

**MODERATOR:** Recipient of the 14th James R. Killian, Jr. Faculty Achievement Award. This award honors, at one and the same time, two people-- Dr. James Killian, former president and longtime patron of MIT, who I'm happy to see is in the audience today, and this year's recipient of the award, Professor Franco Modigliani.

Now, this year's Killian Award may be unique in one respect. I believe that it is the first time that the recipient has received the Nobel Prize in the same year as the Killian Award. Now, we would like to think that it was Dr. Modigliani's receipt of the Killian Award that persuaded the Nobel Committee to make him their choice.

If I may digress for just a moment, before getting to the serious part of my purpose for being on the podium, let me mention just a story or two about his visit to Sweden last December, when he went to receive the Nobel Prize. I asked his wife-- Serena Modigliani is here-- whether the festival of Saint Lucia had been celebrated while they were there. And, indeed, it had been. Now, the custom is roughly this-- for young maidens to appear in one's room at dawn on the festival day with candles.

Now, fortunately, the Modiglianis were at a reception with the King and Queen of Sweden the night before, and the lovely Queen of Sweden was able, tactfully, to hint to Franco, that he should be sure to wear pajamas the next night.

[LAUGHTER]

Another tradition to which Nobelists are evidently subject is a round-up by Swedish students, who oblige each Nobelist to sing in turn, and then they award a prize. And I'm happy to report that Franco won the prize.

[LAUGHTER]

This has, then, been an active year for Professor Modigliani. Rather than review the distinguished career that led him to this point in his lifecycle, let me refer you to an account that's in your program.

And now let me, however, sum it up in reading the citation, which goes as follows-- "The President and faculty of the Massachusetts Institute of Technology have the honor to present the James R. Killian, Jr. Faculty Achievement Award to Franco Modigliani, and to announce his appointment as Killian Award Lecturer for the academic year 1985-1986, in recognition of extraordinary accomplishments in the social sciences.

His contributions to macroeconomic theory and to finance are foundations on which generations of scholars and policymakers continue to build. His pursuit of understanding in the dark complexities of social life, and his generous encouragement of others in this pursuit, exemplify all that is best in MIT intellectual life and collegialship."

Professor Modigliani, may I present you with this citation.

And now may I introduce the first of Professor Modigliani's two lectures. The overall title of these lectures is *The Determinance of Individual Thrift and National Wealth*. The first lecture is titled *The Lifecycle Hypothesis*. And the second, which will be given in 10250 next Wednesday at this time, is titled *Application of the Lifecycle Hypothesis to Policy Issues*. I'm delighted to present Professor Modigliani for the first lecture.

**MODIGLIANI:** Thank you very much.

[APPLAUSE]

It is a great pleasure to be here today. I'm a little tense. This is an important day for me. I hope that gives me a chance to explain to so many non-economists that there is something to economics, that it is not all idle chat.

And, of course, it has been an incredible year for me. In this year, in which I have reached 2/3 of a century into my lifecycle. It's been extraordinary because I have been given, have bestowed, with two awards. First, the most coveted and prestigious award given by the most prestigious university in the world, namely the Killian Award. And then, the Nobel Prize, which is the most prestigious award, period.

[LAUGHTER]

They came in quick succession. And it was good that they did, because in the interim, some bad things were going on in my mind, which I have kept as a secret, but now I must confess.

When I received the Killian Award, I was, of course, happy. But I had a gnawing feeling that I did not deserve it. That there must have been something wrong with the committee. I was *passee*. I was shopworn. Why would they ever want to give me the award?

Were they incompetent? Didn't seem likely, looking at the names. Didn't seem like Suzanne Berger is an incompetent person. You can think of many things, but not that. So what must have happened, I thought, is that they were negligent. They overrated me, and they goofed.

But then, within a couple weeks, or a few weeks, I got the Nobel. And contrary to the hypothesis that was made by [INAUDIBLE], I thought that it was very unlikely that the Nobel people gave me the award just because the Killian had done. And so I had to agree that there was an independent set of judgments of great minds that decided I was awarded. And then I started thinking back on that I'd thought, and I decided that maybe, after all, it was I who had goofed.

[LAUGHTER]

I have since, many times, apologized in my heart for having thought of the Killian committee as being incompetent.

[LAUGHTER]

And, of course, if I had read this very detailed explanation here, perhaps I would've known better. But I did not have the fortune of receiving this until now.

