[SQUEAKING]

[RUSTLING]

[CLICKING]

**JUAN PALACIOS:** I hope that without the coffee, you can still stay awake for the next 90 minutes. Especially the first 45 is going to be mine, and I'm going to take it very personally if you fall asleep. So please don't do it.

So in the first part of the course, we've been talking a lot about mitigation. Basically, how do we make investments in the built environment, and how do we understand the business case of reducing emissions to reduce the chances of suffering, climate change, climate disasters, and so forth? That's been the whole first part of the block, brainwashing you into, emissions are bad. Don't do it. It's actually profitable if you do it in a proper way. So please take action. That's the first part.

Now we're going to have three sessions into the consequences of climate change. So once we put a lot of these emissions in the atmosphere, we increase the likelihood of a lot of bad stuff to happen. And we are going to learn what are the consequences for real estate markets.

We are going to do this in terms of, what are the consequences for real estate value, real estate prices. We are going to talk about the basics of climate science. And we're going to start thinking about how to adapt and how to make resiliency investments into the built environment.

So three sessions-- today, Thursday, and Tuesday-- we are going to be very deep into that topic onto how real estate assets, how real estate markets, how real estate investors are impacted by climate risk and climate disasters. We are going to do it with the usual suspects. Siqi and me are going to be here in front of you. But we are also going to have industry leaders that are willing to come here to see how, actually, the action is being taken on the ground in the sector.

Today, I'm going to talk for the first half. But the second half is going to be by Kevin Fagan, who was sitting here 12 years ago, 13 years ago, an MSRED alum, that went one day to New York, he was telling me, and got an offer after one hour-and-a-half interview and was good enough to keep him for 12 years.

He's at Moody's, the head of the CRE unit there after being for many years in the climate-- in the credit risk department, one of the people that I encountered that knows the most about climate change, climate risks, also transition risk, and real estate. So if you want to learn about that, he's one of the best people in the world to do it.

And he's going to be with us the whole day, with you this lecture, and also a reception afterwards. So please come. Enjoy the coffee, but also make sure that you talk to Kevin because he's one of the people that you can learn the most-- much more than with me, but you guys are trapped with me. What can you say?

So let me give you a little bit-- you see bad and good. Bad-- brown buildings, polluted, bad. So let me give you a little bit of an outline for today's lecture, or at least for my part. We are going to talk about the basics of climate change. And the idea is to give you the logic of what it is and how that it's actually going to be here to stay and how, actually, climate scientists are talking about it and discussing about climate change and the changing climate in a way that is useful to understand how that will impact the built environment and real estate markets.

So I'm not going to give you a very thorough discussion around deep science, but just enough for you to understand what you are talking about and for you to understand that when the United Nations comes out and puts out the next report, how that affects your investment, your holdings, or your decisions in the real estate market.

Then we are going to get into the nuts and bolts of this in the real estate markets using the four-quadrant model I've been casting a little bit around. And there are some people that are more nervous and other people are less nervous about four-quadrant models and so forth. So we are going to add that toolbox to understand actually how, when one side of the market is impacted, how it's going to be impacting the whole market as a whole, all the stakeholders.

And then we are going to talk about more empirical assessments of climate risk and so forth. So we are going to connect it to a lot of the tools that we cover in these settings. And a big part of this is going to be when we are thinking about DCS or we are thinking about assessing climate, it's going to be about the discount rate that we are going to assess to that, the cap rate, how a lot of the risk measures that are impacted are introduced into these valuations that are going to be affected by climate risk.

So this is going to be a big discussion into what is appropriate to discount climate risk and so forth. It's going to be today and Thursday we are going to cover a lot of this. And we are going to cover also the role of beliefs in all of this, the role of climate beliefs, and also the role of the differences between commercial and residential real estate markets for everyone to see.

So some basics-- basically, this is what happens with climate change. We are emitting a lot of CO2, all of those things that we are saying that you shouldn't do and we should reduce in the built environment. Once we put a unit of CO2 out there by burning fuel, that sticks into the atmosphere, and it prevents the radiancy of-- the radiant power of sun to go back into the universe and basically gets trapped, warming the planet and warming the atmosphere.

That's a very basic thing. Every time that we put an extra unit of CO2 in the atmosphere, we create an extra layer out there that prevents the sun to come out into the universe and keeps warming up the planet. And what happens with climate change and the whole discussion is that CO2 is nothing new. It's nothing that we create as humans. It's there in the atmosphere. The plants, the animals, a lot of these things are creating fluctuations into CO2.

If you see, even over 1 million years ago, there's still a fluctuation and going up and down of the levels of CO2 in the atmosphere. And you can actually do that in a very clever way with taking even layers of old ice in the North Pole and so forth. You can actually see how the level of CO2 was back even 1 million years ago.

So you can actually-- based on some clever physics models, you can actually see how the level of CO2 was fluctuating. But after the first Industrial Revolution, this is what is starting to happen. So this is what we are now, and that is around double the amount of CO2 in the atmosphere that it's been for the last 1 million years. So this is what we are thinking about. This might be a problem.

