[SQUEAKING]

[RUSTLING]

[CLICKING]

ROBERT CABALLERO: OK, let's start. So today we're going to talk about technological progress and economic growth. And that's a big topic, certainly, at MIT. Perhaps this is one of the main ways we contribute to human well-being. But before I do that, let me do a brief review of the things I did in the second half of the previous lecture. For two reasons, I want to do that brief review.

First, after spring break, so I assume there is some depreciation of knowledge since the last time. And the second is that while the equations I showed you at the end with population growth are correct, I think I said something which is not correct. I think I kept saying-- I don't know why. But I kept saying, look, if x is small, 1 over 1 plus x is approximately equal to minus x. No, it's approximately equal to 1 minus x not minus x. So I wanted to correct that typo.

So let me remind you what we had. So we started with a production function. One important part of economic growth is we're going to have capital accumulation will be a very important variable here. And so we haven't talked about capital in the production function in the previous part of the course. But now we were explicit about it. And we started with a production function that had constant returns to scale on capital and labor.

And here, remember in this part of the course, we're not talking about unemployment or anything like that. So whenever I say labor, I also mean population. I mean labor force, all of them together. You know the distinction between each of these concepts, but they're not that important for growth matters.

Mostly because all of those aggregates move in tandem over the long run. It's very difficult for a population and the labor force to diverge for a very long period of time. Maybe fluctuations and so on, but then tend to move together. So but we decided that we wanted to look at things normalized by population.

And so output per person is an increasing function of capital per person but also is increasing at a decreasing rate. There is decreasing returns with respect to the capital labor ratio. And so output per capita grows as the economy becomes more capital intensive, that is you have more capital per worker, but it grows at a decreasing rate.

The second key equation of our model was that we're saying this part of the course, we're going to assume that the government is not running any fiscal deficit or anything like that, and the economy is closed, which is an assumption we have maintained and we will keep assuming until three lectures from now.

And so in closed economy, no fiscal deficit. We have that investment is equal to saving. And we made an extra step to assume that the saving is proportional to income, so S proportional to income. So with all these things together, putting these two things together, we got to a very important equation in any growth model, which is the capital accumulation equation.

And this equation says, well, the capital stock tomorrow-- tomorrow means in the next unit time, next year, or whatever --is equal to the current stock of capital minus the depreciation of that stock of capital minus the delta times kt plus investment. But investment is equal to saving, and saving is proportional to output, OK. So that was common across all the things we did in the previous lectures. Is there any question about these equations? No, no, good.

OK, so the next step was to say, OK, and I did remember all the initial derivations. I assumed that n was constant, population was constant. And so the next step was I divided by a constant here. So we did everything in terms of capital output per person. But actually, since population was constant, the per person part was just trivial. We just divided by a constant.

The last thing I did, though, in the previous lecture, was to say, OK, what if that's not the case? What if population is growing over time as well? How does our analysis change? And so I did this. Now, I said, well, OK, let's start by dividing everything by nt plus 1. So then we get capital per person at t plus 1. Problem is, I said is when I divide the right hand side by nt plus 1, I don't get what I want. I want capital T divided by population of t. I want output of t divided by population at t, not at t plus 1.

So what I did is I multiply and divide by nt both of these. So I multiply by 1 and t over nt is 1, so I multiply by 1 everything. And then rearrange terms, so I got expressions like this. I got what I wanted here, which is capital per person at the same point in time. But now it's multiplied by nt over nt plus 1, OK. And the same I can do for this expression here.

OK so this is what I'm using the approximation here, in which x is equal to gn. This thing here, is just 1 over 1 plus gn. And I'm saying this is approximately equal. I can approximate-- if gn is a small number, this is approximately equal to 1 minus gn. So that's what we have.

And this is the second approximation going from this line to this line in which we did the following. We said, OK, this is equal to 1 minus delta minus gn plus delta times gn. But the delta time gn is the multiplication of two small numbers. So I said assume that it's close to zero.

And the same we have here. We have saving rate times 1 plus gn. You get you get the saving rate plus the saving rate times gn. But the saving rate times gn is also small number, so we also drop, OK. So those are the more explicit steps of what I did in the previous lecture.

And I think the final equation I showed you was this, but it comes from, again, two approximations. The one down here, which I use here. And then the fact that I dropped the second order terms, OK. That's it.