Now, what I want to talk about is, in general, the determinants of saving behavior. Of saving and accumulation, if you like, of individuals and of nations. What determines the saving of a person. What determines the saving of a whole country.

This is a very old topic in economics, one that is regarded as being very important, because, as everybody knows, saving is the basis on which we are able to make investments-- that is, to build factories, to build machines, to build tools-- that make man's labor more productive. It is, essentially, as economists say, an important factor of production. And it contributes to the productivity of man.

This very old view-- we'll now shift to here-- this very old view-- I'm going to lay out here-- this is the outline of which I will be speaking. So you know where I am, when I'm through, when I'm talking about something, I will mark it.

No, no, no, no, no, no, no, no. That's not a marker. That's not a marker. Sorry. I had the marker here. I will mark it so you know where I am. I am talking about introduction.

[LAUGHTER]

And you can see it there.

This subject, this [INAUDIBLE] in saving, however, is, in reality, rather more recent. It really goes mostly the years of the Great Depression, and the years in the period following it, due to influence if the Depression, and of Keynes.

Specifically, what happened is that the traditional view that saving was a very important contributor to human welfare, it was a virtuous thing. And you know that in all religions, in every [INAUDIBLE] ethical tradition, saving is an ethical thing to do. It's a good thing to do. Each person should save a good fraction of his income every year.

This point of view got suddenly changed with a new interest in saving when, during the Great Depression, Keynes wrote *The General Theory*, because he pointed out that saving is good, if, whenever people save more, there is immediately more investment to replace it.

If there is less consumption, people save more, they consume less, but there is more investment to take the place.

But what if investment does not take the place of a increased saving? Well, this is what Keynes was concerned with. He described the number of reasons why this may not occur. And some of these reasons were generally valid. But many of them were very specific to the Great Depression. There were things happening at that time that are not generally true, and made the possibility quite real that more saving would lead, not to more investment, but simply to less income. And because it was being replaced by other activity.

So this was the concern, and this led to a great deal of interest in what determined saving. And particularly, we came out of the war with the feeling that the problem of there being too much saving, which was true during the Depression, might really be a universal truth in the future. It was on this principle that there was a school called the Stagnation School, that was particularly concerned with the danger of over-saving.

And this danger was seen to come from two considerations. One, that there was not seen to be much need for investment any more. All the big investment-- the railroads, the big things-- had been done. And so, there was no need for the great investments.

On the other hand, as people got richer, they would be saving more and more, a larger and larger fraction of income.

The second part reflects the second statement-- saving a larger and larger fraction of income-- reflects the view of the saving process that was going on, very broadly accepted, during the late '30s, early '40s and '50s, based on what Keynes himself had said. Keynes has said some very general, some very famous propositions about saving, which essentially say that the only thing you can say for sure about saving is that, if income rises, people will save more, but less than [INAUDIBLE] income. Or, as economists say, the propensity to save is a number between zero and one.

Now, that was the basis, and it laid emphasis on the notion that income mattered. And it also laid, somehow, less emphasis, but still some emphasis, on the notion that as income grows, people not only would save more, but would save proportionately more.

And, of course, that would mean that poor countries would save less than rich countries, and all the related inferences.

Now that study-- and I have now covered the role of thrift in the Keynesian revolution, and early Keynesian theories of [INAUDIBLE] saving, that's what I'm talking about now-- that particular view got tremendous acceptance. It was generally agreed that saving depended essentially on income. And that the relation with [INAUDIBLE] income could be described by a linear function, most likely with a negative intercept.

That view was based not only on Keynes' writing, but also on empirical evidence. Imagine yourself being in the 1950s, when this problem all came to heading, and observing what had happened in the United States over the previous period, which was the only period from 1929 through the war, but you knew the war years shouldn't be counted, because they were distorted. So you could look at the peacetime period, '29 to '41, and that is what you would see if you look at the data.

What I've graphed in there is a graph of the real income against real saving. Now, real simply means that I have not taken the dollar saving, but I have adjusted them for purchasing power, so they measure the purchasing power of the income and the purchasing power of the saving.

Now you see, first of all, the 1929, which is the peak of the cycle, was large saving, relatively speaking. You see what happened as people got poorer, they saved less and less and less. 35, 34, 30. Finally, the saving got negative. Okay?

Then, there was a pickup again, thanks god, and saving again began to grow. And they grew in '34. They grew in '35. Sorry, I mentioned them at the wrong time. From 31 you jump to 32, 33, then 34 and 35. Now they keep rising. And they rise again to 36 and 37 and 39. Look at 40, and boom! There is 41. Look at the gigantic saving.