And the problem ends up being related to the amount of the temperature levels into-- in the planet. So this is what-- again, relative to 1980, this is how for the last decades and centuries, it's been like, the temperature in the atmosphere. And this is how it changed over the last years since we started burning fossil fuels to produce goods to move and to heat our buildings and to do all sorts of things.

So you see how the levels used to be something like here, fluctuating around 0. And around the mid-last century, this starts to go all the way up to 1 degree higher, abnormally higher, than that it used to be. These are the blue line.

And how do we know or how do we think about the role of humans in all of this is that if you model with some clever physics models where the temperatures will be using only physical parameters-- so different things of development of the-- forestry, development of animals, and so forth, using the blue modeling and using 1,000 or 1 million or multiple millions of simulations, this is all where it should be without the influence of humankind.

So you can actually predict and forecast how the evolution of temperature will be under any potential scenario that you can actually think of without human gain. And you see that that is way off of what the black line that is what we are observing. The only way that you can really fit in that black line into simulations is if you introduce the idea that there are abnormally high levels of CO2 produced by humankind.

So that's really how the climate scientists and how all of the policymakers are thinking about the role of humans in all of this, is that if you use any clever physics models here to predict the evolution of temperatures, you can never fit what we are observing now in the atmosphere in terms of temperature. The only way that you can fit this line if is you actually incorporate the man-made production of CO2 emissions in the atmosphere. And that's why the scientists are saying that climate is changing, and it's changing because of man-made emissions.

And the forecasting is not really helpful for us, because if we keep producing CO2 in the amounts that we are producing, no matter what the scenario-- every line here is an a scenario. You have millions of lines here. No matter what the scenario you pick, the temperatures are going to keep going up, and it's going to have a lot of bad stuff that we will see now in a bit.

This is one of the things that happens is not only that temperature is 1 degree here or 2 degrees, it's going to be just kind of like the average day is going to be 1 or 2 degrees hotter, but it's also that the number-- especially here, the number of days that are extremely hot are going to increase by a lot.

So this is not a pleasant increase in the temperature, especially in a place like Boston. We can always appreciate this 1 or 2 degrees extra in the winter. The number of heatwaves, the number of days that are extremely hot is going to increase by a lot. And that is going to generate all of the problems that we also discussed in the healthy building lecture in terms of health and cardiovascular problems and so forth. So this is the issue in terms of temperatures, that the amount of days that are unbearably warm is going to increase disproportionately compared to the past decades.

And now, beyond all of that, we are going to cover now all of the disasters that are associated with that. But I want to make a distinction here when we are thinking about weather and when we are going to think about climate, too. Each of these lines here, ultimately, color is one day. So one day here will be like this amount of-- this temperature, like 30 degrees or whatever it would be in the [? arc ?] [? exit. ?]

The distribution here will tell you the climate. So climate describes long-term patterns of weather. So every day, you have a certain weather-- the weather is cold, the weather is warm. Climate is this long-term distribution of weather.

And that's what is changing. And that's what people are responding to because it is stupid to believe that people will make an investment in a building that they're planning to hold for 20, 30, 40 years based on today's weather. They are going to be thinking about it in terms of what they expect the weather-- all the weather, the daily weather-- to be over the period of 30, 40, 50 years that this asset is going to be in our hands.

So what we are interested here is about this long-term distribution, this long-term climate, these 30-year averages of temperature, 30-year averages of rainfall, 30-year averages of cyclones, hurricanes, and so forth. This is what we are going to discuss here today. And this is what we are going to discuss here over the next two, three weeks.

We are not going to discuss how people are impacted or the decisions of people are impacted by these one day cold day, one day that is warm, one day that is rainy. No, we are thinking about over the last 10 decades, the average temperature has been 20 degrees Celsius, 80 degrees Fahrenheit. And now, actually, our average temperature goes to 90 degrees Fahrenheit, and our average temperature goes to 30 degrees Celsius.

That's what we are thinking. We are thinking about we are here in terms of temperatures and we go here in terms of temperatures. And this is here to stay. And this is nothing that is going to be a fluctuation from one day to the other, because these long-term trends is going to change, and it's going to shape the expectations or the forecasts of a lot of our analysts that are going to consider what to make in terms of building an asset, transforming an asset, and so forth.

This is what really matters because this is going to shape all of our evaluations in terms of considering what to do with an asset, what to do with a portfolio. What matters for us is always the long-term expectations, the long-term beliefs that we have there. And this is what climate change is about, is those expectations in terms of how the amenities of a place, how the cost of assets are going to be-- are going to change just because the climate that this asset is exposed to is changing. All right?

They are not going to be shaped by what happens today in Boston. It's going to be shaped by what we think that in the next 10, 15, 20 years is happening in Boston or in New York or whatever we are considering that. Carlos? Good. I saw you a bit confused.

And this is what is changing, and this is what you see. If you see the UN IPCC reports, they are the ones that are actually investigating how the climate is changing and the attribution of that change to humankind. This is what you see, that there is a change in beliefs and change in expectations of how the climate is going to be.

