



**2009 Blue Planet Prize
Commemorative Lectures**

財団法人 旭硝子財団

THE ASAHI GLASS FOUNDATION

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Professor Hirofumi Uzawa (Japan)

Member of The Japan Academy

Professor Emeritus, The University of Tokyo

Selection rationale: He has advocated the concept of Social Common Capital as a theoretical framework for confronting environmental issues such as global warming from a very early stage, which contributed to pioneering and highly original achievements.

Education and Academic and Professional Activities

- 1928 Born in Yonago, Tottori Prefecture
- 1951 Graduated from the Department of Mathematics, Tokyo University; Special research student from 1951 to 1953
- 1956 Research Assistant, Stanford University; Assistant Professor in 1959
- 1960 Assistant Professor, Department of Economics at the University of California, Berkeley
- 1961 Associate Professor, Department of Economics, Stanford University
- 1962 PhD in Economics (Tohoku University), Thesis: “Studies of the General Economic Equilibrium Theory of Léon Walras”
- 1964 Professor, Department of Economics, University of Chicago
- 1966 Fellow, Churchill College, Cambridge University
- 1968 Assistant Professor, Department of Economics, Tokyo University; Professor in 1969; Dean in 1980
- 1989 Appointed Professor at the Department of Economics, Niigata University after retiring from Tokyo University; Professor Emeritus at Tokyo University
- 1994 Professor, Department of Economics, Chuo University (retired in 1999)
- 1999 Full-time researcher, The Institute of Economic Research, Chuo University; Adjunct Professor, Institute of Advanced Studies, United Nations University
- 2000 Professor, Research and Development Initiative, Chuo University
- 2003 Director, Research Center of Social Common Capital, Doshisha University
- 2009 Senior Fellow, Keiyu International Institute of Medicine

Major Awards Received

- 1983 Person of Cultural Merit
- 1997 Order of Cultural Merit

In addition to the accomplishment of internationally cutting-edge research in the field of mathematical economics, Professor Uzawa has made a great impact from early on with his economics-based analyses and proposals for the issues on pollution and the environment. He has tackled the social cost of automobiles, urban problems, and global warming, and as a theoretical framework in confronting such issues he has advocated the concept of Social Common Capital, a pioneering and highly original achievement.

In addition, he has contributed to the peaceful resolution of the Minamata disease issue and the Narita Airport construction issue, and has been consistent in his work as an economist who confronts the real world with a sincere outlook. Professor Uzawa continues to sound the alarm with respect to contemporary economics and civilization and remains a major influence on both the international stage and in Japan.

From Mathematics to Economics

Professor Uzawa graduated from the Department of Mathematics at the University of Tokyo in 1951 where he continued to work as a special research student until 1953. At that time, he discovered the true nature of economics in the words of John Ruskin, “There is no wealth, but life.” which was featured in the foreword to *Tale of Poverty* by Hajime Kawakami, and set out to educate himself about economics.

In 1956, a paper on decentralized economic planning written by Professor Uzawa caught the eye of Professor Kenneth Arrow at the Department of Economics, Stanford University, who invited him to be a research assistant. After becoming Assistant Professor at Stanford in 1959 and in 1960 at the Department of Economics of University of California, Berkeley, he was appointed Associate Professor of the Department of Economics at Stanford in 1961, and in 1964 became Professor at the Department of Economics of University of Chicago. During this period, he researched the issue of optimum economic growth resulting in his remarkable paper *On a Two-Sector Model of Economic Growth*, which covered the production sectors of consumer goods and investment goods in manufacturing equipments. During his time at the University of Chicago, Joseph E. Stiglitz and George A. Akerlof, later Nobel laureates in economics, were among the students attending his seminars in mathematical economics.

