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**PROFESSOR:**

Hi everyone. So I am Esther Duflo. I am the other person who teaches this class. You had Abhijit for the first class. I am going to start by doing a bit of housekeeping. Keeping in mind that maybe some people are going to arrive, so it is your responsibility to inform everybody else of what I said today. I got some requests of clarifying what was the requirements for this class, so I'll just go through it once.

So we are going to post essay topics. For 10 topics. And we are going to give three or four choices. You can also make your own essays. Whatever it is. You do have a chance to write up to 10 essays. But you don't need to write that many. You are going to be graded out of the best five. So you can write any between one and ten. And if you have one you're not going to have a very high grade but-- Any between five and ten and then we'll just take the best five, OK?

I think the syllabus said seven and Abhijit said five, so I went for the easier thing. So that's one thing. The syllabus also said that we might not grade all of them but, actually, we are going to grade all of them. So I would suggest that you do the first one so that you get used to it.

Traditionally, it has been the case that when students can decide how to arrange their deadlines, they think that it's efficient to set all the deadlines late in the semester. I can tell you by experience that it's actually exposed not to be such a good idea. So if I were you, I would arrange things to do as many of them early as possible so you don't get panicked by the end. So that's one.

The other component of the requirement for this class is to do the readings. And so to be prepared to discuss in the class. One way in which we're going to ensure that you're doing the reading is a very, very short pop-quizzes every once in awhile. It also means you have to come to class. It's not a class that's very difficult. But one thing that it requires is that you actually come. And so we're going to have those at any random times. Very simple. 2, 3, 4 questions just to check that you've actually read the thing. And today the questions for the first topic were already posted on Stellar. So you already have access to them as well as the deadline for the

first thing. And that's it.

Other than that, I think I gave a version of this spiel in 14.74 yesterday. There are two development classes. If you're wondering which one you should be in, this one is going to be more based on the readings and discussion and lectures. And the other one's going to go more in the detail of the techniques of papers and solving the models and replicating empirical papers, et cetera. So this one's a better introduction and the other one is better if you already have a fair amount of economics and econometrics. So that's the trade off.

Other than that, obviously, the themes that are going to be covered are going to be pretty similar. So my sense is, probably, that you don't want to take both at the same time. Although you could think of taking them both in sequence. Then you would do 73 first, 74 second. I don't recognize any 74 students, but you shouldn't want to take 74 and then 73. That would be a bit boring. So you're welcome to shop a little bit for some time and then decide what's more appropriate. You're welcome to take both but I would have warned you that there will be some overlap between the two. That's it for housekeeping so if you have questions, that's a good time. I'm happy to answer questions by email also but chances are that if you have a question on the logistics, a lot of people share it as well. Any questions? No.

The class is being recorded, that's for OpenCourseWare. But don't worry about saying anything embarrassing. That would be edited out. I'm the only one-- and Abhijit-- is going to be the only ones who are being recorded on tape saying things embarrassing. I'm assuming if you say something extremely smart we can keep it though.

**AUDIENCE:** [LAUGHTER]

**PROFESSOR:** So there is no danger. Feel free. Just ignore them. And hopefully, the idea is that if it works well, it will be one of these classes that people can take on their own down the line. Anything else? Any questions? No questions?

When you speak, at the beginning, if you at least would state your name so that I can possibly get to know who are. I can address you by your name. That would be nice. And otherwise, we're ready to roll. Shall we dive in? Let's dive in.

So, in the video that you saw last time, you saw quite a few people who were maybe trapped in some kind of poverty trap. So for example, there was this farmer who, before he was given fertilizer, had very low yield. And because he had very low yield he didn't have much money.

Because he didn't have much money, he couldn't buy fertilizer and, therefore, he continued to have very low yield.

And what the Millennium Village Project did is to give him the fertilizer. And the hope was, that with this first gift of fertilizer, his yield would increase by a sufficient amount that, down the line, he would be able to buy his own fertilizer. And grow more and more maize. And then, progressively, maybe start feeding his children better and buying them books and all of those things you want to think about. So in that video, the Sachs and Jolie video that you saw last time, this argument that there might be these poverty traps keep coming over and over again.

So for example, in the Kennedy story with the farmers, you see it in the schools. The schools don't have computers so the kids cannot really learn well. You start putting computers and kids can learn better. They will then make more money. They will then be able to buy computers for their schools, et cetera, et cetera.

So one of the things that we are going to do a lot of in this class is to try to understand when there are such poverty traps and when, in fact, maybe it's not so obvious. And for that, we have to understand what creates the conditions for such poverty traps to emerge. So what I want to do today-- we are going to delve in on one example of one particular poverty trap and how that could work. Which is going to be the fact that we are physical, biological bodies. But what we're going to go over as a mechanism, it's going to carry us during the entire class. We are going to have to be looking for the same type of conditions.

So I want to start with a story of someone that actually I met. I met some guy called Pak Solhin. Pak means mister. Mister Solhin. So people in Indonesia don't really have a first name and last name. They just have a name. And so, for example, Mrs. So-and-so is Ebu-- I would be Ebu Esther, for example. So this guy is Pak Solhin. And I met him in a village in Indonesia-- in Java, which is one of the richest parts of Indonesia. This is the main island, most densely populated-- in the summer of 2008. In the summer of 2008, I was-- probably for you it's already ancient history, it's before the great collapse of the world economy and stuff.

--One of the key events at the time, for the developing countries in particular, was that the food prices were very high. Basically since 2005, food prices have increased enormously in the world for reasons that are not fully understood. And then they collapsed again when the whole economy went berserk. The world economy went away, the food prices also collapsed, and they have started to increase again.

Part of the hunger that you see now-- in Egypt, Tunisia, et cetera, all over the Middle East-- part of it is fueled by a re-increase in the food prices which are almost reaching the 2008 level. For people in urban areas, this has, of course, immediately threatened their livelihood. Because they don't produce food. They buy food. So as soon as the food prices increase, that immediately affects them. So the beginning of 2008, 2007 you observed this kind of food riots-- nothing like we are seeing now in Egypt-- but dis-content in various urban areas. And generally, people were wondering what was happening to food prices.

What people have been thinking is that there are several factors that are responsible for the increase of the food prices. One is there are many more people in China and India making more money. And as they are making more money, not only they eat more but, more than that, they eat more meat. And it turns out that to produce 1,000 calories of meat, you need much more grain than to produce 1,000 calories of grain. That may sound strange, but it turns out that the cow is not a very efficient way to transform the calories from grain into calories that we eat. The cow has started by using a lot of it, et cetera. So to produce 1,000 calories of cows, you need much more than 1,000 calories worth of grain. So as China and India is becoming richer and eating more meat, then there is a demand for more grains. That's one.