So you see that they started with saying that there is a relationship between greenhouse emissions and-- there is a change-- abnormal levels of greenhouse emissions. And then they started to connect it to climate. They started to use words that are stronger and stronger in terms of the probability of a climate change to be occurring.

So you see from 1995, they go from "suggests" to 2001, they go to "likely," "very likely," "extremely likely," all the way down to "is already impacting us." So this is something that when you are making decisions, you see how the approach and the belief is changing over time, and therefore, that should have consequences into the decisions that people are making in terms of long-term allocations of capital, long-term investment decisions.

And especially when it comes to 50 years, when it comes to things that are kind of two, three decades ahead, this is something that it is not anymore something that our next generation will be impacted by. It's actually that our generation is impacted. And especially when you think about insurance companies, pension funds and so forth, those are already within the investment horizon of those folks.

And when you are thinking about buying an asset to hold it for using purposes and so forth, 20, 30 years is something that it is not anymore the next guy that buys the building, but it's actually something that it is me the one that is going to suffer the expected damages of a hurricane or the expected cost associated with having an AC running full power not 20 days a year, but actually 40 days a year.

So this is exactly-- this is the key of climate change. This is actually what we have to think about. How that changes is going to influence the real estate market. That is going to influence the real estate investment decisions.

It is going from, ah, it seems nothing changes to, oh, it seems that there is a change here in the atmosphere, and actually, it seems that it's actually something that is related to how we produce goods and how we heat buildings, the CO2 emissions that we produce, but it's also something that we know is not going to change in the next few years. And this actually is something that, hey, it seems that we have enough evidence to see that the climate already changed when you compare it to the last 20, 30 years beforehand.

OK, how is it changing, and where is it changing? If you see-- so on the one hand, as I said, as we saw, the weather is-- the climate is getting hotter and hotter. The amount of heat waves are increasing everywhere in the world. So if you compare the differences with 1980s in temperature, you see that everywhere in the world is getting hotter.

And that means that people are exposed to uncomfortably warm weather when it comes to selecting where to live much more than it used to be, especially in areas that were already warm. You have more problems with health, more problems with different heat-related diseases, with cardiovascular problems and so forth.

And then you also have a change in the distribution of precipitation. So as the atmosphere gets warmer, it has a different capacity to absorb moisture and actually distribute that moisture. So you see that on the one hand, you get more problems with droughts and people that have-- droughts.

And people that are coming from the area of California and so forth can speak to the idea that it is much more severe than it used to be ten, 15, 20 years ago, and also people-- I come from Spain. We have-- what used to be a bad year in terms of having the lakes almost empty, now it's sort of the normal routine to see that the lakes are really being really empty and having problems for the agriculture and having problems for giving water to certain cities.

And if you combine hot temperatures with dry temperatures, you have the perfect scenario for wildfires. So, again, if you see something from California, you see that, year after year, you have in the news that there has been a wildfire somewhere near a city and that has some infrastructure being destroyed, some buildings being at the risk of fire, and so forth.

So, again, something that used to happen once in a decade is now happening every year. And that is, again, the probability change that we want to use in terms of how do people respond in the real estate market and how that is affecting the value and the different decisions that are happening in the built environment.

And on the other hand, you also have the problem of too much water in other places. So if you see the level of ice in places like Antarctica, in places like the North Pole or Greenland, you see that the amount of ice that is in there is much, much lower than it used to be. And it's not only the ice that is generating from year to year, but actually, the ice that has been there for thousands of years is now being melted, and it's going to take a lot of time, if ever, it's going to be recovered.

That is going to be more water that is coming into the oceans and the seas. And it's going to make, ultimately, that the coastal cities like Boston is going to have a sea level rise problem.

And not only that, so even if you are not in the coastal areas, what you see is that because of the distribution in moisture in the atmosphere, you are not only having more problems with droughts, but also you have it that when there is rain, it's more likely to be a bigger storm that is going to discharge a big amount of water in a given point of time in a given region.

And it's going to make it very difficult for that region to absorb-- the soil to absorb that. The water is going to generate a lot of problems with floods all over the place, and especially next to these big rivers.

So there is no area that is not impacted by this risk in a lot of places like the United States-- not only the ones next to the sea, but also, all over the region, you have the problem that you can have the chance to these big storms being larger and, therefore, having big problems for water management and being able to cope with that amount of water in a very short term.

This will happen, for example, in Germany, for those that are from Europe. A couple of years ago, I was actually really nearby. There, out of the sudden, there was a big storm, and there was this-- one of the main rivers that got flooded. And areas in Belgium, in Germany, and in the Netherlands got completely dilapidated by the water.

And a lot of people died because, especially in Germany, people can live in basements. And they were warned too late. They couldn't escape the basement. And then the water came in into their houses, and then they died.

And at the same time, Siqi is originally from--

**AUDIENCE:** [INAUDIBLE].

**JUAN PALACIOS:** --Zhengzhou. At the very same time, there was a big flood in Zhengzhou for the exact same reason of big precipitation coming in and being unable to absorb all of that water. So those events that, again, used to happen once in a lifetime now are happening more and more often.

