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ANDREW LO: The other item that I auctioned off-- that's a good question. Well, first of all, before I tell you that, you'll note that I put those two packages up here in the front of the room for this first section. One was bigger than the other. And you guys got the smaller one, right? And you obviously know what that was. The bigger one turns out to have been a book. In fact, it's a book that I recently published on hedge funds. Now it turns out that the bidding of that second item went for \$60. The bidding of the item that I sold to this auction went for \$45. And the fact that it's a smaller package I think makes some sense of why it went for a smaller amount. That shows you the power of information, or lack of information, in terms of determining values. Yeah, question?

AUDIENCE: Yeah, I was just going to ask if there was some insider information that would up the value of that second box?

ANDREW LO: Well, I don't think so. And one of the reasons that I had two different packages and I showed this entire section the two different packages is to try to eliminate a bit of that private information. I don't believe there was any. If I used the same two items, then I think there would have been a concern that there might have been some information spill over. So I don't think that was it. In fact, I think what it was the size of the packages, believe it or not. So anybody that tells you that size doesn't matter I think is not being realistic. Was there another question back here?

AUDIENCE: I had the same question.

ANDREW LO: OK, yeah?

AUDIENCE: How much did the book retail at?

ANDREW LO: The book retails for \$45. Now of course, I autographed the book, so--

[LAUGHTER]

--so that probably reduced the resale value. We played-- I took the \$60. No tears. Fair is fair. So this class, the individual who bid \$45 for that iPod did very, very well indeed. And the student who bid \$60 for the book didn't do quite as well. But that's the point of this example.

It's that when you don't know what you're bidding for, when there's literally no information, you're obviously not going to get it exactly right. But you have to admit that in the grand scheme of things, it's actually not that far off, and not that far off in a very particular way. I want to, in particular, talk about the iPod. Because we are looking at something like a 70% discount off of the retail value of that for this class.

Now I want to comment on that in the context of what's going on today. I want to spend a few minutes, before we start the lecture, talking about current events. Because finance of course involves current events. And right now we are going through an extraordinarily interesting set of times. I think that's a Chinese curse-- may you live in interesting times. Well, we're going through some really extraordinary times. Because what happened over the weekend is something that has probably not happened since the Great Depression.

What happened over the weekend is that the federal government took over two of the largest government-sponsored financial entities in the world, Fannie Mae and Freddie Mac. These are two government-sponsored entities. They're private organizations but they have the backing of the government in some ambiguous sense. And it was ambiguous, up until this weekend, what that meant.

What happened was that these large financial institutions were responsible for purchasing the mortgages from various different regional banks and lending institutions. And why would they do that? What was their function? Anybody know? Yeah?

AUDIENCE: To provide a secondary market for mortgages so that the banks that are the initial lenders can generate more mortgages and make credit more available.

ANDREW LO: Exactly. Their goal was to really make credit more available in the housing market, and the student loan market, and the auto loan market-- these consumer finance markets. The purpose of these two organizations was to buy up the various different obligations from banks and other financial institutions so that the banks and financial institutions could then go out and lend more money to more individuals that wanted these kinds of loans. So the purpose of these two organizations was really to support and grow these various markets.

And it turns out that over the last 20 years, these markets have grown to epic proportions, tremendous proportions. And now, as the housing market has turned down, the original lenders that made these obligations are facing some severe pressures. And that's carried the ripple effects all the way through the financial system, to the point where these two

organizations literally could not stand on their own. And if there had been a default of these two organizations, there would be some major repercussions. We're going to talk about that in about four lectures. The material that we're going to develop over the next three lectures are going to allow us to analyze the situation and really try to understand what's going on in these markets.

But I just wanted to alert you to the fact that something really big has happened. You won't understand fully what it is. You might read the newspapers, and I would encourage you to do so, but you won't fully appreciate the importance of it for another three or four lectures. But you're going to see this event unfold before your very eyes this semester. And that will provide the motivation for developing the tools to understand what's going on. Yeah?

AUDIENCE: Can I ask you now, or can we ask you now, do you think that was the only option, or do you think that was the right--

ANDREW LO: Well, that's a very tough question. In terms of the possibilities for the Secretary of the Treasury Paulson and the government, there aren't too many left in the sense that these two organizations are in a real bind in that they have issued lots of securities based upon their activities. And in order to maintain the quality of those securities, in order to make good on those promises that it has made to other counter-parties-- very important counter-parties I might add, including the governments of India, China, and a number of sovereign wealth funds that we depend on to loan us the money that has kept us in the style to which we have become accustomed in this country-- in order for us to maintain those kinds of relationships, we have to make good on our promises.

And it's getting harder and harder for these two organizations to do so. Because while they've got all of these promises that they've made, the money that's supposed to be coming in order to allow them to make good on these promises is dwindling. And as they've tried to raise more money in the open market, it's become harder and harder, because people realize that they're in trouble, and it's very difficult for them to raise that money. In fact, this is related exactly to the point about the iPod auction that we engaged in last time. Think about how little I received for that \$150 item. I received basically \$0.30 on the dollar. And why? It's because none of you knew what was in that package.

So now instead of an iPod that's in a wrapped package, imagine if that wrapped package contained paper issued by Fannie Mae or Freddie Mac. And now I'm going to ask you, can

you bid on this paper? Now I don't know whether Freddie Mac or Fannie Mae will still be around in two years, but I'd like you to bid on this paper anyway. And by the way, what you get for this piece of paper, I don't really know, so it's wrapped up. And you don't know either. You don't know. I don't know. You know I don't know. And I know you know I know I don't know. So what's that piece of paper going to go for? Well probably less than \$0.30 on the dollar, right?

So what we saw happen in this classroom last time is exactly what's happened in spades to these two large organizations. At some point, there has to be a day of reckoning. And the Treasury decided rather than waiting for that day of reckoning-- because if that day of reckoning came before they were able to do something, it's very hard to put the pieces back together. So in my opinion, I think they had very little choice but to do something right now, before it got out of hand.

And we're going to talk about this again. In fact, we're going to run a trading game where all of you are going to get a chance to engage in this kind of trading. It's not exactly the kind that involves credit. But it'll be a trading game, where you'll get to see what it's like to be under pressure and to have to make decisions and value securities in real time. And you'll have a much deeper appreciation for the kind of issues that we're up against. Yeah?

AUDIENCE: Sorry, what did the government exactly do to agree to pay for all their--

ANDREW LO: Yes, so the government said, OK, you guys, Fannie Mae and Freddie Mac, you can't make good on your obligations because you've got some problems. So we, the Treasury, will stand by all of your claims.