Now you see that if you take a regression line, if you fit by these squares a regression, you get the line which I have drawn there. That line has a mammoth negative intercept. That intercept is minus 30, which is roughly a fourth of the mean value of the variable.

What does that mean? It means that you'll have here, as you can see from the graph itself, a relation between saving and income which is not one of [INAUDIBLE]. As saving rises, the saving rate increases, the saving rate is the slope of a line from the origin to the point. And you can see, in particular, that there is some income, the famous break-even income, at which you are poor enough so you save nothing.

And there you see it. It's at roughly what occurs around 1931, around '31, '32. Okay? And there was the study. And there was nothing else to say. Very good fit, fits very well. Now, you take that line and extrapolate it to the present. The present income is sort of way past that curtain, and imagine what kind of saving rate we would be. 30% or something like that. Just for your information, the saving rate today is about 3%. Okay? But we'll get there. That 3%, by the way, is a fake. It's really higher than that. But the official figure is 3%.

Now, what can we say, what can one say about this theory? It was an incredibly naive theory. Incredibly naive. Because a moment of reflection could have shown that that theory could not be true. Could not be describing the world forever. For instance, if you go back to the graph for a moment, you would find that this was '29, but that the income, let's say of 1900, was here. And the income of 1860 was way down here. Where were they saving 15% of income in 1860, or in 1870, or in 1880? And if you will be saving 15% of our income, how in heaven did this country get build? On the saving? Clearly, something was wrong.

Similarly, the other basic source of data was looking at the behavior of individuals. You had budget studies. Budget studies are, essentially, you use information from inquiries made to individuals to obtain information on their income and their saving. And you can make a graph like that. And that graph looks exactly like that. There is a break-even income, which is close to mean income. And below that, people they save, and above that they save. So it all fitted.

But nobody asked himself the following question-- suppose that a person is always, all the time, to the left of the break-even? Can he go on the saving forever? That is a trick which nobody's invented. In our world, you cannot be saved, unless you have saved first, or, very rarely, you can borrow and be a net debtor. But most of the time, you cannot be, you cannot have negative wealth, let alone growing negative wealth. So there was something wrong with this model.

And somewhere, around the early '50s, there began to develop a series of criticism of the simple notion, and a series of facts which were inconsistent with the simple notion. First of all, it is what I refer to here as three landmark empirical studies.

The first was a study that answered the question as to what happened in 1860. That study was made by Kuznets and others. And Kuznets got the very simple, elegant result that people in 1860 were saving as much, or more, than 1929. And people in 1880 were saving as much. Roughly speaking, throughout the period he studied, which ended in the late '50s. In the mid '50s, people saved about 10% to 11% of income, 10%, 12% of income, from the very beginning of the data available. Okay? So you had something to explain there. That's fact number one.

Fact number two was the following. That there were two great women-- one unfortunate dead, Dorothy Brady; the other alive, Rose Friedman, the wife of Milton Friedman-- who did a study of these budget studies. They looked at the budget studies, not for one year, but for all the budget studies that were available as of 1950. This was roughly 1950.

And when you did that, they found something very fascinating, which I will try to draw. I don't have a drawing for that, but I will try to give you an idea of what happened. Let us suppose that you have saving here and income there, and you have one of these lines. And that, let us say, was the line for the latest year, 1920. If you got to an earlier year, you found the same line, but the line was shifted, like this. Sorry. I'm covering. Is that right?

[LAUGHTER]

Okay. 1910. Okay? And that occurred, systematically, every successive shift, every successive survey, was higher than the previous one. All of them steep lines. All of them had this break-even point, but all of them higher and higher.

Now, that meant, if you look at that at face value, it meant that people were getting less and less thrifty, less and less virtuous, as time went on. Because, at this level of income, in 1910 they saved so much, but in 1920, only so much. So you could have explained the whole thing by a theory of decadence. People were getting more and more and more decadent.

But they were smarter than that. And what they showed is, first of all, they observed that the break-even point seemed to be always close to the mean income of that particular year. And what they showed is that, if, instead of scaling income as dollars, you scaled income as a percent of mean income, all the lines collapse together. Okay? You can sort of visualize, not exactly, but all this problem disappeared.

So what that said was that saving depended not on income, not on how many millions of pennies you had, but on relative income. The rich guy is the guy that has 10 times as much as the average. The miserable guy is on that has 1/10 of the average, regardless if the average is \$1 or \$300 million.

