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MD Interview

AN INTERVIEW WITH HIROFUMI UZAWA

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Hirofumi Uzawa is one of the giants of modern economic theory. Hiro is probably best known to the readers of *Macroeconomic Dynamics* (*MD*) for his seminal articles on two-sector economic growth. The two-sector technology is more general than the one-sector technology: it allows a production possibility frontier that is *strictly* concave to the origin as opposed to being necessarily flat. This generality allows richer and more complex dynamics. This makes it especially useful for the analysis of economic fluctuations. The two-sector model is perfect for dynamic international trade.

Hiro is also well known to macroeconomists for his seminal contribution to endogenous growth. In his article in the 1965 *IER*, productivity permanently increases as the result of permanent accumulation of human capital. Uzawa was thus a first mover in the new growth theory. The symbol H (for Human Capital, or for Hiro?) is today everywhere in models of economic dynamics.

On his own and through his many students and mentees, Hiro has been the major inspiration for the modern theory of optimal economic growth. He taught a generation of pure and applied economists how to apply Pontryagin's maximum principle in economic dynamics. It seems that Uzawa introduced—or at least pushed the use of—phase diagrams in economic dynamics. Where would we be without this essential tool?

Most readers of *MD* are likely to think first of Uzawa's contributions to macro, but Hiro is equally well known for his superb works on mathematical economics, general equilibrium, and demand theory. Hiro's mathematics is elegant and often very deep. Like the quality mathematician that he is, he does not apply technique for technique's sake.

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FIGURE 1. Hirofumi Uzawa delivering a public lecture at the Iwakuni Foundation, about 1991.

Hiro has made fundamental contributions to nonlinear programming. For the convex (but not necessarily smooth) case, he employed Slater's condition to obtain Kuhn–Tucker multipliers that satisfy the saddlepoint property necessary for an optimum. For the smooth (but not necessarily convex) case, Arrow, Hurwicz, and Uzawa introduced the current version of the constraint qualification, which ensures that optimality implies the existence of Kuhn–Tucker multipliers satisfying the saddlepoint property.

Hiro's paper "Walras's Existence Theorem and Brouwer's Fixed Point Theorem" in the *Economic Studies Quarterly* (1962) is a hidden gem on general equilibrium. This paper can be seen as foreshadowing Sonnenschein's result on excess demand functions. Hiro clarified old, important questions about recovering preference maps from demand functions. Hiro was probably the first to convincingly show—in the context of tatonnement adjustment—the important distinction between local stability and global stability in economic dynamics.

We have given here only a glimpse into the very large body of beautiful, influential Uzawa papers. Hiro's splendid bibliography is given at the end of the interview. Some of the work that Hiro has pursued energetically has yet to be widely recognized. One thinks, for example, of the Penrose Effect, Hiro's modeling of the organizational costs incurred in adding capital or making other changes in the way a firm does business.

Hiro has had many successful students and mentees. Your *MD* interviewers are lucky to have been among those whom Hiro has influenced profoundly. A very incomplete list of the others would also include Dave Cass, Steve Goldman, Harl Ryder, Hajime Oniki, Bob Lucas, George Akerlof, Joe Stiglitz, Miguel Sidrauski, Morris Teubal, Assaf Razin, Guillermo Calvo, Bill Ethier, and Lenny Mirman.

Hiro is widely recognized and even revered in Japan. He was elected to the very selective Japan Academy in 1989 at a remarkably young age. He was named "A Person of Cultural Merit" in 1983 and elected to the Order of Culture in 1997. Hiro has received significant international recognition. He was President of the Econometric Society. He is a Fellow of the Econometric Society, Member of the American Academy of Arts and Sciences, Foreign Honorary Member of the American Economic Association, and Foreign Associate of the U.S. National Academy of Sciences.

This interview took place nearly 10 years ago. We apologize to the readers and to Professor Uzawa for the delay in getting the transcript to the editor. The interview was held at the Research Center on Global Warming of the Development Bank of Japan, at which Hiro plays an important role. Four of us—Uzawa, the two interviewers, and Yumiko Baba, who was then a post-doc in economics at the University of Tokyo, there to operate the tape recorder—were collected at the Meiji Gakuin University in central Tokyo and whisked away in a large black automobile to Hiro's home court at the Bank. Hiro is an imposing figure: tall and erect with a very long, pointed white beard. His eyes are very active. He strokes his beard in a soothing manner. It is not difficult to be in awe of him. The interview took an even more formal tack because there were two in the room with the nickname "Hiro." It was hence efficient to use last names at times.

The interviewers had agreed to try to steer Uzawa toward a discussion of his well-known basic technical contributions and away from his less well-known and more political contributions. In the end, we failed to steer Hiro onto any course other than his own. This is mostly as it should be. In this interview, you will

hear about some of the technical contributions for which Hiro is widely known. You will also hear about what motivated him to enter economics, his strong social concerns and strong political views, the turbulence of the war years and the postwar years, and his recent work and interests. A few of the paragraphs at the end of the interview were added to bring the record up to date. What comes through is a picture of Hirofumi Uzawa, a truly distinguished scholar and a person dedicated to human betterment.

Hiro talked in his usual warm, friendly voice. He peppered the interview with his strong opinions about other major economists, often with lively anecdotes. Of course, Hiro's opinions are his own, not those of the interviewers or the editors. We hope that the readers will get as much out of this conversation with Hiro as we did.

Keywords: Endogenous Growth Theory, General Equilibrium, Global Stability, Nonlinear Programming, Two-Sector Model

STUDENT DAYS AND MATHEMATICS

MD: Professor Uzawa, what led you to pursue a career in economics? You began in mathematics.

Uzawa: First, I was a pre-med student in the old system of Japanese education. I was supposed to go to medical school. However, just before I had to take the entrance examination for medical school, I had some hesitation because of the Oath of Hippocrates, which says that to be a physician you have to be intelligent and thoughtful, and you have a noble character to commit yourself for all of your life to the care of your patients. I thought that I was rather unintelligent and, in addition, I thought that I did not have such a noble character to devote all of my life to the care of patients. I had to switch my major. At that time, at the University of Tokyo, each department had an entrance examination of its own, quite independent of any other departments. Mathematics turned out to be the only subject I could barely be qualified in taking the entrance examination.

I liked mathematics when I was in middle school. I then had acquired a fairly advanced knowledge in mathematics. I remember when I was in the third grade in the middle school [that is, the ninth grade in the American system], I succeeded in proving Newton's theorem. Newton's theorem is based on Kepler's laws concerning the movement of the earth around the sun. The sun is located at one of the foci of the ellipse that the earth moved around. This is the first law. The second law is that the areal velocity of the segment formed by the earth and the sun is constant. [Areal velocity is the rate at which area is swept out by a particle as it moves along a curve.] From these two observations, it is possible to prove that there is a force operating between two bodies that is related to the product of the weight of these two bodies and inversely proportional to the square of the distance. I think that one of the main reasons why Newton came up with the idea of the differential calculus was precisely to prove this proposition. Anyhow, I went into mathematics.

