PROFESSOR: So today is the fourth and last lecture on the sort of microfounded macro models. And then next class, we will turn to a section on measurement, which is like a halfway point, or not really, in terms of total number of lectures. But we'll get into them-- to the micro evidence.

I must say, this is sometime-- I said this last time-- in reverse of what I sometimes do. I often start with the micro stuff and build it up. But this isn't a bad idea, because you'll get to see this way how different assumptions matter within each of these models as you compare the predicted solutions. So it hopefully heightens your sensitivity to assumptions. And then we'll get into the microdata and really scrutinize what we see there. This paper, in particular, is part of that conversation.

The way it's organized in terms of the lectures is this paper features mostly something other than limited commitment. Almost every single model has had sort of very limited credit or financing constraints, collateral constraints, basically putting a damper on sudden transitions and generating growth paths. And here, we're going to be looking at transition somewhat-- also, steady states.

The main thing is we're going to be featuring on other alternative underpinnings of the models-- costly state verification, adverse selection, moral hazard. Again, the irony, for those of you coming down from the advanced macro class, is that Alp was featuring costly state verification up there early in a lecture. And these things are somehow related, in the sense that the dynamics that are created with the debt contracts and so on have to do with what you assume about the information structure, as well as adverse selection and so on.

So you'll be perhaps a little relieved to know there isn't as much material on the front end of this lecture as there was last time. That's kind of a sad comment on the literature. Almost everybody assumes limited commitment, so there really wasn't much to choose from. We sort of scoured the earth to find some relevant papers in this genre.

So there's three, and the third one is what I'm going to focus my attention on, the tree, so to speak, of the lecture And now we'll look at several trees. The first two are a bit different.

This one is Greenwood, Sanchez, and Wang-- Jeremy Greenwood, as of Greenwood and Jovanavic, which was a key feature of one of the first two models we talked about in lecture 2. And he's going to focus on Levine's comment.

It's kind of cool the way these things come together. Levine worried that the finance causes growth. Empirical literature doesn't have a microfounded view of what really impedes intermediation. So that's what this paper is about. And it's going to be sort of a costly state verification point of view with diminishing returns and exogenous, technological progress.

There's a telling sentence. In the paper, Uganda could more than double its output if it would adopt best practice in the financial sector, which is something like the US or Luxembourg. Although, there are other things in the model, so that that's not enough to get it up to, quote unquote, "its total potential output." Again, you see this language of gaps here that we focused on earlier in one of those financial possibilities frontier. So this is very much trying to get at gaps in terms of the underlying model.

AUDIENCE: What are these other factors?

PROFESSOR: Hmm?

AUDIENCE: What are these other factors?

PROFESSOR: There's going to be some technological progress that varies across countries, which is pretty standard stuff. And then this is kind of layered in, or it's actually more of the heart of the model, given that other. Well, we've seen that was done in the China paper as well.

So another interesting thing, 29% of US growth is due to improvements in financial intermediation. So this paper both has transition paths in it, as well as steady states. This is a comment about steady state. There's exogenous technological progress going on, not at the level of the sort of TFP shocks that are in front of the production function, but in terms of the monitoring technologies which intermediaries can use to verify some private information. And that's where the technological progress is that's driving, say, steady state US growth rate according to their calibrated version of the model.

Now, there are two key variables here that they focus a lot on-- the interest rate spread and the capital output ratio. So let's look at them. These slides are interest rate spreads. This is the US. That's Taiwan. This is the spread in the US, maybe 3%, maybe declining, but not so clear-- modestly so.

And this is sort of the capital to GDP ratio. And it's paired to Taiwan, where it's a bit more-- at first at least-- easier to interpret. This spread is high and declining. So this is the transition part. This is Taiwan experiencing technological progress that's lowering, or even I guess it was in the steady state, at different levels of technological progress in monitoring output.

And as that happens, as the intermediation system becomes more efficient, capital is increasing. You can make better use of capital because banks have better information, and they can lend more appropriately and adjust for risk more appropriately. Now, even then, this diagram is kind of striking. Because you can see that this is steadily rising as the spread is coming down. But relative to US, the capital to GDP ratio is quite high. So you know, just be mindful.

There's two variables here, and one of them is GDP. So low levels of GDP kind of make that ratio high, and that's going on and also moving these variables as you compare over time and over countries. So the idea is that firms, banks, really monitor cash flows. The efficiency depends on the amount of resources you devote to monitoring and to the productivity of that monitoring technology. And as well, firms have differences ex ante in the structure of returns that they face.

So they get the usual sort of why money doesn't flow from low productive firms to high productive firms. And the answer is this monitoring. At any moment in time, there are firms with high expected returns. They tend to be underfunded. But it's underfunded relative to this world with complete information. Whereas, we're in the constrained second best world. Others have low returns and they're overfunded. So these are the sort of not so talented wealthier firms.

That theme keeps coming up in all the lectures. In China, it was the state-owned sector. And last time it was firms drawing talent, and some people having low talent which is persisting and so on, which is sort of what's true here. And of course, as efficiency increases, funds are reallocated from less productive to more productive firms, and the interest rate spread goes down. There's going to be perfect competition in the banking sector. So the cost of borrowing is going to fall because these firms are going to be kind of less able to walk away with the money in terms of the monitoring technology.

So here is a picture of the interest rate spread. And it kind of goes the way you would think. The low interest rate spread countries are these highly industrialized countries, and they tend to have low capital to GDP ratios, in part because they have high GDP. And here's a cross-section of countries that vary with respect to the level of income and the capital output ratio.