And then I just rearrange things. I move kt over n to the left-hand side. And so we have the change in the stock of capital per person is an increasing function of investment per person, which is this because this is saving per person. And I can replace this by the production function, which is f of k over n. And so what I have here is a difference equation in capital per person.

Why is this? So this is investment. So the capital stock per person will be growing as we invest. It shrinks with the passage of time just because of depreciation. Some things break down. That reduces the stock of capital. But the new term that we introduce at the end of the last lecture, is that now this ratio also declines with population growth. And so who can explain why we get this term?

I'm saying, look, suppose that we have take as given the amount of investment. We take as given depreciation. But now I say, well, if gn rises, and all the rest remains constant, then the left-hand side will start declining, or it will grow less rapidly than what's going to grow before I increase gn. Why is that the case?

Sometimes it's counterintuitive. That's the reason I thought I rush in the previous lecture over that. And since it's going to be an important intermediate step into the next one, which is going to introduce technological progress, I want us to understand why that gn appears with a negative sign there. Yep.

AUDIENCE: [INAUDIBLE] returns for the same amount of capital that have increased in [INAUDIBLE]

ROBERT CABALLERO: That term is going to be captured here. And it's going to play a role. But this one comes from something much more mechanical than that. Hint, observe what I have on the left-hand side. I don't have on the left-hand side, the change in the stock of capital. I have the change in the stock of capital per person.

So suppose I don't change the stock of capital at all from this period to the next, but population grows. What happens to this expression here? Decreases, it becomes negative because I haven't changed the capital stock, but the denominator is growing. That's the gn part. And that means this term's negative.

And that's what this term is here for is to capture the fact that the denominator Now. Is also moving on the left-hand side variable. And you say, so what? At the end of the day, I care about the capital. Why do I care about capital per person?

Well, my analysis, I told you it's much easier if I do it on something which has a steady state. And that's the reason I'm looking for this normalization. But once I look at the dynamic equation of accumulation of capital in this divided by population, then I need to take into account the fact that my denominator is also moving, OK. So that's the reason that gn is there.

And again, the reason I wanted to pause on this is because when we introduce technological progress, we're going to have a similar effect. And so I want you to understand. It's going to be counterintuitive because it sounds like technological progress is something negative. No, it's not negative. But in this space, it turns out that if population grows very fast, then you need a lot of investment to keep up the capital-labor ratio constant, OK. That's the idea.

If population is not growing, I don't need a lot of investment to keep the capital-labor ratio constant. But if population is growing very fast, then I need a lot of investment to really keep that ratio constant. That's what this is capturing there. So to repeat, if this guy is very large, then I need a lot of investment here to make this thing equal to zero. So the capital is stock per person is not declining. That's idea, OK.

Good, OK, so and then I said-- OK, this is where we finished. Then I said, OK, so let's go back to our diagram. Once I have everything in this space, k over Ni, n, I can go back to our diagram. Assume that ga is equal to zero. You don't even know what a is for the time being. You will know in five minutes. But assume ga is equal to zero, then that's exactly the model we had before.

So and remember, this is exactly the same diagram. It looked the same, at least, that we had when population was not growing. I'm saying I can use the same diagram when population is growing as well. But there is one important difference, which is this curve looks exactly the same. This is just output per worker, OK. That's the blue line.

The green line looks exactly the same as in the basic model. It's just little s times the blue line. So that's exactly the same. But this line is different. What happens to this red line as gn goes up? So what happens to this line as gn goes up? Becomes steeper, no? So it rotates up, OK. It goes up.

And that can sound counterintuitive sometimes because you say, look what happens here. Let's spend time on this. Suppose that we are at some steady state, say this one. And now population growth rises. OK, it sounds like Ireland in 2000s and so on. So population growth rises a lot. What happens in this diagram?

So suppose we are at the steady state here. No, and that steady state investment saving, which is equal to investment, is exactly what you need to maintain the stock of capital per person constant, OK. That's what the red line tells us, that here. So the gap here is-- this is a gap between investment and what you need to maintain the stock of capital per person constant.

So when the gap is zero, then this left-hand side is equal to zero. OK, that's the red line. That's the green line. When this is equal to zero, that's equal to that. That's exactly that point. OK, but I'm saying, suppose we are at that point, and now population growth rises? So what moves in that diagram? Does the blue line move?