Departing from Mathematical Economics to A Theory of Social Common Capital

In 1968, Professor Uzawa accepted a position as Assistant Professor of the Department of Economics at the University of Tokyo and returned to Japan as protests against the Vietnam War in the United States turned violent. Then, the words of John Ruskin came back to him and he started to think about the concept of Social Common Capital or “how to incorporate the natural environment and the social environment in economic theory,” renewing his resolution to study the “economics that value the human spirit,” which later became his consistent set of beliefs. Even though he realized that “it would be a full-frontal critique of the work I had done so far,” he nevertheless criticized the status quo of mathematical economics (neo-classical economics) and sought to build a framework for economics with a solid foundation in the social environment, nature, education and healthcare.

In this period, he also turned his attention to the issues of pollution worldwide following in the wake of industrialization and urbanization, taking a strong interest in the Minamata disease and immersing himself deeply in pollution and environmental issues.

In 1972, he published for the first time the concept of Social Common Capital, which later became extremely important in thinking about global warming countermeasures. Social Common Capital refers to a natural environment and social infrastructure that enables the people living in a country or a specific region to enjoy a prosperous economy, develop a superb culture, and maintain in a sustained and stable fashion a society that is attractive on a human level. It has a strong connection to human life and existence, one might even say that it is a way of thinking that attempts to socially manage common assets including resources, goods, services and systems that are important for a society to function smoothly. As a result, Professor Uzawa constructed the theoretical foundation that lies behind the concept of the commons. The following three elements constitute Social Common Capital:

1. The Natural Environment: the atmosphere, water, forests, rivers, lakes, oceans, coastal wetlands, soil etc.
2. Social Infrastructure: roads, transportation facilities, water and sewerage, electricity and gas etc.
3. Institutional Capital: education, healthcare, finance, the judiciary, public administration and other systems

Each category must be managed and operated by professionals in accordance with professional standards and based on specialist knowledge.

Building on ideas based on the concept of the Social Common Capital, Professor Uzawa became involved in the pollution problems, authoring *The Social Cost of the Automobile* in 1974, which turned the focus on the extent of pollution

and damage caused to the natural environment and the social infrastructure of the Social Common Capital by the use of automobiles. Next, he attempted to calculate the social cost of automobiles. He measured the cost of creating ideal roads that do not infringe on the basic rights of the community by rebuilding roads which had numerous defects such as the lack of separation between pedestrians and cars. Setting this value as the index, he calculated the necessary cost of converting road structures and found that the social cost per automobile per year was at minimum two million yen.

The Economics of Global Warming

Professor Uzawa also put his attention to the issue of global warming from an early stage. As well as participating in the first conference of economists on the topic of global warming in Rome in 1990, he authored *The Economics of Global Warming* in 1991 where he focused on the implications of global warming on 20th century civilization and proposed preventative measures. His understanding on global warming was that it was caused by the mass consumption of fossil fuel and logging in the tropical rainforests. And the global environment came under great stress as a result of the insatiable pursuit of “affluence” and material comfort of advanced industrial nations that have turned waste habit into a virtue. In contrast, in developing countries where poverty dominates and economic development is nowhere in sight, people are forced into a predicament where they cannot but destroy nature and pollute the environment in order to survive. Consequently, Professor Uzawa pointed out that rich and poor countries equally destroyed the global environment, inflicting damage that cannot be undone by future generations. On the other hand, Professor Uzawa also turned his attention to carbon tax, in a broad sense an environmental tax, which was an initiative developed among economists as an effective policy for preserving the stability of the natural environment far into the future and for preventing global warming. Professor Uzawa stated that from the viewpoint of fairness there were major problems with the intergovernmental terms for reducing total emissions of greenhouse gases by country, including the plan to reduce carbon dioxide emissions by 20% proposed at the international conference on atmospheric change held at the same time as the 1988 Toronto Summit in Canada. He has pointed out that, generally speaking, international agreements for stabilizing the atmosphere were extremely lucrative for developed countries and, moreover, that their character was antisocial to the extent that countries that consume fossil fuels profit from them. He is an advocate of the carbon tax system as a measure for stabilizing the atmosphere that could actually be put into practice. On the other hand, a uniform carbon tax system was not only problematic from the viewpoint of international fairness, but as there was a risk of nipping economic development in the bud in the majority of developing countries, he proposed a “proportional carbon tax” according to per capita income in each country.