And this is, again, very similar, except this is TFP over here. So you can see that interest rate spread is a bad thing, and the higher the spread, the worse the system. So as the interest rate spread goes down, TFP is going up. So TFP is a function of this sort of financial efficiency. Yeah, Matt.

AUDIENCE: What data do they use for the interest rate spreads?

PROFESSOR: Oh--

AUDIENCE: [INAUDIBLE] the interest rate [INAUDIBLE].

PROFESSOR: I don't know if they grabbed some IMF statistics. I think IMF financial statistics [INAUDIBLE] have that. I'm not sure if that's what they used. But basically, yeah, it's some measure of the difference between the lending rate and the borrowing rate.

And then that sounds good at first, until you start thinking about all the many ways you could get at the borrowing rate. Often, these things ignore the informal sector entirely, for example. This is-- which this paper is doing as well in the theory.

And this is the usual growth accounting stuff. OK? I don't know that we should have had this on the earlier slide. You want to predict a country's per capita income. It's efficient countries with higher TFP. So this is sort of behind the Lucas thing, which is why isn't money flowing very quickly from low-income countries to high-income countries, since high TFP tends to mean high marginal product of capital and so on. But it's amazing. They almost all lie on the line.

AUDIENCE: Is there a TFP solo residual?

PROFESSOR: Yeah. It's just a solo residual. And that's a good comment, because this paper is about the different ways to decompose at the firm level the sort of coefficient that's hanging outside the front of the production function. And then add it up the way [INAUDIBLE] were doing.

So they also do this sort of Rajan/Zingales thing, which is to try to calibrate against the US economy, they look at the firm size distributions and the interest rate spreads in the US to get some of their parameters, and then take it to these cross-country data.

AUDIENCE: Sir.

PROFESSOR: Yeah.

AUDIENCE: Actually, are [INAUDIBLE] distributions similar? Or is it developed [INAUDIBLE] country?

PROFESSOR: No. So what they're saying is the US would be a more or less efficient financial system. So you could sort of think about grabbing the relative technology parameters from that, and then take those sort of what are counterfactual-- those parameters are put in the context of a developed country with lots of other restrictions. So the idea is to get the technology right, and then somehow figure out what difference the financial system makes. Yeah?

AUDIENCE: What are the main assumptions you have to make in your own model to get that [INAUDIBLE] distribution [INAUDIBLE]. Because I mean, [INAUDIBLE] then it seems to be about the distribution of talent or distribution of [INAUDIBLE].

PROFESSOR: Yeah. Each one of these models tries to be really careful about how to map the data into the notation and assumptions they're making. And that's-- here, I can give you a hint of that, although I can't get to it in as much detail as I would like.

So here's this production function. There is some aggregate shock that hits all the firms. There is some theta, which is an idiosyncratic-specific firm-level shock. And then we have the usual-- Cobb-Douglas actually just noting constant returns to scale. Different papers differ on that.

And where do these idiosyncratic shocks come from? They're drawn at random from-- in this case, some simple two-point distribution. It could be high or low. But here is over and above that, another source of the heterogeneity that different firms have different sets of thetas. So the whole sort of range domain can be different, depending on, quote, "the tau type" that these firms are.

Intermediaries are competitive. So they're going to sort of not get any surplus out of this. They raise funds from consumers and lend them to firms. That's typical intermediation structure. And the intermediary knows the firm's type tau. However, it doesn't know output. It doesn't know the idiosyncratic shock theta. And it doesn't know the labor supply.

So all he's doing here is being careful to throw in enough sources of unknown that you can't basically back out from the output the unknown things on the right-hand side. And he probably could have gone with different assumptions, but that's certainly the spirit of it. Or at least, doesn't observe these things costlessly.

But there is this monitoring technology. The firms experience their true productivity, say, high or low, call it for the theta i for a given firm. And suppose the firm lies about it and says theta j. Theta's not observed nor inferred from any of the other ex ante or ex post. Then the intermediary devotes labor to monitoring the claim. So this technology of verification is actually resource using. It's another production function.

And then the size of the loan is determined. That's the capitalization of the firm. They don't have any wealth on their own. That's kind of the scale of the project. The level of productivity and monitoring is z. So that's kind of like whether it's a completely noisy signal, or an extremely accurate signal of the actual true state theta i.

So this object, Pij is-- that's the probability that if the firm made a counterfactual report of theta j and really were a theta i, with this amount of labor devoted to monitoring, given this loan size, and given this index of the productivity of the technology, this is the probability of finding out what the truth of it really is.

And so-- and then this mapping here is to provide between productivity and financial sector z, which, say, we don't see. And the things that we do see, at least we, as econometricians, see output and interest rate spreads. Now, let me pause for a second because you might well think of the obvious thing is, wait a minute. Didn't you just say output was unobserved?

Well, this model and others make a distinction between the exposed data that we have as analysts about firm output, as opposed to what the intermediary is seeing along the way. So we're imagining we do see output and these interest rate spreads. Those were the slides I just showed you. And then this is where I'm going to-- Matt-- going to be a bit vague.

If you looked at the equations in the notation, they can basically invert those equations to get x and z. And you can do it at a point in time for a given country, or you can do it at two different points in time. If you're getting z, you're getting a measure of this productivity of the monitoring technology. And that's why, for example, they are able to make statements about Taiwan's productivity increased over whatever it was, 10, 15 years, along with the drop in the intermediation spreads. They infer that from the drop in the intermediation spreads and the capital output ratio.

AUDIENCE: Question.

PROFESSOR: Yep.

AUDIENCE: So the assumption that the probability of getting [INAUDIBLE] is decreasing.

PROFESSOR: Yeah. So this is a scale effect. This came up in Alp's lecture the other day as well, which is if you have a fixed cost of monitoring or something, and then the country gets richer and richer, and credit is going up and up, then basically, the cost of verification is going down and down.