I don't see gn in the blue line, so the blue line doesn't move. If the blue line doesn't move, and the saving rate hasn't changed, then the green line doesn't move either. So for this diagram to be interesting, what moves? Something has to move. So the only thing that it has that can move here, is the red line. And the red line, we already said, if gn goes up, it's going to rotate upwards.

That means, OK, so now we have that line there. So what happens at the previous stage stock of capital per worker at this level? What happened? Is that a new steady state? No, but what happens in particular? So I'm saying, suppose that you are here, and now I rotate the red line up.

OK, so that means the red line that represents the amount of capital I need to maintain the stock of capital constant is greater than how much is society saving and therefore investing. So what will happen to capital per worker?

AUDIENCE: Decrease.

ROBERT CABALLERO: Decrease, exactly because you need more than you're investing. So the capital stock has to decline. And that's what will happen. The new steady state is going to be to the left of that point there. That sounds very weird. How can it be that-- after all, labor contributes to output. How can it be that we end up with a lower output per worker when we increase population growth? Is population growth bad in a sense for growth itself for output?

Well, the answer is no. It's true that the new steady state will have lower output per person. So in that sense, it's bad. You have lots of population. If you don't change the saving rate or something, then output per person will be lower, but output will be higher than it used to be at any point in time.

It just happens that in the transition, the growth of output-- so the growth of output in this model is going to be equal to the growth of population. OK, that's if you have a steady state, where population is growing and output per worker or per person is not growing, that means output is growing at the same rate as population.

So that means that if I increase the rate of population growth, the rate of growth of output will increase together with the rate of growth of population. But in the transition, as the output per capita goes lower, output will grow less than population. And that's what is happening here. But output is growing. If population starts growing, if you increase migration, you're going to see output grow.

But output per person will start declining, until you get to a new steady state. And then you'll get the same-- you'll get the higher rate of growth if you continue with population growth with the higher population growth. But output per worker will be slightly lower rate, OK.

Anyways, this may have been fast, the last part. But since I'm going to repeat it now, in the context of technological progress, we should be fine, OK. So if you're a little confused now, it's OK. If you're a little confused at the end of the lecture, it's not OK because I'm counting with you sort of getting it in the second pass, OK, the second try, OK.

So next step is following. So here, we assume already population growth, but we assume the technology, so the production function stay put for any combination of capital and labor. The next step is to think what happens when the technology itself is getting better over time. And that's what we call technological progress, OK.

This is TFP. Let me not get into the specifics. At the end, I'll say a little more. But this TFP stands for Total Factor Productivity. And this index here captures the level of TFP in the US over time. And it's clearly growing. So technology is getting better and better over time. What that means? Well, I'll say a little more, not a lot more, but it's getting better.

And so the question we have here is I'm going to address next is, how does this? So now we're going to put together our entire economic growth model. We're going to have population growth. We're going to have also technology growing. Up to now, the only reason you could grow output per worker, was because you were accumulating lots of capital. You were catching up with your steady state. That's what would make you grow faster, but then there was nothing else.

TFP is going to be the only growth in technology. It's going to be the only thing that will give you sustainable growth in the long run in output per person. So this is a very important component of growth. Again, it's the only thing that will make you growth in a sustainable manner in per-person terms.

The previous model didn't have that. In the previous model, we had a steady state on output per worker. So in the previous model, we didn't have growth in output per worker in the steady state. We could have transitional growth when we were catching up.

If you started here, then you were going to have growth, fast growth, but eventually, we'll put it out, OK, output per worker. So up to now, we don't have a reason to explain why we see that output per worker grows in most economies in the world. And the answer will be this. This is the reason really output per worker can grow in a sustained manner. Technology is getting better and better over time.

So let's see, so the question is, let's now see what this does to the model we have. Now, in practice, technological progress takes many, many forms. At the most basic level, it means that you can produce larger quantities of output, and that's really the meaning we're going to have here, larger quantities of output for the same amount of capital and labor.

So you have 10 machines 10 workers, technological progress means, well, you used to produce 12 units, now we're going to produce 12, 14, 15, and so on and so forth. That's one of the main ways technological progress shows up. We can do more with the same if you will.

Second dimension is better product. So it's not that you produce more cars, but you produce better cars, better computers, and so on, OK. That's another dimension of technological progress. You can produce new products, things that didn't even exist, but now you have.