I was graduated from the mathematics department and appointed as special research fellow in the department. In the old educational system in Japan during the war, special research fellow carried a handsome stipend and was exempt from

being drafted into the Army. By the time I was graduated from the university after the War, the Army was abolished, but that system remained. I stayed there for two years. Then I began to be seriously concerned with the state of affairs of the Japanese economy—poverty, inequality, inflation, and unemployment were the order of the day—so I could not feel at home in continuing my study in mathematics. I originally wanted to pursue a medical career because I wanted to cure people of disease. Economics appeared to cure society, at least to me at that time. I switched to economics.

I was studying economics all by myself, and virtually the only books available on economics in Japanese those days were those written by Marxian economists, and naturally I became interested in Marxian economics.

When I was a student in middle school and First High School during the war, the Japanese Imperial Army had a difficult time in China because they could occupy cities but whenever they went out of cities, Chinese people were united to fight against the Japanese army—the so-called "guerilla tactics" then and "terrorist activities" nowadays—and they were really effective. The Japanese army had a very difficult time in occupying China. So one person in the Japanese army came up with the brilliant idea that if we take promising Chinese youths to Japan and educate them in the Japanese way of life, they could become reliable allies and the occupation would become peaceful. They chose First High School for this program, and they assigned one dormitory to these Chinese students. At the beginning, there must have been 100 of them in this very small high school, consisting of about 1,200 students all together.

MD: Except for quality, do you mean by high schools what an American would mean by high schools?

Uzawa: Maybe a college. Something like a liberal arts college. At that time there were only about 30 to 40 high schools all over Japan, and to get into a university you had to be graduated from one of these high schools. First High School is now a part of the University of Tokyo.

MD: I noticed the old sign says Meiji Gakuin was a high school then.

Uzawa: Yes. Then, I remember that there was some excitement. At first these Chinese students had a very intensive argument among themselves, divided between those for Chiang Kai-shek and those for Mao Tse-tung. And finally the Mao Tse-tung group won over. They began to teach us the philosophy and political ideas of Mao Tse-tung. They were quite successful. The irony was that the Japanese army brought these Chinese students to Japan to teach them the Japanese way of life, but they succeeded in educating the Japanese students according to the revolutionary philosophy of Mao Tse-tung. After the war, this high school became a hotbed for very radical leftist student movements.

MD: [Laughter]

INTO ECONOMICS AND MARXIAN INFLUENCES

MD: But when you studied economics, after giving up mathematics, didn't you study mostly non-Marxian economics?

Uzawa: No. At the beginning, most of the books I read were written by Japanese Marxists. Furthermore, I belonged to a study group organized by a very brilliant colleague of mine from high school days. He was so brilliant; later on, he became one of the leaders of the Japan Communist Party. I remember that he seemed to be devoted to Stalin. My understanding of Marx was very poor. So I could not put myself at ease with the ways of Marx and Marxist writings. Among them, Stalin's writings were the worst. I could not make any sense out of what Stalin was saying. At that time Stalin's writings were considered as the bible for Japanese Marxists. This friend of mine told me that with my scant knowledge of Marxian economics I would never be able to pass the entrance examination to the Japan Communist Party.

MD: [Laughter]

Uzawa: So I thought that I should resign from the post of special research fellow in the math department to devote myself full time to the study of Marx so that one day I might be able to pass the entrance examination. Many years later I found that there was no such thing as an entrance examination to the Party.

MD: [Laughter]

Uzawa: I wonder why he said that. . . . Maybe, to save me from. . . .

MD: And what track from all this led you in the direction of Stanford?

Uzawa: Then, there was a brilliant professor of economics at the University of Tokyo; his name is Hiroshi Furuya. I belonged to the rugby football team at First High School—a fraternity type association. The legendary captain of that rugby football team was a person by the name of Ken-ichi Inada. You know who he is ?

MD: Yes. Inada of the classic Inada conditions on production functions.

Uzawa: He was also in the math department, but he left to study economics. When he heard that I also switched to economics, one night he took me to the study group organized by Professor Furuya. Professor Furuya didn't care whether I was a student in economics, nor a University of Tokyo student at all. Professor Furuya simply cared that I was interested in economics; however, not from the Marxian point of view. So I was fortunate in joining the study group organized by Professor Furuya. At that time, the University of Tokyo had a summer program inviting one professor from Stanford University to give a seminar course.

TO STANFORD BY ARROW'S INVITATION

MD: What year would this be about?

Uzawa: 1952–1955, around that time. In 1954, I remember Professor Hendrick Houthakker came to Tokyo to give a seminar course on demand analysis. At the time, I didn't have any knowledge of non-Marxian economics at all. I was really fascinated by his beautiful lectures. It was supposed to be a six-week course, but I remember it was after four weeks that he contracted a strange contagious disease from dogs, I think. The lectures had to be canceled.

Anyhow, one day, he brought with him a number of unpublished manuscripts by Ken [Kenneth] Arrow and Leo [Leonid] Hurwicz on the decentralized system

for economic planning. I was really fascinated by these writings; I think it was the first time I learned that mathematics was used at all in economics.

There is a very classic writing of Karl Marx, a very short note, entitled "Note on Mathematics," that was really a bible for Marxian economists in Japan at that time. The main theme of that note is to prove that the concept of the derivative is in contradiction. Marx's proof runs as follows:

Suppose dy/dx exists and takes an arbitrarily given value a:

$$\frac{dy}{dx} = a.$$

However,

$$dx = 0, \quad dy = 0.$$

Hence,

$$\frac{0}{0} = a, \quad \text{i.e.} \quad 0 = 0a.$$

Therefore, dy/dx can take any arbitrarily given value; a contradiction. Q.E.D.

How did I not dispute Marx's proof? It is still a mystery. In those days, I must have been influenced by the conviction held by the Japanese Marxists that the logic of economics is different from that of mathematics. Mathematics is heavily contaminated by the bourgeois ideology.

So Marx never used even algebra, and he only used numerical examples to prove whatever conclusions he wanted to derive. The majority of the Japanese Marxian economists were strictly following this teaching of Marx. Now, after Michio Morishima wrote this book on Marx (*Marx's Economics: A Dual Theory of Value and Growth*), some Japanese Marxian economists now use advanced mathematics. But in those days, it was really forbidden to use mathematics.

Then I wrote a very short manuscript and sent it to Ken Arrow. He seemed to be pleased by what I sent. Almost immediately he sent me a letter of invitation to Stanford.