But here, a country's getting richer and richer, and you don't want this sort of information imperfection to go away other than through investment in improved technology. So it allows that-- I guess that conceptually, it's like bunch of little firms all spread out. And the bigger the loan size, the more plants you got to go to see- something like that.

AUDIENCE: And is the result partially depending on this assumption? Because it might be the direction is--

PROFESSOR: Yeah. Yeah. It matters quite a bit. Now, this is kind of linear. If it's diminishing, the effect eventually goes away. If it's convex, then I don't know what happens. But it matters. All right. So that's the spirit of that paper. Again, hopefully, it whets your appetite and-- or at least you can get some sense of what people are doing in the literature.

And there's one other that I want to talk about before we get to the main paper of this lecture. And this I discovered recently, actually-- "International Capital Flows and Credit Markets-- A Tale of Two Frictions." Somehow everyone's got taken with Dickens. The one we looked at last time was "A Tale of Two Sectors." I don't know whether you thought that was clever or not. This paper was written after that. So it's kind of intriguing, and I'm not quite sure I totally believe it. But let me try to walk you through it.

So the idea is we see a lot of capital moving around the world, and we see boom/bust cycles. And they're going to try to get both of those things in into one model. So it's ambitious. Global imbalances, large and persistent capital flows coming out of Asia to the US-- we talked about that last time in the-- last time in the China paper.

And there the idea is it's hard to make good use of it within China for the reasons that that model and others postulate, namely, financial friction. So then it should go somewhere else. But you could also think about it on the other side of it. This is the tricky part. Namely, that that money is going to unproductive investment in the US. So at least that's ex post the judgment. So then you have to model sort of what's going on with the US interest rate that would allow the existence of bad projects and the coexistence of bad projects with good projects. So they try to do both.

So again, there's credit market which intermediates the money that comes from savers and goes to investors. Individuals are endowed with some resources and with an investment project. And they have to decide whether to do the project and become an entrepreneur, in which case they're going to want some credit to fund it, or to forego their project and become savers, in which case they supply resources to the credit market.

Now, this building block is the same on almost all the papers that we've looked at. It's an occupation choice model of-- that's used to address financial issues. To give adverse selection a crucial role, we assume individual productivity is private information and unobservable by the lenders. That kind of sounds like the previous Greenwood paper.

So there is some cross-subsidization between high and low productivity entrepreneurs. A key assumption-- there's only one interest rate. So there's no menu of contracts. There's no other ways to separate good from bad. And the thing, to say it intuitively, about adverse selection is, who wants to borrow at a given interest rate? Well, that's really attractive for people who expect never to repay loans. So the lender is going to have to somehow break even on those bad types that are indistinguishable from the good types. And that is a force determining the interest rate.

Now, the question is whether that kind of perverse dynamics would move around with wealth and so on. Yes.

AUDIENCE: Are the lenders endowed with mechanisms to prevent that? Is there physical collateral, or is there some sort of reputation--

PROFESSOR: Not here. Not here. But there is a big literature that argues--

AUDIENCE: OK. So in this-- this environment has the potential for the sort of adverse selection [INAUDIBLE] type things.

PROFESSOR: Yeah. There is always an issue in papers and as researchers at what-- how much-- how many substantive things you want going on at the same time. I would say this is among the simpler adverse selection thing. Personally, I would always think menus of contracts could select-- allow selection or sort of truth-telling. And that's just shut down. But Rothschild/Stiglitz shut that down. So maybe that's off to a tradition of sorts.

So what are the implications of this adverse selection? The interest rate has to be higher than it would have been otherwise. But on the other hand, there's a lot of borrowing and investment. Now, be careful here, because these low productivity guys are happy to be borrowers. So not all borrowing is a good thing. And that's kind of the seeds of the bust getting created.

Because of adverse selection we have this wedge between the equilibrium interest rate and the marginal return to investment. Again, it's a common wedge. We just did an interest rate spread. Here's another way to think about that spread. That doesn't mean it doesn't matter. The underlying assumptions do matter. But this phenomenon is pervasive across countries in the data, and is a big part of almost all these models.

So adverse selection means that the economy can attract more capital, and boost in that capital flows seems odd just to say it there. You can see it written. But again, the idea is that somehow the interest rate is higher than it would have been in the full information economy, and outside investors seek the higher interest.

So that's kind of what they mean by that. But the true marginal return lies below the interest rate. So something bad is happening. And the way it comes out in the bath here is the capital-- there's lower aggregate consumption because you've used resources inefficiently.

And then they claim this adverse selection actually is a force for volatility. This is kind of key. The incentives of less productive individuals to become entrepreneurs are strongest-- there's bad types borrow and don't expect to repay much. That force is strongest, ironically, when the capital stock is low and income is low.

And what's that all about? Well, basically this debt overhang problem is more severe when the capital stock is low, because you have to borrow more than you would if the capital stock were high, and you could almost self-finance. And there's a lot of untalented firms borrowing when the total income and capital stock of the economy is low. Or conversely, as capital and income increases, that cross-subsidization is decreasing. There's more self-financing, and entrepreneurship loses its appeal for less productive individuals.

Well, I mean, it's actually kind of interesting. Because you can see the dynamics of occupation choice that we've had in the other papers. Who's going to be a firm as opposed to a wage earner depends on what happens if you were a firm and decided to borrow. And then they actually get a boom/bust cycle. They claim to show that capital inflows are going to fuel this accumulation period. And then you'll get a contraction.