Now this second study, and the first, produced some interesting preoccupation among scholars. And there were attempts at fitting them into the framework of Keynes. And I'm partly responsible for having tried that, until I saw the light. But, essentially, there was work done by Jim Duesenberry and myself, simultaneously and independently, in which we tried to explain that phenomena.

First of all, Jim was concerned with explaining the relative income. And he said, essentially, consumption is a function of relative income, and he gave an explanation for that. And the explanation is an ingenious one. It doesn't happen to be true, but it's an ingenious one. And the explanation is that the rich people, they have no constraint. They are so rich they can consume what they want. So they buy the new gimmicks, they buy the new cars, and they buy the house in the country, and so on.

And the people behind them, who are less rich, feel the pressure of this beautiful new gadgets. And they are forced to buy them, even though they don't quite have the income. And because they buy the gadgets, they don't save. And so, the poorer they are, the less they save.

Now, this explanation, one reason why it cannot work, you can see immediately, is that it doesn't tell you what happens to the guy who is always poor. Does he go on borrowing and borrowing and borrowing to buy a car, and to buy elegant foods and elegant thing? Fortunately, he can't. Even if he wanted to, he cannot imitate the rich because he ain't got the resources.

So, but the other part was to explain why it was that the saving rate had been rising, moving so fast with income during the Depression, and yet, in 1860, it was the same as it was then. And that explanation was given by both of us, by using the notion that consumption depends on income, and the highest previous income.

Now, the highest previous income has the virtue that is, the income the economy develops, it moves with you. So that the saving rate always moves, all that the whole line, moves together with the developing economy. So you have a steep line. But that line, just like in the budget equations, in the budget studies, moves with you.

That explanation is, I gave most of the emphasis on the consideration that the relation between current income and the highest previous income can be taken as a measure of cyclic opposition of the economy. When the income is below previous peak, the economy is depressed. No matter what the level of income is, whenever the income is much above the previous peak, then the economy is elated. And it cannot be much above, actually, because it can't develop that fast.

So I said, in effect, saving is a cyclical variable. There is this saving in '32 because that's deep depression. There is saving in '29, because that's peak. And Duesenberry made more evidence to the highest previous peak as a mechanical fact of memory. People keep remembering what they consumed in '29, and they base their consumption on what they remember then.

Now, one other explanation is, these were the attempts at salvaging the framework, the Keynesian framework. Then there came a third study. And the third study is one by another great woman, Margaret Reid. She is now 80. She lives in Chicago. She gave me a ring recently, asking me if I would help her with some very new things that she's doing. She's full of pep, full of ideas. And she is the person that has inspired both my work and the work of Milton Friedman on the consumption function.

What she pointed out was that the steepness of the line, that the line, essentially, which you have seen there, which applies to budget study, and in budget study, the line, the steepness of the line, depends on the variability of income. That if income is very stable, the line will almost go through the origin. That the saving will be proportional to income. If the income is very, very variable, then the line will be very steep. So farmers will appear to save a lot more at the margin than city people, even though, on the average, they may not save more. But the line is being much steeper, you get this higher margin of [INAUDIBLE].

And the reason, she said, is-- and this, of course, is the key to what follows-- the reason is that people base their consumption not on income, as Keynes said, but on, quote, "permanent income," end quote. What is permanent income? Permanent income is the income you expect to earn over your life. All right? An estimate, the best estimate you make, of what you can afford, what standard of living you can afford. You choose a standard of living. And then, if income fluctuates cyclically, or fluctuates for personal reasons, you don't let that interfere with your consumption.

So people who are transitorily poor will tend to, they save. This explanation then says, farmers, who have a tremendously variable income, will have a tremendous amount of saving when their income is high, because it's far away from the normal, and very much dissaving when income is low, because it's very far away from their normal. So she prepared the notion for the next step.

In my own career, and my own development, the next step was the development of the life-cycle theory. This is a work which I began circa 1950, '51, together with a very young graduate student and colleague by the name of Richard Brumberg, and which we developed over a period of two or three years.

Before I got into the substance, I think it might interest you to know that, from the point of view of intellectual history, that when I went to University of Illinois in 1950, I was in charge of a project called "Expectation in Business Fluctuations." When it turned out that that project, itself, never produced a great deal-- a book or two, but not a great deal-- but that, in the course of that project, I learned a lot of things which were the seeds that then grew.