MD: What was the subject of the paper that you sent to Arrow?

Uzawa: I don't remember the title of my note, but later on that paper was published as "Gradient Method for Concave Programming: Global Stability" in *Studies in Linear and Non-Linear Programming*, edited by Arrow, Hurwicz, and myself. Arrow and Hurwicz's paper was concerned only with local stability. But it turns out that we can extend it to the more general situation. You may start from any point in the programming, proceed with the gradient method, and you are guaranteed to approach the optimum state.

MD: So you sent the paper to Arrow for his reactions and comments and his reaction was "please come to Stanford"?

Uzawa: Yes. Incidentally, I spent some time last year at the University of Minnesota and we were talking about the old days with Leo and Evelyn Hurwicz. Evelyn told me that, when I sent the paper to Arrow and Hurwicz, I wrote an

accompanying letter. In that letter, I apparently wrote that I had read their article "with ardor," and they were quite impressed by the unique expression of mine, because "with ardor" apparently means "with urgent love." So they were expecting. . . . my English is very poor.

MD: Your English is very good. And then you arrived in Stanford in what year?

Uzawa: In the summer of 1956. It was really exciting.

MD: Did you have an office in Serra House first?

Uzawa: Yes, that's right. That was the area.

MD: Who were the people that you met in your first year at Stanford?

Uzawa: The first occupants of the house: Ken Arrow, and Pat [Patrick C.] Suppes [psychologist], and Sam [Samuel] Karlin [mathematician]. These three professors each operated a small research outfit there. Dick [Richard] Atkinson was the assistant to Pat Suppes. Herb [Herbert] Scarf was to Sam Karlin, and I was the assistant to Ken Arrow. So these were the people.

MD: Only six people.

Uzawa: Yes. Then as the group expanded, and a few years later, you [Karl Shell] and others came to join us. Those were really the formative years.

MD: When I arrived, I think you were spending one year at the CASBS [Center for Advanced Study in the Behavioral Sciences].

Uzawa: Yes, at that time they were starting a new research center called the Ford Center, now the Center for the Advanced Study in the Behavioral Sciences. That was set up by the Ford Foundation. Each year they would invite about 30 fellows. Then, each fellow got a stipend for one year in the same amount as he or she was getting from the university without any specific obligations. The center is located on the hill behind the Stanford Campus. But I think I often came back to Serra House to talk with. . . .

MD: There is this possibly apocryphal story. Your CASBS year was enormously productive, and you either wrote or put together the ideas for many future papers during that year?

Uzawa: Yes, it was really great. I felt very free from all sorts of social and personal constraints that I was suffering when I was a student in Japan. At Stanford, my mind was liberated.

TWO-SECTOR GROWTH MODEL

MD: The readers of *Macroeconomic Dynamics* are macroeconomists. They'll want to know if that was the time you did your thinking about the two-sector model?

Uzawa: Ah, yes. The two-sector model. You see, I had still a sort of uneasy feeling about *Das Kapital* and Marx's other writings. But the more I read Marx, the harder it became to understand him. I think I spent almost the entire summer, trying to put the second volume of *Das Kapital* into a more coherent, precise analytical form. And that was how I came up with the idea of the two-sector model.

MD: Were you influenced by any of the non-Marxist writers on the two-sector model?

Uzawa: No. After my paper was published, Bob [Robert M.] Solow wrote me that there were quite a few literatures on that subject, including James Meade's classic book. James Meade's book was published almost at the same time as my two-sector paper was published. There are two versions of the two-sector model. The first version is based on the concept of classes, à la Marx. The basic assumption there is that the capitalists do not consume and the laborers do not save. It turns out that created some difficulties in proving stability where the Inada condition is related. I think that, in the next year or so, Bob Solow spent a year at the Ford Center. I used to see him often, over coffee. The more I saw him, the more I began to feel uneasy. Marx's concept of class was very natural to me: you look at the economy in terms of capitalists and laborers. But this was very strange to Bob because he always looked at the economy in terms of individuals who behave themselves as *homo economicus*. The basic premises of his classic growth model are that the economy is composed of homogenous individuals, so each would spend some portion of his income on consumption and the rest on savings. In Solow's model, saving is equal to s times income, $S = sY$. In my model, saving is equal to the capitalist's profits, whereas consumption is equal to the wage bills. I don't think I noticed this basic difference until Bob pointed it out, and I looked at it and said "Oh, yes." So at that time I always looked at things in terms of the class struggle between capitalists and laborers.

After the two-sector model, I wrote an aggregate model where I think technological progress is endogenous. That was a mere extension of Solow's aggregate model.

ENCOUNTERS WITH THORSTEN VEBLEN

Uzawa: And then at that time, I had a number of quite impressive encounters. Around that time, I got married at Stanford, so we were looking for a house where we could live. We found a very attractive house with a cottage next door for rent. There was a sort of forest behind the Serra House at that time, and if you go through the small paths into the woods, you come to a rather lovely district. That is where we lived. One day, my wife was talking with the landlady. The landlady asked my wife what I was doing at Stanford. My wife answered "Economics." Then the landlady said that her father was also an economist; his name was Thorsten Veblen. Thorsten Veblen was divorced and remarried to a lady with two daughters. This landlady, Mrs. Sims, was a stepdaughter of Thorsten Veblen. She was a very friendly, reserved, and intelligent person. While I was still in Japan, I read some of Veblen's writings, but mostly I couldn't make any sense out of what he was saying, because most of the books of Veblen that I read while in Japan were not on economics, but on cultural anthropology and other related subjects. At that time I was attending the lecture courses on basic economic theory, given by Bernard Haley. Do you know who he is?

MD: The former editor of the *American Economic Review* and—along with Ed [Edward] Shaw—possibly a founding father of Stanford's economics department. I think that Haley and Shaw might have hired Arrow.

Uzawa: Haley gave beautiful lectures. He had only six or seven graduate students. It was a three-quarter series. In the first quarter he spent a long time on Veblen. Veblen was his model professional economist, so I began to interest myself in Veblen. One of the books I read was *Theory of Business Enterprise*, published in 1904. I was shocked to find out that the book contained the essence of Keynes's *General Theory*. The content is much clearer and more logical in substance. What I called social common capital many years later was already discussed in that book by Veblen. It is almost a classic, but no one really took notice of Veblen at that time. When Veblen died in 1928, just before the great crash of the American stock market, what happened was exactly along the lines Veblen predicted in his book. Before he died, Veblen became very depressed about the state of the capitalist system in America. And this stepdaughter, Ann Sims, inherited Veblen's concern for peace and his socialist orientation. This was 1957 or so. Around that time, she organized peace meetings all over the Bay area. Almost every night she took me to one of these meetings. I had a difficult time saying "no" to her. Very often, she took me to the famous bookstore: Kepler's, do you remember? The owner of Kepler's was devoted to her and her political philosophy. He had only socialist books on the shelves. He converted half of the store to a coffee shop so they could have meetings there. Joan Baez, the legendary singer at the Vietnam time, then a Palo Alto High senior, often came to the shop to sing, with a complete fascination for everyone who happened to be present.

