Introduction to Economic Growth- I

Dr. Sohini Sahu

Department of Economic Sciences

Indian Institute of Technology Kanpur

Lecture-16

So, instead, there is another related concept, which is conditional convergence. So, what does conditional convergence entail? As we said that the earlier assumptions that were made for unconditional convergence. Now, they also seem a little unrealistic, right, if we are considering all kinds of countries together. So, here instead this assumption that was made earlier, now a weaker hypothesis is presented that is countries can differ in terms of s and n, we call what is small s. So, countries can differ in terms of their saving rate, countries can differ in terms of the population growth rate that is small n. But there is free knowledge transfer.

What does this imply? This implies that g is the same. Remember what is g? g is the rate of growth of technological progress. Now, why is g generally assumed to be the same across different countries, as we said, because you know this is there is knowledge transfer these days if we also think about how technology travels, you know, even if you know, let's say, iPhone was invented by Apple in the US. In no time, everyone around the world adopted it, right? So, if we think about technology like that, technology, in some sense, is borderless, right? So, that diffusion takes place very quickly.

So, maybe in that sense g might not be very different across countries. However, when it comes to population growth rate and savings rate, they might differ. So, if we now make this assumption, instead of making the assumption that n has to be the same for all countries, s has to be the same for all countries, and of course, g has to be the same for all countries, instead with this kind of an assumption, the kind of convergence that we get is known as conditional convergence. And, these days when we talk about convergence in the economic context, we mostly talk about conditional convergence. So, what is the implication? This is very interesting and this is very important.

So, the implication of conditional convergence is that countries then converge to a common growth rate because recall that at a steady state with technological progress, per capita output or GDP grows at the rate g. So, this is about convergence in growth rate. Although per capita incomes might vary from country to country, unlike in unconditional convergence what we had seen was that all countries converge to the same per capita income. Which we also when we look around we see that is not what is happening. Rather,

the conclusion that is drawn from conditional convergence is that countries converge to a common growth rate, which is this small g.

Now, if you are trying to distinguish more between unconditional convergence and conditional you know, maybe I can give a parallel, not a great one, maybe you can come up with your own parallel, but the way I look at it is like you know saying that all students in the class they should be kind of like a topper or they should all get 95 percent. Now, this is implausible or the other way around this is only possible if the characteristics are all similar. So, let us suppose that they have the same IQ; they have access to the same books, they have similar upbringing, etc., which induces them as to how much effort they put in. If that is the case then yes, eventually everyone will perform very well and reach let us say that 95 percent.

But in real life what actually happens is that we are all not competing to reach the first spot. What we are actually you know living up to or competing is to reach our own potential. This is the important distinction between conditional and unconditional convergence. So, actually if we also now go back and revisit the diagram that we had drawn earlier, you know couple of slides back. Remember, we had clubbed all these 4 countries together in one particular figure here and we could do that because we said that all the parameters are the same that is what we had assumed, but now if the 4 countries are different in terms of their s and n.

Ideally, what we should have is we should have a different figure for all these different countries. And what these different countries are doing? They are all moving towards their respective steady state. This is why we use the parallel that as students or as individuals, we are not really competing against each other in the sense that we are not all trying to reach the same goal. We are just trying to reach our own potential. And everyone's potential is different.

So, this is how perhaps one can look at it. In other words, there is no now one single steady state for all countries. Each country has its own steady state paths, although they have been made parallel to one another given the hypothesis that the rate of technical progress is same for all countries. That is one point that has remained unchanged. So, if we now go by the definition of conditional convergence, then do we test if poor countries grow faster compared to richer countries? No, now that is not the case because now each country remembers will get its own figure for, you know, the Solow growth model thing that we have drawn.

And they are going to approach their own steady state. So, growth rate convergence implies that a country that is below its own steady state will grow faster. So, now do we see the distinction between the two? This requires us to first find each country's steady state that is the convergence is now conditional on the position of the steady state. So this is now

the important distinction that we make between unconditional convergence and conditional convergence. So conditional convergence naturally now sounds more realistic because you know that stringent assumption that we had made.