Actually, toward the end, the tale of two obstacles or two frictions, is they throw pledgeability on top of it. So the more traditional sort of collateral constraint reduces investment and lowers the interest rate. We've seen that, right? You can't borrow as much, so there's less pressure on the interest rate. So the interest rate would be lower. Ironically, that low interest rate, though, decreases the returns to savings.

And why be a wage earner and get a lower return on your savings when you can be a not so good entrepreneur and borrow money at low interest? So you get this sort of, they claim, a kind of accelerator or exacerbating feature, that the adverse selection is interacting with the limited collateral constraint. And that should whet your appetite for that paper.

Now again, I apologize in a way, although it wasn't my intention to go through all the details of that paper. And it is on the Stellar website. And we can study it in more detail. But I offered it here just to show you the kinds of phenomenon that people are trying to address with the interplay of financial frictions.

And then we come to the paper I wish to focus on, which is, again, a tale of two frictions. But we can't use that title. But we're doing it in a different way. We allow moral hazard and also limited commitment. So on the one hand, we're going to take the traditional limited commitment constraint and remove it, and insert a moral hazard constraint explicitly. And this time, I can show you the equations.

But we also allow-- we don't get rid of the capital constraint entirely. And then you say, well, what are the rules here for making this stuff up? And my answer is the data. And in particular-- this is the reverse order coming here-- you will see a paper that I've written with Alex Karaivanov, where we have consumption, output, investment, and capital stock data, and we actually estimate a variety of financial regimes.

And it turns out that the so-called limited commitment regime fits the data best in the rural data that I have and in the Northeast, and the moral hazard regime fits better in the urban areas and in the areas in and around Bangkok. So that's the way to think about these two frictions. They're, for us, going to be microfounded. Although here, we're just borrowing that and putting it in. So--

AUDIENCE: Sir.

PROFESSOR: Yep.

AUDIENCE: So basically, are you-- you're going to sort of let these two things interplay, and you're going to have them be differently important in different places.

PROFESSOR: Yeah. So that's where we end up. And where we start is we have an economy, and I'll tell you all about the environment. And then I'll describe what goes on with the limited commitment constraint as if it were the whole economy. I'll do the same for moral hazard, the whole economy. Then I'll have like 50-50, and use the general equilibrium.

And the punch line is going to be the general equilibrium with the two frictions is not just a simple convex combination of the two extremes. And the reason that that's going on has to do with the general equilibrium. So you're going to get-- roughly, you're going to get interest rates and wages that are somewhat between the two extremes. But then given that, the question about who is to be a firm or a worker depends on the obstacles that you face.

And actually, what turns out to be cool at the parameters we have, which we think are reasonable and are largely similar to what Alex and I had, that in the places with moral hazard, output is substantially higher. There are slightly more firms there. They're larger. Those firms are renting more capital or borrowing more. The ratio of credit to GDP, the financing ratio, is higher. And they employ more labor.

Without any geography somehow, we've created these-- replicated these stylized facts of development when you think about rural areas versus urban areas. Money is flowing from savings in rural areas to the urbanizing cities. Now, I'm not going to claim that we've captured everything going on in all these countries. But this simple sort of combination of financial frictions allows that. In that sense, this is very different from the other paper. Yes.

AUDIENCE: And so do you have something that endogenously makes these two regimes being relevant in those areas?

PROFESSOR: That's a good question, and it's-- at this point, it's hard to answer. I mean, it looks as if either there is a legal restriction on collateral, or the set of financial institutions that are operating in the rural areas is different from what's going on in the urban areas.

And if we were going to follow Jeremy's path, we would ask your question. We are asking, and we just don't have answers yet, as to what is the configuration of the financial service providers? You'll see there is a heavy distinction-- we've already seen, actually, where the commercial banks are operating and where this government agricultural bank is operating. And I think that's probably part of the story. But in this paper, we do not take a stand on it. We take as given just this sort of difference in the financial information regime. OK.

So this, we've already said. This, we've already talked about. So we get to the model. So a household that could decide to be either a wage earner or a firm will maximize discounted expected utility. Beta is the discount rate. u is the common utility function, the arguments of which are consumption of this household i, and effort of this household i. We'll parameterize this when we need to compute something. At this level, it's quite general.

You can-- if x is equal-- this is like a binary choice. You can be a worker or a firm. By convention, when x is 1, you're a firm, and when x is zero, you're a worker. And that's going to be endogenous. If you do become a firm, you have this productivity draw z, and it evolves over time according to sort of a standard Markov process. I was rushing toward the end of the lecture last time, but this was the thing that was in the [INAUDIBLE] paper toward the end, and I guess in some of the other papers.

And finally, we have wealth. So at the beginning of the period, everyone has some predetermined level of wealth, and it's in the bank essentially. And so an individual is characterized by their initial wealth and their current talent.

Here is the production function. It's diminishing returns to scale in capital and hired labor. And then we have these sort of things out front here. The notation varies from one paper to the next. But epsilon is here, an idiosyncratic shock. iid over households, and z is that level of productivity we already talked about that's evolving over time.

Now, there's actually-- the effort of the entrepreneur is another factor of production. And that's basically little e. So the way that the effort of the entrepreneur is modeled is through this. The epsilon, the idiosyncratic productivity, depends on how hard the entrepreneur is, quote, "working," or thinking, you know, staying up at night worrying-- basically, due diligence. This is not measured. You do see the epsilon, but you don't see the e. And that's if-- well, at least in the moral hazard model, you don't see the e.

But I should qualify that we're going through the standard environment, and there's going to be a full information environment with limited commitment in which everything is seen and full insurance is possible, versus the moral hazard environment which is going to be the source of limited insurance, and it's going to interact-- both frictions interact with productivity.