The second thing that is happening is bio-fuels. With the increase in the world prices of fuel there is more and more demand for bio-fuels, so entire strips of Brazil have been covered into maize that is being used to make ethanol. A third thing is oil is actually an input into the production of food. Because oil is a very important input into the production of fertilizer. So as the price of oil increase, the price of fertilizer increase, and therefore the price of food increases. So all of these factors are fundamental forces which explains why, after the short dip right after the crisis, the food prices again started to increase.

So that's the backdrop of my visit to this village in Indonesia. And I met this guy. And he was all alone. He has a small, dingy, little house. And he was a bit depressed, or very depressed. And why was he depressed? Well he was depressed because he was all alone at home. And he was all alone at home because his wife had gone to the city to start working as a maid. His oldest son had also gone to the city to start working as an apprentice on a construction site. And the two young kids were with the grandparents. So he was all alone, he didn't have anything in his house, he didn't do all that much, and he wasn't happy. So the question is, why did that happen? Why was he not working?

And what he explained to me is that he was not working because he didn't have a job. And he

didn't have a job because when the fertilizer prices increased, the farmers that used to employ him decided that they had to do something to cut costs. They weren't very sure whether they were going to be able to sell their outputs and they were facing those increases in expenditure. So they decided they had to cut costs. And so they could have done one of two things. What could they have done? Yeah?

**AUDIENCE:** They could have cut wages or cut the number of people employed.

**PROFESSOR:** Right. They could have cut wages or they could have cut the number of people who worked for them. So of course, if they had cut wages, he still would have a job. But instead, they cut employment. And why did they cut employment rather than cut wages? Well his theory was that if they had cut wages, his wages would've been so low that he would not have been able to buy enough food-- especially as the food prices were rising at the same time-- with the equivalent of one day of wage that would have been too little to sustain himself to be strong enough to actually work for a whole day.

So seeing that, the employer, instead of cutting the wage and therefore making him unable to work, then you give a wage of someone, let's say, 1,000 rupiahs-- 1,000 rupiahs is not enough to get yourself energetic for a full day of work. So you've spent your 1,000 rupiahs but the person can't feed himself for a day of work. You get nothing out of him, so there's no point. Yes?

**AUDIENCE:** The question that came to my mind was, is there any truth to his theory? Did you find any other examples that would back up that that's the reason why the farmer, that he used to work on his land, decided to cut jobs instead of wages?

**PROFESSOR:** Right. What you're asking is whether-- that's fine-- whether maybe it's a plausible theory. But is there any truth to it? We're going to spend a fair amount of time on this very question, not on Tuesday, but starting Thursday. In terms of the empirical truth of his theory, in terms of the biological soundness of it, it sounds plausible a priori. That you need to start with a certain number of calories just to get going, right? Your body needs maybe 1,000 calories just to survive. So the first thousand calories that you're consuming are not very useful to you to help you to actually start exercising. Then, once you are alive, the next calories will start being useful. So a priori, maybe there was some plausibility to this theory. That's only one theory.

So that means that he lost his job so he couldn't do much of anything. He was not doing

nothing, otherwise I would not have met him. He would be dead. But he was doing things that was not taking too much effort for him. For example, he was sitting next to the bank of a lake and he was fishing. He was getting a little bit of rice from the government program. He was getting a little bit of meals from his brother. But he was not really living a full life. He was sort of surviving.

So at the heart of his theory-- and I think your question of whether this is true or not is a very interesting question which certainly came to my mind when I was talking to him-- but at the heart of this theory was this purely biological mechanism. And then on top of this biological mechanism, other things crept up. One is the fact that he was not doing anything, and that his kids were gone. That made him depressed so then it gave him very low energy to actually you do anything. So even if his theory was wrong, he sort of became trapped in a poverty trap that may have been more of a psychological one. Because he was there, sitting all alone in his hut, unable to do anything, thinking that he was worthless, therefore, in some sense, becoming worthless.

There are other parts of his stories where we start seeing other bits of poverty trap. For example, what happened with his kid. So the kid who had to drop out of school to start working as a construction worker was actually a bright kid. So that's another place where you see now an inter-generational poverty trap. Where because the parents are poor, the kid has to drop out of school because he has to go to work and therefore himself will probably make less money down the line.

And that's another thing where we have to ask exactly the same question you were asking before. Is it an isolated example? Or is it something that is generalized. That it's actually something like the inability to work for the parents, or the lack of income, that forces kids to stay out of school that could have otherwise have gotten an education. That's another place where we can find, potentially, a poverty trap. Where the kid got some schools. He got a few years of school but maybe not enough for it to be sufficient for him to actually get a good job down the line.

And for himself, he couldn't work as a construction worker because he was too weak for the basic jobs which require some strength, and too unskilled for the better jobs, and too old to be an apprentice like his kid. He was kind of trapped. So what is happening in this story that you would think-- even if we accept the biological mechanism, which I want to go back into in detail in a moment-- something else could have happened. So for example-- if we're thinking that his

being out of a job is a temporary phenomenon-- maybe he could have gotten a loan to sustain his family so that the kid could at least stay in school until the time for him to graduate. Then at least you wouldn't have that inter-generational trap. So at the heart of it, we have this biological phenomenon and then other things sort of creep in that maintain him in this position that creates the poverty trap.

So what I want to do now is go through the biological story in detail. And then we're going to see how the other things add up, creep in, and create that trap. So let's go through the biological poverty trap. I should say that it's one of the most ancient ideas in economics. A very old idea . It dates at least from the 1950s. And this is an old idea exactly in this form of the biology.

So the idea is that the first few calories that you get to consume are used by your body just to survive. So they don't make you strong. And then, when you start eating enough to survive, the next calories start giving you strength. So that's when you can start working out or you can work. So someone who is very poor, like Pak Solhin, may not have enough to eat to be very productive but if he could eat more, then he would become productive.

So at the heart of this is this idea of what they call a capacity curve. And a capacity curve has something like this shape. It relates how much effort you can exercise to how much income you have, and, of course, how much income you have is supposed to be related to how much you consume. So what is the assumption that is underlying the fact I have put income here on the x-axis? Yep?

**AUDIENCE:** The more money you have the more you eat.

**PROFESSOR:** Right. The more money you have the more you eat. So for example, the simplest case would be, all you have, you eat. Of course, we know that it's not true because you also need to take care of your basic needs. You need to clothe yourself. You need to pay your children's school fee. Maybe you need something for your housing. So maybe you will only consume a part of your income. But maybe some fraction of what you have, you're going to eat. So that creates a relationship between the income you have today and how much you get to eat.

