That the subprime mortgage has enabled literally millions of homeowners to become homeowners who never could have. But what if there's a problem in terms of interest rates going up and your mortgage payment going up because you ended up getting a very low teaser rate for your mortgage? You've got an adjustable rate mortgage because they said, gee, you could buy this house with virtually no money down. And you've got plenty of resources to be able to pay for it because your payment is only \$300 a month. And then, a year later, that mortgage payment is \$1,000 a month. Then it's a real problem.

OK, then you've got a decision. The decision is, are you going to keep paying all of your income and have a hard time making ends meet for a house that you'll never get the money back? It's literally taking your money and burning it because you've lost your equity. And you've lost so much more beyond your equity that in order to make money you'd have to hold onto the house for 20 years, and you can't afford the house anyway. Do you do that? Or do

you put the key in the front door and move out and say, you know what, bank, it's all yours. I'm moving on.

That's what's happened across the country. It's the fact that people can't afford these mortgages because they got in at low teaser rates, and now the rates have come up because the interest rates have been going up. Now, something very significant is going to happen tomorrow. Tomorrow, the Fed is almost surely going to cut rates because they want to reduce the pressure on the system for exactly these kinds of issues. They want to reduce the kind of default rates. And by keeping interest rates low, they actually are going to be able to encourage liquidity and reduce the kind of pressure that we've been seeing. Yeah, question.

AUDIENCE: I was going to ask what happens if you put your 5% down, and the value of the house goes down, say, 25%, it's been only a year. You feel like you're not going to get-- it's never going to come back up. Can you literally just go to the bank and say it's yours?

ANDREW LO: Well, that depends on what you signed when you got your mortgage from the bank. Most mortgage contracts are known as non-recourse loans, meaning that they've got your house as collateral, but that's all they've got. They don't have your firstborn, they don't have your pinky finger. And depending on where you borrow, in some cases, you may have to give that up.

But no, the fact of the matter is the most they can do is take your house away and sell it. And a lot of homeowners are saying, great, it's all yours. I'm moving out of Stockton, California. I don't need the house. I don't need to have these mortgage payments where I'm throwing in good money after bad. That's their perspective.

AUDIENCE: What about your credit score?

ANDREW LO: Yes, so your credit score will go to hell. So you wait. So you'll wait five years or seven years, and then you'll be back again. There's a finite limit on how long they can keep those kind of credit scores. And beyond a certain point, you will have a clean record.

But even with that bad credit score-- I mean, don't forget, that's how the subprime mortgage market got created. You saw the TV ads, right? Doesn't matter if you're in default, doesn't matter if you have no credit, doesn't matter if you don't have a job, we'll still give you a loan. Now, that's not true today, or not as true today, but at some point when the market recovers, we're going to see that come back again. And so you will be able to borrow again. Yeah.

AUDIENCE: Given that the interest rates are now going up, does that mean the [INAUDIBLE]--

ANDREW LO: Going down.

AUDIENCE: Despite the fact that the financial cut [INAUDIBLE], the actual interest rate that homeowners are paying hasn't changed.

ANDREW LO: Right.

AUDIENCE: So does that mean that those with good credit are effectively subsidizing those with bad credit?

ANDREW LO: Well, yes and no. I mean, I think that the subsidization that you're talking about really happens very, very indirectly. The fact that there are large numbers of defaults ultimately may mean that it's harder to get a subprime loan. So the folks that are actually good credits, but don't meet the prime borrowing rate criteria, yes, they will suffer.

But at equilibrium-- by equilibrium I mean when supply equals demand-- the price is the price. So it depends on what kind of a borrower you are, but whatever type of borrower you are, if you can signal that that's the type you are, you will be able to get that appropriate kind of credit. All right, so in that sense, it's not as if taxpayers are footing the bill for the particular interest rate shifts that are going on.

Taxpayers may end up footing the bill for what happened with Bear Stearns, what happened with Fannie Mae and Freddie Mac. And that's one of the reasons why, over the weekend, when the Fed was approached by Lehman Brothers and said, hey, you've got to help us out here, the Fed said, you know what? We're done with that. You know, sorry, but we can't ask the American taxpayer to foot this bill either. Otherwise there's going to be tremendous backlash.

And so when Lehman Brothers was left without backing from the Fed, they went to a number of private organizations like Barclays. Barclays said that they would be willing to do it if the Fed was able to provide some kind of backstop. The Fed was not willing to provide a backstop, so Barclays said thanks, but no thanks. And at that point, Lehman said, we have no choice because we cannot close a sale within a matter of 24 to 48 hours from this point on. And we've got some notes coming up. We've got to do something, so they filed for Chapter 11. Yeah.

AUDIENCE: If they cut the rates [? as far as ?] they do, what's the negative part? Inflation?