In addition, there was an inherent risk that the carbon tax itself would deter economic progress in developing countries and, even if the system of a proportional carbon tax is adopted, Professor Uzawa thought that it was not an effective strategy in resolving the North-South problem. Accordingly, he devised the concept of an international fund for stabilizing the atmosphere that would eliminate the economic disparities between industrialized and developing countries and act as an effective deterrent to global warming while stabilizing the atmosphere.

The principle behind the concept is that every government donates a fixed percentage of the silviculture subsidy deducted from the proportionate carbon tax revenues to the international fund for stabilizing the atmosphere. The fund distributes the contributions from each country to developing countries where the allocation is used for measures to protect the global environment such as protecting tropical rain forests, sustaining agricultural communities or developing alternative energies.

Professor Uzawa’s concept of a proportionate carbon tax and an international fund for stabilizing the atmosphere that would protect tropical rain forests and facilitate the prevention of global warming has won the backing of many economists as an international concept that considers intergenerational and regional disparities, but it has not been

accepted as policy yet.

A Message to the Contemporary Society

In recent years, Professor Uzawa has turned his attention to movements that aim to “rehabilitate human beings,” referring to the “urban and natural renaissance” that is taking place in Europe, and he is engaged in the research to spark this trend in Japan as well. He favors removing the concrete that covers riversides and returning to the meandering rivers of the past, planting the periphery with local trees and shrubs, and preventing floods not by building dams, but by creating rich woodlands in the upper reaches of the rivers, which social wisdom have long employed to control the waters by means of “green dams” that use the storage capacity of nature.

Professor Uzawa discloses his perception of the relationship between human beings and nature as a form of culture whereby society should communicate by going beyond the generations, saying “The culture of original human society prevented the depletion of natural resources by means of a dialog with nature and accumulated knowledge about the natural environment within social norms designed for the survival of the society, and the culture (social system) also included transmission to the next generation.”

Professor Uzawa points out that in modern times harmony between people and nature has collapsed and environmental destruction has advanced on a global scale because “modern science has played a major role in facilitating a lack of constraints on the exploitation of nature and ideas that place human beings in a position that is superior to nature.” Global warming is a straightforward example. He stressed that we should recognize it is an extremely dangerous environmental change progressing on an unprecedented scale and that every effort must be made to tackle it now.

When considering institutional capital as social common capital, education and medical care assume the most important position. Education has the mission to promote both natural-born and acquired talent of each child as far as possible. On the other hand, medical care shall be performed based upon the professional medical knowledge to treat people who lose their regular functions through diseases or accidents. Those two functions are absolutely imperative to sustain the society that keeps each citizen to maintain dignity and to enjoy civil liberty. To live one’s life in humane manner, I like to emphasize, those social common capitals play important part and shall never be controlled by mere market standards or bureaucrats.

A Paradigm Shift

In the latter half of the 1960s, Professor Uzawa felt “the emptiness and limitation of economics that advances enquiries based on abstract concepts such as capitalism or socialism” and stemming from this, he searched for a new framework, arriving at the idea of the Social Common Capital. The concept of the Social Common Capital offers an important foundation for institutional and political analysis in order to draft and select policies. It is viewed as an engine (mechanism) that creates measures that point to new directions for resolving a range of issues.

Social Common Capital provides a more honest answer than the economic point of view to the enquiry that is the ultimate goal of economics, “what should be done to bring about a sustainable and stable society?” When its social and institutional implications are considered, Social Common Capital furnishes a paradigm that opens the way to a new age.

Today, when it is said anew that social stability is important, the concept of Social Common Capital is an important starting point for economics even as we consider what stability is and what should be done. The concept is a form of social management based on social standards and a way of thinking that emphasizes management systems on a foundation of professional ethics. It is a great achievement on the part of Professor Uzawa to have consistently advocated

this concept, and based on the unshakeable conviction that social problems including environmental issues are “the issues that economics should be tackling,” to have shown such vigor in protecting the fundamental rights of the citizenry, issuing warnings on global warming and proposing measures and policies. In the future, Professor Uzawa will surely continue to have a great impact both in Japan and on the international stage.