Now, we have a variant of that assumption where we allow things to vary, s and n should vary, they actually vary in real life. Once we make that assumption, we are not talking about all countries converging to the same per capita income. They will converge to a same you know steady state growth rate, but are they also going to converge at the same rate or can we say that the poorer countries will grow faster than the rich countries, neither can we say that. All we can say is that for each country, depending on its position of the steady state and from where it is starting, its growth rate will get determined. How or why? We have seen that earlier.

If any country is way below its steady state, its growth rate is going to be faster. And if any country is very close to its steady state, its growth rate will be much slower. So, everyone's growth rate is now relative to its own steady state. There is now no one common steady state that they are all going to converge to. How has this particular hypothesis of conditional convergence how is it tested? So, one of the first empirical tests that was done was by Mankiw, Romer, and Weil in the year 1992.

So, Mankiw is the same Mankiw textbook that we followed for, you know, the Solow growth model. And Romer, Romer's name will come up again towards the end of this week's lecture. And Weil, Weil's name has come back multiple times. If you recall, one is the textbook that we mentioned that we are following; second, when we were doing night lights, and we presented that paper on night lights, that is also Weil was one of the co-authors. So how did they test for conditional convergence? What were the findings? They found that more than half the variation in per capita GDP in 1985 can be explained by the two variables, s and n.

So savings rate and the rate of population growth, it does play an important role to explain the variations in per capita GDP. Signs of the coefficients, they are as per the model prediction. That is also the good thing. What do we mean by that? Remember what are the model predictions? If s increases something that we had also checked graphically, then we saw that k star also increased. If n increased then k star actually decreased.

So, with s, the coefficient sign should be positive. That is what they found; with n, the coefficient sign should be negative, which is exactly what they found. However, the coefficient magnitudes were not close to 0.5; they found slightly different values, but by and large, if one tests for conditional convergence, there is, by and large, evidence of conditional convergence. So, I think that pretty much covers, you know, the Solow growth model, the augmented Solow growth model, what comes out from the Solow growth model, and if we are trying to answer questions like, you know catch up effect, is it there,

then what would be the right approach to such questions, these are the things that we have covered thus far.

Now, the next thing that we cover is something known as growth accounting. I call it a very small and sweet exercise per se and gives us very useful insights so as to say. What is the purpose of growth accounting? When is it done and what kind of evidence do we have? Now, what is growth accounting in trying to answer this particular question? We should have a background to this, right? And why are we suddenly talking about growth accounting? In some ways, growth accounting is also related to the Solow growth model and everything that we have covered thus far, but in a slightly different context. So, one justification for doing the growth accounting exercise is that it helps us to actually measure technological progress or productivity growth. This is an issue that we have talked about earlier when we were talking about the augmented Solow growth model, how exactly do we, you know, kind of capture this technological progress parameter, like in terms of numbers, right? As economists, we love numbers.

It is easier also to work with numbers, but how exactly can we capture that, because it intangible in nature. So, growth accounting answers that question. Also at the same time why we find growth accounting exercises very useful is that it gives us one can say the preliminary steps to analyze the fundamental determinants of economic growth. So, this is just like the starting point. So, let us say for a country like India and we will shortly see a comparison being made between India and China whose growth comparisons are always done.

Suppose, we would like to know that for India and for China in recent times, what actually has been the source of growth? First, from which sector is it coming from? Second, now that we have studied the Solow growth model, we would also like to know how much of this growth is due to growth in technological progress or productivity. How do we then answer questions like this? So, what growth accounting does? Now, as the term suggests, it is an accounting exercise. So, the right hand side and the left hand side, it has to match. We will see how we arrive at that equation and how the number matching is done. But just before we reach there, just to quickly mention what is this growth accounting exercise.