The more I read Veblen, the more I was impressed by his deep thought and profound ideas. For the first two-sector model, at the beginning, I wanted to put Marx's ideas in more complete and analytical terms, but the more I read *Das Kapital* the more I felt unhappy. The second version of the two-sector model is a conversion to Veblen and Keynes. And then years later, I came to the concept of the Penrose effect and others, in which the institutional constraints would be the core of whatever model I have formulated. How to understand and interpret the institutional characteristics of capitalist societies (or any other) would be more important than the mere description of philosophical ideas.

Mrs. Sims was a divorcée, and had a lovely child of the age about 10, I remember. Many years later, Paul Sweezy [former editor of the Marxist periodical *Monthly Review*] often came to Tokyo, and we used to have dinner together. At one such occasion, Paul told us that a few weeks before then a granddaughter of Thorsten Veblen was married to the son of Paul Baran [late Marxist economics professor at Stanford]. Sweezy called it "the marriage of the century."

A few years later, I left Stanford to go to Chicago and lost contact with Mrs. Sims. Then, Vietnam became very serious. I was certain Mrs. Sims played a pivotal role in preserving peace at our difficult time.

MD: Did Baran introduce you to Sweezy or the reverse?

Uzawa: Yes. Baran introduced me to Sweezy.

MD: Maybe by telling us the story, you can bring us to Chicago.

Uzawa: I had some difficult times at the time at Stanford because I was specialized in economic crisis and social disorder, rather than in harmony. I thought that Stanford was too rich and languorous a place to bring up our children. We had two boys. We had a house on the campus. Somehow I thought if they were brought up in such an apolitical and quiet and unexciting place. . . .

MD: And rich and sunny. . . .

Uzawa: Then they would end up very dumb. That was the first reason why I decided to accept the offer from Chicago. There was another reason: the influence on me of Ken Arrow was too great and too serious. I felt so small in front of him. I began to feel a need to restore my own personal integrity. In the beginning I felt very free, but the more I worked with Ken, the more I felt entrapped by his intellectual power, personal charm, and broad social concern. There was something that made me always feel very small in his presence. I couldn't do anything on my own. I had to borrow his shadow.

Ken has a vast knowledge, of history, of philosophy—not only of economics. I don't know how he accumulated such a deep knowledge on so many subjects. Also, he had a very quick mind. Whenever we would discuss something he could come right to the point. Also, he had a very attractive, very charming sort of personality. I never met a person as great as Ken Arrow.

There was another reason why I took the offer from Chicago. At that time, at Chicago I had a close friend, almost my teacher: the late Professor Lloyd Metzler. He was one of the greatest economists of our time.

TO THE UNIVERSITY OF CHICAGO, METZLER, AND FRIEDMAN

MD: Did you first get to know Metzler when you arrived in Chicago?

Uzawa: No, before that. When I had an offer from the University of Chicago, I was very concerned with [Milton] Friedman. I did not want to do anything with Milton Friedman. But Lloyd Metzler was very insistent that I come to Chicago. One day, Metzler came to Stanford to urge me to accept the offer from Chicago. We had lunch together and I asked him how things were done in Chicago. I asked him the most important thing to me, that is, what were the relations between him and Milton Friedman. Metzler said "Oh, I am getting along with Milton very well, because I don't pay any attention to what he says." That was a classic statement typical of Metzler. A few year before that, about four years before that, Metzler suffered from a serious disease, a brain tumor, and he had a major operation. That was the reason why I was invited to come to Chicago, because he was the house Keynesian. So, I was invited to come to Chicago to work with him.

MD: What does the phrase "house Keynesian" mean?

MD: The phrase suggests that they were not embracing Keynesianism but they had to have a resident Keynesian.

Uzawa: Yes, that is right. When T.W. [Theodore W.] Schultz was in charge of the Department of Economics at Chicago around 1943 or 1944, he wanted

Milton Friedman to join, but T. W. Schultz had a second thought. He wanted to have Lloyd Metzler together with Friedman so the department would be balanced with a (house) Keynesian. Then a few years before I went there, I think in 1961, they imported Harry Johnson from England as a house Keynesian. That did not work well, because Harry Johnson worked on his own perspective. He was good in interpreting and putting in excellent forms the writings and ideas of what others had done. He was a very capable economist, and he was excellent. But he was not a match for the powerful influence and arguments advanced by Friedman. Furthermore, Lloyd Metzler was not working as productive as previously. So that is how I felt that, in addition to the two reasons I have said before, I thought that I should take the challenge of Chicago.

When I accepted the appointment at Chicago, quite a few people were very upset. Tjalling Koopmans told me "You are a traitor." Koopmans and Friedman had a violent argument, and that is the reason why the Cowles Commission left Chicago. Koopmans never forgot the humiliation he suffered. Not so much for himself, but Koopmans was very upset that Friedman jumped on his old mentor, Jacob Marshak. That was something Koopmans could not stand.

MD: An attack on too much mathematics or some sort of thing like this?

Uzawa: I do not know exactly. Friedman, somehow he has a sort of way of life, he has his own set mind about how economics works, and also he has a firm mind about whom he regards as his enemies. Jacob Marshak and Tjalling Koopmans wanted to seek the truth. The reason we are doing economic research is to try to find out what are the truths about the workings of the economic system with capitalist or socialist institutions, and that is Koopmans' classic article, "The Theory without Measurement." He was very critical of Friedman and others, because they formed the opinion first and then tried to manipulate data and come out with logical, occasionally fallacious analysis, in order to promote their predetermined political or philosophical premises. That was what Marshak and Koopmans could not stand. These circumstances are well documented in Don Patinkin's fascinating book, *In and out of the Chicago Tradition*. Anyhow, that was how I ended up in Chicago.

But I found Chicago a very exciting place, particularly the Department of Economics. Whenever there was a disagreement at the department meeting, then it was always Friedman in the minority alone vis-à-vis the rest of the members of the Department. Friedman was very proud to be the minority of one, and if someone else joined him in the same boat, he said he was uncomfortable, saying "What am I doing wrong?"

That was how things were done in Chicago. But somehow the Vietnam War really changed all of this, as the society sank in a chaotic mess.

MD: In 1965, I think it was, you visited MIT briefly, and invited the now distinguished members of the optimal growth seminar to visit you for a couple of months in Chicago. Do you remember those days?