So there are banks or financial intermediaries, and you should think of them as basically risk syndicates. Because not only do they sort of lend out of the wealth that households have been depositing with them, they can also smooth over idiosyncratic shocks. So there's a state contingent payment that the banks can make-- it could be negative-- say, to the households as a function of their realized and observed epsilon.

Now, in some respects, it's still-- we're not solving a massive programming problem and then capturing the interest rates and wages off some first order conditions. Instead, we're going to imagine that these risk syndicates, these banks, and the firms and the households all take as given economy-wide interest rates and wages. And like many of the other papers, we're going to have to determine those by supply and demand mechanically. So that's a computational burden, but it is one that other papers have faced as well.

Now, what to do about talent-- is it insurable or not? Well, we kind of decided to try to be realistic and to not let it be insured. We could go the other way. In some sense, we know exactly how to do it. And there's some duals which would be satisfied if we had allowed it.

But we thought it was just on the side of realism to say don't worry about your job market. We're going to cover that. NYT is going to fully insure you. Well, of course, we could put moral hazard on the z thing. But anyway, we didn't get into that.

So you're going assign the occupation, induce effort-- where did I say-- I guess I didn't say it. It'll come up in a second, hopefully. Yeah. It was right here. We actually also allow there to be some insurance and moral hazard issues on the worker side. Now, for simplicity, we give them this same p of e function. We could have allowed it to be different. What is this?

Well, the idea is you can sort of put a lot of effort into working, and the firm is going to observe your total sort of productivity. But the firm doesn't see your effort. It's like piece rate in some sense. So we just got tired of being asymmetric, as so many papers are about-- you know, there's an insurance problem for intermediaries and wage earners don't suffer from things like that.

So here's the timeline. The household comes in with-- a certain household i comes in with a certain amount of wealth and talent. There's going to be an assignment, if you will, of who's a worker or a firm. Then if a firm-- well, if a worker or firm ever gets determined, if a firm-- the capitalization and labor hiring of the firm gets determined, then the epsilon hits. Effort comes first. Epsilon comes after that and gets in the way, so to speak, especially if effort is not observed. So this is like idiosyncratic risk subject to moral hazard potentially.

Then consumption and the level of your savings that you're carrying over putting into the bank for tomorrow, those things are functions potentially of those epsilons. So the point is, you do bear the consequences in the moral hazard model of shirking. If you shirked and your productivity were low as a consequence of that, you're going to have to take a hit in terms of lower consumption and lower savings from tomorrow on.

So here's the optimization problem really of the bank, but it's more like an equilibrium outcome. The banks are basically competitive. There's free entry. And for any sort of cohort fully observed, by the way, az sort of people out there-- there's a lot of them in every little cubbyhole-- the banks compete to offer them contracts. In effect, they would bid down things until utility is maximized. So it's as if they're maximizing the utility of this cohort by choice of all these things I just went through.

And this is the resource constraint that the risk syndicate faces. Partly it's familiar and partly not. Namely, you've got uses and sources. The uses of money or resources is in consumption and how much you save for next time. And the sources comes from if you're a firm in this syndicate, your net profits, after subtracting off the cost of labor and capital and depreciating the capital, and from the other guys who are wage earners. And as is standard in many models, you begin the period with basically the savings that you had as a bank. But now they've sort of accrued interest. So you have principal and interest at the beginning of the period.

Now, it looks like a standard sort of incomplete markets model, where you have the choices between saving and, quote, "borrowing/lending." The difference here and-- well, and some profit maximization embedded. But the difference really is the summing over epsilon.

So this is the total sort of assigned consumption and savings throughout the whole syndicate, the average per capita number. And this is the per capita sources. The intermediaries in trying to break even on every epsilon type in the population-- that's the risk-sharing part of it, that some people could have higher output than other people. but subject to incentives or insurance. The intermediary will smooth that by assigning, say, higher consumption than output for the low epsilon guys, and conversely for the high epsilon guys. Yes.

AUDIENCE: So the financial intermediary, they can control the distribution between consumption and asset?

PROFESSOR: Yeah. That's all observed.

AUDIENCE: So household can't bypass that by saving themselves.

PROFESSOR: They don't. Yeah. We assume not. But you could assume that they get their sort of assignment of assets, and then they act on their own. But they would put it in the bank because they accrue interest. So there's really no loss in letting it sit in the bank.

Now, we can have banks competing with one another. That's a bit more subtle.

AUDIENCE: [INAUDIBLE] the other way around though, right?

PROFESSOR: Hmm?

AUDIENCE: You can't like really-- OK. Like, the household can choose to save, but household can choose to consume too? I don't know. I feel that here, bank has more control over household, and they can say exactly how much you can--

PROFESSOR: Well, that's probably a better way to think about it anyway. Because as you'll see, these information frictions and collateral restrictions create pressures that make savings more or less than what households might want to do if they were just following their Euler equation. So in the end, I agree with you.

What's going to be actually interesting is that it's going-- and you'll see this-- it's going to go a different way. In the collateral constraint model, you would like to borrow more, actually, in order to have more assets in the future. That's not allowed to happen. So they're going to be borrowing-constrained in terms of looking at their intertemporal consumption path.

The guy subject to this sort of incentive moral hazard constraint, they're actually going to end up being savings-constrained. They would like to save more. So it's already a hint that the dynamics of the household decision problems are very different, not just of the firm, but the households.

So what do we mean by the incentive constraint? Well, when effort is unobserved, you want to induce the assigned effort. So these are the good boys. They were recommended to do e, and they actually do it. So this is the distribution of output, epsilon, that results from it. And they go into tomorrow with the assigned levels of savings and draw talent. But effort is not seen. So they actually contemplate some out of equilibrium behavior, like doing e hat, which is other than e.