So instead of income here, we could have calories consumed. And one first big question that we'll have to answer next time is, how steep is this relationship between how much income people have and how much they are eating. Here we are assuming that there is some relationship and it's formidably steep enough. So whenever you have income, you start eating.

And what we have here on the left, on the x-axis is the work capacity. So how many bushels of wheat are you able to harvest or something like that. How many trenches can you dig. So the work capacity, you think of it as physical output. But of course, there could be a relationship between this physical output and your income tomorrow. Because, for example, you could be paid by the piece. So if you're paid by the piece, however many bushel of wheat you harvest, you get that much income. That creates the work capacity and your income tomorrow are related one for one. Right? So here we have income today, work capacity. And instead, we could have income today and income tomorrow. OK? Now why is this shaped the way it is? What does the shape represent?

**AUDIENCE:** The left part is the part where your body is just able to survive. And then afterwards he gets a chance to actually make more money tomorrow because [INAUDIBLE].

**PROFESSOR:** Exactly. So the left part is the first part where you're just getting enough to survive. You are just eating enough to survive. So the first few calories are good because they keep you alive so you can actually move about. But after that it just keeps you at this kind of low level. Right? And then you start having, maybe 1,200, 1,500 calories. And then suddenly, it's a good breakfast you're eating before going out for your run. It shoots up and then, why does it flatten out again? Yeah?

**AUDIENCE:** Because after a while you're satisfied and it levels out once [INAUDIBLE].

**PROFESSOR:** Right. After a while it satisfy and it levels out. And if we had continued the curve, what would happen? It would really go down. Just think of post-Thanksgiving slump and she probably gets a deep down going line. So that creates this kind of funny shape between you're income today and your work capacity and, therefore, between your income today and your income tomorrow. Or it could be within a week or something like that, right? Which seems to have a reasonable biological sense. Now what happened when the price of food went up? What does it do to the work capacity? Yeah?

**AUDIENCE:** I suppose it goes down because those people have to spend more of their income on food and then buy less food.

**PROFESSOR:** Exactly. So what happens when the price of food goes up is that, in terms of bushels of wheat, that's the same thing. But in terms of actual income that the bushel of wheat transform into-- how much income-- that creates a jump down. Because to go from income to work capacity, to



create from income today to calorie, that's more expensive. So the curve shifts down because for every dollar that you spend, or rupiah that you spend on food, that's fewer calories and, therefore, that shifts down whatever you are able to achieve in terms of capacity, right? So if we have it in the form of income to work capacity, the prices of food going up makes the curve going down. Yeah?

**AUDIENCE:** Could you also, if you were talking about students, instead of saying the word capacity, I'd put the way you pay attention? Would they pay more attention if they ate more? Or is it just physical spending that [INAUDIBLE]

**PROFESSOR:** Right. Here, if we're thinking of Pak Solhin, we are thinking about physical [INAUDIBLE]. But if we're thinking about Pak Solhin's children, for example, it could well be their capacity to focus in class. And it could easily have the same shape. In fact, there are other thing that competes also for calories for children. For example, whether or not they have intestinal worms. And the intestinal worms also shift your work capacity, your attention capacity, down because they are eating your food. Therefore, that tends to make the kids anemic and less likely to be listening. That's exactly right. Yeah?

**AUDIENCE:** And so increase in food prices, does that cause a shift or a stretch?

**PROFESSOR:** It specifically causes shift and a-- how would you call it, west-southwest, right?-- It is both a shift and a stretch. Which is, it will take more of your income today to have you switch to the-- think of it going this way. And alternatively, what happens when the wages go down? That's another thing we can look at. What happens to the work capacity? Not to the work capacity, but if we put income on the y-axis now and the wages go down?

**AUDIENCE:** It shifts lower.

**PROFESSOR:** It again will do the same thing because now the same work capacity will translate into less income. So what was happening in Indonesia in 2008 was, on the one hand, food prices were going up. On the other hand, farmers were stressed out because the input prices were going up. So at the same time they wanted to reduce the wages when the prices were increased. And both of these phenomenon create this southwest shift in the capacity curve. Yeah?

**AUDIENCE:** Why didn't the farmers just increase the prices they were selling the crops at [INAUDIBLE]?

**PROFESSOR:** That's an excellent question, so why didn't the farmer just increase the prices? The thing is that with the agricultural cycle, you produce and then-- so you put your fertilizer in the ground,

then you put your crop in the ground and then you wait around. Then the crop comes and you try to sell it. And you're exactly right, the fact that the input prices have gone up while the demand, in principal, would not have gone up. It would have meant that the food prices sold by the farmer would probably go up.

But what happened is that they weren't very sure whether or not the food prices were going to go up by the time they sold their food in proportion to the input prices. So the situation that prevailed in 2008 is a lot of volatility. The prices were high but they were also increasing. And that was true for the input prices and that was true for the output prices. And when you were talking to the farmer, everybody felt that they were holding the short end of the stick. The farmers were saying, well, yes, the food prices will increase. But we don't know whether it will increase enough to cover our input prices.

Moreover, the farmers found it difficult to get loans, for example. So even if they know that the prices are going to go up for that input in the future, in the meantime, they still have to buy the fertilizer. So they sort of had to cut costs now. So this is a little bit what was happening. It's a mismatch between the price you have to pay for the fertilizer today. And you're going to realize the output in the future. So that creates this uncertainty plus the fact that you need to finance it one way or the other. Which is why, at that time, there were two things going on which were both against the poor guy.

So this is what we have with the capacity curve. So we've had this reasoning for food but let's think a bit about other reasons-- forget that we are talking about physical work capacity. Think about other reasons why there might be a relationship between your income today and an income at some point in the future. Think of the next generation, think of next month, or anything like that.

Can you think of other reasons why this kind of funnily shaped curve might appear? So food might be one. What would be other reasons why this funnily shaped curve might appear? Yeah?

**AUDIENCE:** Over the long term, maybe education.

**PROFESSOR:** So let's go through the education one. Why do you think--

**AUDIENCE:** Before, the less long you can afford to keep you're children in school. And so their income capacity isn't as low as yours was. But the richer you are, the more schooling you can get and

the higher income you can [INAUDIBLE].

**PROFESSOR:** So this is right. That there is probably a relationship between how long you can keep the kid in school-- because if there are school fees you might or might not be able to afford them. Or there might also be an opportunity cost for the child to be in school. Like Pak Solhin's son couldn't afford to be in school because he had to work.