Uzawa: Yes. But somehow, the Vietnam War changed me to the point that I could not really continue my work in economics, or whatever other subjects I

was doing. Because at the time, almost all brilliant students in Chicago had to either leave their own country or return to their home state or were put in jail, and that was something strange. I remember I had one student who later on joined the Milwaukee 14. He was a really conservative student at the beginning, but he became very radicalized. I was really shocked to find out in the paper that he was arrested as one of the Milwaukee 14. Remember the group of anti-war activists, 14 of them, lead by the brother Daniel Berrigan, entered the draft bureau in the city of Milwaukee, and brought out all of the draft cards and burned them. Then they telephoned the FBI, which had them arrested. He was sentenced, I think, for several years in jail. This was in 1967. Of course, he resigned and did not do economics since. But he was not an exception.

VISIT TO CAMBRIDGE (UK) AND JOAN ROBINSON

MD: Did your visit to Cambridge [UK] affect your political ideas?

Uzawa: At the height of the Vietnam War, I went to Cambridge and spent a year there, 1966–1967. It wasn't Joan Robinson who invited me, but it was Frank Hahn who invited me to go there.

MD: This was not your first visit to Cambridge.

Uzawa: No.

MD: You were also there in 1964, perhaps.

Uzawa: Yes. Somehow . . . being a Japanese, I regard old age as most important so I pay great respect to whoever is older than myself. Joan Robinson was one of them, but she had a talent to intimidate others.

MD: A Milton Friedman of the left?

Uzawa: Ah, yes, that's very good, quite similar. But Friedman is logical.

Joan Robinson is philosophical and very insistent. I had a really difficult time because one of the major reasons why I went to Cambridge was I wanted to work with James Meade. But James Meade and Joan Robinson were on such bad terms. Joan Robinson offended Meade so often. Meade, out of frustration, resigned from the professorship in the Faculty of Economics at Cambridge, saying that he could not stand her abusive comments, and wanted to have a quiet life.

We had the first Far Eastern Meeting of the Econometric Society, in the summer of 1971 or thereabout, inviting James Meade, Michael Bruno, and Joe Stiglitz from abroad. After the meetings were over, I organized a three-day seminar meeting at the gracious villa of the Development Bank of Japan in Hakone. James Meade gave an opening lecture, really a beautiful lecture, typical of him. Then Joe Stiglitz asked him, "What Joan Robinson would say if she were here?" Meade was quite upset and replied, with a stern voice, "I have not come this far to hear that name!"

MD: You went back to being a Fellow?

Uzawa: That's right. When I was a Fellow at Cambridge, I got acquainted with Richard Kahn, Lord Professor Kahn. He was a modest economist, very quiet and reserved, but whatever he said contained profound truth and deep insight. Later

on, in 1978 or thereabout, I spent the summer at Cambridge just to work with Richard Kahn. Then I was beginning to concern myself with the logical inconsistency of Keynes's *General Theory*. As I said before, I was very impressed by Veblen's *Theory of Business Enterprise*, and I looked at the Keynes *General Theory* in the light of the way of thinking of Veblen as expressed in that book. I came with a number of ideas that I wanted to check out with Kahn. I spent maybe three weeks there. Every day I went to his room and almost for a whole day we sat together and discussed. That is how I formulated the *Theory of Dynamic Disequilibrium*, which was later published, though in Japanese.

The night before I left Cambridge to return to Japan, Richard Kahn invited me and Joan Robinson to dinner, at a very fancy restaurant in Cambridge. Kahn at the time was suffering from some trouble with his health, but he drank wine. I never saw such an occasion when Kahn was talking so jovially. He said, "Last year, I read Keynes' *General Theory* for the first time in my life." This was 1978.

In the preface of the *General Theory*, Keynes acknowledges Richard Kahn for his constant advice and constructive criticism. That means that when you proofread the manuscript, you don't dig inside the content, and apparently Kahn meant that. Then he sipped wine and said "It is badly written and I cannot make any sense out of it." In hearing this from Kahn, Joan was so stunned that she could not utter a word. If you said that in Cambridge, you are almost sacrilegious because you bring very dirty things to God.

When John Hicks wrote his classic review article concerning the interpretation of the *General Theory*, it was completely disapproved of by the economists in Cambridge, because it did not capture the kind of feeling that dominated at Cambridge at that time.

MD: So IS-LM would be thought to be for stupid people, or something like that.

Uzawa: Once, Harry Johnson, his mind being flexible, adopted this sort of sentiment about Keynes, but they didn't really approve of that. There was a classic article by Joan Robinson in which she classified various Keynesians. One classification was "bastard Keynesians." Once I asked her who would be a bastard Keynesian. Her answer was "Harry Johnson."

MD: Was IS-LM a bastard Keynesian?

Uzawa: No, that was not regarded as Keynesian at all.

ABBA LERNER

MD: How did you get interested in the Penrose Effect and the concept of capital, like the Cambridge [UK] versus Cambridge [MA] controversy?

Uzawa: One of the basic concepts in Keynes's *General Theory* is "marginal efficiency of capital." The Penrose Effect is related with the concept of marginal efficiency of capital. There is a classic article by Abba Lerner that was regarded as one of the most important theoretical contributions after the *General Theory*. It clarified one of the basic contradictions in the basic premises upon which

the *General Theory* was constructed. Lerner constructed a beautiful figure, a three-dimensional diagram, to explain the relationship between investment, capital, and output, clarifying the intricate relations that exist between two concepts: the marginal product of capital and the marginal efficiency of investment. Lerner was a genius, his mind could construct three-dimensional diagrams. We have a friend who could do with four-dimensional figures, you remember, Harl Ryder [Brown University].

But three-dimensional figures, even that is something. You know the reason? Lerner was born in Russia. But when he was young, he became an apprentice in a tailoring outfit, and he was sent to London to learn the art of tailoring, because at the time, maybe even now, London had the highest quality tailors. He very often used to say that tailoring men's suits requires the ability to visualize and work in the three-dimensional world.

Then he attended night school at the London School of Economics, and came under the influence of Lord Robbins.

MD: At a relatively late age, like maybe late 20s.

Uzawa: That's right. I remember that when Paul Samuelson gave his presidential address at one of the American Economic Association meetings, in New York, I was seated next to Lerner, and Samuelson's address was about the important contributions he had made, in order of importance. The first was the revealed preference theorem and the second the factor-price equalization theorem. Somehow, Samuelson regarded this factor-price equalization theorem very highly and of high priority, putting it among one of the two most important contributions of his. After Samuelson's address, I had coffee with Lerner. Lerner was the first to develop the factor-price equalization theorem, proved with a very beautiful diagram. Samuelson's was a very complicated thing, using all sorts of difficult differential calculus, but Lerner had this very beautiful diagrammatic presentation.