Now, what are the consequences of that? Well, first of all, there's a direct consequence in the utility function, because shirking might be good in terms of higher utility. But also, there is a direct consequence in terms of the distribution of output. So this is sort of the moral hazard induced productivity consequence. And if you do some typical monotonicity or something, then higher effort is associated with likely getting higher epsilons. So that's a standard-looking incentive constraint. The-- yes.

AUDIENCE: So probably we could introduce some costs associated with changing jobs between [INAUDIBLE]. Does it change the analysis at all?

PROFESSOR: Well, you get to choose. But yeah. There's no extra cost. It would increase the dimensionality of the state space rather enormously, because then you'd not only have to worry about the current distribution of wealth and talent, you'd have to worry about what these guys were doing last period. And it's actually hard enough to get any kind of solutions, analytic or numeric.

So I think that's the constraint here is keeping the state. I mean, there is-- you'll see that there's already a huge distribution of wealth, and we're going to have to keep track of how that histogram is evolving the population jointly with the talent distribution. So hopefully, good enough for starters.

Oh. I'm going to skip this slide. I'll tell you what was on it, and then we'll come back to it when we get to the microdata. Basically, instead of solving directly for consumption as a function of epsilon and all of that stuff, we trick it into a linear programming problem. And we do that by keeping track of histograms of things, basically, the joint distribution of consumption, epsilon, recommended effort and so on, respecting the timing. So in words, hopefully, you would think that's kind of equivalent. Anyway.

Now, what's the gain? The gain is it literally is a linear program. So that little module can be solved as a linear programming problem, and that's how we're computing the solutions to that part. But this isn't the right context to go into the notation. We'll do it in a very simple convex cost or a fixed cost problem first, and then build up to it later.

So I'm missing something. Oh, yeah. This thing. So this is the other constraint, that the capitalization of the firm is just some proportion of your wealth. Lambda could be greater than 1, but it's not infinity. So this is the constraint that we had on so many of the other papers.

And you can tell stories and model this about running away with a capital and so on. But this is the essence of it. We could do both. We're going to imagine that it's one or the other. I mean, both simultaneously for a given firm. But we're going to put people in one sector or the other.

So then we're going to solve for the factors occupation choice, labor, hiring, capitalization. And you want to think about labor supply-- it's just only slightly tricky. X means entrepreneur. 1 minus x means wage earner. What's the total labor supply coming from wage earners? Well, epsilon is units of labor supply. It's induced by the effort.

There's a histogram. So we basically add up overall the epsilons at the fractions with which they exist in the population. And this is total labor supply. And so then the rest is pretty less daunting in terms of notation. We have-- we're going to equate labor supply to labor demand. This is the l being employed within the firms. The firms vary in terms of their a and z. And everyone's facing these economy-wide wage and interest rates.

But this does depend on the az argument, so we have to add up over-- or integrate up over-- all the az people in the population. So again, in practice, we're going to have a large finite number of wealths, a finite number of talents, and this is going to be some kind of summation.

This is also the capital clearing constraint. All that wealth sitting there-- forget the d. Don't know why that's there. You have all that wealth sitting in the bank, and it's going to be lent out at interest to the firms that are renting the capital.

So we grab some parameters and some functional forms. These are pretty traditional. I guess we didn't want to do anything unconventional, because we want to show what difference the obstacles make rather than force you into a utility function you don't believe. Also, we can grab from the literature values for these that people believe.

I don't mean to belittling calibration all the time. Beta is realistic here. It's about basically 5%, or 95% of the future is valued. Sigma's the degree of risk aversion. It's 1.5. People have values well within that range-- just utility is a bit tricky to parameterize of effort, but the power function is the Frisch elasticity. People have estimated that.

This is a simple transition which we made up. But in other papers, people talk about entry and exit of firms, and we could imagine doing that. And they are also similar to the parameters that Alex and I estimate would likely [INAUDIBLE] functions.

So here is the-- with the Euler equation, it's at the household side. Borrowing-constrained households have a Lagrange multiplier on that limited commitment constraint. It turns out to be tomorrow, but in expectation, it leads to this same phenomenon that the marginal utility of consumption is high today and lower in expectation tomorrow. So these guys are borrowing-constrained. Yes.

AUDIENCE: Question, sir-- going back to [INAUDIBLE]. So when you described it earlier, so something that entrepreneur can do to [INAUDIBLE] to make productivity high. If it was mainly labor monitoring, I guess it would maybe sort of really only scale with labor. Would that-- how much would that change what goes on in the model.

PROFESSOR: Oh, that's a bit like in the spirit of Jeremy's model, and we're not doing that. But yes, you could put-- it's very much like what Jeremy is doing. You could put the technology for monitoring effort to create a signal at least of effort, and that would mitigate-- that would move us more toward the full insurance solution.

And this is the weird one. And I'm not sure if you've seen this yet or not in public finance. But-- so I'm just going to basically assert that the first order condition, when you're subject to moral hazard, looks like this. And for obvious reasons, this is sometimes called the inverse Euler equation, because this is 1 over u prime.

The point here is Jensen's inequality. You know, if you replace-- if you pull the expectation operator outside of it, you'd have 1 over u prime, but the inverse would take it back to u prime. But when you move that expectation operator outside, you're taking an average over the interior object. I'm sorry. This is an average over the interior object as opposed to an integration from the outside.

So it is basically a classical example of Jensen's inequality, and it makes the right-hand side higher. That's mechanical, but hopefully-- we've already talked about this. You can see that in the limited commitment, people cannot borrow as much as they want. That's going to make the demand for funds less, and the interest rate is going to be less when all the economy is subject from that limited commitment constraint, as opposed to the moral hazard economy where households and firms are savings-constrained.