ANDREW LO: Yes. We're actually going to talk about that in this next segment-- inflation. If the Fed cuts rates, one could argue that the reason we're in the mess that we are is because the Fed had kept the Fed funds rate so low for so long that even after the stock market crashed with the internet bubble bursting, the housing market continued on with its bubble because it was still so cheap to borrow. And I'm sure I've mentioned before that when I was an assistant professor at the Wharton School back in 1986 looking to buy a house, the 30-year fixed was at 18%. 18% for a 30-year fixed mortgage. I didn't do it because I couldn't afford it at the time, but think about that versus today. Mortgage rates are maybe at a recent high of 6%, 7%, 8%. That's not bad, relative to historical standards.

OK, so yes, I mean, I think that's the concern that if we keep interest rates too low, that's going to encourage inflation. And inflation will have its own costs. Anybody who's from any Latin American country will know the ghost of inflation is tremendously frightening. And we don't want to let that get out of hand. If you remember back to the 1970s, we had some inflation in the US that was a real problem. So we're going to talk about that in just a couple minutes. Any other? Yes.

AUDIENCE: I mean, is one thing to do [INAUDIBLE]. You said that when the market comes back, we will still have another bubble.

ANDREW LO: Absolutely, yes.

AUDIENCE: And do you think this is reasonable?

ANDREW LO: Do I think it's reasonable? You're not allowed to ask that question to an economist. Or rather, an economist is not allowed to answer that. Reasonable is relative. And there are moral and ethical overtones that economists don't like to get involved in.

It's human nature. Is it human to suffer from fear and greed? Well, yes, and I don't think I'm going to change that any time soon, nor are you going to be able to change that any time soon. So that's one of the reasons why we study finance is to develop an intellectual and disciplined framework for thinking about these issues. Because if you don't, if you don't have a framework for thinking about this, then you're left responding to fear and greed.

Right now, we are in the absolute grips of fear. Those of you who aren't in financial markets, if you read the papers, my guess is you'll start getting scared anyway. And if you're in financial markets, I promise you this is the scariest time that we've been in, including August of '98,

October '87, '94, 2001. All of the kind of periods of market dislocation is trumped by what's been going on over the last few weeks. And it's exciting from the point of view of being a finance student because you actually have the opportunity to understand and do something about this. But it requires a certain discipline to do that. Yeah, Ingrid.

AUDIENCE: What does it exactly mean that Lehman Brothers are bankrupt? Because everybody, I guess it's not a written one, but if I have some money deposited there, will they give it back to me because I am a liability?

ANDREW LO: Well, that's exactly the problem. The answer is I don't know. And that's one of the reasons why there is this dislocation. Nobody knows because nobody knows how large the losses could be. And part of the thing is that the losses at Lehman and other financial institutions, including Merrill Lynch-- Merrill Lynch in some ways has bigger exposure than Lehman. The difference is that Merrill Lynch has other sources of revenue that are able to let it get through this situation a bit more gracefully.

But the problem is we don't know because we don't know how the value of these large assets are going to be valued. If you value them at zero, then they're in deep trouble. And not only are the shareholders going to get wiped out, but a lot of the creditors are going to get wiped out. If you value them at what they're valued now, well, then there are going to be some hiccups along the way, but a number of people should get out without outrageous losses.

AUDIENCE: And can't you sort of declare default, stop paying now, until thing get better? I'm sort of applying my Latin American experience here.

ANDREW LO: Yes, yes. I mean that's exactly what filing for bankruptcy does. When you file for bankruptcy, you basically go to the courts and say, I cannot make good on my IOUs. And I recognize that this is a problem. So I'm going to ask the court to appoint a conservator or supervisor to oversee the disposition and dissolution of my assets in order to make an orderly transition to pay off all of the creditors. And you know who's last in line? Shareholders. That's right.

So most people think the shareholders are going to get nothing, which is kind of astonishing because take a look at their closing price in 2007. The closing price of Lehman Brothers stock, \$62 a share at the end of 2007. Nine months later, it's worth zero. Zero, from \$62 a share. That's a huge destruction of value.

And you know what? Part of that loss in value is really due to the loss of brand and the loss of

business viability. It's intangible assets. It's not like all of a sudden, the Lehman investment bankers and proprietary traders and asset managers, they had brain damage and they're a lot stupider than they used to be. They're just as smart, just as savvy, just as experienced, just as knowledgeable as ever were.

The problem is that because of the magnitude of their exposures, there is general concern about their viability as a business. And when you don't want to do business with them, when everybody doesn't want to do business with them, when nobody wants to do business with them, they're not a business. And the value of their business goes to zero.

And so there's a chicken and egg problem and you know the bottom line is that irrespective of whether it's the chicken or the egg, when the egg breaks, you're done.

Yeah?

AUDIENCE: [INAUDIBLE] Bear Stearns [INAUDIBLE] extremely high?

ANDREW LO: Yes, what happened with Lehman is quite similar to what happened with Bear. Except that with Bear, there was a panic that was triggered by what seems to be some kind of a rumor, not necessarily large exposures coming due.

Bear Stearns actually hedge funds that were engaged in these kinds of subprime mortgages, CDOs and CDSs. Those funds went under during the summer. But Bear Stearns as a business collapsed because individuals really didn't want to do business with it because of this kind of a risk. And the same thing happened at Lehman. Except Lehman's exposure was much larger. They have much larger exposure to these markets. They're one of the biggest players in these particular kinds of securities.