AUDIENCE: And the government paid that?

ANDREW LO: Absolutely. You know how? How can the government pay that? What?

AUDIENCE: How, issuing money?

AUDIENCE: [INAUDIBLE]

ANDREW LO: Exactly. The government-- they own the printing presses. So they just-- you want to get paid dollars? I'll pay you dollars. Here, how many dollars would you like? I'm going to run it. Here you go!

AUDIENCE: So we're probably getting hit with inflation?

ANDREW LO: That's the concern. So the concern is that if you do this too much and you do it without anything backing up the pieces of paper you now print and give to your debtors, then there'll be a problem. Because pretty soon they're going to realize that the piece of paper isn't really worth as much as they thought it was. So inflation could be a problem. It could be a problem. We'll have to see. But right now the paper, the dollars that are being printed, are backed by the full faith and credit of the US Government. And for the time being, that still means something. Yeah?

AUDIENCE: Are all the levels of debt being guaranteed with interest? How much of the Fannie and Freddie is debt?

ANDREW LO: So the question is, is all of the debt being guaranteed or is it just how much Freddie and Fannie issued? Well certainly it's what they've issued. So all of the paper that they've issued will be backed by the government. In addition, there is some new paper that they have to issue in order to finance additional mortgages. And the government will back that too. Now this is not for free. It's not just printing presses. That sounds a little too easy. Somebody has to pay for it. The money's got to come from somewhere.

Or I'll put it another way. That money that is spent now backing these instruments cannot be used for other things. So if you believe in balancing your budget as opposed to spending on credit, which frankly is what got us into the problems to begin with, then there will be additional reckoning. People have said that the American taxpayer will pay for this. Well, that's true. But the question is which set of taxpayers? Is it us? Is that your children? Is it your children's children?

There are a lot of intergenerational questions about where the burden lies. But the fact of the matter is yes, we are on the hook, that the American taxpayers are on the hook for tens of billions of dollars. Now in the grand scheme of things, tens of billions of dollars is nothing. The federal budget is much, much larger than that, so this is not a big deal. The concern is if this spreads and ends up costing us more because of ripple effects and knock on effects that we don't yet know about, that could be a problem. And that, frankly, is one of the reasons why the Fed and the Treasury have decided to step in now to try to contain this problem. How good they will be at doing that we don't know. Read the newspapers over the next few weeks and let's see. Yep?

AUDIENCE: Do you think the common stock basically has to be worth zero at this point now?

ANDREW LO: Well, it's not worth exactly zero, but it's pretty darn close. And in fact, it's come down quite a lot, I think, over the last couple of years. I don't know what the peak of the price was. I haven't looked at it. But I think that the decline has been on the order of 90% to 95% decline of what the peak was over the last couple of years, which is--

AUDIENCE: This morning it's down 83%.

ANDREW LO: Yeah, 83% since when?

AUDIENCE: Since yesterday.

ANDREW LO: Yeah, that was just a day ago. But I'm talking about since the peak. I think it's come down dramatically. So effectively, the value of the shareholders' equity is pretty close to zero. But that's what happens in a bankruptcy. And by the way, we're going to talk about bankruptcy too. That's going to be a very important part of what we do when we analyze fixed income instruments. So we're going to get to that shortly. Yeah?

AUDIENCE: Has there been anything about potentially going private again down the road? Is that--

ANDREW LO: There have been discussions about them going private, but private in a much smaller way. So the discussions that have occurred at the Treasury-- and we don't know which way things are going to end up because it's a political process as well as an economic one. But there's a feeling that these two institutions got too big, too quickly and that there wasn't enough oversight to allow them to be able to fail. In other words, they grew so big, so quickly that after a point they were in fact too big to fail. And when you're too big to fail, all sorts of abuses and improper risk management practices can go on, which we will talk about in probably eight or nine lectures. So there's a variety of proposals that have been put forward. And we'll talk about those also over the next six or seven weeks.

AUDIENCE: Who did the government actually bought the shares from? Are they federal agencies? Are these private companies? Who--

ANDREW LO: So Fannie Mae and Freddie Mac are called GSEs, Government-Sponsored Entities, which means that they're not a federal agency. But they are backed by the federal government in some manner that has been, up until now, relatively vague. So they're meant to be private companies. They had a CEO. Both of them had CEOs, who were fired over the weekend. They had separate boards of directors. And they pay pretty attractive salaries, private sector

salaries. But they were related to the government in the sense that their objectives were to try to support and expand the housing market financing, which was a government-dictated mandate to this--

AUDIENCE: Their main goal is not to earn money? It's to bring a secondary market for mortgages?

ANDREW LO: Their main goal was to create additional financing to allow the mortgage market to grow and to allow people to buy homes at reasonable rates. Their secondary goal was to make a profit on top of that. So that's why they're not just a government entity, but they have a kind of a quasi private sector type of mandate. And by the way, they did a great job. They did a great job in the sense that the housing market has grown tremendously. Now you could argue that that was irresponsible and that created all these problems that we're facing today.

But you talk to somebody who has a subprime mortgage that otherwise couldn't have afforded a house that now has made every single payment, and really enjoys living in their home, and has a lifestyle that they couldn't have otherwise had. You talk to them and you tell them that it was a mistake. So it's not at all clear that this is a total disaster. It's unfortunate. And it's a catastrophe from the point of view of the current holders of various pieces of paper that are related to these subprime mortgages. But there's a whole group of people out there that have benefited from these subprime mortgages.

And so you've got to balance the costs and the benefits. And we're not doing that right now. Right now we're just panicking because we're all scared like hell that something really is going to break. But there's a positive side as well as a negative side to every story. And so we're going to have to talk about that in a little bit more detail. But we can't do that unless we have the framework to think about it. So that is going to lead me to today's lecture. Yeah?

AUDIENCE: Just to follow up on another question, who were the shareholders in Freddie and Fannie Mae system, and did the investment go to zero overnight?

ANDREW LO: So there are two groups of individuals that are involved. One are the shareholders of the companies themselves. And these are investors. A number of them are pension funds, institutional investors. So therefore, you and I, in our 401(k) plans-- we might actually have an investment in one of these organizations through the plan sponsor that invests in various different entities. So they're a stock that was traded on the exchanges, just like any other stock. That's one group. And those are going to lose most of their capital. They're going to lose their investment, just like when a stock goes belly up, the investors of Enron, too bad.

They lose everything. They're gone. They knew it. They took the risks and the risks don't always work out, so that's that.