So I think it's not very controversial to say there might be a relationship between your income today and how long your kid will stay in school. And then, there is probably a relationship between how long your kids can stay in school and their income. Which will create a relationship between your income today and the income of the child. So that creates a relationship of some form or another. But what would be necessary for this relationship to have this S-shape? So what you have explained, I think and I think most people would agree-- we can ask around-- but I think what you have explained clearly is that we might expect through education-- a relationship between income today and income of the children. Now what else do you need for that relationship to have this funny shape?

**AUDIENCE:** At the start, you need to invest more. So like if they just learn to fifth grade, or if they just learn to second grade, it isn't going to make that much of a difference. But as they finish middle school and high school, it's a much steeper curve. But then, going to college versus Ph.D. levels off.

**PROFESSOR:** Yeah. Sadly, going to a Ph.D usually leads to a drop in income compared to having gone to a Master's. Especially if you choose the Master's properly. But this is exactly that, which is we need one more thing. What you're saying is exactly right. What's your name?

**AUDIENCE:** Yousef.

**PROFESSOR:** Yousef. But what she told us is you need one more thing. You also need for the benefits of the first few years of education to be relatively low. And that's an empirical question that goes back to the plausibility question that you were asking earlier. Is it the case that the first few years of education are useless, or not very useful? Or is it the case that every year of education is a year of education.

And there will be an S-shaped based on education if the first few years of education are not that useful. And [INAUDIBLE], if in fact, even the first few years of education are that useful. I'm not going to answer this question now. But we are going to answer it in due course,

whether or not this is the case. You see that this is not something that we can just think of in the abstract. We have to find out. There could be reasons the other way.

You could feel, for example, that the first years of education are amazingly useful because this is when you learn to read. And once you know how to read, who cares about all of these things that I'm trying to teach you because you can teach yourself everything you need to know. Or you could think that education is not useful unless you have a secondary degree. Because that's what opens the door to you for various formal jobs.

Right? It could easily cut one way or the other. I don't know if you guys have an insight. For example, what is your view? Do you think that this is likely that the first few years of education are not so useful or--

**AUDIENCE:** I think the first few years are very useful because some people learn to develop, like, love for reading. And actually realize that they can learn things by reading [INAUDIBLE].

**PROFESSOR:** So for example, you think that, the first few years of education are very useful. So there would be a relationship between income today and income of my children. But it wouldn't have this shape if that is the case. In fact, it might have a completely opposite shape where it's more like an inverted L as opposed to an S. So education would be one. What would be another possibility for this funnily looking shape to appear between income today and income at some point in the future? Is it on my income in the future or the income of my children or my income next year? What would be other sources of such shapes? Yeah?

**AUDIENCE:** Access in knowledge of, like, the job market. In the sense that if you were raised in a family that's a higher income and so, therefore, your parents would teach you more from a younger age and would allow you to have a higher income.

**PROFESSOR:** Right. So for example, for access to the job market, it is possible-- if I can rephrase what you are saying-- that people who live in a village, their horizon is the village. Where they are growing whatever. They are growing stuff and they are making some income. But they don't have the perspective in mind that they could go to the city where there a number of other jobs available. So in that case, for people who have very little money and live in the village, well, their children will again also live in the village and have very little money.

If suddenly something opens the possibility to go to the city-- for example, someone comes into some money, gets the option to buy a train ticket, goes to the city and figures out the

options there. Then suddenly you have access to a number of other opportunities, potentially much more rewarding, that would potentially create this S-shape. Where the fact of being poor means that you live in a relatively restricted environment. You stay there. And then when you become just a bit richer, that opens this opportunity that helps you you become much richer. That's a very nice example. Yeah?

**AUDIENCE:** Another option is savings which depends on how much income you have. Because the more you save, the more you invest and the higher income producing activities. So the poor people have no money to save so they're stuck there. But as they get more income you can afford to save more and invest more and it pushes your future earnings.

**PROFESSOR:** Right. So saving is a very interesting example. Again you could say-- well, suppose for example, that people saved some fixed fraction of their income. Then if I have more income today I will save more. Therefore, I will invest more, therefore, I will be richer in the future. Now if it was a fixed fraction of my income, again, I would definitely see a relationship between income today and income tomorrow just because I save more. But if it's a fixed fraction of my income, what else do I need for this S-shape to come? Yes?

**AUDIENCE:** You need for poor people to not be able to save this fraction. Because they, for instance, spend their money on food or things that they need to buy today. And so are either a fraction of [INAUDIBLE] income or it's just lower for poor people.

**PROFESSOR:** Right. So the first possibility for an S-shape to appear due to savings is that actually people do not save a fixed fraction of their income. Is that for some reason, the poor save less than the rich. So if that's the case-- and let's talk through whether we have reasons to think that the poor would save less than the rich-- but let's first take it as given for a moment, and let's assume the poor save less than the rich. And if that's the case-- assume the poor save nothing-- then if you're very poor, you have no income tomorrow coming out of investments. And then if you start saving when you become a little richer and that money is invested, that starts creating some return for that money and you get into this steeper part of the S-shape. So that's a first mechanism through which savings could create a relationship between your income today and your income tomorrow that would have this S-shape.

Now what we do have to explain is why is it the case that the poor would be able to save less than the rich? And that is something that, I think, we all have in mind. Say, yes, of course, the poor don't save because they have no money. But one thing I want you to keep in mind is that

the poor have no money but they have a present and they have a future. So unless they think that they will have more money tomorrow or unless, for some reason, they are extremely impatient, then the poor should want to save as well. Because, of course, today they have very little money for food. But tomorrow they'll have very little for food as well. So we need to go a little further than to say, well, of course the poor save because they have no money. Right?

Again, let's not go into the details of that. I think there are good reasons to think that the poor would be less able to save than the rich. And we're going to have a whole set of lectures about that. But just keep in mind that it's not so obvious that the poor would be less likely to save. Another-- sorry, you wanted to talk.

**AUDIENCE:** [INAUDIBLE] access to healthcare and medicine.

**PROFESSOR:** Right. So let's go to health. Let's finish saving and then I'll go back to you for health. Another reason why there might be a relationship between income today and income tomorrow of this form due to savings. Suppose that the poor and the rich saved both a proportion of their income. There could still be a relationship like that. Yeah?

**AUDIENCE:** The rich could be able to invest their savings more effectively.

**PROFESSOR:** Exactly. It could be that the rich have access to better investment opportunity. For example, it could be that the bank is just not interested in very small saving accounts. And in fact, it's the case that the banks are not interested in very small saving accounts. Because as soon as you're a bank and you take the saving of someone, the government is on your back to make sure that you don't run away with the saving-- which is a good idea-- but that costs money. So maintaining a saving account for someone costs some amount of money. And regardless of the size of the account, it still costs the same money because you need to do all the paperwork.