By doing growth accounting exercise, we break down economic growth into two major factors. One: what amount of growth has come from technological progress, and what amount of growth has come from factor accumulation? What is factors of production? As we know that L and K labor, capital, and land these are factors of production. So, essentially growth can occur because of growth in productivity okay. Or because of growth in these factors of production, because the population has grown because physical capital has grown, etc., and in most cases, growth is a combination of both of these factors.

So, now, can we segregate these two factors? Can we say that more growth has come from either factors accumulation or has it come from productivity? So, to answer those kind of questions, we use the growth accounting methodology. There is one thing that we would like to keep in mind when we are doing growth accounting, that growth accounting exercise gives us what we call the proximate causes of growth. It cannot give us a very detailed answer. So, for instance, if you are looking at the Indian growth story currently. And if we are doing a growth accounting exercise, what this will tell us is most of the growth is coming from the services sector and the services sector is very productive.

But now let us suppose if we would like to go one step further and we would like to ask ourselves the question that, but what exactly in the services sector? has led to this productivity growth. Is it because of the reforms of 1991? Is it because of maybe more MNCs being present? Is it because of some other factor? That is because of deeper factors, in other words, that cannot be uncovered from this kind of exercise. All it will tell us is that is why these are known as proximate causes. They will just tell us that you know where we should be looking, but anything beyond that cannot be answered by a growth accounting exercise. So, typically the way we look at it is it is a very good starting point.

It gives us a very good picture of where is it that we should be looking at if we are talking about growth. But anything deeper than that, the exact causes or the drivers or what has propelled growth, no, that cannot be answered by this particular exercise. So, there are a few steps that we follow in order to arrive at that equation and a very simple four-step methodology that we apply here. The starting point is the neoclassical production function, something that we had seen in the Solow growth model. So, let us say we can consider a Cobb-Douglas production function.

And we have to remember to use or to add that time subscript because the factors have to vary over time. So, Yt, At, Kt, Lt, we have to add that; otherwise, we would not be able to do the next steps. And also we consider the time series, we had talked about this earlier I think in one of the earlier lectures where we were talking about different kinds of data. What is time series data? So, let us say for India, we are doing this exercise, which we will see an example of shortly. So, we will look at the output data for India over a period of, say, 70 years now, the capital accumulation data of India over the period of the same 70 years, labor data, etc, etc.

So, this requires time series data and this is done for each country individually. Now once we have let us say the neoclassical production function, we then take log on both sides. After taking log on both sides what we do is we differentiate it with respect to time. This is how it looks like again a very generalized production function is there. So, what has been done log has been taken and it has been differentiated with respect to time.

And what do we finally get from here. This is the interesting part of it. In fact, I would also like to take some time to explain what is it that we get here. So, this term is growth in output. This term that we have is growth in capital stock; this is growth in labor. What are these two terms that we have here, and where are they coming from? When we do the differentiation, we will find it.

Try doing this: suppose you are doing this Cobb-Douglas production function; try and do it. So, this will turn out to be alpha and this is 1 minus alpha. And so, what is g? This g is, this is growth in technology or productivity. So, this is how it appears like I would, you know, urge you to please use this particular Cobb-Douglas production function and, you know, do the following steps and arrive at this point. This is a very generalized production function that has been taken.

What is the message? The message from growth accounting is very important and that is why it has become very useful. So, the message is growth in output, which is our left hand side. Growth in output comes from two important sources, one this happens due to growth in productivity and second it occurs due to growth in factors, factors of production. It is not necessary that labor and capital are the only factors of production. If one has data, one can include land also as a factor of production.

So, that is why I have just generally written factors of production. And it is not just growth in factors of production, I should also add here it is weighted growth. Why weighted? Because you have this alpha here and this 1 minus alpha here. So, together the growth in productivity plus this weighted growth in factors of production should add up to growth in output.