The other parties that are involved are the folks that do business with these agencies, the counter-parties that bought the paper that they issued, these IOUs and other complex instruments that Freddie Mae and Freddie Mac issued. Those individuals, we're hoping, will be relatively happy about the outcome of the government backing the paper. Because now the paper that they once held and thought was in trouble will have the full faith and credit of the US government behind them. And that is a major concern.

Because these counter-parties are very, very substantial investors. If they decide that this paper is no good and they start getting rid of it wholesale, that will create some really significant market dislocation and mass panic. And that's what the Treasury stepped in to stave off this weekend. And hopefully they will have succeeded. In fact, if you look at the data, it looks like they did succeed.

But I'm not going to talk about that for another three or four lectures, because I want to show you exactly how to think about these instruments. And then we're going to look at the data and see whether or not they've actually done something significant. And you'll be able to tell. By looking at market prices, by looking at the outcome of auctions like we did last time, we're going to be able to tell exactly what happened.

All right, well, that took a little longer than I thought, but I think it is useful for motivation for what we're going to do in the class. What I want to do today is to start on lectures two and three, present value relations. And I have to tell you, this is one of the most interesting lectures of the entire course, not because of the underlying material, but rather because of the novelty of the perspective that I want to give you about these kinds of issues. This is the very first step in changing the way you look at financial transactions.

We're going to start by discussing cashflows and assets. I'm going to define some terms. And I want to change the way you think of an asset. And then we're going to talk about the present value operator. And then we're going to apply that to the time value of money. I want to make that concrete so that all of you will start thinking differently now about money today versus money next year. And then-- probably not today, but next time-- we're going to cover two very special kinds of cashflows, the annuity and the perpetuity.

These are two mathematical abstractions that provide some really interesting insights into this

whole notion of present value. And then I'm going to talk about a couple of technical issues, compounding and inflation. And that will lead us right to thinking about fixed income securities, and how to value them, and how the market values them, and whether or not the two are the same or different.

For the readings, I'd like you to start on Brealey and Myers, Allen, chapters two and three. You should have already read chapter two from last time. I'd like you to reread that and also focus on chapter 3 for the next couple of lectures.

So first order of business, let's define some terms. I think you all know what a cashflow is, right? It's just money that's coming to you or going away from you, a flow of cash. And you all know what cash is, I presume. The next question I want to take on is, what is an asset? We talk about valuing assets. But we have to start first by agreeing on a definition for what an asset is. And I've just put some examples up here of what assets are.

Business entity is an asset. If you guys decide to do a startup, that startup has value. It's an asset. Property, plant and equipment, patents, R&D, stocks, bonds, options, and even something as difficult to value as knowledge and reputation are assets. Does anybody know of an example of a really valuable asset that is not physical at all? You can't touch it or feel it. Yeah?

AUDIENCE: The algorithms that Google is using?

ANDREW LO: The algorithms that Google is using. That's right. Now how do you know that those are assets?

AUDIENCE: Because they generate revenue.

ANDREW LO: They generate revenue, right. And has anybody turned them into anything concrete, like any type of legal structure to make them assets?

AUDIENCE: Patents.

ANDREW LO: A patent, exactly. A patent-- and Google has many patents-- those have value. Not only are they considered assets, but you can actually trade them. You can buy a patent, sell a patent, license a patent. Yeah?

AUDIENCE: Are they patents or are they trade secrets?

ANDREW LO: Well, they're both. So Google has patents. But there are also a number of trade secrets that it uses to protect its intellectual property. What's the distinction?

AUDIENCE: I think a trade secret is if you have a patent, but not an implicit patent.

AUDIENCE: No, it doesn't have any patents.

ANDREW LO: No, no.

AUDIENCE: What does that mean?

What What is a trade secret?

AUDIENCE: It's a secret.

ANDREW LO: It's a secret. Thank you.

AUDIENCE: A patent without legal backing.

ANDREW LO: Well, I'm not sure it's a patent without any kind of legal standing. In fact, it's sort of an anti-patent, isn't it?

AUDIENCE: It's not a patent. It's a secret, specifically. Like Coke, for example-- the formula for Coke is a trade secret that is not patented. When you apply for a patent you have to disclose fully what your patent covers. And that means that at the at the end of the life coverage, you're out. And so I could go and-- if Coke would have applied for a patent however many years ago, it would have expired. I could be making Coke right now. But a trade secret is secret forever, as long as you take steps to keep it secret.

ANDREW LO: Right.

AUDIENCE: So they are taking the risk of the secret.

ANDREW LO: Exactly. Coke is taking a big risk in that it has not filed for a patent. And frankly, if it did, it would have expired long ago. Now what exactly is a patent? What's the motivation for a patent? A patent is a legal agreement that says that if you tell me everything there is to know about how to construct the item or algorithm that you want to patent, if you're willing to disclose that to me and the whole world, and I acknowledge that it is new and useful, then I will grant you the ability to be the sole user of that algorithm, product, or business process for a

finite period of time-- say, 17 years.

So for 17 years, if anybody wants to use that algorithm, they have to pay you for that privilege. So it's a monopoly. It's a monopoly that the government grants you for a fixed period of time in exchange for what? In exchange for you to be willing to disclose everything there is to know about it. And why is it? So that everybody else can learn from it. And after 17 years, and after you've made a god awful amount of money, somebody else can take that idea and incorporate it into what they're doing and make money off of that. The patent process creates assets out of ideas.

And it allows you to derive economic value from that in exchange for freely sharing those ideas. That's one path to go. And the other path is I don't want to share because I think that I can do better by keeping it a secret. And that's what Coca-Cola has done. That's the example that I was thinking of, of an idea that has no legal standing but that's one of the most incredibly valuable ideas in the world today. The amount of money that Coca-Cola produces is unbelievable given this simple recipe that apparently people haven't been able to figure out how to reproduce. How hard could it be? You just mix a few things and add some coloring and then you get Pepsi. I don't know. Yeah?

AUDIENCE: But a lot of their value is also in the brand.

ANDREW LO: That's right.

AUDIENCE: There's the trillions of people who associate a red dot with feeling happy.

ANDREW LO: That's true. Now that's the case. They've spent years building the Coca-Cola brand. That's one of the most recognizable brands in the world. And that has value, too. And by the way, that value is different from the trade secret. So now we see that there's lots of different assets. And that's an asset, right? Yeah?

AUDIENCE: I'm just curious. Is there a financial reason-- or maybe not-- for why you would patent something versus have a trade secret? And what I was thinking of is pharmaceutical companies. Why would you go and patent Lipitor? Wouldn't it be better to keep that a trade secret and be the only company in the world ever to make it?