OK, because we're running short on time, I'd like to just take one more question and then let me go on with our lecture. And believe it or not, we are going to cover material exactly related to this when we start talking about fixed income securities. So this is very much apropos.

Yeah, [INAUDIBLE].

AUDIENCE: How do you think this affects us in terms of the people that want to [? be bias? ?]

ANDREW LO: Yeah, great question.

AUDIENCE: [? 25,000 ?] people from Lehman [INAUDIBLE] jobs [INAUDIBLE].

ANDREW LO:

Absolutely. So this is a great question. I'm actually talk about that specifically Wednesday evening. But let me let me give you the short answer now. The short answer is that within the next two or three months, Wall Street will be frozen.

They're going to be a deer caught in the headlights. They won't know what's going on. They won't know what their hiring plans are. They won't know the number of slots.

There's resumes flying back and forth. So it's going to be a bit of chaos for the next two or three months. It's not clear that that's going to affect you. Because internships still have to be filled. Entry level positions are actually of least concern to businesses because those are the ones that they want to fill because the new generation are hungry and smart. Ready to do anything, take on anything, and cheap. That's right. I didn't want to say that but you said that.

Good value. Let me put it that way. You're a good value. So what's going to happen is it will be virtually impossible for a senior managing director from one firm to easily get a job at another firm within the next two or three months until things settle down.

At the entry level job market, I suspect that there will be some disruption. For example, just a simple indication of that today after my 4 o'clock session, I was supposed to meet with the CFO of Bank of America, Joe Price. As many of you know, we established a relationship with Bank of America just recently-- the Laboratory for Financial Engineering to work with B of A to do some interesting research and to get access to their tremendous database. And we were going to launch that set of discussions today with Joe Price.

Not surprisingly, at 3:00 in the morning, I got an email from a B of A employee saying that he will not be coming to MIT today after all. He was a little bit tied up.

By the way, B of A also looked at Lehman over the weekend. So over the weekend, B of A folks wee pretty busy shopping. They looked at Lehman. But again, when the Fed wouldn't guarantee any kind of a backstop for Lehman, B of A passed as well. So that's an example of the kind of dislocation I'm talking about. There will be scheduling glitches and things like that.

Going forward though, after the two or three months, I actually think this is a fantastic time to get into the industry. Because when you have these kind of dislocations, opportunities get created. And opportunities for people that are smart, that are hungry, that are willing to work hard-- I mean, that's exactly the kind of situation that you want to be in. When things are going well, they don't need you. They're going to hire people just to be clerks and to get people

lunch. But now is the time where you can actually have a big impact.

So rather than be discouraged, I think all of you have perfect timing in terms of being in school now. In two years time, you'll get out. That's when all of the businesses are going to be recovering and certainly doing quite well, I suspect. And even within the next six months, you're going to see that a number of firms are going to be hiring.

And by the way, the dislocation we're talking about is on the broker-dealer side. On the asset management side, hedge funds, pension funds, asset management companies, foundations, endowments, non-financial corporations-- they're hiring and they need people with financial expertise to deal with these kind of market dislocations.

So I think that the job prospects are actually quite bright for this class and the class after. The folks that are going to be in a little bit of a tough bind are the second years who will be interviewing for their jobs in the next two or three months. They may end up having to wait a little bit longer. And I suspect that they will take a little bit longer to settle on their jobs. But even then, MIT students end up having a bit of an advantage over other MBAs simply because of the expertise that we bring to the table.

OK. So sorry about taking them so much of your time, but I think this is relevant and will be useful for what we're going to be talking about next.

Let me turn to what we ended with in the last class, which is the inflation topic. Last class, you'll recall, we talked about the two formulas that you're going to know very well by the end of this course, perpetuities and annuities and compounding. And where we ended with was this notion of inflation.

How many of you already know what inflation is and you've talked about it in macro?

OK, some of you. So let me go over it briefly. And I think you'll see very quickly exactly what the idea is. It's really meant to capture the fact that the purchasing power of your money can vary over time, irrespective of the time value of money. And let me explain it this way-- at a particular point in time, let's say time t , you've got a certain amount of wealth, w_t . And the value of the kinds of things that you like to buy is given by an index. Call it $I_{sub t}$. So you could think about that as the price of the basket of goods that you enjoy. OK?

So this will include consumer items, food, clothing. As well, it may include other items-- leisure, entertainment, and so on. And the fact that you have a certain amount of wealth doesn't really

tell you how happy you are. It's really how much you're able to consume. How you use that wealth that tells you how happy you are. So economists really like to focus not on total wealth as a measure of your standard of living, but how you are able to consume that wealth.

So we're going to come up with a basket of consumption goods and call that price of that basket, I at t , all right?

Now let's move from time t to a different point in time, t plus k . So k periods from now, you're going to have a different amount of wealth. Hopefully bigger. And presumably, you're going to be able to consume more. Well, that's presuming that the prices of what you like to consume don't change. But if those prices do change, then in fact, you might not be really better off in any way.