MD: And it was not like the Harrod–Johnson diagram?

Uzawa: Yes?

MD: So what we know today as the Harrod–Johnson diagram is. . . .

Uzawa: The Harrod–Johnson diagram was slightly different from Lerner's. Lerner's, I think, was more accurate and beautiful. In 1948, Paul Samuelson's classic article on factor-price equalization was published in the *Economic Journal*. When Robbins read Samuelson's paper, he thought it was somehow familiar, very similar to a paper presented in one of his seminars at the LSE. Robbins searched his files and found an old paper of Lerner's, so he had that printed in the *Review of Economic Studies*. At that time, [Nicholas] Kaldor was the editor. I think that the paper of Lerner's was written around 1933, long before Samuelson's. It was really a very beautiful paper.

MD: Did you know Lerner at Stanford, is that where?

Uzawa: Yes. Years ago, he published a classic article on competitive socialism and the use of price mechanism.

MD: What became known as Lange–Lerner price mechanism?

Uzawa: That's right.

KEYNES, KAHN, PENROSE EFFECT

Uzawa: Cambridge Circus, or rather Keynes's Circus, was organized around 1931. You know, in 1930, Keynes's *Treatise on Money* was published in two volumes. But Joan Robinson and Richard Kahn were very concerned because England was then in serious economic trouble. England's depression began earlier than in America. England's trouble began in 1926 or 1927. By the time Keynes's *Treatise on Money* was published, England's trouble was much more serious than in the United States. But the argument in the *Treatise on Money* presupposes harmonious adjustment processes of the price mechanism, full employment, and everything. They organized a study group called Keynes's Circus. At the time Keynes was adviser to the Exchequer and he stayed in London. He came back to Cambridge only on weekends. So Kahn would summarize what his group did during the week and Keynes would comment and offer some advice. James Meade wrote a rather interesting essay on Keynes's Circus. He referred to Keynes as God and Kahn as the archangel; and they could not see God, but they only knew him through the words of the archangel.

Anyhow, then Kahn first came up with the theory of the multiplier.

MD: Can I interrupt? Do we know what Meade meant by God and the archangel? Did he mean that Keynes was very brilliant and that Richard Kahn was interpreting him?

Uzawa: That's right, I think so.

MD: Because there are rumors I've heard to the reverse; that Richard Kahn was very brilliant and Keynes was interpreting him. You have more evidence.

Uzawa: Yes, that may be.

Then Richard Kahn came up with the theory of liquidity preference. When I came up with the idea of Penrose effect, I went to see Richard Kahn, that was in 1965, or thereabout. Kahn brought from his study a huge notebook. He filed all of the notebooks in time series, and he searched one of the oldest, and said "Here, I have it." He had a beautiful formulation of the Penrose effect, although in terms of numerical examples. In fact, it was he who suggested that I should use the term Penrose effect. So he had this theory to understand Keynes's *General Theory*. It was important to have this Penrose effect, otherwise you don't have Keynes' marginal efficiency of investment schedule. But the liquidity preference was a good contrast. The Penrose effect has something to do with fixity; you can't change things overnight, only through investment do you accumulate productive facilities. But liquidity preference is different. Overnight you can reshuffle the whole portfolio.

MD: If you were describing Penrose effect to a young student, would you think it would be adequate at first to call it the theory of costly adjustment of capital?

Uzawa: That is different. One has its form by Sherwin Rosen, Lucas, and Treadway.

MD: Yes. Is this not the same. . . .

Uzawa: All of the adjustment, not just the cost of adjustment. You see that the cost of adjustment is something that, though you acquire some things for investment, somehow they disappear in the process. Just like Lerner's pencil.

MD: But the emphasis is the distinction between stocks and flows.

Uzawa: Well, somehow it has something to do with the problems of productive, organizational entities in charge of production. They have a sort of institutional fixity and the capacity may be measured some way or another. You may invest to build factories or install machinery, but that would not increase capacity in proportion to the amount you added. There is something similar between the human body and an organizational entity. We eat things, then we have to digest, and make it part of our body. The way our body grows is not proportional to the amount of food we eat.

MD: So what you think of capital is different from the neoclassical view of capital?

Uzawa: Yes. Conceptually, my capital is a mere index of all the production facilities put together. Capital is some institutional entity, including machinery, organizational entity, and the like, and the concept of quantified capital is just an approximation of the first order.

MD: So from a purely technical point of view, you might accept this Strotz–Eisner as roughly capturing this idea.

Uzawa: Yes. Look, this idea was the center of Veblen's *Theory of Business Enterprise*.

PONTRYAGIN'S MAXIMUM PRINCIPLE AND TWO-SECTOR GROWTH MODELS

MD: Could I ask a technical question? You have a paper. Maybe not as widely known. It's optimal growth in the two-sector model, in which you have a linear criterion, and positive discounting. You were brilliantly able to do the analysis by your own means by combining the Kuhn–Tucker Theorem and the calculus of variations. Now, very soon after that, you started doing problems like that using Pontryagin. Who introduced you to Pontryagin?

Uzawa: When I was working on the two-sector model of optimum growth, I had a really difficult time because all the solutions were corner solutions while the calculus of variation must have interior solution or, otherwise, it's hopeless.

MD: Not all of your solutions were corner solutions.

Uzawa: No. You are right. But most of them are. So, I really had difficulties. I really struggled to, but I could not find a way out.

MD: So it worked out fine?

Uzawa: Yes. Then I remember it was Sam Karlin who told me that some Russian mathematicians were doing something like that. So then I managed to borrow one of the books imported from Russia and someone translated it into

English. I was really shocked to find the beautiful results. The author of the book was Pontryagin. When I was a student in mathematics, my most favorite mathematician was Pontryagin. I was very fascinated by Pontryagin.

MD: Qualitative things in differential equations. Is that what interested you as a student?

Uzawa: Yes, to a certain extent. But my main interest was with algebraic number theory with group theory emphasis. Pontryagin's maximum principle requires a very difficult proof, relying heavily on the results from his classic book on continuous group theory. He became blind at the age of 10 and his mother read books to him so his writings always had a very lucid style. Most of the writings by mathematicians are very difficult to understand but Pontryagin's are different. I was then working on optimum growth. At the time, I did everything in a very half-baked manner.

MD: One of the questions that one is prompted to ask is, starting with some of your technical works, they've taken on wonderful lives of their own. There are two things that I think about. One is how your model of human capital has become so important in the theory of endogenous growth, and also, you may not know this, in empirical models of sunspot analysis. Also, when Bob Solow first read your two-sector stuff he reported in print that factor intensities were too trivial a matter to affect something as important as the long-run dynamics of the system. And today I think we just came from a conference in which different factor intensities can give you very complicated long-run dynamics. So we invite you to comment on the technical developments that have taken place over time.