And what used to be something that you wouldn't care at all when you were underwriting any asset or making any decision, now it comes to be very responsible if you have no consideration for them, because it's very, very-- much more frequent than it used to be. And this is, again, the probability that we want to think carefully about how that impacts the real estate market.

And this is the overall trend. This is the number of-- every bar is the number of $1 billion disasters across different type of events-- so droughts, wildfires, flooding, and so forth. And if you see, over the last decade, there is a clear upward trend into the number of events that are happening.

And these are events of $1 billion events. These are not the smallest storms that you are seeing. These are actually storms that are causing big damages.

And then you see in the lines how also the amount of the cost in billions of those disasters are also going up. So those are billions of dollars that are happening. And they used to be just this much.

And they used to be this small here and now are going all the way up. So those billions are being distributed ultimately among the public sector, among the insurance companies, and among the private sector. But it's very clear that somehow we will all pay in one form or the other for it because the insurance are not going to keep absorbing billions and billions of dollars of climate disasters, because there is just no way that you can actually keep making business sense of keep absorbing billions of dollars in places like Louisiana, places like Florida, and so forth.

Kevin and I and Siqi were talking over breakfast how insurance companies are exiting markets like Louisiana just because there is just no financial model, no business sense to keep absorbing a lot of those damages if you have such a frequency of those disasters in that region. So, you know, for a while, they can be a-- they can give you some bandwidth.

But if this becomes the systematic change there, where, every year, you have to absorb all of those billions, and even more because you see that the trend is going upward, then ultimately, you will go bankrupt, or you will just decide to exit to make to keep making money out of your own business, because if you keep just absorbing the punches, eventually, it just doesn't make any financial sense.

So this is the situation. I hope that you are all depressed.

[LAUGHTER]

No? When someone tells you that they hope that you'll be depressed, you shouldn't laugh. So impolite.

**AUDIENCE:** [INAUDIBLE] this will also bring us a lot of job opportunities.

[LAUGHTER]

**JUAN PALACIOS:** Yeah, for rebuilders, yeah. Exactly.

**AUDIENCE:** All the real estate companies, they need us to [? start ?] the kind of risks, right?

**JUAN PALACIOS:** Yeah, job opportunities for those that know and understand this. Yeah.

**AUDIENCE:** Only from us.

**JUAN PALACIOS:** Yeah. Well, definitely, I mean, there is a lot of people that never got these type of insights. And they keep living and making decisions in a world that look like this, while hopefully, after these sessions and after this course, you understand how to make decisions and how to think in a world that looks like present.

So that's where your job opportunities come, thinking not like this, but thinking like this. And this is also one of the sessions. Carlos, you want to think like this.

**AUDIENCE:** I have a question.

**JUAN PALACIOS:** Sure.

**AUDIENCE:** Looking into the graphs and seeing that the green component, which is severe storm count, is the one that has grown substantially, and also looking at the 5-year average cost line, is there any correlation between how population has grown into big urban areas and how that has affected, indeed, the costs of the ongoing disasters that are related, at least with the storms and floodings?

**JUAN PALACIOS:** Yeah.

**AUDIENCE:** Because I imagine it's more costly if you have more people living in dense areas than maybe separated, small, rural, suburban concentration of people. I don't know if it has any correlation with the ongoing growing of costs.

**JUAN PALACIOS:** Yeah, yeah. It will not-- that's a very good point, and that's a very good question. So it will not explain the total amount of damages. But it is true that one of the market failures that are creating that the damages are more severe is that we keep letting people develop in areas that we know are at risk of flooding and we know that are at risk of suffering some of those events.

So it doesn't make sense that, if you think about areas that are at very high risk of suffering a wildfire or suffering a storm, that you keep letting people develop in those areas. And you have-- for example, in the United States, you have the FEMA maps where you have a very accurate view on what are risky areas, what are not risky areas.

And in a lot of places, we let people develop as that risk is not there. And we let people develop in areas where we know that sooner than later, there will be something that will blow away those houses, and therefore, the damages and the human lives that are involved in that are at risk. So we definitely need to rethink about different zoning areas that are helping to mitigate those risks by avoiding that people are exposed to certain things in certain areas that we know are at disproportionately high risk of suffering, a wildfire, flooding, and so forth.

So this is part of the problem, that we let people keep developing next to the coastal line, we need to [INAUDIBLE]. And while we don't put infrastructure in place to prevent the flooding, we let people to be living next to river flows that are at risk of flooding when there is these severe storms happening.

But a lot of it is that as you see in the-- let me go back. As you see in this map, those events-- this is only for heat waves, but that happens everywhere in a lot of those events, too. Those events are being more and more widespread. And they are more and more damaging year after year.

So that is the big part of that graph, that something that if you see here-- if you think about Latin America here, you see that it used to be-- it starts in blue. And it's really nothing there. But as you go on, you see that it starts to be part of Latin America.

And now, as the graph goes on, it's the entire Latin America that is affected by heat waves. So it is growing more and more widespread, and it's growing more and more damaging. And that is what is causing this trend to go up, together with the idea that we don't let people be protected, given that it seems that we don't learn from the past.