ANDREW LO: Well that depends. It depends on whether or not you think you can keep it a secret. Coca-Cola apparently has been kept secret pretty well. But there are a lot of other people working on the various different kinds of cholesterol reducing drugs, not just the folks that develop Lipitor. So

if you can keep it a secret, great, keep it for yourself. But very often you won't be, because other people are working on the same research.

Also there's a certain cachet to having a patent. And it provides you with a certain kind of business viability. You can go to an investor and say, here, I've got this idea. The idea has been certified by the US Patent Office. It is patent number XYZ, and that's why you should give me money, versus you go to an investor and say, hey, I got a secret. I can't tell you what it is. You know what? You're back to the iPod. Andy, question?

AUDIENCE: Oh, no. I was going to say the same thing.

ANDREW LO: Yep, OK. So now we know that there are all sorts of assets. Even intangibles, even things that you can't hold in your hand can be an asset. I want you to forget about all of that. I want you to think about an asset in a completely different way. I want to reduce an asset to its fundamental core properties. And to do that, here's my definition of an asset. An asset, at a given point in time t , is simply equal to a sequence of future cashflows-- CF_t , CF_{t+1} , CF_{t+2} , dot, dot, dot.

That is the definition of an asset that I would like to adopt for the next 12 weeks. Now this might seem trivial to you, but trust me, it's not. It's a very subtle idea. And it's going to have all sorts of interesting implications that we're going to discuss over the next few lectures. But I want to make sure that everybody fully appreciates what I mean when I say an asset is a sequence of current and future cashflows.

Let me just describe a couple of interesting things about this definition. First of all, it doesn't involve past cashflows. So when I define an asset I have to define it relative to a point in time. That, in and of itself, I think is something new. So it's not enough to say an asset is Coca-Cola. You have to say that the asset is Coca-Cola today, versus Coca-Cola 10 years ago, versus Coca-Cola 100 years from now. Those are different assets.

The point in time actually matters, in other words. This is like the zen paradox. You can never step into the same river twice because water is moving. It's always a different river. In that sense, an asset, as at every point in time, is a different asset. And that's not that surprising. Because if you believe, from my definition, that an asset is equivalent to its current and future cashflows, then those cashflows are very different depending on where you stand.

So for example, the stock of Fannie Mae and Freddie Mac as an asset was very different five

years ago than it is today. They're both assets. They're both cashflows. But the cashflows are very different depending on what point in time you're talking about. So when I think about a cashflow, I'm thinking about a particular sequence that occurs given market conditions. An asset is comprised of those cashflows. They are one and the same. When you tell me that you have an asset, I immediately think of OK, what's the sequence of cashflows?

That's all I care about. From the purposes of financial analysis, that's all that matters. So over the next few weeks, we're going to be building up a theory of financial analysis. The basic building blocks of that theory are assets. So you could think of assets as the molecules or atoms of a unified field theory of finance. And the protons and electrons-- those are the cashflows. Yeah?

AUDIENCE: Do the cashflows have to be positive?

ANDREW LO: No. They don't have to be positive or negative. But they do have to be real numbers, so no complex numbers here, OK? Positive or negative-- that's what an asset is. Now you might think, well, gee, if all the cashflows are negative then I don't really want that asset. Well that's the nature of an asset. Maybe then instead of an asset you call it a--

AUDIENCE: Liability.

ANDREW LO: --liability, exactly. But from my perspective, developing this atomic theory of finance, I'm going to focus on this as the basic building blocks. And I don't care whether they're positive or negative for the moment. We're going to talk about their characteristics later. But I just want to agree on a definition of what an asset is. Question, yeah?

AUDIENCE: So it's a sequence of cashflows, it's not a summation?

ANDREW LO: Right, it's not a summation. It's a sequence, meaning it's basically just a list of cash flows at different points in the future, including the present, but not the past. So according to my definition, the past doesn't matter. When you talk to me about an asset, all I'm looking at is current and future cash flows. And it's a sequence of cash flows. So that means they're ordered in time. And I'm not even telling you whether or not what the cash flows are. So it could be that the future cash flows-- I'm writing them as letters, but who knows what the letters stand for. You might not know what the future cash flows are. But you can still, nevertheless, acknowledge that they exist as an abstraction.

That's what an asset is. I don't care what you use to value your various different cash flows. But the definition of an asset is simply a sequence of current and future cash flows. All right, that's what we're going to talk about as an asset. So all the things that I listed up there-- knowledge, reputation. Can reputation be considered a sequence of future cash flows? Does that make sense? How? What?

AUDIENCE: Goodwill.

ANDREW LO: Goodwill. How would you use that goodwill? Yeah?

AUDIENCE: Your reputation is such that people choose you instead of a competitor. And so that cash flow, from that choice, is coming from your reputation.

ANDREW LO: Exactly right. The additional cashflow that you get based on that reputation-- that's the value of the asset, or that is the asset right there. Yeah?

AUDIENCE: Can assets have common elements?

ANDREW LO: Absolutely. No reason why you can't have common cash flows across different assets. But nevertheless, a single asset is a collection of present and future cash flows. Yeah?

AUDIENCE: I'm not sure if I can explain correctly, but as you said, if I have one asset, a building, and if she has a building, and if I am a lender, that means I have a different cash flow on that asset.

ANDREW LO: Yes.

AUDIENCE: But however, there is a market of the building. But if the sequence of the cash flow, how can you like--

ANDREW LO: We're going to get to that. That's actually a very deep question that will require three more lectures before we get to. But I will answer that exact question in three lectures, if not before. Before we talk about how to value these assets I want to make sure we agree on what a definition of an asset is. So I think we agree, right? Any questions about that? Yeah?

AUDIENCE: So if, say, you have a bunch of patents, but they can't generate any incremental cashflows they don't exist. Like, you have them, but incremental cash flow from [INAUDIBLE] matter?

ANDREW LO: Well, not to be anal about this, but mathematically, a sequence of 0, 0, 0, 0 is a bona fide cash flow. So the zero asset is possible too. So this is absolutely general. And you might argue, at

this level of generality it's useless. Well not quite, not quite. Because I think it helps us to formulate a perspective. And the perspective is when you start thinking about various different kinds of assets-- and I'm talking really complicated assets, assets with all sorts of options and triggers and various contingencies-- the more complicated it gets, the more important this framework is.