One of the important things I learned was that the main reason, the main ways that expectations were used in production planning, was to smooth out sales. To smooth out production. It is costly to let production go up and down. You would like to have it as even as possible. You make a forecast of what you will sell this year, and you don't let the production fluctuate seasonally, but you smooth out the production.

Well, that idea, which still is being pursued by many other people, is the foundation of the life cycle, which says people base their consumption on the income they can afford, on the forecast and history of the income they can afford, all their life. And they smooth out the ups and downs that come from, first of all, short-term things like disease, unemployment, and the long-term things like being young and being old.

When you're old, you're poor. And then, essentially, a person sees when he is rich, relative to himself, the standard of richness is yourself. The person dissaves when he's poor, relative to himself. Retired people are very poor, relative to themselves, so retired people you would expect to dissave. And, of course, to a large extent, they do.

Now, but this, we were able to derive this-- and this was, I think, a good piece of luck, in a sense-- not from another piece of ad hocery, like Keynes, who simply said, income, I affirm the following proposition as being obvious, but there was no theory. We went back to economic theory, and started from the notion that people are rational. They plan their consumption rationally all their life.

Now, the theory of allocation of resources is well-developed by economists. Economists particularly spend a lot of time in our classes, in our introductory courses, talking about how a consumer allocate his resources over many commodities. In the life cycle, the consumer allocates his resources over many periods. Each period corresponds to a commodity. So we assume that this allocation is done optimally.

Now, what, from this, follows an immediate, dramatic, and important consequence. When you look at the equation that says, what does consumption here one depend to, you would find that it depends on life income, because that is the budget constraint. So immediately, we got away from the Keynes consumption depends on income, to consumption depends on life income.

Now, then, from then on, I mean, that was really a very important proposition. And it turns out to be the same as the thing on which Milton Friedman was working, the so-called permanent income hypothesis. Which said exactly the same thing, with exactly the same inspiration. And he also assumed a perfectly rational allocation.

The difference between-- and I will mention here, now, because we will have few occasion to come back to Milton Friedman-- his permanent income hypothesis is quite close, in many ways, to mine. What is the difference? The difference is very simple. In our model, a crucial role is played by the fact that there is a life which is varied in its nature. There is a youth, there is a middle age, there is a retirement, and there is a death. And that is a very solid fact. Okay?

What does Milton do? Well, he simply says, conveniently, that infinite good life is infinite. So in his model, the allocation is over the infinite life. Now, one can show-- I know that laymen are inclined frequently to laugh at this. There's nothing wrong. We make that assumption all along. The problem is that, for many purposes, it makes no difference. For purposes of short-term analysis, whether you're going to live another ten years, or another infinity of years, makes really difference. But there are points in which the finiteness of life is absolutely crucial, and you will see in a moment why.

Now, here comes the next observation of a [INAUDIBLE] nature. There are two styles of theorists. There are those who will strive for generality, and those who strive for specialty. The guy that strives for generality derives a theorem, and under that theorem, anything can happen, because it's so general.

The guy like me just likes the opposite. I like to make a very special, whatever assumptions are needed, justified as well as I can, so that I narrow down very much what is true under the model so I can reject it. Because the model will now have very concrete specification what will happen if you change this or that, which I can reject my observations. So I am a known generalist.

And what we did was to introduce a few assumptions, just two or three, but they were pretty crucial. And the first assumption was that-- seemed reasonable-- that the guy allocating consumption over life, by and large, wants it smooth.

That it's very unlikely that a person wants to plan his life in such a way that he will drink champagne when he is young, he will eat just soup when he is in the middle age, and then he'll eat steak when he's old. I would imagine that if you can afford to eat hamburger every day, that's what you aim for.

Of course, there are [INAUDIBLE] and fringes and the like. But fundamentally, you would expect a person to choose a smooth path, which is not necessarily level-- it could be a growing path-- but certainly a smooth path.

Now, to that assumption, we added a few other postulates in order to derive what we have since called the stripped-down version of the LCH. The way essentially I want to go is to have very realistic assumptions, show that these assumptions give predictions about the world which are largely true, and then ask myself, what will happen if I relax assumptions?

But first let's start from the convenient simplifying assumptions. So the next assumption which we made was that people left no bequests. And in the earliest version, we even said the interest rate is zero. Now all this are very easy to relax, but it was just convenient. Why is it so convenient? Because if you have a level consumption and no interest rate, then the behavior of saving and wealth over life becomes very, very simple and very easy to understand.