And then we keep letting them live wherever a developer decides them to live, or they themselves decide to build a parcel of land. And we will talk about resiliency, and we will talk about those things later, too. Bill?

**AUDIENCE:** Kind of off of that point-- and if you're going to touch on it later, then feel free to skip the question. But--

**JUAN PALACIOS:** Sorry.

**AUDIENCE:** --we're dealing with finite amounts of public funds, private sector funds. And like you said, there's already people living next to that river that's going to start overflowing every 5 years rather than every 100 years. Where do you put money into adaptation, and where do you put money into mitigation? Is it context-specific?

**JUAN PALACIOS:** Yeah, that's a very good point. A lot of it comes down to a political decision of where do you want to do. And a lot of it, we will talk about beliefs about climate change and so forth. So then it is also some belief story there.

We will talk about, later today or early on Thursday-- I think it will be early on Thursday given the time --and I want to give Kevin enough time to talk-- about resiliency investments. So we will talk-- we will go through the case of Boston Seaport and how do we make those decisions, all going down to the valuation of those disasters and the valuation of the expected effectiveness of defensive investments that we are going to do with different city walls and so forth.

And then we are going to see how those decisions are being influenced by mitigation versus adaptation preferences, and also your beliefs about different risks associated with it and so forth. And there we can talk more about it with those numbers in front of it. Anyone else? David?

**AUDIENCE:** Matching that spike in disaster cost in 2005 is Katrina. Do you know what happened in-- what's 2007?

**JUAN PALACIOS:** 2007.

**AUDIENCE:** Sandy.

**JUAN PALACIOS:** Sandy, yeah.

**AUDIENCE:** 2008?

**AUDIENCE:** '16 [INAUDIBLE], Sandy that destroyed New Jersey?

**AUDIENCE:** Pretty sure '17 was either Harvey or Irma. But then there was a ton of wildfires that year.

[INTERPOSING VOICES]

**JUAN PALACIOS:** Great. So one of the things that I want to do now is all of those disasters have some implications for real estate. And now what we are going to do is also thinking about how those type of disasters are going to translate ultimately to the bottom line. One of the first steps is to start classifying those disasters.

It's not the same for the built environment and for an investment in real estate to be thinking about exposure to a heat wave, to being exposed to a wildfire, or to being exposed to sea level rise or flooding.

Some of them have direct risk of destroying our properties. Some of them will have implications for the operating cost of that property. Some of them are actually things that are related to risk. And some of them are thinking related to experiencing disamenities and this utility of being in that place.

If you look at the classification that is usually taken in the real estate industry, and if you see the reports of ULI and other big think tanks, you will see that you have a classification of physical risk that is divided into two. You have acute climate risk. That is basically all of these catastrophic events, these $1 billion events that I showed you in the previous slide.

But you also have more chronic climate risks that are basically disanemities like the increasing heat waves and also sea level rise, those things that are not necessarily things that will generate an impact as of now, but it's actually increasing the risk of a lot of other stuff to happen. So that's a big difference.

And then we have the transition risk. That is a lot of the things that we also cover in the first block-- regulatory changes, market changes that will actually make those assets be less attractive. So it's not only here we have-- the physical risk is the first-order effect. So once my asset is hit by that event, how will that respond?

But also, you have all the market responses associated with people believing that that heat will happen more often and will be more severe. These are the two things that we're going to cover in the course, and especially actually thinking about the market risk and transition risk.

So before-- we want to be preventive here, and we want to actually teach you how to avoid the punches. So we actually want to teach you how to be ahead of those severe events and actually how to cope with them using market signals and market strategies.

There are a few things here that you'll want to think about. It's a lot of the things of rising sea levels, rising average temperatures, have to do with things that are happening on a very continuous basis. Year after year, you have more higher temperatures. Year after year, you have also a higher level of sea rise.

Those are things that we are experiencing. We can actually almost continuously incorporate it into this. And then you have a lot of things that are catastrophic events that will happen every 10 years, every 15 years. And those are events that are related to the risks. You don't experience them on a daily basis. You don't experience them on an annual basis. Those are things that are the risk to happen of very severe bad things in 10, 15, 20 years.

Let me skip this. And now we want to do-- in the last 10 minutes of this, I want to actually use one of the key tools that you learn in real estate economics to understand how all of this translates into real estate markets and real estate building and asset values.

There is a lot of-- and the reason why this is important is that there is a lot of literature-- every year, every month, you get a new paper showing that there is this climate event or this disaster that is linked to a drop in value and so forth. So there is a lot of different scattered pieces out there, and it will happen more and more over the years.

So when you graduate, and when you need to incorporate those things, there will be tons of new papers. And what we need to do here is to give you a good framework and a good way to understand how those translates, ultimately, into asset values and how those actually connect with each other in a way that if you see that on the one side, tenants are affected, how you actually think from your developer chair about the consequences of your decisions.

So one of the things that I want to do is get someone to help me understand the four-quadrant model. So who can tell me what it is, and who can tell me who is in each of the spaces? So who is in this space?

You start here from the top right. Who is in this space? Who meets in this space? The developer, the construction companies, the tenants, the banks? Landlords and tenants. All right. And how do they relate to each other? Julio?