Because no matter how intimidating the problem you are faced with, the bottom line is an asset is a sequence of cash flows. It's simple, conceptually. The hard part is figuring out what those cash flows are. But the conceptual framework is what I want you to start with. Because that will clear your mind of a lot of cobwebs that really don't belong in any kind of financial analysis. So we start with cash flows. Sequence of cash flows is an asset.

Now that I've told you that, there's lots of examples that you can come up with. So I've given you some in the notes. Please take a look at them. Each one of these is an asset. And each one of these represents a certain sequence of cash flows. Some may be more subtle than others. But they are, nevertheless, cash flows. So I want you to think about that, read through these examples, and make sure you understand why they are assets. Now valuing an asset-- that's the question that [INAUDIBLE] was asking about.

How do you value a sequence of cash flows? Because you and I-- we might have a very different perspective on what that cash flow is worth. So for the moment, I'm not going to answer that question, or rather I'm going to answer it with a typical device that economists use all the time, which is I'm going to just create some notation to answer the question. And the notation I'm going to give you is V , in particular V sub t . That's a function that takes as its input a sequence of cash flows and spits out a number, which I'm going to call the value of the asset at time t .

So how do you value a cash flow? Well, you use the value operator V sub t . You stick in a cash flow and out pops a number. We're going to have to spend the next three lectures figuring out what V is. But I can tell you one answer right away. In fact, all of you know what V is, or one definition of V . What is it? Can anybody tell me what V is? Where do you get V from? Yeah?

AUDIENCE: What you pay for it?

ANDREW LO: That's right, but you're close. Where did that come from, what you pay for it? What do you mean by that? Market price. What market? What market? Yeah?

AUDIENCE: Any market where someone's willing to sell it.

ANDREW LO: Exactly. Any market. This is what you were getting at. What you pay for it-- any market. If there's a market, you've got your V . So V -- one example of a V_t is a market at time t . That's what we did last time. We had a value operator. Stick in a gift wrapped box and you get out \$45. That's an example of a V . What we're going to try to do, though, is to take apart that box and see how it works and whether or not it does work.

AUDIENCE: Would it be any market or the markets that generate the best cashflows?

ANDREW LO: Well we don't know what best means. So for our discussion right now any market will do. But then you can have a separate discussion as to whether or not there are better markets or worse markets. And we have to define what that means. So we're going to get to that when we start talking about how the V operators work. Yeah?

AUDIENCE: Does this work for a perfect market? Or perfect market just means that the value would be the summation of the--

ANDREW LO: So we don't know we don't know what a perfect or an imperfect market is yet. And I'm going to hold off on that for quite a few more weeks. All we know is it's a market. So let me put it to you this way-- in the last lecture, when I auctioned off that iPod and I only got 1/3 of the price, would you consider that a perfect market? It didn't feel that way to me. But on the other hand, it worked. I had something that I wanted to unload and I unloaded it at a price that two mutually consenting adults agreed to. So that worked. It was pretty good.

But in order for us to understand whether or not it really works, we've actually got to take apart the box. We've got to open up V_t . I'm not going to do that just yet. I want to first acknowledge that there exist V_t s out there. And more often than not, when you let the market dictate what that V_t is, you actually get some pretty interesting results, results that will require a little bit more structure to interpret.

One way to interpret the structure is to acknowledge that there is a time element to the cash flows. So when I ask you to analyze a V_t or an asset, the first thing you're going to want to do is to draw this picture right here. And I'm serious about this. In order for you to understand the value of an asset, you have to know the timing of the cash flows. Time means everything in finance. A cash flow today is not the same as a cash flow next year. Yeah?

AUDIENCE: So are we going to divorce the accounting definition of an asset from the finance? For

instance, land has to be recorded at book value [INAUDIBLE] in accounting.

ANDREW LO:

Yes, right. So what I'm asking you to do is to think abstractly in terms of the cashflows themselves. I haven't talked about accounting practices at all. I'm going to come back to how we actually implement this. And at that point, it'll be important to bring in the accounting elements. But for now, let's set them aside. So these are actual cashflows that you will receive at different points in time. And by the way, I want you to use this exact same framework for analyzing accounting practices.

Because financial analysis can actually be used to ask the question, are accounting conventions good or bad? Some accounting conventions are favorable. Some are unfavorable. But the only way to analyze them is by using this kind of a framework first. So I would argue that this will be certainly useful for looking at accounting practices. But it won't necessarily be the same. So you'll need to have to make that distinction.

So, so far, nothing I've said is all that controversial, I don't think. I've simply defined that there is a value operator. Operator means function. You stick in a sequence of cashflows. Out pops a number. And when you analyze the value of an asset, I want you to always draw a timeline and make sure you understand the sequence of cashflows. Without the timeline I don't know that you really understand what's going on. So first of all, as a tip for your midterm and final exams, any time you have a calculation, which you have to do a present value or a valuation exercise, I want to see this. I want to see that you know when things are going to happen. Because nine out of 10 times, when you make a mistake in valuation, it's because you lined this up incorrectly.

Now what is V ? Well we said that one example of a V is the market. But is that objective? Is it subjective? Does it work well? How is value determined? And what we're going to do in this lecture and the next one is to take apart this function V in the case of no uncertainty. So remember I told you the two important factors in financial analysis that makes finance interesting and exciting is time and uncertainty. And we've seen both of those things happen this weekend. A lot of time has passed in resolving the uncertainty with regard to Fannie Mae and Freddie Mac.

What I'd like to do is to abstract from the uncertainty part. For the next couple of lectures there's no uncertainty. I'm going to get rid of the randomness. And I'm only going to focus on figuring out the value operator, this V sub t function, for cases where we have cashflows at

different points in time but where the cashflows are known for sure. So there's no uncertainty about whether they're going to happen or not happen.

After we do that, after we do the no uncertainty case, for which we have a complete solution, I will then come back and introduce uncertainty in a somewhat more natural way. And then we're going to focus on valuation with uncertainty as well. So let me start with the perfect certainty case about how to figure out what this V sub t is. And I'm going to start with a very simple example that has to do with manipulating cashflows. And I'm going to talk in particular about foreign currencies.

So I wanted to ask you, what happens when you add 150 yen to 300 pounds? What do you get when you add those two? 150 yen plus 300 pounds is equal to 450 what? \$450? If you believe that, please see me after class and we'll need to do some transactions.

Well look, obviously 450 makes no sense, right? It's like adding your weight to your age. That number might be interesting, but there's no interpretation for it. So 150 and 300-- you would never add those two and talk about 450 what. You don't even have a unit to be able to ascribe to it. Well that natural reaction that you have, that natural aversion you have to adding up dollars or yen in different currencies-- I want you to develop that exact same attitude towards cashflows at different points in time.