Uzawa: In fact, factor-price equalization was the first thing that I became interested in capital intensities. But about that time, I used to know [Prasanta C.] Mahalanobis very well. He was the advisor to Jawaharlal Nehru [First Prime Minister of India] and he was the author of the second Five Year Plan of India.

MD: Where did you meet him?

Uzawa: He often came to Chicago. But I was also reading some of his earlier works. He had a four-sector model where the specifications of capital intensities among four sectors were very strange. So what I did was to formulate everything in terms of two-sector models. The more I studied Mahalanobis's work, the more I felt somewhat uneasy about this relationship between the stability of the dynamic system and factor-price intensities of consumption goods and investment goods. This was really important, not only in market economies, but also in planned economies. And this became rather serious over the real factor intensity problems in India; a very serious dispute was developed between [Sukhamoy] Chakravarty, therenowned economist, and [Bagicha Singh] Minhas.

MD: Minhas had Stanford connections and I think Chakravarty had MIT connections.

Uzawa: That's right. Minhas is one of the four authors of the classic CES production function paper [by Arrow, Chenery, Minhas, and Solow], and yes, that is another sort of concern for factor intensities. Then, over the strategies for

Indian economic planning, Minhas and Chakravarty had a very bitter argument. They were both members of the Planning Commission of the Indian Government. The Planning Commission was an important administrative post, a kind of superministry, and Chakravarty succeeded in persuading Mrs. Gandhi [the Prime Minister] to fire Minhas. Minhas wanted to put priority on agriculture in the allocation of investment, whereas Chakravarty wanted emphasis on industrialization. Chakravarty won that debate, and Minhas lost. That was in the early 1970s. And then they ended up with disastrous results. If India were able to convert their basic planning strategy from the Mahalanobis–Chakravarty type to the Minhas type, then I think the Indian economy would have been much better off.

INSTITUTIONS AND SOCIAL COMMON CAPITAL

MD: One simple way of describing part of your legacy in macroeconomics would be in terms of the accumulation, for good or for bad, of nonconventional factors of production: human capital, public goods, social common capital, and so forth. Do you agree with this?

Uzawa: Yes. In the last several years, I have been mostly working on the problems of social common capital, especially on the institutional capital, such as education and medicine. On education, I feel very dissatisfied with the human capital theory. Not in the way it is used today but in the way Friedman advocated it. Friedman's basic hypothesis is that you have human capital and nonhuman capital both measured in terms of their yields. Then Friedman's argument proceeds on the premises that one is free to choose the optimum combination of human capital and nonhuman capital components. But that can be done only if you are the owner of slave plantations in the American South before the Civil War. I feel very unhappy with this. The primary purpose of education, from the point of view of those who are to be educated, is not to increase the stock of human capital embodied in themselves. I feel more sympathized with the idea of Thorsten Veblen, John Dewey, and Noam Chomsky.

MD: Probably the readers may not understand very well what exactly you meant by combining human capital and physical capital. . . .

Uzawa: Maybe not. In Friedman's theory of human capital and nonhuman capital, he applied optimum portfolio theory.

MD: What would be the proper way of conceptualizing the human or educational capital?

Uzawa: This is the difference. One may look at the effect of education in terms of its effects upon the accumulation of knowledge and technologies in human bodies reflected in the change or increase of productivity overall. That is all right. But I tend to look at education from the point of view of those who are to be educated. Friedman's theory is that before you enter the university you calculate how much you would gain and how much it costs you to come out with the optimum amount of education you want to take. In 1965 or thereabout, I remember, Friedman gave

a workshop in Chicago. The theme was the problem of blacks and poverty. They are poor and their incomes low. They are the first to be fired when depression comes. And he said that black children, when they are teenagers, had to make a choice either to study or to play. They have rationally chosen to play and not to study. So after they grow up they become poor, and that is it. As an economist, we have no right to say anything against that. That is typical Friedman. Then there was a black graduate student in the audience; he stood up, and said, "Professor Friedman, did I have the freedom to choose my parents?" Because if Friedman's theory of "as if" were to be consistent, then you would have to go back all the way to the very beginning.

MD: You are not only concerned about education? Aren't you more generally interested in institutional arrangements and social common capital? Can these functions be decentralized?

Uzawa: Yes. That's decentralized, but social common capital is concerned with the very core or important functions of the society, which are important not only from the individual point of view but also from the social point of view, such as education and medicine. And so is the monetary system. The monetary system is one of the more important components of social common capital, and how to manage it is really important from the social point of view. When we deal with these various components of social common capital, the most important thing is that each component has to be managed by professional experts who are specialized in that particular branch of social common capital and to obey the professional ethics and master the professional proficiency. In the case of Japanese monetary and financial system, it had been controlled by the Ministry of Finance to such an extent that it has been very difficult to have professional efficiency to be accumulated and to have professional ethics to come. . . .

MD: In order to manage themselves?

Uzawa: Yes; because there was too much control by the Ministry of Finance. When I was a sort of an adviser to Prime Minister Murayama [the Socialist Prime Minister in the mid-1990s], I made a number of proposals to him. One of them was to set up an independent commission to investigate the relationships between the Ministry of Finance and all the banking institutions in Japan, and to investigate the circumstances under which they collapsed. But I made a mistake; there was a reporter from *The Economist* in London, whom I knew well. I had a small farewell party for him when he was transferred to Washington, DC. At that party I confided in him and, even more, I must have given him a copy of the confidential document that I prepared for Mr. Murayama. But this reporter from *The Economist* printed a very strange article about me. I felt very upset, but I had only myself to blame. The Ministry of Finance was very upset and apparently pestered Mr. Murayama so much that Mr. Murayama apparently out of frustration resigned from the post of the Prime Minister.

Uzawa: It is time for Karl's [Karl Shell's] seminar on learning by doing and recipes.

MD: Thank you for this interesting interview.

SOCIAL COMMON CAPITAL AND THE NEW *RERUM NOVARUM*

Uzawa: May I spend a few minutes in describing in detail what I mean by social common capital? The details are spelled out in my recently published book, *Economic Analysis of Social Common Capital*.

Social common capital provides members of the society with those services and institutional arrangements that are crucial in maintaining human and cultural life. It is generally classified into three categories: natural capital, social infrastructure, and institutional capital. These categories are neither exhaustive nor exclusive, but they merely illustrate the nature of functions performed by social common capital and the social perspectives associated with them.