Social Common Capital

Professor Hirofumi Uzawa

***Rerum Novarum* Inverted: The Abuses of Socialism and The Illusions of Capitalism**

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 100 years after *Rerum Novarum*, the *New Rerum Novarum* was issued by Pope John Paul II on May 1, 1991, identifying the problems that plague the world today as “the abuses of socialism and the illusions of capitalism” (John Paul II, 1991, and Uzawa, 1991a, 1992c).

Contrary to the classic Marxist scenario of the transition of capitalism to socialism, the world is now faced with an entirely different problem of how to transform a socialist economy to a capitalist economy smoothly. 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, whereas 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 the 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 productive ethics has 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” (Mill, 1848). 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. [Regarding Mill's stationarity state, one may be referred to an excellent discussion by Daly (1977, 1999).]

We may term such an economic system as institutionalism, if we adopt the concept originally introduced by Thorstein Veblen in his classic *The Theory of Leisure Class*, (Veblen, 1899) or *The Theory of Business Enterprise* (Veblen 1904). It has been recently reactivated as a theory of institutions by Williamson (1985) and others, where institutions are defined by the rules of games that specify the incentives and mechanisms faced by the members of the society engaged in social activities. We 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. Institutionalism 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* (Smith, 1776) 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 we 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 optimum in terms of a certain well-defined, socially acceptable sense.

Social Common Capital

Social common capital provides members of a 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. 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, financial and monetary institutions, cultural capital, judicial and police systems, public administrative services, and others. They all provide members of a society with those services that are crucial in maintaining human and cultural life, without being unduly influenced by the vicissitudes of life.

Social common capital in principle is not appropriated to individual members of the society, but rather is held as common property resources to be managed by the commons in question, without, however, precluding the private ownership arrangements. Nor is it to be controlled bureaucratically by the state. Thus, a problem of crucial

importance in the theory of social common capital is to devise the institutional arrangements that result in the management of social common capital that is optimum from the social point of view. The theory of social common capital provides us an analytical framework in which economic implications of social common capital are fully examined and explored the conditions under which the intertemporal allocation of scarce resources, including both social common capital and private capital, is optimum from the social point of view.

Natural Capital

Natural capital consists of the natural environment and natural resources such as forests, rivers, lakes, wetlands, coastal seas, oceans, water, soil, and 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. However, the rapid processes of economic development and population growth in the last several decades, with the accompanying vast changes in social and natural conditions, have altered the delicate ecological balance of natural capital to such a significant extent that their effectiveness has been lost in many parts of the world.

The sustainable management of natural capital may be made possible when the institutional arrangements of the commons are introduced, as indicated by the historical and traditional experiences of the commons, with a particular reference to the fisheries and forestry commons, as in detail discussed by McCay and Acheson (1987) and Berkes (1989).

However, processes of industrialization themselves, together with the ensuing changes in cultural, social, and political conditions, have made the survival of the commons extremely difficult. Only a handful of the commons now remain as viable social institutions in which economic activities are effectively conducted with natural capital prudently sustained.

Social Infrastructure, Institutional Capital, and Cultural Capital

Social infrastructure is another important component of social common capital. It consists of roads, bridges, public mass transportation systems, water, electricity, and other public utilities, communication and postal services, and sewage, 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, and so on.

Cultural capital may also be regarded as an important component of social common capital, as extensively examined in particular by Throsby (2001). Cultural capital comprises those capital assets in society that yield goods and services of cultural value, including artworks, historic buildings, and so on, together with intangible assets such as language, traditions, and others.

Social Capital

A word of caution may be necessary regarding the concept of social capital, originally introduced by James Coleman, Robert Putnam, and others. The standard reference is Putnam (2000) and an extensive discussion is reported in Dasgupta and Serageldin (2000). Social capital refers to intangible social networks and relationships of

trust that exists in communities. It means the connectivity of the social network each individual is embedded in, and facilitates the exchange of information and encourages reciprocal altruism. It is an interesting and fascinating concept, molded in the traditional framework of sociology and political science, though in good contrast with that of social common capital as envisioned in this book. [See also Arrow (2000) and Solow (2000).]