So let me continue on with this. Obviously if you want to add the two, you know that you have to convert them to the same currency. So 300 pounds converts to a certain number of yen. And so when you add that up, you get 46,050 yen. Or if you want to convert it to pounds, it converts to 300.98 pounds sterling. Those numbers make sense. The reason they make sense is because they're in the same units. So apples to apples is the familiar adage that we use. You can't add apples to oranges. Actually, in theory you could. You could make fruit salad. And you need apples, and oranges, and pears, and all that. But for argument's sake, when it comes to money it really doesn't tell you much that you've got 450 blah. You need to have a set of units.

Well it turns out that this actual analysis requires that we pick a base currency. We pick what's called a numeraire. A numeraire is a unit of account, or a standard, by which we measure everything. So either yen or pounds will work just fine. It doesn't matter which. If you're a British investor, you might care about pounds. If you're a Japanese investor, you might care more about yen. It just depends upon your perspective, but either one will do for the purposes

of analyzing how much money you have at a point in time.

Well that exact same exercise has to be applied to money today versus money tomorrow. Because those two things are not the same. It's like yen and pounds. They're not the same. They can't buy the same things. They aren't used in the same way. They have different markets. The markets are related, but they're different. So once you know the exchange rate, and once you pick a base currency, you can combine the thing. The same idea holds true for cashflows at different points in time. Cashflows at different points in time are like different currencies. In order to add them together, you've got to use the appropriate exchange rates. Once you do, then all of the valuation that we're going to conduct over the next couple of lectures becomes absolutely trivial.

So let give you an example of that. Here's my timeline. And my timeline has payoffs at various different dates. Now I'm arguing that the past and the future cannot be combined without converting them. So we have to have a set of exchange rates that convert all the various different currencies into a numeraire or single base currency. And for the sake of argument, I'm going to just pick, times 0, dollars today as my base currency. So in other words, I want to convert every cashflow into the single currency that is today's dollars. So in particular, over the course of t days, days 1 through t , how many different currencies do I have apart from my base currency of time 0 money. Yeah, I've got t different currencies, t dates. Every single date, it's a different currency. And I need to convert them in order to add them up.

So I'm going to argue that sequence of cashflow, CF_1 , CF_2 , dot, dot, dot-- if I want to figure out what it's worth in a single currency, date 0 currency, I got to multiply the cashflows by the appropriate exchange rate. What's the exchange rate? The exchange rate is how many dollars at date 1 per dollar at date 0? How many dollars at date 2 per date 0 dollar? How many dollars at date 3 per date $\$0$ and so on. I'll have t exchange rates for the t different kinds of currencies that I have. Each currency is dollars denominated as of a particular date. Any questions about that? Pretty straightforward. You think it's straightforward, but you're going to have to think about it for a little while and do some problems to really make sure you appreciate this perspective.

Now we're ready to talk about what this value operator is. I'm going to argue that once you've got the exchange rates across the various different currencies, then the value of the collection of cashflows is just the sum of all of the values of the cashflows denominated in the same currency. But instead of currency, meaning pounds or dollars or yen, the currency is going to

be date 0 dollars. Questions about this? This is important now.

So I'm going to define something called the net present value operator, NPV, as the date 0 value of the cashflows. Now why is this called net present value? Because typically, when you are valuing an investment, you have to pay some money up front and then you get cashflows later on. And so your net investment is going to be given by some summation of those pieces. But it's not a simple sum. You can't just add the numbers. That would be like adding 300 yen to 150 pounds or whatever. You have to figure out how to convert all the currencies to the same unit of account, dollars today. And so that's why it's called present value. That's the value at the present, today.

And the reason it's net is you're netting out any initial investment, which is the cashflow at time 0. So V_0 is equal to CF_0 . Notice, there's no exchange rate, because we're doing it in today's dollars, so that's the base currency-- plus the cashflow tomorrow. Multiply by the exchange rate between dollars tomorrow and dollars today and so on. If there's an initial investment, then the initial cash flow is negative. That just means you have to put money in to the project or the investment. And then, over the course of the next t periods, you get cashflows, which could also be positive or negative. And you have to convert them into today's dollars. And once you do, you look at that number and you see whether or not you like it. That's the value, the net present value, of the cashflows.

Now I have one unanswered question for you. What's the unanswered question in all of this analysis? Sounds good, right? This is pretty simple stuff. But I pulled something out of the air. What did I pull out of the air?

AUDIENCE: The exchange rate.

ANDREW LO: Exactly, exactly. Where do I get the exchange rates? You should be asking me, where do you get the exchange rates? And you know what I'm going to tell you? What's the answer I'm going to give you? Where do I get the exchange rates?

AUDIENCE: From the market.

ANDREW LO: From the market, exactly. From the market. I get it from the market. How do I get it from the market? Well, we did it last time. You know how. We're going to auction it off. You want to see how? I've got a security that pays \$1 a year from today. It pays \$1 a year from today. Who will offer me a penny for that piece of paper? Who will offer me \$0.50 for that piece of paper?

\$0.75? \$0.80? \$0.90? \$0.95? \$0.97? \$0.98? Well, all right. \$0.97 to the dollar. There you go. That's the exchange rate right there. We're done. And by the way, I appreciate that. That's a lot of confidence in my credit worthiness. It's only a 3% discount.

All right, well that's the exchange rate between today and next year. What about today and five years from now? Where do we get that from?

AUDIENCE: The market.

ANDREW LO: Exactly, the market. OK, I've got a piece of paper. It pays \$1 five years from now. How many people will pay me a penny for that? We'll go through the whole motion and come up with the same kind of process. And we'll get a number. So the market-- now in a few weeks, we're going to have to question whether or not that is a good way of getting the exchange rates. I'm not going to talk about that just yet. But that's where we get it from.

So I've begged the question a little bit, but I think I've actually made some progress in providing a framework to think about valuation. Once we establish the exchange rates, you will agree with me that I can value any, any cashflow whatsoever where the cashflow payments are known with certainty in advance. So that's a pretty impressive achievement in the space of 45 minutes. We've actually figured out how to value any cashflow whatsoever under perfect certainty, given the exchange rates. And I've told you where to get the exchange rate from. You get it from the marketplace. That's why financial markets are so important.