And so in order for you to tell whether or not you're better off or worse off, you need to know not only how much wealth you have, but how much that wealth can buy you in terms of the stuff that you like to consume. So the idea behind inflation is to measure the purchasing power of your dollar. And that's completely different from time value of money.

Time value of money simply says that people are impatient and they prefer money now to money later. But inflation is a comment about the purchasing power of that dollar now versus later. And it can go either way. In other words, it's possible that a dollar next year will buy you more than a dollar today because if prices decline, as they have right now for energy, for example.

Energy is below \$100 a barrel. Just a few months ago, it was at \$130 a barrel. So if we had a winter a few months ago, that would have been really bad because home heating oil would have been a lot more expensive than it looks like it's going to be. However, it's still going to be more expensive than it was two years ago, when oil was at \$40 a barrel. So you need to know what you're going to consume in order to get a sense of whether you are better or worse off. And that's what we measure by this price index, I of t plus k .

So when you're looking at your portfolio, you might ask the question what's my return on my portfolio. And the way you calculate that return is look at your wealth at time t plus k divided by your wealth at time t , subtract 1 from it. And that's your return, right? That's often called the nominal return because it's in name only, meaning it's the actual number of dollar bills that your wealth will grow to. So if you've got \$1,000 this year, next year you've got \$1,100, your

nominal return for your wealth is 10%. That's the number of dollar bills you'll have more than you had this year. 10% more.

Now if you want to know how you're doing in terms of your level of happiness, your purchasing power, your cost of living, your standard of living, you've got to look at what's going on with a cost of living increase. $I_{sub t} + k$ divided by $I_{sub t}$. And we can write that as a fixed growth rate, π , per year. $1 + \pi$ to the k

So let's suppose that all the prices of the things you love and enjoy-- they go up by 10% as well. Well, then have you made any money? Have you made any progress? You've made money, but you haven't made progress. You've made 10% in terms of your return on your initial \$1,000. But the stuff that you like to eat and buy and use-- that's also gone up by 10%.

So in fact, you can't do any more consumption next year than you could have this year. Because while your wealth went up by 10%, the cost of living went up by 10%. So from a real perspective-- real meaning what you really care about-- you haven't really made any progress.

Inflation is a measure of how much progress we've made. And so when you engage in analysis of these kinds of present value problems, you've got to ask the question whether or not you're focusing on nominal returns or real returns, OK? And ultimately, as a consumer, what you all care about is real returns. You want to know whether you're getting better off in terms of what you can really consume.

So how do you do that. Well, first of all, you have to change the units. Sorry, question?

AUDIENCE: Why π ?

ANDREW LO: Why that letter?

AUDIENCE: [INAUDIBLE]

ANDREW LO: Oh, no, no, no. I'm sorry. Thank you for pointing it out. No, by π , I just mean a variable name called π . I don't mean 3.14159.

Only at MIT would I get that question. I've taught at other universities and they ask me what that funny-looking symbol looks like.

So yeah, sorry about that. This is just a Greek letter that denotes a variable. It's like r or something. All right? Thank you. So here, what I've done is to define a variable called your real

wealth at time t plus k . Real meaning this is what you really can do with your money in terms of consuming. What it is is your nominal wealth divided by the rate of inflation.

So in the case of the example I gave you, where your nominal wealth goes up by 10% and your inflation rate goes up by 10%, when you take your nominal wealth and you divide it by that growth rate in inflation, what do you get?

You get \$1,000. In other words, your wealth hasn't changed in real terms. OK?

So in the example that I gave you your wealth went up by 10%. Your inflation rate for a year is also 10%. So if you divide your total wealth by that index, you're basically going to get back to your original amount of wealth, right? So here's the general framework. Your real wealth is going to be your nominal wealth divided by the rate of inflation. You're dividing by it because you're using, as your units of comparison, today's consumption basket. Right?

So the way you can look at your real return, which is denoted $1 + r$ real to the k -th power, your real return over k years is equal to the real wealth at the end of year k years divided by your wealth today. That's your real rate of return, right? Because it's how much real dollars you have at time k .

That's just given by your nominal rate of return of your wealth. And then divided by the rate of inflation. OK?

So this is the expression that is the basic relationship between real and nominal consumption goods. And then we approximate this ratio with this very, very simple relationship here. The real rate of return is approximately equal to the nominal rate of return minus the inflation rate-- not divided by anything. That's the approximation.

So getting back to my example. My example of if you have a 10% nominal growth rate for your investment and you have a 10% inflation rate, then in that case, there's no approximation. In fact, your inflation rate, your real rate of return, is zero, right? 10% minus 10% is zero.

Where the approximation happens is when you have something a little bit different. For example, suppose the inflation rate were 10% and suppose your nominal rate of return was 15%.

According to this approximation, what's your real rate of return? 5%, right. It's not exactly 5% because if you take 1.15 divided by 1.10, it's not exactly 5%. But it's approximately equal to

that. OK?

What this says is that you ought to think, as a consumer, not just about the total dollars that's growing but the purchasing power of those dollars.