Sustainability

Social common capital is held by the society as common property resources to be managed by social institutions of various kinds that are entrusted on a fiduciary basis to maintain social common capital in good order and to distribute the services derived from it equitably. Social common capital is in principle not appropriated to individual members of the society, without, however, precluding the private ownership arrangements. Nor is it to be controlled bureaucratically by the state. Thus, a problem of crucial importance in the theory of social common capital is how to devise the institutional arrangements that result in the management of social common capital that is optimum from the social point of view.

The concept of sustainability is formally defined as the efficient pattern of intertemporal allocation of private capital and social common capital for which the imputed price of social common capital is assumed to remain at the stationary level at each time. As the imputed price of social common capital expresses the subjective value of social common capital each generation inherits from the past, the concept of sustainability thus defined may be regarded as expressing in formal terms the concept of the stationary state as envisioned by John Stuart Mill. It is closely linked to that introduced by Pezzey (1992), in which the utility remains constant over time. On the other hand, it is not apparent to see the link with Page's concept of sustainability which emphasizes maintaining life opportunity from generation to generation (Page, 1997).

Externalities

One of the intricate problems inherent in social common capital concerns the phenomenon of externalities. Since the classic treatment of Pigou (1925) and Samuelson (1954), the economists were always puzzled by the phenomenon of externalities, but it was put aside as peripheral and not worthy of serious consideration. Concern with environmental issues, however, has changed this habit of economic thinking, and a large number of contributions have appeared where the issue of externalities occupies a central place, both from theoretical and empirical points of view. The analytical treatment of externalities in the theory of social common capital is adopted from that introduced in Uzawa (1974a, 1974b, 1974c, 1975, 1982, 1992a), in which two kinds of externalities, static on the one hand, and dynamic on the other, are recognized with respect to the services derived from social common capital. Static externalities occur when the levels of marginal products or utilities of individual economic units are affected by the aggregate amount of services of social common capital used by all members of the society, assuming that the stock of social common capital is kept at a constant level. Dynamic externalities, on the other hand, are observed when the conditions of production and consumption for each individual economic unit change over time due to changes in the stock of social common capital, either accumulation or depreciation, that occurs today.

The Commons

The natural environment, or rather natural capital, has been subject to an extensive examination in the literature, particularly with respect to the fisheries and forestry commons. The analysis of the fisheries commons

was initiated by Gordon (1954) and Scott (1955), and was later extended to the general treatment within the framework of modern capital theory by Schaefer (1957), Crutchfield and Zellner (1962), Clark and Munro (1975), and Tahvonen (1991), among others. The simple dynamic model of the natural environment introduced in Uzawa (2003) that has the case of the fisheries commons primarily in mind belongs to the lineage of their approach. It is an extension of the analysis developed by Uzawa (1992b), where it is used to examine critically the theory of the tragedy of the commons, as advanced by Hardin (1968).

The model of the natural environment developed in Uzawa (1992b) may be applicable to the dynamics of the forestry commons as well. As with the fisheries commons, the dynamics of the forestry commons has been extensively analyzed in the literature. Indeed, it was made a central issue in economic theory by Wicksell (1901), who developed the core of modern capital theory with the analysis of forests as the prototype. The most recent contribution to forestry economics was made by Johansson and Lögren (1985)

The theory of social common capital provides us with the theoretical framework within which the role of institutional arrangements concerning social, cultural, and natural environments in the processes of resource allocation and income distribution may be effectively analyzed. Social common capital is generally composed of those scarce resources that are in principle neither privately appropriated nor subject to market transactions. Social common capital or the services derived from it play a crucial and indispensable role for each member of the society in concern to conduct at least the minimum level of human and dignified life. The management of social common capital thus is entrusted on a fiduciary basis to autonomous social institutions, to provide the environmental framework within which all human activities are conducted and allocative mechanism through market institutions work. The analysis of social common capital, as introduced by Uzawa (1974a, 1989, 1991a, 1991b) and recently developed in Uzawa (1998, 2003, 2005), may be applied to discuss some of the difficulties arising out of the tragedy of the commons phenomenon. Particularly, the institutional arrangements whereby the sustainable use of resources in the commons may ensue are examined in terms of the concept of imputed price of social common capital.