So as a result, if you come to a bank with your five rupiahs, the bank is going to say, thank you, but I don't want your five rupiahs. Whereas, if you come with your 5,000 rupiahs they're, sure, I'm going to put it in this very nice account for you with a nice return. So that's one reason right there. That the poor might have to save under the mattress where the money might disappear. Where it might be stolen. And so the return on saving for the poor might be very low. It might even be negative. Whereas, the return for the rich might be higher, either because they have access to this savings account or they can, for example, start a small business. For example, when you want to start a small business, is it worthwhile starting a tiny

business with almost nothing? Maybe not. Maybe it needs to be large enough for it to be worthwhile. So even if the poor and the rich were to save the same amount proportionally, there might still be something related, not to how much they save, but what's the productivity of those savings.

You were talking about health care. Why don't you tell us what you're thinking about healthcare.

**AUDIENCE:** So at lower incomes you can't really buy a lot of medicine. And maybe you can reach a point where you can start buying medicines or buying healthcare. And maybe towards the end when you have higher income, it levels off because you don't encounter the health problems that you might at low incomes in the first place.

**PROFESSOR:** Right. So healthcare might be another source of that. For example, if you're very poor, you might not be able to purchase very simple, relatively cheap technologies that prevent you from getting sick. It could be a covering for your water. It could be a water filter. It could be a bed net to put on top of your kids when they sleep so that they don't get malaria. So all of these things might all be like some fixed investment that, if you can't afford them, you can't afford them. And then you are getting sick more, therefore you are less productive, therefore you make less money, et cetera. So that's another source where we would have this S-shape.

Then we again have to think about these goods as things that are a little bit lumpy. Like a bed net, for example. Or a water filter. That you can either afford or not afford. So if you have enough money you afford it and then you can be generally healthier. You don't lose all your calories to diarrhea and other nice things like that.

And if you're poor you would be sick all the time. Or paying for the doctors, for example. So for example, if someone is sick and very poor they might not be able to pay for the doctor. Then they'll stay sick so they can't earn money. And again, a doctor visit is one big lump investment which you may or may not be able to afford. That would be another source of an S-shape like that.

So the reason why I went through all of these examples is that we are going to have a lot to say about the exact story that Pak Solhin told me about the food. Whether this was a real story in this case or whether it's some stuff that he was telling himself to explain the situation he was in but, really, there was something else behind his problems like depression or something like that.

But the first time it was formalized was in this context of nutrition. And it's very natural to think of it in the context of nutrition but it could apply. And a very important part of the discussion that I want you to keep in mind is that it's not enough for there to be a relationship between income today and income tomorrow. To create a poverty trap it needs to have this funny shape. And I want to discuss why.

So the way that we are going to think of it is we are going to think about what is the dynamic of someone's income over time. So let's start with this picture which brings inherited income on the x-axis-- so think of it as income today-- and income from work. What I have plotted here is this S-shaped curve. Think of it, for example, as coming from nutrition. But any of the examples that you talked about if you don't like the nutrition one. And the line that goes through the diagonal is the 45-degree line. So why is the 45-degree line relevant and interesting here is that, , on the 45-degree line, income today is the same as income tomorrow. Right, so we're going to make use of it.

Now I want to try and look at the dynamic of someone's income over time. So suppose someone got this little income,  $y_0$ . Where do I read their income in period one? Yep?

**AUDIENCE:** It would be going from curvy line to the 45-degree line horizontally.

**PROFESSOR:** Exactly. So to go from income  $y_0$  to  $y_1$ , I go on the vertical line up to the curve. That tells me this is what someone who starts his life with some income,  $y_0$ , can make his decision about how much to eat, creates some calories, creates some work capacity, goes to work, generates an income that he takes home. That's the income that we have on the curvy line.

And then I want to say, well, that becomes  $y_1$ , right? And then  $y_1$  is going to become the  $y_0$  of tomorrow. So to find it, I'm doing exactly what you're saying which is I'm going horizontally to the 45-degree line. And I could go down again. So from  $y_0$ , I go to  $y_1$ . Then horizontally on the 45-degree line gives me  $y_1$  again. And then how do I find  $y_2$ ? I go vertical again, that gives me  $y_2$ . I go horizontal again to the degree line and I continue like that. And where will I end up?

**AUDIENCE:** Where the two curves intersect.

**PROFESSOR:** I will end up at the intersection of the 45-degree line and the S-shape curve, right? At the first intersection.

Now what if I start with a higher income. If I start with the income  $y_0$  double prime. I go vertical



to the curve. That gives me  $y_1$  double prime. I have to go horizontally to find it when it becomes income tomorrow. Again vertically, et cetera. And I again end up at the intersection of the 45-degree line and the S-shape curve but now it's a higher intersection.

Now what happens if I start at the sixth point in the middle over there? Which way will that go?

**AUDIENCE:** That will go down.

**PROFESSOR:** That will go down. If I go to the sixth point, I go vertical then left then down. So what is the key point after which I will start going to the high point? Yeah?

**AUDIENCE:** Where it intersects the 45-degree line again.

**PROFESSOR:** So the intersection from below. So at this point P where the capacity curve intersects the 45-degree line from below. Anything to the right goes to the high steady state. Anything to the left goes to the low steady state. So this possibility that there are two steady states depending on where you start from is the formalization of the poverty curve. Which is anybody who is poorer than the unstable equilibrium over there-- if someone starts with exactly this income, where do they go? If someone starts with exactly the intersection of the 45-degree line and the S-shape curve, do they go down or do they go up? They just stay there.

So it is also a steady state but it's a very unstable one. If anything happens, any small perturbation. If they go slightly to the left, they go all the way down. If they go slightly to the right, they go all the way up. So we call that an unstable statistic. So there is one unstable statistic and two stable ones. And those two stable ones is what we're talking about. They could be a poverty trap. Yes?

**AUDIENCE:** Why are they moving toward that 45-degree line?

**PROFESSOR:** Can someone explain that? You want to know why we are going horizontal to the 45-degree line? Yeah. Can someone explain that once? And then I'll re-explain it as well.

**AUDIENCE:** Because yesterday's income is going to be your today's income. And your today's income is going to be your tomorrow's income. So if we start with a value zero, so that value can come from work. It's going to be tomorrow's [INAUDIBLE]. So if you get the income from work, the  $y$ -value of that will be your incurred income tomorrow. So you have to go to the 45-degree line.