OK. For the purposes of doing NPV calculations, I want to just mention one rule of thumb that will do you in good stead, no matter what kind of calculations you do. And that is simply to keep track of whether you're using nominal or real cash flows. And then to use nominal or real discount rates to match. In other words, nominal cash flow should be divided by nominal discount rates. And real cash flow should be denominated by real discount rates.

Most of the cash flows that you will get in your analysis will typically be nominal. Nominal meaning that's the actual number of dollars you will see on those dates. But occasionally, you may get a forecast that is made in real terms-- in terms of purchasing power. And in that case, you have to just be careful to use the right interest rate when you're doing your discounting. You have to take into account inflation.

Nominal gets discounted by nominal, real gets discounted by real. That's all you have to remember, OK?

Any questions about that?

OK. We're now done with lecture 3 and we're moving on to lecture 4, which is fixed income securities. And this is the focus of much of the dislocation in markets today. So this is very topical. And something that I think you'll find very useful when we start trying to understand exactly what's been going on in these markets.

Let me start with a little bit of an industry overview. And the industry overview will give you a sense of why these markets are so important as well as so large. OK.

So we're going to start, as I said, with an overview of markets and participants. And then I'm going to talk about evaluation of fixed income securities. It turns out that all of the hard work that we've done just over the last three lectures are going to be able to get us through all of valuation for fixed income securities. In other words, you now know all that you need to know to price virtually any fixed income security without default. Without uncertainty. Remember, we said no uncertainty until lecture 12.

It's a pretty significant accomplishment because there are lots and lots of securities out there

that are fixed income securities. And you now have the tools-- you don't know that you have the tools yet, but you do, believe me, to price them all. So we're going to go over the valuation principles and apply them to discount bonds and coupon bonds. And then I'm going to talk to you a little bit about uncertainty. I want to bring in interest rate risk in a very simple way.

I want to simply talk about the fact that interest rates do change over time and that change can actually cause some concern as well as some opportunities. I want to discuss what those opportunities and concerns are. And then I'm going to conclude by talking about default. I'm going to talk about corporate bonds. And I probably won't talk about the subprime issues in this class because I want to focus on the material that's required. But I will talk about it in this pro seminar, which is optional. So you're welcome to come on Wednesday and we'll go over that material.

And if you want, you can take a look at it yourself. It's pretty self-explanatory so I think you'll see how it goes. For readings, I'd like you all to read chapters 23 through 25 of Brealey, Myers, and Allen. You'll have three lectures to do that. Lectures 4, 5, and 6 will all be focused on fixed income securities.

So let me talk to you a bit about the industry now. The name fixed income securities means exactly what it says. What we're going to do now is to focus on pieces of paper where the payoffs are fixed and known in advance. Unlike a stock where you buy a stock and you don't know whether it's going to pay off at all and the cash flows, the dividends or repurchases or capital gains are uncertain-- you don't have any idea what the cash flows may or may not be-- in contrast of those securities, fixed income instruments have fixed incomes.

So they have very, very clearly stated payoffs that you know in advance. So from a pricing perspective, these are probably the simplest kind of securities that could possibly be constructed, right? Couldn't be simpler than a piece of paper that says every year on this date, I will pay you \$10,000 of nominal currency, right? That's a fixed income security.

Examples are anything from treasury securities, securities issued by the United States Treasury and other foreign treasuries, to federal agent securities. We know about those now, right? Fannie Mae and Freddie Mac securities. To corporate security-- securities issued not by the government or by government sponsored entities, but by private corporations and public corporations.

And then municipal securities, these are securities issued by local governments. And then

mortgage backed securities, securities that are payoffs of pools of other securities, including mortgages.

And then the whole mix of collateralized debt obligations, collateralized loan obligations, credit default swaps, and other complex instruments. That's a lot of securities.

And to get a sense of how many securities we're talking about. let me show you the market.

This is as of the end of 2006 because that's the only data that I could get that is timely. At the end of 2006, the US bond market consisted of just tremendous, tremendous amount of assets. So \$6.4 trillion in mortgage-related securities, 24% of the market. \$2.3 trillion in municipals. \$4.2 trillion in treasuries. \$2 trillion in asset backed securities. \$3.8 trillion money market. \$2.6 trillion in federal agencies, securities, and so on.

These numbers-- they dwarf the stock market. So we're traditionally focused in financial analysis on pricing stocks and analyzing stocks. And we get all excited when Google tries to take over Yahoo and so on. But the size of the markets, the size of equity markets are dwarfed by fixed income securities.

And again, these are apples and oranges. And I'm just saying that there is a hell of a lot more apples and there are oranges. You can figure out what you want from that, but these are really big markets.

And on this slide, I show you the evolution of these markets-- how they've integral over time from 1985 to 2006. And what you'll see is that the mortgage-related market has just grown by tremendous, tremendous amounts. As well as federal agency securities-- that's Fannie Mae and Freddie Mac. And asset backed markets was nothing in 1985. It didn't exist in '85. And now we're talking about a \$2 trillion market here.