What are they doing here? What is this curve telling me? I see stock. I see rent. Who decides what?

**AUDIENCE:** The [INAUDIBLE] demand curve like the one you see right now. It's not showing the quadrant, but you also have the supply curve. They both [? reach ?] [INAUDIBLE] price based on the supply and demand.

**JUAN PALACIOS:** Mm-hmm. So the way that we usually start is that the supply is fixed. We don't move the building stock from year to year. It takes some time to build housing, to build the buildings.

So this zero is a starting point. And then, given the demand for a space of tenants, this is the amount of rent that they will pay. If the tenants want more space than this, this line will go to the right. If the tenants will go less, will need less space, this curve will move inwards.

So if you think about nowadays, working from home and so forth, these tenants will actually demand less space. So this curve will go inwards. So for whatever the amount of buildings are in a city like New York, I will need less space than it used to be. OK?

So now we have supply and meeting the tenants. What about the asset market? Who meets there.

**AUDIENCE:** It's buyers and sellers. So given that--

**JUAN PALACIOS:** Buyers and sellers.

**AUDIENCE:** --level we just established will then determine what the market price is for transactions. So like you said, if your rent increases, the price increases. But if it's decreasing, the price will decrease-- fewer transactions.

**JUAN PALACIOS:** And how do we think about movements in this curve? What makes that move? Here, moves that curve to the right.

**AUDIENCE:** Stronger fundamentals in the market. So higher rents means higher value, or lower rent would mean lower value.

**JUAN PALACIOS:** Yeah, but that would be movements along the curve, right? So if this trend will be here, then that price will be there. But how should we think about movements in this curve? What would make that for a given rent, the price would be higher, or for a given rent, the price would be lower?

**AUDIENCE:** Changes in cap rates?

**JUAN PALACIOS:** OK, and what generates changes in cap rate?

**AUDIENCE:** Underlying financial systems, economics, interest rates.

**JUAN PALACIOS:** OK. So what about asset-specific perception?

**AUDIENCE:** Sure.

**JUAN PALACIOS:** Risk? What happens if the risk of an asset is higher or perceived as higher?

**AUDIENCE:** The cap rate would increase.

**JUAN PALACIOS:** And that means that these guy will be here.

**AUDIENCE:** Right.

**JUAN PALACIOS:** Because for a given rent, the risk will be higher, and therefore, the more reluctant I will be to hold that asset, because at the end of the day, as an investor, what I care about is not how beautiful is the building or anything like that. What I care is about my chances to retrieve back cash flows.

So as those cash flows are getting riskier, then my willingness to pay for that asset is going to be lower because, you know, it might be that the tenants go away. If you think about holding the same asset before and after COVID or before and after the work-from-home changes in New York, it is broadly the same lease structure and so forth in a lot of assets.

But now I'm way more worried that those tenants will leave. And even though I'm buying the same set of contracts, my expectation that those leases will stop is much higher. So for whatever the rental value is, as of now, I'm going to pay much lower price because I'm way more worried.

OK, who can help me with the bottom? Bill?

**AUDIENCE:** As prices increase for assets, the developers respond by building more square footage.

**JUAN PALACIOS:** OK. And what about this-- why is not-- the rest of the lines start here, in the cross of the two axes. Why is that line started only here?

**AUDIENCE:** I'm assuming because you already have a certain amount of stock, you're not going to go to zero. You're going to always have some square footage, some stock. And that's why it doesn't start from zero. But I'm just guessing there.

**JUAN PALACIOS:** Any other thoughts?

**AUDIENCE:** At that point, contractor doesn't make any money. So at a certain price, it started to make some profit, and that's where it stopped.

**JUAN PALACIOS:** Yeah. So you can think about this as the number of square feet that are built. If you don't reach a certain amount, you will not build at all. You will not make any sense of building a building at all. What makes this curve move?

Here we have preferences of tenants. Here we have the cap rates and the assessment of risk of an asset. What do we have here? Julio?

**AUDIENCE:** Construction prices and--

**JUAN PALACIOS:** Construction cost.

**AUDIENCE:** Yeah.

**JUAN PALACIOS:** Yeah. And something else?

**AUDIENCE:** It doesn't change a lot, but let's say permitting and--

**JUAN PALACIOS:** Yeah, so those are costs of building that asset-- material costs and other things. So, Carlos, you were saying maybe we shouldn't let people live in areas that are going to be hit by certain disasters. If we make those things more difficult and we make the resiliency requirements for assets to be higher, it is great on the hand that the assets that are going to be built are going to be safer.

But on the other hand, there will be some assets that will not be built because the cost of construction are going up. So then you need prices to be higher up to make sure that you compensate for the increased requirements in building certain buildings. And what about the last one?

This one relates the amount of buildings that are constructed with the amount of buildings that are standing in the market. [? Amir? ?]

**AUDIENCE:** In the market, there's the existing assets, and there's a depreciation of the existing stock. And the new amount of construction that comes in from the third quadrant will increase that value. But if construction slows down, you already have the existing stock, but that's decreasing at the depreciation rate.