**PROFESSOR:** Exactly. The reason why we are using the horizontal line is that-- so from  $y_0$ , I know that I go

to  $y_1$ . And then I want to know, from  $y_1$  where do I go? For that I need to put  $y_1$  on the x-axis. And the 45-degree line allows me to do that because the 45-degree line is where the vertical is equal to the horizontal. So I'm going right to find  $y_1$  on the horizontal line which helps me to find it on the x-axis. And then I know that from  $y_1$ , I go to  $y_2$ . And then again horizontal, and then again vertical, and then again horizontal. That makes sense? Is it clear for everybody? It would be better if we were all on the same page. That we have that here. This is not obvious. It's not meant to be obvious. Yeah?

**AUDIENCE:** [INAUDIBLE]  $y_0$  or  $y_1$ --

**PROFESSOR:** So, the first one you mean?

**AUDIENCE:** Oh, is that because that's the--

**PROFESSOR:** That's the capacity curve. Exactly. Your  $y_0$  is what you start from. And then the curve gives us what is the relationship between income today and income tomorrow. So think of it with the food example. You start with some income. You decide how much to eat-- let's say you eat 80 percent of it-- you eat it. That gives you some strength. You go work. That gives you some wage. That's your income from work.

**AUDIENCE:** And then, when we're determining the distance between  $y_0$  and  $y_1$ , is that determined just by the distance from the curve to the 45-degree line?

**PROFESSOR:** Exactly. So  $y_0$  goes to  $y_1$ . Do you understand the first vertical step here right?  $y_0$  goes to  $y_1$  for the first vertical step. And then we're looking for  $y_1$  on the vertical axis, but now we need to find a way to put it back on the horizontal axis. And the 45-degree line helps us to do that because on the 45-degree line the vertical distance is the same as the horizontal distance. So the horizontal line is just a trick to help us find where is  $y_1$  on the horizontal axis, which helps us go to  $y_2$ . That make sense?

So from  $y_0$ , I go to  $y_1$  vertically -- that's just a capacity curve. Then the horizontal line is just to the left. Now what is the new  $y_0$ ? The new  $y_0$  is  $y_1$ . And then again, we go vertically to  $y_2$ . Horizontally to find it on the horizontal axis, vertically, et cetera. Yeah?

**AUDIENCE:** What's the unit of time--

**PROFESSOR:** The unit of time is whatever we think is the right unit of time depending on the problem we're looking at. So, for example, if it is food, that might be the date. If it's the income of your

children, that may be a generation. In some sense, once we have decided what problem we are looking at, the unit of time doesn't really matter. We adjust to it. Yeah?

**AUDIENCE:** How did you determine which states were stable and which ones were not stable?

**PROFESSOR:** Well, look at it, and for any point, you're figuring out whether or not you're going to stay here. Whether things tend to bring you back here or things tend to pull you away from it. Think of it, for example, as magnets. Either they cling together or they are trying to go away. Or think of it as a stick. Does it stay vertical or does it fall down?

Suppose that we start with income and the first income we are getting is  $y_3$ . That's going to pull you. You're going to go vertical a little bit, horizontal a little bit, et cetera. That's going to pull you exactly at that first statistic. Right?

So now, if you start from the first statistic and something slightly pushes you away from it, it is going to bring you back to it. If you are a little bit richer than the first statistic, you're going to, again, go back to the first statistic. If you're slightly richer, it's pulling you down. If you're slightly poorer, it's pulling you up.

Now, if you're looking at the one that's here on top, that's the same thing. At the very top, if you're slightly poorer, it's pulling you up towards it. If you're slightly richer, it's pulling you down towards it.

Now if you look at the one where the line intersects from below, if you're exactly at it, you stay at it. But if you're slightly poorer, where do you go? All the way down. If you're slightly richer, all the way up. So that one is not stable.

So basically, you follow your arrows wherever they are going to take you. OK? Any more question? Yeah?

**AUDIENCE:** What are the axis labels for it? Like income from work. I thought we were trying to connect on a time scale--

**PROFESSOR:** Right, so it doesn't really matter. Think of it as income today versus income tomorrow. Or income that you inherited versus income that you create yourself. Whatever scales we are talking about.

So in the food example, it would be the income you had at the end of today. And then, that

would be inherited income you inherited from yesterday. And then the income from work would be the income of the end of the day. So here the scale would be one day.

In the education example, you would go from your income to what your children will make. That's a whole generation. So the time scale, it depends on the problem. I think in the food example, it's useful to think of a day. In the health example it might be a month.

**AUDIENCE:** Why is there a tendency to move to the intersections?

**PROFESSOR:** Well, that's where the arrows are pulling you, aren't they? Because the closer of the intersection is where you are-- first, you go from wherever you start to the curve. And then the curve is trying to go back to the 45-degree line.

So the closer you are to the intersection, the less you move. Which is why this is, everything pulls you back there. --Not all the intersections. No, it's the stable ones. The one to the left and the one to the right, not the middle one. Which you have a tendency to go away from.

Any other questions on how this works? Yeah?

**AUDIENCE:** How do you guys actually gather the data to [INAUDIBLE]?

**PROFESSOR:** So that's an excellent question. Right now, I've just asserted that it's the form of the curve. And then we have to go back to the question that a neighbor-- whose name I don't know-- asked earlier, which is what is, actually, the shape of the curve? And that's a key question.

That's going back to the questions we were asking in the case of education, for example. Is the relationship between income today and income tomorrow due to education? Is it really of this shape or is it of another shape? That's what we have to assert empirically. And it's going to have to be gathered on a case-by-case example.

So for example, for food. To create this shape, to know what is the form of the shape, we are going to need to know two things. We need to know what is the relationship between how much income you have and how many calories you consume. And what is the relationship between the calories you consume and your work capacity? And the product of the two will be that curve.

And the shape it has-- God knows, I mean, actually even we know, but we're going to cover that next time.

So this is assuming that the capacity curve indeed has this shape. Then we can see how the poverty trap can emerge.

Now, if instead, the capacity curve had this shape-- think of your example of education. And think that, in fact, the first few years of education are very valuable and the next years you guys are kind of wasting your time-- not to speak of me-- and the next years of education are not so valuable. What is really important is to learn how to read.

Imagine that's the case. Then it means that the relationship between income today and income tomorrow is not as steep anymore. It starts very high and then it tapers off. And so we can play the same game again that we were playing before.