So a lot has happened in the last 20 years. It's been exciting times for financial markets. And right now, we're in the midst of some market turmoil because of that unbridled growth.

Now this is the amount outstanding. This chart shows you the issuance that is the amount of debt that's being issued at any given point in time. So the first was an example of the stock of debt at any point in time. And now, I'm talking about the flow of debt year by year. And you can see that as of 2006, mortgage-related bonds were the fastest growing segment, by far. And that continued up until 2007 and then the brakes started being put on to that market. OK?

And you can see over time, the growth of these various different markets and the fact that federal agency securities grew but mortgage-related securities probably was the fastest growing subject to the asset backed market as well, which is related. Yeah?

AUDIENCE: [INAUDIBLE] asset backed and mortgage-related?

ANDREW LO: Mortgage-related is specifically about mortgages. Asset backed could be any asset. So for example, consumer credit card loans-- you can package that up and sell claims on that and that would be under asset backed securities, not under mortgages. But they're related, obviously.

OK. So these numbers will give you an idea of what's out there, what's significant and what's not. This gives you a sense of the amount of trading that goes on. While these securities are large in size and large in flow, they are not that large in terms of transactions.

So unlike stocks that trade all the time, we don't have an organized US bond exchange like the NYSE, where people trade bonds every minute of the day. There are bonds being traded every minute of the day, but they aren't typically the same ones. Whereas I would argue that Microsoft and Google are traded every minute of the trading day.

So typically, bonds do trade, but they don't trade on organized exchanges. And that makes them less liquid. Even the very, very safest and most liquid bonds do not trade as frequently as equities and futures. So the liquidity characteristics can be very, very different for these instruments. And these complex securities, like collateralized debt obligations, mortgage backed securities-- they trade even less frequently because they are highly complex and it's not easy to figure out what their prices are from minute to minute every day.

Now the fixed income market participants that we're going to be focused on fall into three groups-- issuers, intermediaries, and investors. Issuers, of course, are the end users of these instruments. They include everything from governments down to foreign institutions. These are the folks that issue pieces of paper that are IOUs and they get cash in return for that to finance their operations. And in return, they pay interest, OK?

The investors, of course, are the folks that are buying the paper or essentially providing loans. So every once in a while, when I go out with my colleagues for lunch in the finance group, one of my colleagues will say, can I sell you a bond, I didn't go to the cash machine today, and I need you to help me finance my lunch. These are how finance professors speak,

unfortunately.

The idea about buying somebody bond is you're lending them money, right? So instead of saying could you let me \$5, we have to say, well, I'm going to issue a bond, can you buy my bond.

The investors are the ones that are loaning the money to the issuers. OK? And these include, as I said, governments, pension funds, insurance companies, banks, hedge funds, and so on.

In the middle of all of this are the intermediaries. Primary dealers, other kinds of dealers, investment banks, the credit rating agencies, the credit enhancers. What do I mean by credit enhancers? Folks that help credit markets by providing insurance to the credit, like private mortgage insurance. And liquidity enhancers. These are the counter-parties that try to bring buyers and sellers together to increase the liquidity of the markets.

The dislocation has been going on in the intermediary sector and of course, the issuers are having some difficulties now because they're going to have to make good on these kind of claims. And the people that are going to be hurt ultimately will be the investors who are holding pieces of paper that may not be worth as much as possible.

And so the efforts now at trying to shore up the finances of Fannie Mae and Freddie Mac, Lehman, Merrill, and all of these other institutions is really aimed at trying to help out a combination of the intermediaries and the issuers. Because if you don't help out this group, then what happens is that this group is going to get hit.

So Lehman Brothers, for example, is an intermediary. They are one of the biggest dealers in these kinds of securities. Merrill Lynch is also one of the biggest dealers in these kind of securities. As dealers, they end up taking exposure on their own books.

That's not a great idea in general because the best of all worlds is you're the toll collector that's collecting tolls for traffic going back and forth and back and forth. You don't take any risk. But if not everybody wants to go back and forth and back and forth and back and forth, you might stand ready to do one side of the business and let other folks do the other side of the business. But if you're not careful in laying off your exposure you can end up getting hurt pretty badly.

An example of this that happened in equity markets in 1987 was when the stock market crashed. That was a very serious event on October 19, 1987, where in one single day, the US

stock market lost approximately 20% of its value. In one day. Now, that's a serious dislocation. We're going to talk about that this Friday when we run this trading game. I'm going to have all of you engage in trading over a very short period of time. So you're going to be under tremendous pressure as well. You tell me how easy it is to think on the fly.

What happened that morning of October 19, 1987, is that the specialists, the dealers, who are supposed to be making markets-- their job is to buy when everybody wants to sell and to sell when everybody wants to buy. They got it there in the morning at 9:30 and were overwhelmed with everybody wanting to sell. So they ended up buying-- the specialists. And they bought. And as they bought, what happened to the price? Kept going down. That means more people wanted to sell. So they kept buying. And as they bought, what happened?

Price kept going down. And it kept going down all the way. So the stuff that they bought in the morning was worth 20% less in the afternoon. And these market makers also used leverage. So many of their capital bases were wiped out by that 20% decline in a day because they were just doing their job.