So they would like to save more. Savings is less. It's scarce. You have a higher interest rate. So these interest rate numbers kind of make sense. Don't be too spooked by the negative interest rate. You know, we have a depreciation rate in this economy. So it's still sort of on net-- it's positive.

And then you can see, comparing these two different countries, GDP, TFP-- the TFP dynamics are very different, although the numbers, though different, are not radically different. TFP is dragged down in the limited commitment economy, because high productivity firms cannot borrow as much as they want. They can't exploit their z. Whereas, in the moral hazard economy, you have to induce effort, and that's kind of a drag.

I mean, if you were draconian and you had no insurance, then yes, people would be working very hard. But that's actually not optimal. The right thing to do is to have this blend between insurance and productivity.

So partially, it's-- this language people use about moral hazard in the banking system and in the press and the policymakers, pick that up like, let's get rid of moral hazard. That's not the right way to think about it. Moral hazard is an information problem. You want incentives to do as best you can, given the moral hazard problem. But it's like-- eliminate moral hazard is like, let's just shut down all the insurance, then you don't have a problem. But yeah, well, you got other problems.

Wages are a bit different. They're higher in the moral-- these are economy-wide wages and interest rates, of course. But you can also see a bigger difference in the financing ratio. Actually, labor here tends to compensate for the more restricted capital, and the drag makes labor lower in the moral hazard economy.

External finance is more limited in the limited commitment economy. Why? Because you can't borrow. You run into that lambda constraint. There's nothing like that in the moral hazard economy. So the external finance to GDP ratio is higher.

AUDIENCE: So why is the interest rate negative?

PROFESSOR: That's, again, because there's an interest rate going on here. I mean capital gets utilized, and it gets-- it's depreciating. And you've got to basically pay for that somehow. So it lowers the net yield.

And here's interesting-- you know, I didn't get to say much at all about Joaquin Blaum's paper on inequality. But I get to be reminded to say something now, because here the wealth inequality curve's generated by the different constraints. And you can see there's actually more inequality in the limited commitment economy than there is in the moral hazard economy.

But again, that has to do with this dispersion of the capital. Capital tends to be more-- not identical, but more compressed in the moral hazard economy. And capital is very limited. You can't take advantage of your productivity in the other one. So the wealth dispersion is playing a bigger role, and feeding back in turn to-- it's like you can't get the convergences.

And then we take 50-50. Same economy-- now we have the urban/rural of the same size, and--

AUDIENCE: Question.

PROFESSOR: Yep.

AUDIENCE: So in the slides with the parameters, you don't talk about lambda. How much do you think that to be? The-- so the-- how much is the constraint?

PROFESSOR: I'm not sure I remember the number.

AUDIENCE: But-- I mean, do you remember how you configured it?

PROFESSOR: It should have been on that list of parameters? It wasn't on that page? No. I don't remember. We probably-- it was probably something like 1.3, because that's-- but that's right off the top of my head.

AUDIENCE: How do you-- [INAUDIBLE] in the same way? Because that's how-- like, that's something you estimated somewhere else?

PROFESSOR: Hopefully, we just drew it from this literature, the [INAUDIBLE] paper that you've seen before. I don't think we matched it with data. That's actually hard to pin down in the data.

AUDIENCE: Would it be particularly sensitive to the choice of lambda?

PROFESSOR: Oh, yeah. Yeah. Remember the [INAUDIBLE] thing, where lambda goes from-- I think it was 1.3 to infinity. And at infinity, there's no constraint at all. You're back to the full insurance, full productivity solution.

AUDIENCE: So some of the things about like the wealth inequality and [INAUDIBLE] expect those [INAUDIBLE].

PROFESSOR: Oh, yeah. Now what-- so what you're not seeing here, although we have recently done this, is run a whole suite of computations for all kinds of-- we put sort of error bands or confidence intervals on these just to make sure that none of the things that we want to emphasize are-- either they're always true, or we're going to say they're not always true, and they depend on these parameters. But you're absolutely right, that just showing some simulations looks a bit arbitrary, especially for things like lambda, which I'm not even remembering in the moment, so--

But different things would matter for the moral hazard economy too. You know, the curvature of the labor supply utility that generates labor supply-- that's going to be that Frisch elasticity. We'll see that again when we get to the sort of microdata. And the chi that sits in front of labor disutility-- that's a huge number, important number.

So what are these slides? Well, this is a bit like generating many, many, many simulations. We have many economies, and we vary this fraction from zero to one. I just showed you the 50-50 economy. But this allows everyone to be in limited commitment, everyone to be in moral hazard, or anywhere in between.

And so you can see how GDP, TFP, and so on, how these things move around with the fraction of the population that are subject to moral hazard. And partly, this mirrors what I said before in labor supply. But on other things, you can see things aren't monotone. So those are surprises. It actually goes up, and then it comes down again.

GDP climbs pretty fast, and then it kind of wobbles around a bit. We've tried to get rid of as many wobbles as possible for worries that they're just computational. But some of them-- some of the wobbles remain. So I've kind of learned to not pay too much attention. But this is not numerical error. This is systematic, this drop. And you can see what the wages and the interest rates are doing, and the fraction of firms for that matter.

Now, here is back to 1/2, 1/2. But within that economy, we have the limited commitment sector and the moral hazard sector. Obviously, there is economy-wide wages and interest rates are the same. It's one economy clearing. But other things vary across these two columns.

Probably the most exciting part is this, which is let's look at labor, for example. Labor employed in the sector 0.38; labor supplied by the sector 0.53. So they're exporters of labor, if you allow me to use that terminology. Or people are costlessly migrating from the limited commitment sector to the moral hazard. And indeed, you'll pick up the other side of this thing, basically, labor supplied, 0.46; labor demanded, 0.61.