And let me exhibit to you what exactly it becomes. Now I'll try not to cover it by moving over here. We assume that the person has a constant income. That income is-- oh, it's other.

[LAUGHTER]

I couldn't find the income.

[LAUGHTER]

Okay. The person has a constant income,  $\bar{Y}$ , and he wants to plan a constant consumption of a life, even though income ceases at the age of retirement. So there has this income [INAUDIBLE] zero thereafter. And he wants to plan a constant consumption. That constant consumption is given by the broken line here. Okay?

What will then happen to the saving? The saving is the difference between income, when he earns it, and consumption. So this broken, this period piece here, is saving. And what you get here is that saving is constant through the life, until he retires, at which point he has huge dissaving. Now you can readily work out the following proposition, that if I made the income larger, say twice as large, then everything would be twice as large. The saving would be twice as large, but the saving rate would be the same.

In this world, the saving rate does not depend on how rich you are. The saving rate is the same for everybody of a given age. It's very different for people of different ages.

Secondly, what happens to wealth? Well, wealth, as we all know being at MIT, wealth is the integral was saving. It's the cumulant of saving. So if you save at a constant rate, wealth is rising at a constant rate. It keeps rising 'till the peak, which is at retirement, at which time it begins to come down, at this rate, which is much larger, so the line is steeper. So you see how we can learn something very simple. It has very strong implications of this nature.

Now, what sort of implication came from this? Well, there were two kinds of implications. One implication was about individual behavior. Now remember that on that graph, if you describe a person's actual life, then his income, instead of being constant, is wobbling. And it has a wave. It starts, their income rises with age, then declines with age. So instead of a constant income, we can allow for a non-stable constant income.

But what will happen, in an event, is the fact that consumption will depend on permanent income. And therefore, saving will depend very much on whether you're rich or poor relative to yourself. Retired people who are poor relative to themselves are great dissavers. People who are rich relative to themselves are savers.

If you have a good year, you save a lot, because you don't change your consumption standard. If you have a bad year, you dissave a lot. So saving is mostly related to the transitory aspect of income.

Now, this is an aspect that has very many implication. One can show, then, that why, for instance, the budget lines are a biased measure of the relation between saving and income, because, essentially, they measure the relation between saving and transitory income, not between saving and permanent income. And if you correct for that, you'll find that you tend to have proportionality, at least within limits.

I will not go any further into this, because this is the part of the theory which is common to the theory of Milton Friedman. He also calls it permanent income. I call it life resources. He calls it permanent income. Either one will do. He says deviation of income from permanent income is transitory income. Fine. I am willing to call it transitory income, but I call attention to the fact that, in his model, all transitory income is essentially in the nature of a random shock.

In my model, that is not true, because there is a transitory component which is very long-lasting that connected with the cycle of life. Okay? You are constantly poor in the first 30 years of your life. And you are constantly poor in the last 20 years of your life. And in between, there is a period where you're richer. So there is transitory, but transitory in a very different sense.

Now, we are now ready to attack some of the implications, namely, the really interesting implications. So I want to shift out now from the implications about individual behavior to the implications about aggregate behavior. And it is here, of course, that the life-cycle theory has really paid the greatest dividends. And it's completely different from Milton.

What the life-cycle theory implies-- and let me tell you immediately what is the punchline-- is that the saving of a country is not dependent just on the saving of the individuals. In the sense that, if you have two countries in which the people, individuals, behave identically, one for one-- there may be a million people-- each of them, over his life cycle, has identical behavior. Will the two countries save the same? No, says the life cycle. They will not. If one is growing, the other is not, the one that grows will save more. The faster it grows, the more it saves.

And let me demonstrate this result. For this purpose, we can perhaps find it useful to go back to this graph. Imagine that you had a community of people all like that. And remember that I can generalize that appreciably. But just for the sake of simplicity, all the people are like that, although some are richer, some are poorer. But they all have the same life cycle behavior.

Now I say, and suppose that in this community, population is constant and productivity is constant. So there is no growth, either from population or from productivity. I say, in that society, saving is zero. Why? Because the integral of this area of saving-- there are all these people who are saving, and the integral of that area is exactly equal to the integral of the dissaving area.

So you have  $2/3$  of the people, or  $4/5$  of the people are saving,  $1/5$  is dissaving, and the net is zero. Okay?