The society generally allocates a significant portion of scarce resources for the construction and maintenance of social common capital, particularly social infrastructure, and one of the central issues in the dynamic theory of social common capital is to find the criteria by which scarce resources are allocated between investment in social common capital on the one hand and production of goods and services which are transacted on the market on the other.

In the theory of social common capital, we formulate an analytical framework in which economic implications of social common capital of various kinds are examined and explore the conditions under which the intertemporal allocation of social common capital and privately owned scarce resources is optimum from the social point of view. It may be regarded as the general equilibrium versions of those formulated in Uzawa (1992b), where, however, the phenomenon of externalities is not explicitly discussed. In the dynamic models of social common capital introduced in Uzawa (2005), the phenomenon of externalities, both static and dynamic, is incorporated in the construct of the model and their implications for the processes of resource allocation, including both social common capital and privately managed scarce resources, are fully explored. The sustainable allocation of scarce resources occurs when the imputed prices associated with the accumulation and use of social common capital are

used as signals in the allocative processes. Privately owned scarce resources and goods and services produced by private economic units are allocated through the mechanism of market institutions.

In the dynamic models concerning the accumulation of social common capital referred to above, the technological conditions are assumed to remain largely constant, independent of the accumulation of the stock of social infrastructure. Technological progress induced by the availability of social infrastructure and the accompanying increase in investment activities in the stock of privately owned scarce resources may be regarded as the central issue in the theory of social infrastructure, particularly within the context of developing nations, also examined in detail by Hirschman (1958) in terms of the concept of social overhead capital. Social overhead capital as defined by Hirschman comprises those basic services without which primary, secondary, and tertiary productive activities cannot function. In its wider sense, social overhead capital includes all public services from law and order through education, public health to transportation, communications, power and water supply, as well as agricultural overhead capital such as irrigation and drainage systems. Thus the theory of social common capital introduced in Uzawa (2005) may be regarded as an extension of Hirschman's concept of social overhead capital, in which natural resources are included in addition to social infrastructure and institutional and cultural capital.

The theory of social common capital may also be regarded as an extension of the two-sector models of capital accumulation originally introduced by Uzawa (1962, 1963, 1964). Similarly, the problems of designing institutional framework in which the optimum allocation of both social common capital and privately owned scarce resources may be realized are crucial in any attempt toward practical implementations of the theory of social common capital.

When we include all components of social common capital in a particular nation, the social institutions entrusted on a fiduciary basis with their management constitute the public sector in the broadest sense of the word. The aggregate expenditures incurred by all these social institutions are nothing but the governmental expenditures, either on the current account or on the capital account. Thus, the problem we address may be interpreted as that of devising an institutional framework in which the ensuring governmental activities are optimum from the social point of view.

Environmental Problems

In the last several decades, we have observed a significant change in the nature of environmental problems and the economic, social, and cultural implications that the degradation of the natural environment has brought about. During the 1960s and in the early 1970s, our primary environmental concern was with the disruption of the environment and the ensuing hazard to human health that were caused by the rapid processes of industrialization and urbanization, both of which were taking place at an unprecedented high pace in many parts of the world. The environmental damages were mainly caused by the emission of chemical substances such as sulfur and nitrogen oxides that themselves are toxic and hazardous to human health. In recent years, however, we have become increasingly aware of the extensive degradation of the global environment, as exemplified by such phenomena as global warming, the extensive depletion of tropical rain forests, with the accompanying loss of biodiversity, and pollution of the oceans. The global environmental problems are primarily caused either by the imprudent use and excess depletion of the natural resources or by the emission of those chemical agents such as carbon dioxide in the case of global warming which by themselves are neither harmful to human health nor hazardous to the natural

environment, but, on the global scale, they contribute to the atmospheric instability and global disturbances.