So new stock feeds that higher, and a stall in construction means that the number comes down.

**JUAN PALACIOS:** Right. What can move that curve? The depreciation?

**AUDIENCE:** I mean, if there is a replacement or demolition of a [INAUDIBLE] asset [INAUDIBLE], that might not have been [INAUDIBLE] [? tend ?] to shift downwards.

**JUAN PALACIOS:** Yeah. So if things like, for example, the amount of-- how harsh is the place in terms of the depreciation of that assets, or maybe even when it comes to equipment, the requirements for that equipment to be full power all the time in terms of temperature and so forth, then the amount of depreciation would be higher.

But also, if you have the risk of these assets to be vanished every other decade, then you also have somehow there a probability that whatever you are building is going to be destroyed at some point. And the stock is not going to translate one-on-one to the construction.

So we are going to use those things. And the important thing is that everything is ultimately connected. So if something is happening to our tenants, it's going to shift this curve, and it's going to ultimately shift the prices of assets in the market, and it's going to shift the construction rate, and it's going to shift ultimately the supply of assets in the market.

So everything is connected. So whenever we have a report, whenever we have a study that will tell us that this quadrant is affected or that quadrant is affected, ultimately, the whole market and everyone in that market is affected. And the key is that if we don't have that view, we will have a very myopic view of the whole climate change because we will only think about this partial view of, OK, rents will change, but yeah, if rent changes, then the investors will act differently, and then the construction companies will act differently, and ultimately, the supply will be different.

So all of these long-term/short-term effects is something that we have to be very present when we are analyzing the consequences of climate change in the real estate industry. And that's where one of the key values of knowing real estate economics when we are thinking about this, and that's the value for those that are doing the MSRED program to come from that course all the way into here.

So if you think about the demand side-- [? Leah? ?]

**AUDIENCE:** I just have a quick question. So can you go back--

**JUAN PALACIOS:** Sure.

**AUDIENCE:** This is for the rental market? How does it work for homeownership?

**JUAN PALACIOS:** Yeah, so here we are thinking about commercial real estate properties. In this center, we have-- thanks to David Geltner that kind of brainwashed us, we think about commercial real estate as any income-generating property. So you can think also here as [INAUDIBLE] a multifamily and, if you will, rent an apartment, it will be part of this.

If you think about homeownership, that would be-- basically, you will not have this, but you will have some sort of utility of living in that place. So you will have a monetization in your head of what it is, what it means for you to live in that place. We will see some graph now also from the empirical studies on how homeowners and homebuyers are actually changing their willingness to pay to live in a certain place depending on the temperature of those places.

So there will be some-- that's how we use it in economics. We will translate your happiness or utility to live in a place into willingness to pay or any kind of monetary value that will translate that into some of demand curve.

And then there will be some investors that is, on the one hand, the equity investors, so someone that is buying or co-buying that property with you. But it's also here there is someone important here-- there are the banks and the debt providers. So they are going to be here, even if you are a homeowner. And that will be applying a lot of the logic to that four-quadrant model, too. OK?

So what can we expect in terms of climate change impacts on the space market? What do we think? Do we think that people are going to be more happy to live in places that are going to be at risk of wildfires-- so let's think about California? Or are we going to think that people are less happy to live there? And how are we going to see that in the market? Yeah?

**AUDIENCE:** Some certain risk areas, people will move [? there ?] [INAUDIBLE].

**JUAN PALACIOS:** Yeah.

**AUDIENCE:** [INAUDIBLE]

**JUAN PALACIOS:** Yeah.

**AUDIENCE:** And the curve [INAUDIBLE] [? shift ?] [INAUDIBLE].

**JUAN PALACIOS:** Yeah. And that will have a direct impact on the rents. But ultimately, because the rents now are lower in that market, prices, and, ultimately, the construction activity. So that's how that shifts the whole idea.

And if we want to put it into what will determine that, it will be the attractiveness of that space. So if you are exposed not only to a couple of days of heat waves a year, but actually now it has to be, like, two weeks, three weeks a year of heat waves, then, as a resident of that place, you're going to be less keen on living in that place. Yeah, Julio?

**AUDIENCE:** That could also work the other way around, right? When you have people moving from one place to the other because of climate change?

**JUAN PALACIOS:** Correct.

**AUDIENCE:** It could have a positive effect in some [? states. ?]

**JUAN PALACIOS:** Correct. Here we are thinking about areas that are badly impacted by that-- so more heat waves, cities like New York, a city like Boston, that are experiencing more and more heat waves and so forth.

Also, impacts of occupants-- So these are for people that want to live there. But companies that are renting space to work there, they will be worried about performance changes. They will be worried about behavior change of consumers. So people are actually less likely to go to the shopping mall because it's impacted for more severe storms, for more heat waves, and so forth.

They are all going to [? beat ?] lower in their leasing [? beats ?] than they used to be. And then, also, ultimately, the impact on amenities and also the climate risk disclosures.

This is what you see. So here, this is translated into this model of Roback model where you say, well, the amount of money that you are going to pay for living in a place of rent is going to be affected by the amount of money that you earn in the labor market and also your appreciation for that place.