Now let's say that exactly the same people, exactly the same, but population is growing. What's going to happen? There are more people who are young than people who are old. Therefore, more people that are saving than people that are dissaving, and the balance is going to be positive. Even if population is growing fast, there's going to be even more young people, therefore even more saving. I hope that this is clear and obvious.

Second, consider the case in which population is stationary, but there's productivity growth. This is the more interesting case. It's a little more intricate. The result is the same, but for another reason. In a society which grows, the young are rich, the old are poor. That's obvious, because the young have grown to a society which has been  $e$  to the power  $o$  2 times  $t$  more productive. Okay?

So if they are born 20 years later, they find that their productivity, over their life, is 30% higher than their parents. But now, if the young are rich, and the old are poor, what happens is that the young are saving like rich people save, and the old are dissaving like poor people do. The saving of the rich exceeds the dissaving of the poor, even though, over his own life, everybody will consume everything.

So productivity growth, just like population growth, produces the fact of increasing saving, [INAUDIBLE] saving, and saving depends on growth.

Now, these are essentially the essential two cases. That happens to be a coincidence, which is sort of fortuitously useful, that when Richard Brumberg and I computed the saving rate for a 3% population growth and a 3% productivity growth, lo and behold, the numbers turned out to be the same, just about the same.

We were puzzled, and found that the function, saving is a function of  $r$ , and population growth, saving is a function of [INAUDIBLE] really are all different. But in the range, which is very small for the function, from 0 to 3%, they produce the same number. Okay? So you can then say, to a first approximation, what methods is growth, no matter where it comes from.

Now, there is another way to look at the result, that growth is the relevant factor. And the other way to look at it is the following. You have that wealth. Now think of the community as a whole. There is an aggregate amount of wealth. If the economy is stationary, the wealth will be constant. Okay?

But suppose the economy is growing. And people behave this way, then the wealth will grow exactly at the same pace as income. So if income grows 5% per year, wealth will grow 5% per year. But the growth of wealth is simply saving. In fact, saving is exactly-- saving, in the very famous formula which all student of economics know by heart-- in a well-known formula, the relation between saving and growth and wealth is, saving is the rate of growth times the stock of wealth.

But I'm interested in the saving rate. Oh, but easy. Divide through my income. The saving rate is the rate of growth times the wealth-income ratio. So you see immediately that the larger the growth, that if  $\rho$  is zero, saving is zero. If  $\rho$  the larger is low, the larger is saving. Now you're going to be a little careful, because it turns out that  $a$  over  $y$  is a function of  $\rho$ . So when you differentiate, you don't get just  $a$ , but you get a second term. It turns out that, if you allow, that if you look at saving versus  $\rho$ , it's not a straight line as it would be if  $a$  over  $y$  were a constant, but it is a line like this. That is, it keeps rising with  $\rho$ , but at a decreasing rate.

Now, so, we have here two rather conclusion, which, at that time, were absolutely amazing, and people just refused to believe [INAUDIBLE]. One, a country's saving rate does not depend on how rich it is. a country's saving rate depends on how fast it grows.

Well, at the time when this position were announced, there was no way of testing them. All we knew was, in the United States, growth had been fairly stable, and the wealth-income ratio had been fairly stable. And it was about the kind of number that came out of our calculation. We calculated that  $a$  over  $y$  should be about five. And, sure enough, at that time Goldsmith produced the first estimate of wealth in the United States, and the wealth-income ratio was about five.

But you can only rely on one country and say, because the growth never changed, the wealth-income ratio and the saving rate never changed. That doesn't seem much satisfactory. It's like saying that in the dark all the cows are black. But within the next 10 years, we had an enormous flourishing of national income statistics. At that time, by the way, besides United States, there was [INAUDIBLE] only for Sweden. That was the only other country for which there was [INAUDIBLE] series. And it seemed to fit our theory.

But since, we have been able to compute national income account. At the present time, actually, there are national income accounts are available for 40, 50 countries. Now, not all the same quality, nor all for the length of time. Here I'll show you a sample of 21 OECD countries. These are the advanced countries, the industrialized countries, for which data are reliable, reasonably reliable.

I can first take my word that the correlation between the saving rate and income is zero. And it's got to be. Because we know that the greatest saver is Japan, who was, then, particularly a poor country. The first data ten years back. On the other hand, the richest country in the world, United States, is not saving much. That, enough-- those two points are enough to make you very much doubt. And the fact of the matter is, for these countries, there is absolutely no correlation between income and the saving rate.