We can say, well, let's draw the diagonal line. Let's start with some income,  $a_1$ . To find out income tomorrow what do we do? We go vertical. We find income,  $a_2$ . Then we have to go horizontal to the 45-degree line to find it on the horizontal line. We go vertical again to find it on the curve. Horizontal again, vertical again. Where do we end up?  $q$ .

Now suppose we had started above  $q$ , where would we end up?  $q$ . Suppose we had started anywhere in between, where would we end up?  $q$ . So there is no poverty trap, in this case. If there is only one intersection because the returns are first high and then low, then there won't be a poverty trap. It doesn't mean that there is no relationship between income today and income tomorrow. There is one. But the point is, that relationship is first steep and then tapers off.

So for example, imagine that the only type of businesses that you can run are businesses that you can run yourself. That for some reason, you are in a business where you can't really have employees. Imagine.

So in that case, your first investment will be quite valuable, right? But then, eventually, you can't really add much more because you won't have enough time to sell all of these things. So your first dollars invested will have a very high return. And then less and less and less and less. And so in that case, everybody will end up at the same place.

An example that could make it clear, is going back to our Kenyan farmer from the MTV video, Kennedy fertilizer. If you put fertilizer on your crop-- well when you put just a little bit, the effects are very high. But when you start putting more, eventually, the soil can't absorb it so the effects are less and less and less high.

So even if you don't have enough to put on your entire field to start with, you could imagine that you would first put it in the most productive part of your field. Because the first unit of fertilizer you are putting is very high return. The second, you need less because you're going to the place of your field that is less productive anyway. At the third, you need even less. The fourth is really not that productive because, now, you end up putting more where you started from in the first place. So that's not really helpful anymore.

So in that case, the returns don't have this S-shape. They have this inverted L-shape. So in that case, there is no poverty trap.

And so that is where the question that you were asking is essential. Which is, how do we know what the shape of this curve? Because the shape of this curve is going to crucially determine whether or not we have a trap. And what I want you to remember is that that's more than a relationship between income today and income tomorrow. It has to be this relationship of this shape.

So that's the first thing, which is if the relationship is inverted-- L-shaped like that, which is the canonical case in economics, most of our economics model-- what you learn in 14.01-- has production function of this form. Where this production function, which we called, have decreasing returns. Where the first unit invested is very profitable and then it becomes less and less profitable.

We've already discussed a number of reasons why the returns might not would always be decreasing.

For example, we discussed the case of calories where there might be an increasing zone and then a decreasing zone. We discussed education might or might not be that way. We got an interesting example about businesses where you might not have a very profitable opportunity for your business if you don't have enough money. We discussed savings, which may or may not have this form. Where nobody wants your small savings.

So there are reasons why it may not always be inverted L-shaped. But if it is inverted L-shaped there won't be a poverty trap.

--You might be very bored with me repeating the same thing for the fifth time now, but the reason why I insist is that this is a confusion that we hear over and over again among policy makers.

In the policy discourse, whenever they're thinking of a double feedback loop-- for example, kids who have less education, make less money, and parents who have less money send their kids less to school. Immediately, people think, ha! If there is a double feedback loop like that, that creates a poverty trap. And the point is, that that's not sufficient. That's necessary but that's not sufficient.

Because if the double feedback loop gives you a nice inverted L-shape, eventually, everybody will end up nicely in the same place. OK?

So there is more, which is, here is another case where we have an S-shaped curve. But the S-shaped curve is a little different, it's a little higher. So why would it be a little higher, for example? Why has it moved up compared to what we had before? Why could it have moved up?

Go back to the food example. Sorry?

**AUDIENCE:** Lower food prices.

**PROFESSOR:** Lower food prices. So for example, the productivity of the land might have gone up. Maybe the government came and built some irrigation dams and the productivity of land has gone up. So to produce the same amount of food you need less effort. So the work capacity translates into a higher income for moi. So for whatever reason, the curve shifts up.

So then what happened-- we gave some person some income,  $y_0$ . We find  $y_1$  by going vertical. We find it again on the horizontal line,  $y_1$ . Going back to  $y_2$ , horizontal again. Et cetera, et cetera. Where do we end up? At the intersection. And now there's only one intersection.

So wherever we start, we are going to end up at the same intersection. In that case, is there going to be a poverty trap? No. In that case there is no poverty trap because, again, there is one statistic. So an S-shape is not even a sufficient condition for a poverty trap. It is necessary but it's not sufficient.

Let's find another example, which is this one. Where in fact, now it's the opposite. There was some flood and the land is now completely washed out. So people are very unproductive. They have to work very hard to produce very little.

So what happened to my poor S-shape? It's shifted to the southwest, right? So now if I start from  $y_0$ -- quite high-- where do I go? So I go up, but then it's not enough. The 45-degree line is to the left. I have to go left, down again, down again, down again, and again. I'm going to end up at the single intersection where I'm always pulled up, which is a very low income.

So in a sense, there is no poverty trap here either. Because it's not that if you're poor, you'll stay poor, and if you're rich, you'll stay rich. Regardless, you're going to be poor.

**AUDIENCE:** [LAUGHTER]

**PROFESSOR:** So you could think it's a universal poverty trap or you can think that's just the way is. Because if you ignore the right side, we almost are in the inverted L-shape except there are stuff that are a little bit irrelevant to the right. The reason why they are irrelevant is that, eventually, everybody's becoming poor anyway. So again, we don't have a poverty trap.

So let's look at those three examples. That's an example with a poverty trap. That's an example that doesn't have one. That's another example that doesn't have one. What is different between the one example with the poverty trap and the one which doesn't have one-- or two?

Yes. Can you tell me your name?

**AUDIENCE:** Zachary--

**PROFESSOR:** Zachary.

**AUDIENCE:** --it crosses the 45-degree line twice.

**PROFESSOR:** Exactly. Well, twice or--

**AUDIENCE:** Three times.

**PROFESSOR:** Three times. It crosses the 45-degree line once from below. So the rule is that you're going to have a poverty trap if the capacity curve-- or whatever is the curve between the income from work and the inherited income-- crosses the 45-degree line, at least once, from below. That is, there is at least one unstable equilibrium where you're crossing from below. And that is necessary for having a poverty trap.

So what you need, in other words, is to have a zone where income is accelerating. And this



zone must be at a place where the income was relatively low to start with. And it needs to accelerate enough that it's becoming high to start with.

In other words, it needs to be a zone where, if you're below the zone, you're making less tomorrow than you started from today. And when you're on the right of the zone, you're making more tomorrow than you started from today. And you need to have this point. Otherwise, there is no poverty trap.