It's because we require those inputs into our valuation process for doing the analysis. We rely on financial markets. Financial markets didn't exist, we can't do this. I'd have to wave my hands and say, well, you can get it from some kind of theoretical source. You just make it up. Just come up with some numbers. That doesn't sound very compelling. And in fact, it's not. The power of financial markets is the wisdom of the crowds. And like it or not, you're the wisdom that we're tapping on. We're tapping your wisdom to come up with these exchange rates.

So we know now that the value of a sequence of cashflows is simply equal to today's dollars when you use these exchange rates to convert them to present dollars, dollars today. And that's often called present value. Notice that these exchange rates are sometimes called discount factors. The reason they're called discount factors is because typically they are numbers that are less than 1, like what we saw today. \$1 next year I was able to auction off for \$0.97 today. That number is smaller than \$1 because people are impatient. \$1 today is worth

more than \$1 next year. So if I promise you \$1 next year, you're only willing to pay me a little bit less than that for that privilege. So it's a discount over what it would be on the day that it gets paid.

AUDIENCE: One question.

ANDREW LO: Yes?

AUDIENCE: What exactly are you discounting if there's perfect, perfect? My impatience?

ANDREW LO: That's a great question. Let me repeat it for everybody to hear. The question is, what are you discounting if there's no uncertainty? Why should \$1 next year be worth less than \$1 today? Because there's no uncertainty. I've ruled out uncertainty, right? So there's no default risk. It's impatience. People want to consume now versus later. And therefore, if you're going to force somebody to consume later, you've got to somehow offer them some incentive to do that. So in order for me to have you give me \$1, so that I can take the dollar now, and I'll pay you back a year from now, so that you can't consume that dollar today, you have to wait a year to consume that dollar. In order for me to do that, I actually have to make it interesting for you, which means you give me \$0.97 now and I give you back \$1 next year. I pay you extra for that time that you have to wait. Yeah?

AUDIENCE: Could you also make an argument that I could take my dollar now and give it to somebody who needs to use it now and charge them for the privilege of using my dollar now?

ANDREW LO: Absolutely, absolutely. We haven't talked about the mechanism for determining what that exchange rate is. And I'm going to come to that. But before we even talk about that, I want to acknowledge that it exists, and it's real, and we can figure out what it is just from a simple auction of market, and we can use it. But I'm going to get to exactly what it means and how we arrive at those exchange rates. That's going to be a very important part of this.

AUDIENCE: For inflation, we know that because of inflation \$1 today is also much less than \$1 next year.

ANDREW LO: That's right. I'm going to get to that at the end of this lecture. That's another reason why there might be some kind of discounting. It's not just the time preference.

AUDIENCE: That's part of the answer.

ANDREW LO: That's right, exactly. So we're going to come back to that as well.

AUDIENCE: Is there such thing as a deflationary environment?

ANDREW LO: Deflation can occur. Negative real interest rates can occur during certain unusual periods of economic development. So that's a possibility. It's not a possibility that we've seen in the United States in recent years. But other countries have experienced that. And when that happens, there are some really serious repercussions. So we're going to come to that. In fact, in 2004 the US government, early on in that year, was very concerned about the possibility of deflation. And it was only towards the end of 2005 that inflation became more of a concern. So we're going to come to that as well.

AUDIENCE: Would you separate the concept of inflation from the time value of money? Would you call those two different fundamental concepts?

ANDREW LO: Yes, I would. And let's hold off on inflation for now, because I don't want people to get confused by it. It's something I'm going to bring in at the very end. So I will come to that. That is a topic for lectures two and three.

So we now know how to value cashflows, at least using this very simple framework with exchange rates. And here's an example-- just a very, very simple one-- where I've got the two discount rates, or exchange rates, for next year and the year after. It's \$0.90 to the dollar and \$0.80 to the dollar. Notice that the farther you go into the future, the more of a discount these exchange rates require. That's also human nature having to do with impatience, and possible inflation, and other kinds of phenomena. But again, I'm not going to tell you how we got those numbers. I got them from the marketplace.

Now what's the net present value of a project requiring a current investment of \$10 million with cashflows of \$5 million in year 1 and \$7 million in year 2? That's trivial. Here you go. Minus \$10 million today, \$5 million next year, but next year's dollars is not the same as today's dollars, so you've got to convert it to the right currency. So that's \$0.90 to the dollar multiplied by 5. And then \$0.80 to the dollar multiplied by 7. When you add it up you get a \$100,000 of today's dollars. That's what this investment is worth.

So the first question is, should you take this investment? Is it a good project? Well let me ask you, do you want a \$100,000? Yeah. If you don't, again, see me afterwards. I will help you with this problem. Remember the first day, I told you that once you figure out valuation, management is trivial. Well, I wasn't just kidding. This is an example. What we've been able to

do is to take a problem. What's the net present value of a project requiring this sequence of cashflows? We've been able to take that problem, that management problem, should you do this or not-- we've been able to reduce that to a simple question, do you want \$100,000? I think the answer is yes. So that's the management part. Let's do this. Done. The valuation part is the hard part. The management part, the decision, is easy once you have the right numbers in front of you.

Second question-- suppose a buyer wishes to purchase this project but pay for it two years from now. How much should you ask for this project? Now the first thing you need to do is what?

AUDIENCE: [INAUDIBLE].

ANDREW LO: Well, that's the second thing. The first thing you need to do-- draw a timeline. Draw a timeline so you know exactly what's going on. Two years from now. Is that next year or is that two years from today? So draw a timeline. And you can figure out, once you have the timeline, what the present values and future values are. So when you work out the numbers, you can actually make a decision and figure out exactly what you ought to charge for that.

That's it for the time value of money. But I want to summarize by telling you what we've learned so far. We've learned that we can value cashflows-- assets, which are sequences of cashflows. And the way we value that is by making some implicit assumptions. The assumptions are we know the cashflows in advance, so there's no uncertainty about what the cashflows are. Second, we know the exchange rates. And if you don't know them, go get them. Where do you get them? You get them from the marketplace.

And finally, there are no frictions in the currency conversions. One thing you didn't ask me about is that typically, when you go abroad and you have to convert your currencies, what do you have to do? You have to find somebody that converts it for you. And typically they will charge you a fee for that conversion. I've been talking as if the conversions happen without any kind of frictions. That's an assumption that can be tested. So we're going to talk about frictions later in the course. But for now, we're going to assume that there are no frictions.

Now of course, these are all hypotheticals. They're all approximations to a much more complex reality. But once we understand how the model works with these simplifying assumptions, we can then go back and say, OK, let's make the assumptions more realistic, and let's see how that affects the implications. So I'm going to first do the plain vanilla version

of this. And then, after we fully understand it, I'm going to come back make this more complex.