In fact, there was a story-- the floor of the New York Stock Exchange was literally packed. I mean, it was tighter than a Tokyo subway train during rush hour, OK? It was packed. I mean literally, you were elbow to elbow against others. Unfortunately, one of the market makers had a heart attack around 1 or 2 o'clock. And he wasn't able to fall to the ground until the market closed at four because he was propped up by everybody else desperate to try to transact.

And he died. And somebody who was near him said, you know, look, I knew the guy was in trouble. But what was I supposed to do. I was 100,000 shares long and I had to unload my portfolio. I mean, they were trading. That's how desperate it was on that day.

So this kind of intermediation can be extraordinarily high pressure. And when you're engaged in an unwinding of portfolios, dislocation can occur. So we're seeing that right now play out. And it's a little different because we're dealing with fixed income security. So I'm going to come back and talk about that.

OK. That's the background to what we're going to study-- these fixed income markets and fixed income instruments.

I'm going to ask you to read Brealey and Myers so that you can get up to speed on institutional details. And there are quite a few, so I would urge you to please do that reading and make

sure that you understand the basic terms of these markets.

What I want to talk about, though, is the framework. I want to give you a framework for thinking about evaluating fixed income securities. And really, as I said, it's a framework that you already know. You already have that in your mind. I've already changed the way you think about financial markets by asking you to focus on cash flows and timing and the time value of money. That's all you need in order to value fixed income securities. The rest is just institutional detail, which, while very important, is not something that we need to worry about in class. But I'll leave to you to focus on.

So let me give you an example of valuation and how to do it. It will be a very short one. You all know how to do this. We've got a sequence of cash flows for a particular security that I'm going to call a bond. And in particular, I'm going to call this a coupon bond. Now with a coupon bond, there are two things you need to know. You need to know what the coupon is and you need to know the maturity-- how many dates that it pays off.

One of the institutional details that you'll need to know is that coupon bonds typically pay semiannually. Some coupon bonds can pay quarterly, but most of them, as a matter of convention, pay semiannually. But that changes depending on the market. So you'll need to learn a little bit about those kind of conventions.

I'm not going to worry about that and I'm going to abstract from that and simply say that here's a three year coupon bond that has a principal of \$1,000. That's the typical principal or face value that a bond comes with. So this piece of paper is an IOU. And it says, I owe you \$1,000 at the end of three years, OK? But I'm not going to pay you just \$1,000 at the end of three years. I'm going to pay you \$50 every year for those three years. So the coupon is a 5% coupon.

So when you hear of a coupon bond that's a 5% three year bond, that term that I just uttered means that it pays off \$1,000 at the end of three years. And in the interim, it pays off \$50 a year as it's coupons. Why is it called a coupon bond? In the old days, the bond was actually a piece of paper and on the bottom of it were little coupons. And you'd clip the coupons and mail them in. And once a year when you mail them in, or twice a year when you mail them in, you get back \$50. OK? Nowadays, it's all done electronically.

So first thing you do in order to value of the cash flow-- draw a time line, OK? We're here sitting at zero, that's today. And you've got three years to go. One year, two year, three years.

At the end of three years, you get paid your principal-- \$1,000-- plus the coupon. There are three coupons for three years. And so at the end of this bond, when the bond matures, you get paid \$1,050. And then \$50, \$50, and here we are at date zero. Question-- what is this worth?

Yeah?

AUDIENCE: It depends on the interest rate.

ANDREW LO: Right.

AUDIENCE: [INAUDIBLE] interest rates are exactly 5%, so it's worth just \$1000, the same.

ANDREW LO: Right. If the interest rate is 5%, it's worth \$1,000 today. That's par. But if the interest rate is worth less than that--

AUDIENCE: Worth more [INAUDIBLE].

ANDREW LO: Right, exactly. So in general, how do you figure out the price of this thing? Yeah.

AUDIENCE: [INAUDIBLE] vice versa [INAUDIBLE]?

ANDREW LO: Well no, I was asking a somewhat different question, which is, how do I figure out the market value of this bond today times 0.

AUDIENCE: [INAUDIBLE]

ANDREW LO: Yeah, compute the net present value, NPV. That's one answer. That was the correct textbook answer. What's another answer of how do I figure out the market value?

AUDIENCE: Through the market.

ANDREW LO: Exactly. Auction it off. How many people want to pay me \$1,000 for this today? No? \$1,001? a thousand and whenever. We can auction it off and figure out what the price is from the market. But in fact, what we're doing by doing so is computing the present value.

And the way we're doing it is by figuring out what the price of a dollar is in date one today. What the price of a dollar in year two is today. And what the price of a dollar is in year three today. Getting those exchange rates and then converting all of those different currencies to dollars today. Right? We know this we've done this many times.

So the way that you figure out valuation is by using discount rates that we get from the market and applying them to compute present values, right? Very simple. So really, the components of evaluation for bonds, if there's no uncertainty, you already know. We've done it. That was last lecture. And for special cash flows like annuities and perpetuities, we've got closed form solutions. Formulas, which you can program up in Excel to figure out.