All right? So that's the mathematical expression of it. And now, in a sense, the game that we're going to play all around this class is to be looking for-- are we in this situation where whatever is the relationship between income today and income tomorrow crosses the 45-degree line from below. Or are we not in this situation.

And now we are in a much better position to ask the question that Zach asked at the beginning of the question which is, are we really believing that there could be a poverty trap based on food? I didn't want to answer his question to start with because I needed some time to specify the question in a much more precise way.

Now we can re-ask the question and say, is it really possible that the relationship between the calories I consume and my strength has this specific form where it intersects the 45-degree line from below? And how does that intersect with the fact that I choose how much to consume?

Because, of course, if there is indeed a strong relationship between the calories consumed and the work capacity, then people should try and get out of it by eating as much as possible when they are very poor. So to the extent that people can choose how much to consume, how much food to eat, they should eat more when they are very poor in order to try and pull themselves to the right of this point. And when they are richer then it wouldn't really matter. So they would eat less. So that would create a force that goes against an S-shape for the capacity curve.

So we have to see-- and that goes back to your question, where do you get it from? Well, we get it from looking at the data and looking at-- to what extent people who have more money eat so much more, and to what extent people who eat so much more are so much more productive. And that's what we are going to do.

We are going to do it for food. But now that we understand the principle for food, we are going

to do it for education. We are going to do it for health, we are going to do it for savings, for businesses, et cetera. Yeah?

**AUDIENCE:**

To go back to the example with the start of the class, would you say that-- I forgot his name but-- that the man was at an unstable equilibrium since as soon as he lost his job, he seemed to go down and not be able to eat enough to get another job, et cetera?

**PROFESSOR:**

Right. So that's a very good question. What we can try now is to re-interpret Mister Solhin's story in the context of this. And you could say, well perhaps, it was exactly something like that. So what would have happened to him? Let's see, I want to-- oops. What would have happened to him?

So we discussed that one thing that might have happened to him is that something happened to the capacity curve, right? We were saying that coincident decrease in the wage and increase in the food prices means that the capacity curve tends to move to the southwest.

So assume that Pak Solhin was at the high equilibrium up there. Right? But right there. And then the curve moves slightly to the right. Then, with the same income, he suddenly is now below what would correspond to the new equilibrium and it would start falling down, down, down, down. And once he starts going down, there is no going up again. It could also have eliminated-- we might also be in a situation where, at the beginning there was just one equilibrium-- so we were, for example in this situation-- and then once the curve moves down, they are now two equilibria, including the unstable one.

So we may have started, in the former situation, where people were productive enough that they were always moving up. And then, with the increase in food prices and the decrease in wages, that curve shifts down and now it creates two equilibria. So some people get trapped like he was.

What was interesting in Pak Solhin's villages is that, in the same villages, I met people who were happily eating enough. So it seemed that there was both kinds, which makes you think that these two things were coexisting. So maybe what happened with him is that we started from a situation like that, and then we moved left and we end up with this double situation. That's possible

So what we had in the Sachs-Jolie video is-- we said when we just started the class-- lots of examples of poverty traps. And in each case, we could try and think, well, what makes us think

that there is indeed a poverty trap in this case? Or what makes us think that maybe there is no poverty trap in this case?

So one example is what happened with the farmer that they meet. So they claim that there was a poverty trap. So what is the implicit argument that they had in mind that would help us think that, for a farmer, the decision to use fertilizer corresponds to that problem versus that problem? What do we need to know about fertilizer and fertilizer use to try and sort out whether we are in the situation that they talk about or in the other situation. Yeah? You go ahead, I have a problem.

**AUDIENCE:** You need to know if there is some minimum of fertilizer used that becomes useful for the farmer.

**PROFESSOR:** Right. So there could be that, minimum fertilizer used. But why would there be a minimum fertilizer used? Yeah?

**AUDIENCE:** Maybe it's super difficult to acquire small quantities of fertilizer.

**PROFESSOR:** So for example, it might be sold by the bag or 50 kg. So in that case, what we have is not so much S-shaped but something which is a degenerated S where you get nothing if you can't invest enough and then you get the return which are, potentially, very steep at the beginning. So instead of a nice little curvy S, we have a flat part and then an inverted L.

But if we have a flat part and then the inverted L, it would still work like an S. Because there would still be an intersection where the curve intersects from above on the flat part, an intersection where it intersects from below at the beginning of the L-shape, and another intersection where it intersects from above at the end of the L-shape.

So the S doesn't have to be a proper S. It could be a flat part and then an inverted L. So this example could be one, which is you can only buy fertilizer by the 50 kg. What other situation could we find? Yeah?

**AUDIENCE:** The percentage of chance for success in using fertilizer. So if you only had [INAUDIBLE] over a small plot of land, it is, like, 20% chance of actually improving your crop yield. You would have to use a larger quantity to actually get an improved crop yield.

**PROFESSOR:** So that could be a possibility if the chance of success depends on how much you use. I think it's not very likely that it would be a purely physical thing because fertilizer is quite scalable.

But one way in which we could have your story is if, to use fertilizer it requires some learning. And there's no point doing all that learning-- and asking all of your neighbors how they do it, and try to understand how they do it. Maybe experiment a little bit, maybe it won't work first. -- Maybe there is no point to go through all of this learning if, at the end of the day, you know that, no matter what, you will always be able to use just a little bit.

So that would be one way in which you would, again, create this. You're not going to use any fertilizer if you know that you, eventually, would be able to use it on the substantial part of your field. Yeah?

**AUDIENCE:**

I think that the main point they made in the video is that there needed to be an initial push. So they needed a lot of fertilizer and you needed to put it on all of the crops for it to make a big impact. And the fact is, if you have a little bit of fertilizer-- the point was why couldn't they invest?

So save would be paying for a little bit of fertilizer. And then buy more fertilizer and then continue to grow it until [INAUDIBLE]. You know, if you started off with a small amount, you couldn't really invest and grow your yield to make more money.

**PROFESSOR:**

Right. Then the third possibility is that if you invest just a little bit-- let's say fertilizer scales nicely, so you can invest just a little bit and you can do it. But then, you're going to make just a little bit more money. And then we need some other mechanism which means that saving a little bit more money is not feasible, or people are not going to do it.

So then we need to bring in something else which is along the line of what we were discussing earlier in the class. We need to bring in something else which is, the banks are not going to take your small amount of money. Or if you have a small amount of money, you are going to waste it. But if you have a lot, now that's enough money to be worthwhile and you're going to keep it.

All right. So we are going to end here for today. So make sure you understand this because we are not ready to go back to it formally a lot, but this is going to be with us all the time. And on Tuesday, we are going to go through experiments.