So until lecture 12-- that's a long ways away-- but until lecture 12 I'm going to assume that these assumptions hold. And after lecture 12 I'm going to go back and systematically question, and expand and revise, each one of these. So when I told you during the first day of class that you can't handle the truth, this is what I mean. We're going to start simple and try to understand the implications of these simplistic assumptions. And then, little by little, we're going to make the assumptions closer to the truth.

Now more examples-- once we understand how this exchange rate mechanism works, we can look at all sorts of other alternatives to calculating value. So in particular, one question that you might ask, that was asked, is \$1 today should be worth more than \$1 in the future because of impatience, because of inflation, because of all the reasons we described. But the bottom line is supply and demand. More people want money today than money tomorrow. And so supply and demand, bottom line, dictates that there is this difference between the two.

So we can actually figure out what that difference is by looking at the exchange rates. So in particular, \$1 in year 0-- if you hold it for a year it'll turn into \$1 times something, the reverse of the exchange rate of \$1 in year 1 brought back to year 0. But I'm going to write it in this format, 1 plus something. Because remember, when we're going the other way, when we have \$1 in year 1 and we want to figure out what is it worth in today's dollars, that's a discount. It's a number less than 1. So if you want to go the opposite direction, if I have \$1 today and I want to know how much is that dollar worth a year from now, it should be greater than 1. In fact, it should be the reciprocal of the exchange rate going the other way. Instead of looking at pounds, you look at yen. And so it's the opposite of the same exchange rate.

But the way I'm going to write it is 1 plus r . Because it'll be greater than 1, typically, so r will be a number typically greater than 0. What about for two years? I'm going to simply write it as 1 plus r quantity squared. And the reason I do that is because I'm thinking about taking that same growth rate and applying it two years in a row. I could have written 1 plus z . And z then would be the rate of growth over a two year period. But I like to think in terms of annual frequencies. So I'm going to just simply assume that a year is my unit of account. And then-- looking at a one year, two year, three year growth period-- I'm going to simply take powers of this factor 1 plus r .

So \$1 in year 0 is going to be worth \$1 times 1 plus r to the T -th power in year T . This r is

often called the opportunity cost of capital. In fact there are like, five different names for this r . It's called the interest rate. It's called the growth rate. It's called the cost of capital. It's called the opportunity cost of capital. John Maynard Keynes called it the user cost. There are tons of names for this quantity but the basic idea is it's the reverse of the exchange rates that we were looking at before when we were trying to bring everything to today's dollars.

Now the reason I'm showing this to you is because it turns out that we're going to want to move money back and forth through time. And in order to do that, we need to sometimes multiply and sometimes divide. And I want to come up with just one set of notation, as opposed to all these exchange rates floating around. So remember when we had T periods and I wanted to figure out what the value of an asset was today given T periods. We had to have T exchange rates. That's a pain in the neck to carry around T numbers.

And moreover, there are exchange rates that you have to deal with between dates T plus k and T plus j . So any two dates, you've got to have an exchange rate between them. So pretty soon the number of exchanges you've got to keep in your head is ridiculous. That's why they came up with the Euro. They tried to unify some of these exchange rates. So here is a way to unify all of the exchange rates into one number, little r . Once you know little r you know everything. You know all the exchange rates for every possible two dates that you care about.

Now where do we get a little r from?

AUDIENCE: The market.

ANDREW LO: Exactly. You're learning. So we get it from the market. Now it's going to be a little bit more complicated than that. It turns out that the market's going to give us many different r 's. So we're not going to get to that yet. So for now, let's just assume that the market gives us one r , this r . Once you have this one number, r , it will allow you to do all of these calculations back and forth. You can move money back and forth through time because you will know what the exchange rate is between any two points in your cashflow sequence.

Now that we have the r , let's go back and figure out what the exchange rates are, what we were talking about in terms of bringing stuff back to date 0. And it turns out that there's a really simple form. It turns out that \$1 in year 1-- if you paid me \$1 in year 1, and I wanted to figure out what it was worth today given this r number that I used, it's actually just equal to \$1 divided by $1 + r$. So what's the exchange rate?

AUDIENCE: O.

ANDREW LO: What's that?

AUDIENCE: O.

ANDREW LO: That's not the exchange rate. What's the exchange rate that allows us to take \$1 next year and bring it to \$1 today?

AUDIENCE: Is it 1 over--

ANDREW LO: It's 1 over 1 plus r. 1 over 1 plus r. Remember, r is a number greater than 0. So 1 over 1 plus r is a number less than 1, like \$0.97 to the dollar. So the exchange rate between next year's dollar and today's dollar is 1 over 1 plus r. What about the exchange rate between \$1 two years from now and today. What is that? 1 over 1 plus r-squared. That's right. And so on. So the exchange rates, or discount factors, are simply related to the little r's in this manner.

That's the mechanics and mathematics of present value. Now this might seem intuitive. And when I say it you might understand it or you might think you do. Please, go back-- between today and Wednesday go over this and test yourself. Try to figure out for a given r-- if you have \$100 today, and r is 7%, what is \$100 worth three years from now? Or if you have \$180 three years from now, and you want to figure out what it's going to be worth not three years from now but a year from now, and the r is 8%, what is it equal to?

Test yourself by coming up with little examples to challenge your own understanding of this concept. Because it's going to be critical. We have to get this right, because everything that we build from here on in is going to rest on the foundations of these calculations.

Now, with these r's, I'm going to leave you with this one last concept, which is that the value of the cashflows that we've been talking about at time 0 is simply equal to the cashflows multiplied by the exchange rates. And now, with this definition of r, this opportunity, cost of capital, this interest rate, this discount rate, we then have an expression for what this value operator ought to be. Using this expression, any cashflow in the world can be valued under perfect certainty and under the assumptions that we described. Any cashflow can be valued, therefore any asset can be valued.

So what we've done in the space of a lecture is to create a valuation operator that works for virtually anything under the sun in certain simplified circumstances. That's a major

achievement. You can congratulate yourself that we've reached this level. But we're going to have to do some more work to think about how to use this. So we're not done yet. We have some additional analysis to do. But this is a wonderful starting point.

Next time, we're going to focus on how to take this and apply it to two very, very special cashflows, an annuity and a perpetuity. And you know what this is going to do? This is going to allow you to figure out what your mortgage payments are every month, when you go apply for a mortgage. You'd be surprised at how subtle that calculation is and how many bankers don't know how to do it. Well, you will. All right, I'll see you next time.

[APPLAUSE]