So, this is the beauty of this exercise. It is very simple as long as we have the data, we should be able to proceed with this. And along with this, I hope you can already see it by now, another related question also gets solved here, which is we had earlier talked about this, how do we measure growth in productivity? Now, as we said that what is the data that we use? There is no data per say, what will capture that really, but from here what we can see is this can be found out. Why? Because this cannot be measured by data per se. Then it can be found out because we have data for all other remaining things. Why? Where do we have data about growth in output? By now we have seen several sources from where we have growth in GDP data.

Do we have growth in factors of production data? Yes, we do. Labor data, capital stock data, we have that data, right? Do we know the values of alpha and 1 minus alpha? Yes, generally, it is taken as 0.3 and 0.7. If we want, we can also find it out, but you know data is there.

So, what is the only unknown on which we do not have data? Only this. So, can we now find this out from this particular growth accounting equation? Yes, we can do that. So, this is the fundamental thing about the growth accounting equation apart from telling us what are the sources of growth and the relative importance of each source when it comes to growth growth and output. This also helps us to find out the rate of technological progress or productivity whichever term we use for it as a residual. This is an important thing and you might have heard about the term Solow residual.

So, this term is known as a Solow residual. So, two purposes you know that this particular growth accounting exercise allows us to do. It allows us to find out the sources of growth. Is more of growth coming from growth in technological progress, or is it coming from growth in factors of production? Because we do not have data on technological progress. The one way of finding it out is from this equation itself, where it is treated as a residual, this is also very important. Why residual? Because as we have seen here before, we have this, we have this data.

This is the only remaining one. So, that is why it is a residual known as the Solow residual. One quick point I would also like to make here before moving away from this particular equation: there are certain drawbacks, or I would rather call them limitations. Related to this kind of calculation. Why? I think you have guessed it by now.

Why? Because it is a residual. What does this imply? It implies that anything that is not accounted for by this and by this everything else has gone in here because it is a residual. So, maybe let us say if we could include land here then the residual would have been lesser because we have included land also as a factor of production. Whereas, if we do not have land and if we just go ahead with this particular production function that we have then the amount of residual will be more. So, that is why we have to be careful about the conclusions that we draw from the Solow residual, and this is subject to a lot of debate per se whether this should be considered as a measure for technological progress, growth in technological progress, or productivity because it is a residual. So the point being whatever has not been accounted for by the factors of production and by growth in output, everything else has been pushed in there okay.

So how do we know how much of the residual is? Maybe you know, energy or oil is a factor that is now embedded there. Land is a factor that is now embedded there. Everything now becomes a measure for productivity. So, this is a caveat, I think it is important here, I do not have a separate slide for this, but we should be little careful when we do the growth accounting exercise, we should be aware of this particular caveat and not get very overwhelmed by necessarily big numbers on productivity. These tables are from Barrow, Barrow has a very nice textbook and these are some of the examples that I am showing from there.

For instance, for the different OECD countries that we can see here for the different time periods, the TFP growth rate. What is the TFP growth rate? I have not used this term before. This term A has many terms actually. Sometimes it is known as TFP, total factor productivity.

Sometimes, it is called a technology factor. Sometimes this is also known as efficiency. So, different people use different terms. And as macroeconomists, we generally use the term total factor productivity or TFP. So, this TFP growth rate is nothing but this is that g that we had seen in the Solow growth model earlier. So, what do we see here for all these different OECD countries? I would urge you please you know pause here for a couple of minutes and then try and see that how these numbers compare in two senses, one pick one country and see whether this has changed over time here.

So, it is basically covering the periods between 1947 till about 1989 right. So, for each country, try and see whether these numbers have changed over time. Yes or no, that is one exercise. And the second exercise is for now fix this. So, one try and do this fix a country and look at TFP growth across time periods.

So, this will help us understand whether TFP has grown or has there been slowdown, or has it been stagnant for each country. So, fix a country that is one approach. The second is fix a time period which is say this. We are fixing this particular time period. Fix a time period and compare the TFP growth performance of all countries during that time period.

So, two ways in which we can do the same exercise and to understand these numbers or rather to infer from these numbers. As I said, just pause here for a while and do both exercises. I think a lot of answers will actually come out from here.