That counts more than having one more unit of good. It counts more because you have things that you couldn't even satisfy in the past, you can satisfy now because you have this certain kind of goods. That the nx is before. That's a very important dimension of technological progress, it just creates new sort of forms of inputs of production and technologies. Think of AI what that will do to technology in general and to consumption very directly.

And that's what I mean. Even within a product, you can get more variety. And more variety, it improves welfare because you can align better the needs with the product and so on. But we're going to make it very simple. In this course, we're going to model technological progress as if it was workers.

So we're going to capture technology with this variable a, which is going to be-- we're going to model it as labor equivalent. That is, if a grows, it's going to count for us as if we had more workers. That's just one way of modeling it. I mean I can do it in many different ways, and many of these are equivalent. But that's a very nice way of modeling, so we can use exactly the same diagrams we had and so on, OK.

So you can think of technological progress. The way I'm going to model this here, is you can think of technological progress as if this economy was receiving more workers. Or a more accurate description is, with the same workers, it's as if it had more labor input, OK. That's one way of capturing technological progress.

So now that means that I'm going to refer to this term a n as effective labor. So with the same number of n bodies, I may get more effective labor because each worker can produce more things. It's a better input of production, factor of production, OK.

And I like to model it this way because now I can use exactly the same diagrams we had before, but rather than normalizing by population, I'm going to normalize by effective label, by a n. So, let me do that. So recall that we had our production function with constant returns. So this holds.

I'm going to set this x now as 1 over a n. We used to have one over n. I'm going to have one over a n. And so I'm going to now have output per effective worker is going to be also the same little function f of capital per effective worker. And what is nice of this, is that now here rather than plotting y over n, I'm going to plot y over a n. Rather than plotting k over n here, I'm going to plot k over a n.

And I have the blue line looks exactly like it used to look. It's just I'm dividing by a over n. Remember, the trick in all these models, is to find the right normalization, that is to find the right x, So I can find a steady state in my diagram. I don't want these curves to be moving around. I want to have a steady state, something, a point that we're going to converge to after enough time has passed.

And I know that the thing that will do it in a model in which I have effective workers growing, is one in which I divide everything by effective workers. OK, so that's what I'm doing here. I'm going to build a diagram that looks like the other one that has a nice steady state as the previous one had, OK.

So I have my blue line. Here I have my blue line. I know I have my green line, no, because the green line was just little s times the blue line. So I have that. The last thing I need, and I already showed you that, but I'm going to show it again, is the red line.

But for the red line, I need to find the term-- remember, the red line represents the capital we need to maintain the current stock of capital per effective worker constant. That's what I need my red line for. So let's get there. And it always starts from this equation.

So this equation is still the same as it used to be. That doesn't change. But what I'm going to do now, is rather than dividing by n, I'm going to divide by a times n. So the same as I did earlier in this lecture. I now I want to divide by a over n. So I get capital per effective worker on the left-hand side.

I don't like what I get here, but you know that I can divide and multiply by a n, n over a n. So I can write the right-hand side after I do all my substitutions as this. So first step one, I divided everything by a t plus 1 times nt plus 1. Step two, I multiply each of these terms by a, t, and t. I multiply by a, t, and t. Divide by a, t, and t and. And then I regroup things, So I end up with that.

Well, this, using the approximation we have here, is approximately equal to 1 minus gan and gan, is equal to ga plus gn. So I already showed you that case for the case in which ga was equal to zero. I'm doing now. The same thing but, since I renormalized things by effective workers, effective labor rather than actual labor, I need to use a n rather than n.

And then by the same approximation I had before, which is that these products are close to zero, then I get to the equation I want. And if I write it in first difference, then I get my red line. This is my red line here. OK. Good.

So this tells me that when the green line is equal to the red line, then I have a steady state. Capital perfected work is constant, and this is equal to zero. That's the way I find my steady state. If I ask you a question, find the steady state of this economy, what you'll do is you'll set this equal to zero and find the capital stock that gives you this equal to zero. That's the way you do it, OK.

So that's that. And then we get back to-- well, this is the same as we had before. That's what I just said. That's the way you find the steady state, OK. And then we get back to the diagram I started with in this lecture. But now we have here a n, and now, in the first part, I said assume this ga equal to 0. Now the main actor is ga positive, OK, and we get this diagram.

So now I can ask you the question that I asked you before with population growth, and see how much I can confuse you. Suppose that ga goes up. That sounds like a good thing, no. I mean, suppose that we are at the steady state here, and this diagram has too much stuff. Let me.