The kind of risks that we're going to focus on later on in this lecture and in the lectures after we talk about uncertainty is inflation risk. We talked about that, right? The fact that when you buy a bond or you sell a bond, if the purchasing power changes, that's going to introduce a new kind of unknown that we need to grapple with. Credit risk. That's a major form of risk that we're dealing with in financial markets today and that we're likely to be dealing with for years to come.

You might like to borrow from me or lend to me, but what about credit issues. How do you know that I'm still going to be around a year from now, two years from now.

Timing, which we'll come back to a little bit later on. Liquidity. And then of course, what currency. If we're doing international borrowing, we have an extra dimension of risk, which is fluctuations in the exchange rate, OK?

So for the next couple of lectures, I want to keep life simple and talk just about riskless debt. Riskless in terms of default. So in particular I'm going to be talking about US government bonds. All right? And I'll come back to risky debt later. But for now, let's just focus on the debt that will not default because you can always print up dollars to pay off your creditors, right? Those dollars may not be worth as much as you would like them to be if you do too much of that, but for now, we're not going to focus on default.

OK so the first kind of bond that we're going to try to price is what's called a pure discount bond. This is a bond that is different from a coupon bond in the sense that there are no coupons. So it only pays off one payment at the end.

And the reason it's called the discount bond is because it is what it sounds like-- the price of the bond today is going to be at a discount from the face value. If the face value is \$1,000 and there's nothing in between, then the price of the bond can't be greater than \$1,000 because money today is worth more than money next year. So the price today is going to be lower than \$1,000. It's going to be a discount over \$1,000, hence the term pure discount bond.

Now there are pure discount bonds out there. US treasury bills are examples, where there's one payoff at the end and nothing in between. But awhile ago, financial engineers came up with a rather brilliant idea, which you may not think is so brilliant because it's so painfully obvious. The government issues coupon bonds as well. And typically, for longer maturities, like five years, 15 and 30 years, there are no pure discount bonds for those longer maturities. When the government issues them, they issue them with coupons.

But you can imagine a situation where somebody would like to have a discount bond for 30 years. And so some clever financial engineer said, hey, here's what I'm going to do. I'm going to buy up a lot of these treasury coupon bonds and I'm going to issue discount bonds that match exactly the coupon payments from my treasury bonds. In other words, I'm going to take the coupons and strip them and offer them up as separate securities. And I'm going to call these STRIPS.

And these STRIPS, which stands for separate trading of registered interest and principal securities, created a huge market for essentially what are government bonds, but that have been pre-processed in a relatively simple way. Now, this didn't happen that long ago. Maybe, I don't know, 15 or 20 years ago they created STRIPS.

So this is why I'm so excited about financial markets and why I think all of you have tremendous opportunities. It's because there are so many ideas that may seem obvious to you but are not obvious to the market. And there's no patent on good ideas. There's no monopoly on good ideas. You can actually create tremendous value by coming up with what you might think of as so simple a solution but that solves problems for very large financial institutions.

Now how do we price these things. Well, this is just a one liner. The price of a discount on is simply equal to its face value discounted to the present by the appropriate interest rate. That's it. Pure and simple. We're now done with pricing pure discount bonds. There's nothing else to it. OK.

It turns out that this is a really wonderful relationship because if you've got two of these three variables in this equation, you've got the third. If I tell you what the face value is and what the interest rate is, you've got the price. If I tell you what the price is and what the face value is, you've got the interest rate. And if I give you the interest rate of the price, you can actually figure out what the face value is, all right?

So this relationship is going to be very handy when we look at the prices of these instruments and we want to now infer what that says about what's going on with interest rates. In fact, what I'm going to show you next time is that when we look at the newspaper and we take a look at the prices of discounted coupon bonds, implicit in those prices is a forecast of the future.

This is as close as any of you are ever going to get to a crystal ball. I'm serious. By looking at prices, you can tell the future. You can't do it perfectly, but neither can Jean Dixon or any of the other astrologers, right?

The point is that this is our way of figuring out the collective intelligence of all market participants and what they think of what was going to happen. And because of that, because of that kind of market knowledge, I can tell you that with 99.5% confidence, tomorrow, the Fed will cut its interest rate.

Now how do I know that. I don't know that. The Fed may not. But if you look at financial markets today, if you look at treasury prices today, if you look at the Fed funds futures, all of those prices-- if you know how to read that, if you can decipher those tea leaves-- it will tell you that tomorrow, the Fed will cut rates. So I want you to watch tomorrow to see if I'm right, OK? It would be very embarrassing and potentially catastrophic if I'm wrong. So listen carefully. Any questions? Yeah.

AUDIENCE: [INAUDIBLE].

ANDREW LO: That's right. In other words, if they cut rates tomorrow, then they're going to be shooting one of the very few remaining bullets that they have. The question is, if a bear is charging at you and you've got one bullet left, you're probably going to use it anyway, right? So why don't we return to this issue on Wednesday since we're out of time? All right, thank you.