Natural capital consists of the natural environment and natural resources such as forests, rivers, lakes, wetlands, coastal seas, oceans, water, soil, and above all the earth's atmosphere. They all share the common feature of being regenerative subject to intricate and subtle forces of the ecological and biological mechanisms. They provide all living organisms, particularly human beings, with the environment to sustain their lives and to regenerate themselves.

Social infrastructure is another important component of social common capital. It consists of roads, bridges, public transportation systems, water, electricity, and other public utilities, communication and postal services, among others. Social common capital may also include institutional capital such as hospitals and medical institutions, educational institutions, judicial and police systems, public administrative services, financial and monetary institutions, cultural capital, and others. They all provide members of the society with those services that are crucial in maintaining human and cultural life, without being unduly influenced by the vicissitudes of life.

PARTICIPATING IN THE PREPARATION OF THE *NEW RERUM NOVARUM*

Uzawa: I had the honor of advising John Paul II in the preparation of the *New Rerum Novarum.* I was told by Professor Ignatio Musu of the University of Venice that I was the first outsider to participate in the preparation of the Encyclical Letters.

In his historic 1891 encyclical *Rerum Novarum*, Pope Leo XIII identified the most pressing problems of the times as "the abuses of capitalism and the illusions of socialism." He called the attention of the world on "the misery and wretchedness pressing so unjustly on the majority of the working class" and condemned the abuses of liberal capitalism, particularly the greed of the capitalist class. At the same time, he vigorously criticized the illusions of socialism, primarily on the ground that private property is a natural right indispensable for the pursuit of individual freedom. Exactly one hundred years after *Rerum Novarum*, the *New Rerum Novarum* was issued by Pope John Paul II on May 15, 1991, identifying the

FIGURE 2. John Paul II and Hirofumi Uzawa at the Vatican for a colloquium on social and ethical aspects of economics, 1991. Robert Lucas is in center background. Edmond Malinvaud is standing next to Uzawa.

problems that plague the world today as "the abuses of socialism and the illusions of capitalism."

Contrary to the classic Marxist scenario of the transition of capitalism to socialism, the world is now faced with an entirely different problem: how to smoothly transform a socialist economy to a capitalist economy. For such a transformation to result in a stable, well-balanced society, however, we must be explicitly aware of the shortcomings of the decentralized market system as well as the deficiencies of the centralized planned economy.

The centralized planned economy has been plagued by the enormous power that has been exclusively possessed by the state and has been arbitrarily exercised. The degree of freedom bestowed upon the average citizen has been held at the minimum. Human dignity and professional ethics have not been properly respected. The experiences of socialist countries during the last several decades have clearly shown that the economic plans, both centralized and decentralized, that have been conceived of by the government bureaucracy, have been inevitably found untenable either because of technological deficiencies or in terms of incentive incompatibility. The living standard of the average person has fallen far short of expectations, and the dreams and aspirations of the majority of the people have been left unfulfilled.

On the other hand, the decentralized market economy has suffered from the perpetual tendency toward an unequal income distribution, unless significant remedial measures are taken, and from the volatile fluctuations in price and demand conditions, under which ethics have been found extremely difficult to sustain. Profit motives often outrun moral, social, and natural constraints, whereas speculative motives tend to dominate productive ethics, even when proper regulatory measures are administered.

We must now search for an economic system in which stable, harmonious processes of economic development may be realized with the maximum degree of individual freedom and with due respect to human dignity and professional ethics, as eloquently prophesied by John Stuart Mill in his classic *Principles of Political Economy* in a chapter entitled "Of the Stationary State." The stationary state, as envisioned by Mill, is interpreted as the state of the economy in which all macroeconomic variables, such as gross domestic product, national income, consumption, investments, prices of all goods and services, wages, and real rates of interest, all remain stationary, whereas, within the society, individuals are actively engaged in economic, social, and cultural activities, new scientific discoveries are incessantly made, and new products are continuously introduced, still with the natural environment being preserved at the sustainable state.

We may term such an economic system as institutionalism, if we adopt the concept originally introduced by Thorsten Veblen. It has been recently reactivated as a theory of institutions by [Oliver] Williamson and others, where institutions are defined as the rules of games that specify the incentives and mechanisms faced by the members of the society engaged in social activities. I would like to emphasize that it is not defined in terms of a certain unified principle, but rather the structural characteristics of an institutionalist economy, as symbolized by the network of various components of social common capital, are determined by the interplay of moral, social, cultural, and natural conditions inherent in the society, and they change as the processes of economic development evolve and social consciousness transforms itself correspondingly. It explicitly denies the Marxist doctrine that the social relations of production and labor determine the basic tenure of moral, social, and cultural conditions of the society in concern. Adam Smith emphasized several times in his *Wealth of Nations* that the design of an economic system conceived of purely in terms of logical consistency inevitably contradicts the diverse, basic nature of human being, and instead he chose to advocate the merits of a liberal economic system evolved through the democratic processes of social and political development. It is in this Smithian sense that I would like to address the problems of the economic, social implications of social common capital and the analysis of institutional arrangements and policy measures that ensue the processes of consumption and accumulation of both social common capital and private capital that are either dynamically optimum or sustainable in terms of a certain well-defined, socially acceptable sense.

John Stuart Mill's stationary state may be interpreted as the sustainable state in the sense that the imputed price of each kind of capital, either private capital or social common capital, remains at the sustainable level at each moment in time. Mathematically speaking, the imputed price of each kind of capital is defined to be at the sustainable level at time t, when the imputed price of that capital at time t, p_t, remains stationary at time t; i.e., the right-hand side of the Euler–Lagrange equation is equal to zero at time t. In other words, investment in each kind of capital is kept at the level at which the marginal efficiency of investment is equal to the social rate of discount at each moment in time.

WRAPPING UP

MD: It is good to try to apply economics to real world problems and construct a new economics in view of the real world problems. Looking back, are you happy to have given up mathematics and devoted your life to economics?

Uzawa: That is a very difficult question. I wrote a book, an *Introduction to Mathematics for Children*, in Japanese. This is for very small children. Then I wrote a six-volume *Introduction to Mathematics*. The last theorem in the last volume is that classic Newton's theorem. I've written these six volumes without any reliance on any books. I've written all of this out of my own memory, which I accumulated when I was in middle school as a boy. When I was working on this project, I began to feel nostalgic. I wrote this six-volume series because I felt that I had to. I had been teaching economics in private universities in the last several years, yet I was appalled by the lack of students' knowledge in mathematics. I felt I had to do something. The Japanese system of education has been strictly controlled by the Ministry of Education in such a way that the majority of students have become intellectually deficient, particularly in mathematics. The reason why I emphasize the role of innate knowledge for children is that we have to try to develop the ability of each child as fully as possible. Language and mathematics are the most important things to teach at the very first stages, as emphasized by Noam Chomsky and other philosophers.

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