OK, so we're here. That's our initial steady state zero. And this line here is delta plus ga plus gn times k over a n, OK. So well first, so suppose we are the steady state. Its output constant there. It's a steady state. Is output constant there? So suppose we are at that point here.

Here, we know that investment is exactly how much we need to maintain the stock of capital per effective worker constant. That's what the steady state means. Question, is output constant there? It's steady state. No. This only says that capital per effective worker is constant. That means that if effective workers or labor is growing, then capital is growing at the same rate and therefore, output is growing at the same rate as effective workers, OK.

Remember, the whole trick, so the curves would not be moving around, is I find the right normalization. So everything is growing at the same rate in that steady state. So let me actually show you that, and then I'm going to go over the experiment I want to have.

So this is what is happening in that steady state. So capital per effective worker at the steady state, so at that point there, is zero. That's my definition of a steady state, OK. Output per effective worker is also growing at the rate zero. That's that one over there. Sorry. That's my steady state level of output per effective worker.

So these are constant. That's a steady state. Those are constant. This ratio is constant. Each of those components is not. So that's what I'm plotting there. So those are not growing. Capital per worker, what about that? Well, you see there. So claim, capital per worker is growing at the rate ga. How do I know that?

So the question I'm asking there, is what is the rate of growth of k over n given that I already know that the rate of growth of k over a n is equal to zero? Well, this, the rate of growth of k over n, is the rate of growth of k over a n plus the rate of growth of a, no.

I mean, if a is growing and this ratio is constant, that means that k over n must be growing. And it has to be growing at exactly the same rate as this a is growing. Otherwise, I wouldn't be able to maintain that ratio constant.

And the same logic applies to output per worker because in that steady state, output per effective worker is constant. But a is growing, so output per worker must be growing at the same rate as a i growing, and that's ga, OK, good. Labor, well, labor is exogenous which in population, is growing at the rate n that's given.

What about capital and output? Well, claim, capital and output are growing at the rate ga plus gn. And I can do the same as I was in here. I'm asking you the question, gk, what is the rate of growth of gk? Well, it's going to be equal to the rate of growth of k over n plus the rate of growth of n. This is equal to ga. So it's ga plus gn. And the same happens for output, OK.

So remember, I said earlier on, that if an economy has more population growth, it will grow more. There's no doubt of that. Obviously, output per worker will not grow more because population growth grows more in the new steady state. gn doesn't show up there. But the only thing that will make output per worker grow, is technological progress, so it;s ga. And that was my claim earlier.

We're going to use this later. No, I'm not going to do this to myself now. I'm going to get back to what I wanted to now. Because I need to tell you a little bit more about the production function to growth accounting, which is what I wanted to do.

So but this is clear. I mean, this is important, OK. Good. So this is the reason ga is such an important variable. What you guys do here at MIT is very important. Afterwards, it's very important, OK. That's the only thing that can drive really growth in the long run, in per capita.

This gn plays also a role. You look at countries, not only the growth in per capita output. You tend to look at growth at total growth. One of the big concerns in big parts of Asia now, in Europe as well, as I said earlier in the course, is that gn is turning negative. That's not going to affect output per worker growth, but it does affect output growth in general.

And you can see it here. So if dn goes down, that will reduce the rate of growth of output. Doesn't reduce the rate of growth output per worker, but it does reduce the rate of growth of output, good.

So what happens-- remember, we did in the basic EOQ we did an experiment in which we increased the savings rate. So we can do the same here. What happens if we get an increase in the savings rate? Do we get more growth in the long run? And the answer is, for the same reasons we had before, no.

If we increase the savings rate in this, now, this full model, all that happens is that this green line moves up. It means that at the initial steady state, now we have more savings. And therefore, more investment than we need to maintain the stock of capital per effective worker constant, which means that we're going to get transitional growth.

Capital per effective worker will start growing, for a while. And as that happens, output per effective worker will also start growing. But eventually, decreasing returns will kick in here, as well. And that transitional growth will stop, and we'll end up at a higher level of output per effective worker and a higher level of capital per effective worker, but the rate of growth, in the long run, will not be affected by the saving rate. We'll get more transitional growth, but we will not get faster long-term growth.