So you can actually be willing to earn less if you are in a place that really gives you a lot of utility, a lot of nice place. So if you are living in a very bad place-- think about a very bad with low amenities industrial area in the middle of nowhere-- they really need to pay you a lot to attract someone as talented as you guys to be working there.

But if someone has a little bit lower paycheck but is in an area next to a nice lake, mountains, whatever, you are going to be less greedy when it comes to negotiating those terms, because you really want to live there, or if you have the family next to you, or whatever you want to give you a quality of life.

So as the quality of life reduces, the people will have-- the companies will have to pay you more, or the landlords will have to ask you less rent because you are less attracted to live in that area. So climate change is actually-- or, for example, temperature exposure will actually reduce that quality of life. That will mean that either you are required to pay less to be in that place or the employers will have to pay you more. But basically, the real rents will actually need to go down. Yeah?

**AUDIENCE:** I have a quick question.

**JUAN PALACIOS:** Sure.

**AUDIENCE:** Considering the change in climate, will more people be compelled to make adaptation, and will that not increase the cost of construction and [INAUDIBLE]?

**JUAN PALACIOS:** Yeah, that is also something that would be there. So that would be the other quadrant. This is more for the demand for a space. So there is not the adaptation, but it's more like if there is a set of buildings that are built for you, and where do you choose to live, and how much are you choosing to pay for those buildings?

And then there will be the construction company that is trying to match those preferences to the characteristics of those of those places. And indeed, if now you require to live in a place or to work in a place that needs an infrastructure upgrade, because now you need to have a fancier AC unit, you need to have a stronger seawall around the property, then that will increase the construction cost, and that will have an ultimate effect on the supply and the cost and the price for those properties.

And this is what you see in the empirical data. So you see that people actually-- this is the amount of money that people are willing to pay per square feet. And this is the winter temperature in Fahrenheit. So you see that people want to live in places that are warmer in winter and also cooler in summer for any region in the United States. And these are the effects on behavior and so forth.

What about the asset market? What happens there. What do we think about climate risk? Is there any impact of climate risk on the asset market or no?

I keep pressing twice, and then I keep giving the answer. But what I like is the logic, not so much the-- [? Ashley? ?]

**AUDIENCE:** Despite being in the space market, if wildfires are burning down trees, [INAUDIBLE] then the building, [INAUDIBLE] building materials might decrease.

**JUAN PALACIOS:** Yes, that is true. That is not the space market but is the asset-- the construction market, because that will ultimately impact the price of timber, and that will ultimately impact how much it costs to build a building. Andy?

**AUDIENCE:** Like we had said before, we're talking about shifts in the curve. Given a current rent level, if there's perceived higher risk or future higher costs to maintaining the property, the curve is going to shift in so that at that current rent level, there's a lower price in the rental market.

**JUAN PALACIOS:** Can we think on a specific event that will make that curve shift or that will increase the perception of risk?

**AUDIENCE:** Insurance premiums double or triple in a given market--

**JUAN PALACIOS:** Correct.

**AUDIENCE:** --your operating expenses are that much higher.

**JUAN PALACIOS:** Correct.

**AUDIENCE:** So you're going to pay a lower price to adjust for that added cost.

**JUAN PALACIOS:** Correct, correct. So the rents-- what you get is not actually the rents. What you get is the ultimate profit of holding that asset every year as an owner of that asset. So that is one.

And there will be also-- so you have it here, an also greater awareness of investors that will actually adjust the risk. Kevin, I'll give you the floor in one minute. And there are things like the TCFD, the Task force on Climate-related Financial Disclosures, where major banks and investors are actually forcing companies to disclose the climate risk associated with their assets so they can actually price it in their in their conditions and terms where they are giving debt to building owners.

So all of these will make that for whatever rent tenants are willing to pay, ultimately, the price for those assets are going to be lower. That is going to impact the construction, too, and it's going to impact the long-term supply in the market.

And I have it here. And that is also something that if you see-- and I'll discuss this next week in more detail. But what you see is that actually, when you see the empirical data, you see that a lot of the changes in property prices are not coming by changes in ROI and rents, but actually coming from increases in cap rate. It's coming from the perception of risk of those properties.

So for any given rent that is out there, actually, now, owners and investors are willing to pay less, because they have a higher perception of risk on those properties. And it makes sense because those are the ones that have a long-term horizon versus the ones that are making a lease for two, three, five years' time.

And finally, just as a recap, finally, the construction-- what you see is that as the cost of materials and the different requirements of companies to construct in certain places, you see that the amount of construction is going to go down. The price is going to also reflect that, and the rents are also going to reflect those.

And finally, as the likelihood of the stock to be destroyed increases, then for whatever unit of whatever amount of construction is happening now is going to survive less, and that is going to decrease the supply and have all the bad consequences for rents and so forth.

And remember that at the same time that we have the climate crisis, we have in a lot of places an affordability crisis. So we really don't want supply to be even more constrained, especially when it comes to the housing market. So all of these things is going to put a lot of stress into markets, and it's going to make a lot of the-- lives of a lot of people even more miserable.