Now, you say, why isn't it all zero and one. No, no, no, no, no. Remember the z's. Remember the productivity. Every sector has some really inefficient people who shouldn't be running firms. They're going to supply labor no matter what, or at least at these equilibrium wages.

And the same thing is true with the flow of funds if we had the geographic decomposition-- and we got Mexico to do this, by the way. It's really cool-- through their CNBV, their financial regulator. And the question there, is money flowing to Mexico City from the outlying areas as they improve intermediation? And what consequences does that have for the outlying areas?

Well, here, money's flowing from the limited commitments sector to the moral hazard sector. So this is where the action is, so to speak. We don't get a lot of difference in terms of the numbers of firms, but you're clearly seeing differences in terms of employment size. And remember the China paper was like this, where labor-- the allocation of labor was playing a huge role.

So-- sorry. We had more results over the weekend. We've been trying to get these. This, we've had for a long time, but I'll show you something else that's quite exciting. First of all, speed of transitions-- you remember that where a paper was all about the puzzle, which is, why don't miracle Asian economies grow even faster if you believe they were in a solo world?

But of course, there is-- and then they assume this financial friction, which slowed things down. The friction you assume is going to make a big difference to the speed of transitions. Actually, here, even in the steady state, you can ask how fast do people go from an az state to an a prime z prime state? This is some big Markov matrix. It's sort of steady state, but it's transition from the household level from one state to another.

So you may remember, you can multiply those matrices over and over times each other, or you can basically do an eigenvalue, eigenvector decomposition. And the closer this eigenvalue is to 1, the slower things are. Things are moving.

The next multiplication of the matrix is kind of very similar-- that times the control [INAUDIBLE] very similar to what is in the previous period. It's 0.93. That's a very-- sorry. 0.93 for one; 0.98 for the other. So there's roughly three more times difference in the speed of sort of within steady state transitions going on.

Now, there's a technical reason for this, basically. On the limited commitment thing we have this forward-looking savings behavior. So people are going to save their way out of these constraints. And they can do it pretty quickly.

In fact, you're going to see some homework and so on motivated by thinking through [INAUDIBLE] papers and job market papers and so on, that kind of get at this thing, which is-- the twist is, why doesn't money flow from the US to India? The answer is, why doesn't India save its way out of constraints more quickly than they seem to? So there's discussion in the literature about that.

But here we do have constraints. It's just that they're different. And essentially what's going on here is you don't want to-- you don't want that wealth to move very fast. You're going to balance off the incentives of today's consumption versus tomorrow's wealth.

Wealth moves a little bit, depending on whether epsilon is high or low. But you don't want it to move a whole lot. Because if it did, that's the bulk of your utility. That's kind of very-- that is actually algebraically in the dual, equivalent with discounted expected utility. And so if you move that quickly, there's a big welfare loss because of the concavity. So you don't want it to move fast. So that's-- OK.

And then if you look at growth rates, the distribution of growth rates looks like it's all zero. Actually, what the point is, the growth rates are all very similar to each other, because there isn't this big dispersion in the moral hazard economy because they don't move that fast. But a limited commitment-- there's a huge dispersion and growth rate.

And you can imagine going to data with this kind of stuff. We didn't look at this in the data. But if you have Panel, you can actually look not only at static firm size distributions but the growth rates, and get some evidence one way or the other for one friction.

Then finally, the weekend-- we've had a devil of a time doing this. We start with the whole economy subject to a limited commitment constraint. And then we move it after 10 periods to a moral hazard. Now, this is meant to mimic some kind of financial reform. If you want to be generous with me, think of there being two constraints, and then we managed to get rid of one.

Well, that's not quite what we're doing. We kind of substitute limited commitment for moral hazard. Basically, they get rid of a constraining legal system, but it turns out that created an information problem.

Anyway, what's really important is that you can actually look at the transition dynamics. Well, let me just show you the pictures. So here, you're in a steady state, and then you do a financial reform. But it's not like-- Kaboski, they did-- they left the financial structure intact, and they did real reforms.

We're leaving everything in the environment and everything intact and doing a financial reform, hopefully in the spirit of what Levine might have wanted. And then we see the implications of that for deeper levels of capitalization. And look at the wage rate. It's no wonder we had trouble finding it-- pops up like that instantaneously.

Now, let me just say, these things are not easy to compute. Because-- and [INAUDIBLE] going to say something about that on Friday. Essentially, when you're out of the steady state, you have to figure out where you're going to go and how long it's going to take to get there. And then you've got to sort of guess about the paths of the interest rates and the wages. And of course, any arbitrary guess about how long it takes and how they're going to move is quite arbitrary. So then you need a systematic way to adjust period by period to get in new guesses and then to try to iterate.

[INAUDIBLE] managed to do it. We have their code. I've shared it with many students working on related problems. It turned out that their code, which is getting better and better because they're playing around with it too, works for this limited commitment better-- much, much better than it ever worked for us with moral hazard. We were quite despondent about being able to compute the transitions. But evidently, now we're in business on that.

So the summary, back to the big picture, is these obstacles matter. Ideally, I think, if you can manage, use the microdata to try to take a stand on what the frictions are. And through the dynamics of Euler equations and debt overhang and so on, you'll generate these dynamic paths. And they're going to be general equilibrium consequences of the reforms.

So it's like doing an experiment on these economies to see what would happen. And this allows us to begin to answer those questions I went over in the introductory lecture about finance causes growth, but then what? What do we do? And how do we engineer it? And what would we expect to happen? And are there winners and losers, and so on?