A lot of the Asian miracle, the Southeast Asian miracle in particular, we saw very fast rates of growth in many economies of Asia, was a lot of that kind, meaning was a combination of what we had before. Economies that were relatively poor had low capital per worker early on in which the saving rate increased enormously. And that combination gave them enormous transitional growth. So rate of growth of 10%, 12%.

That was Japan, and then it was Korea, Taiwan, and so on. All those economies had very fast rate of growth as a result of that. China, later on, and China was a big thing for the world because it was much bigger at the same time. But it was mostly a combination of those two things.

It was having a lower stock of capital early on combined with, for a variety of reasons, an increase in the savings rate. And that combination gave them very fast transitional growth. But they all getting a little stuck now. And they're very concerned with that. Well, they're fighting against this model. There's lots of concerns of what is happening to China. Are we going to follow the Japan path and so on. Well, they're following this model. That's what is happening to our first order. I'll say a little bit more later on about that.

So in this particular case, what I have done is, in log space, so I can have linear things when it's growing, in log space, this economy with the low saving rate was growing here. This is output, so the slope of this was ga plus gn. Remember, in the steady state, output is growing at ga plus gn.

If the saving rate now increases, then output starts growing transitionally faster than ga plus gn. And that's the reason output grows faster than-- here, it's growing faster than [INAUDIBLE]. Here, it's very fast, OK. This is what we saw in [INAUDIBLE] the rate of growth of 12% and stuff like that. We were there moving there.

And but eventually, it sort of peters out. You end up with a higher level of output per capita per worker, a higher sort of path, an entire path. The rate of growth goes back to ga plus gn, but you get this transitional growth, which is very strong.

And once you're here, once you run out of the high saving and the catching up growth and so on, the only way you're going to really change your rate of growth in a sustained manner is doing what? Once you have used the tool of catching up with the world, of increasing your saving rate sometimes to levels that incredibly high, you still want to keep growing very fast. What is the only option you have according to this model?

Particularly, let me bring even more realism to the story. Particularly, if gn is dropping, and you still want to keep your growth high. And your gn now, you used the catching up growth. You used the higher saving rate, which gives you transitional growth, but it doesn't give you permanently higher rate of growth. And on top of that. for reasons you don't control, population growth is declining, even turning negative in some cases.

But suppose you still want to keep the rate of growth very high. What is the only option you have.

AUDIENCE: Increase ga. Increase ga.

ROBERT CABALLERO: Exactly, technological progress, that's the only option you have. So it makes sense. You see, that in the case of China. They're obsessed about technology and so on. They understand the Solow model. If you want to maintain growth at a high pace, you're going to need to work on that side a lot. Now, it doesn't have to be you, necessarily. It's the world as a whole because technology moves around the world. But ga is at the end what puts the limits of what we can do.

What I was going to do is, that's what I was drawing this diagram for, is say, well, suppose that in this situation, we are in a steady state. And we do increase ga. What happens if we increase ga? Well, this curve rotates up, no. And at that point, it's clear that if ga grows, you're going to start growing at the faster rate. But transitionally, actually, you're going to grow less than in your long-term rate of growth. Why is that the case?

So my claim is, suppose we manage to increase ga. So now we know that this line here now is a bit steeper. Or say this. We were in this line, whatever, we were in this line, and now we make it steeper. So we want to start growing faster, eventually, in the new steady state.

And my claim now, is that in the transition, growth is less than the new rate of growth-- in the new steady state rate of growth. It's higher than the rate of growth of the previous steady state, but it's lower than the long run. How do I see that? I need another diagram, I think.

So let me just put the sy curve here. So we're here at this steady state. If I increase ga, the only thing that will move here, and remember the output equation is there but I don't want to put it, the only thing I do, is I rotate this curve up. OK, so this moves up. Do you see? Yes. So this curves moves up when ga goes up.

So at the old steady state, what I have now is a gap between the savings, this economy in investment, and how much I need in order to maintain capital per effective worker constant, which means that I'm going to start moving in this direction, until I reach the new steady state.

OK, during this transition, I'm growing at a lower pace than in the new steady state. In this new steady state, I'll be growing at a much faster than in this steady state. How much faster? Well, equal to delta ga. But in the transition, I will grow faster than that but not as fast as in the new steady state. That's the claim I was making. OK, good.

You know, I'd rather discuss this with more time. So questions about what we have done up to now? Is it clear, or is it very unclear? Probably both. So let me keep this for the next lecture because might take a little time to explain, OK.