How about the relation within saving rate and growth? Well, here you are. I have, in this graph you have-- I have it right? Yes. In this graph, you have the income graphed on this axis. And the saving rate graphed-- I'm sorry. The rate of growth of income graphed on this axis, and the rate of saving graphed on this axis.

Now you see immediately there's a fairly good relation. The circled countries, which [INAUDIBLE] are the big countries, of those that we are more familiar with. You see the United States. It's fall off a little bit, the digression line, but fundamentally, the US has a very small saving rate. You see it's one of the lowest. Why? It's the richest country, but doesn't grow very much, as you can see from its position here.

Who saves a lot? Japan, which is not particularly rich, especially during this time. This is 1960, 1970, so 25 years ago. But had a hell of a big growth, by far the largest that anybody ever remembers, as a stable growth [INAUDIBLE].

Italy, which, to everybody's surprise, turned out to be a great saver. I remember very well the surprise I, myself, had, when Italy, a country of beggars, coming out of Mussolini's terrific exploitation and [INAUDIBLE], began, suddenly began showing up with this huge saving figures. Japan-like saving figures. The reason was, that Italy was growing like mad. Incidentally, that was in the 1960s. It was growing at the rate of 6%. It was saving 20%. Nowadays, it's growing about one or two, and the saving rate is down to 10-- in fact, probably eight.

So you can see that the theory had something to say that is reasonably well born-out, and thus is, by now, generally accepted. And I've made many such pictures with many different countries. This is just an example that I had on hand. But in general there is no question. You can add a few other variables.

Why other variables? Well, we're coming now to the next question, which is-- We have covered the keys of steadily growing economies. We've covered empirical verification, and now we're coming to the effect of dropping simplifying assumptions, which will also lead to other variables possibly being important. Not very important, but possibly having some importance.

Well, some of these I don't want to spend much time, because they are trivial. It takes nothing, you don't need zero interest rate, it's just that it makes calculation simple. You have summations instead of present value of annuities, and that's just happens to be easier. But you can certainly work with present value of annuities, and nothing especially happens, except one important thing.

What happens in the life-cycle model if the interest rate goes from five to six? Will people save more, or will people save less? Well, the answer to that question is that, as it should be, you cannot tell. Because, as it works out, there is a substitution income effect you can show that the higher interest rate makes people richer, and, to this extent, makes them consume more and save less.

On the other hand, and this comes out perfectly clearly out of this model. I just don't want to take the time because it's getting kind of late. That, on the hand, there is a substitution effect. That is, people are induced to consume later, because consuming later is cheaper. If they are sensitive to allocation over time, then they may shift enough to compensated income effect. But offhand, the life-cycle cannot tell you.

Now, empirically, I can tell you that the work I've done suggests that the income effect dominates so that a higher interest rate makes for a higher consumption that is for a lower saving. And that's the important point. Higher interest rate makes for lower saving. Now, this is counter-intuitive for many people. But let me really assure you that there's nothing wrong with this conclusion, and it's, in fact, may even be true.

Now, well, let me just go for one more, and then, the next time, we'll finish the rest. What is it, what can you say about the fact that this theory was originally, as it first came out, did not mention family size. And, in fact, it has been labeled by one of our critics the bachelor theory of saving. But, of course, that criticism was unfair, because it was very easy to introduce a family size.

And essentially, what our model then says is that the way a person computes his consumption is the following. Take the total number of habitants of the family over the life-cycle. Parents for the first 10 years, or the first two years, whatever it is. Parents and children for the next 20 years. Parents alone for the remaining years. And, if you want, you can weight the children as being less than one. That's an easy thing to do.

Then this aggregate is divide that by the total resources, and is the per capita consumption. And then, to establish the consumption at any point, you multiply by those present at any point.

Now, one of the interesting implication of this, which has been verified again and again-- today I found some recent verification-- is the following. Suppose you take two people who are the same age, both people retired, in fact, 70. Okay? Both people are retired. Both had the same life income. One had five children. The other had none.

If our theory is correct, the guy that had five children will have less wealth. Why? Because his consumption over the retired period is smaller than the guy who had no children, since he was one of four who was consuming. So you would expect him to have a smaller consumption. And since the wealth serves to provide for the retirement, you would expect [INAUDIBLE].

This turns out to be absolutely true. It has been shown again and again that people with more children have less wealth than people with less children.

I think, if you don't mind-- I'm sure that you have had enough. You have your head full of life cycles and the rest, and I'll give you a break until next Wednesday. Thank you.

[APPLAUSE]