As for the industrial pollution and similar environmental problems that were rampant and wide spread in the 1960s, the causal relationships were fairly easy to recognize, both from the social and scientific points of view, and the remedial measures were not too difficult to take, both from economic and political points of view, although one has to be aware of a significant number of major environmental problems in the 1960s such as the case of the Minamata disease that left a state of extreme social injustice for the victims.

On the other hand, the global environmental problems concern the degradation and destabilization of the natural environment covering an extensive area, with a large number of people involved. They not only affect the current generation, living in developing as well as in developed countries, but also all future generations are irreversibly involved as exemplified by the phenomena of global warming, the loss of biodiversity, and pollution of the oceans.

The global environmental problems are also noted for the intricate and subtle interrelationships that exist between human activities, both economic and cultural, and the ecological and biological processes in the natural environment. Traditional economic theory has not paid sufficient attention to the damages and threats to the natural environment, particularly with respect the stability and resilience of regenerative processes, that are exerted by industrial, urban, and other human activities. Instead, it has treated the natural environment simply as the stock of natural capital, from which various natural resources are extracted to be used as factors of production for the productive processes in the economy.

However, in the economic analysis of fisheries, forestry, and other agricultural activities, a large number of studies have been made, where the implications of economic activities for the stability and resilience of the natural environment, either in the fisheries ground or in forestry commons, are explicitly recognized, and the patterns of resource allocation that are dynamically optimum in terms of the intertemporal preference ordering prevailing within the society are analytically examined, as in detail described, for example, by Johansson and Lögren (1985), and Clark (1990).

When we examine the interaction of economic activities with the natural environment, one of the more crucial issues concerns the organizational characteristics of the social institutions that manage the natural environment, in conjunction with their behavioral and financial criteria, which realize those patterns of the repletion and depletion of the natural environment and the levels of economic activities that are dynamically optimum from the social point of view. The dynamically optimum time-paths generally converge to the long-run stationary state at which the processes of economic activities are sustained at those levels that are at the optimum balance vis- vis the natural environment, and the problem we face now concerns the organizational and institutional arrangements for sustainable economic development.

Such an organizational framework may be provided by the institutional arrangements of the commons, as have been shown in terms of a large number of historical, traditional, and contemporary commons documented, for example, in McCay and Acheson (1987) and Berkes (1989). The commons discussed by McCay and Acheson (1987) and Berkes (1989) refer to a variety of natural resources extending from fisheries, forestry, grazing grounds,

to irrigation and subterranean water systems. The processes of industrialization, however, together with the accompanying changes in economic, social, and cultural conditions prevailing in modern society, have made these commons untenable both from economic and social points of view, and the survival of the majority of the traditional commons have become extremely difficult.

Agriculture and Social Common Capital

Agriculture concerns not only economic, industrial aspects, but also virtually every aspect of human life: cultural, social, and natural. It provides us with food and the raw materials such as wood, cotton, silk, and others that are indispensable to sustain our existence. It also has sustained, with few exceptions, the natural environment such as forests, lakes, wetlands, soil, subterranean water, and the atmosphere.

Agriculture made possible a harmonious and sustainable interaction between nature and mankind through the social institution of the rural community in many East Asian countries, particularly in Japan. This does not, however, necessarily imply that the traditional, conventional social institutions prevailing in most of the agricultural communities are justifiable or desirable.

The land ownership probably is the single most serious and complex problem in Japan. Japan is noted for a high population density and for a long history of agricultural development. Land had been cultivated literally to the top of the mountains and forestry had been subject to myriads of property right arrangements. The modern Civil Law, enacted in 1898, adopted an extremely narrow definition of land ownership, voiding traditional forms of property ownership for villages as the commons to manage and control the natural resources to be directly or indirectly obtained from land, forests, and other natural environments. The conflict between the modern Civil Law and traditional institutions of the commons had occupied the majority of the legal suits brought before the Grand Court before the Second World War. The land reform measures implemented during the period occupied by the Allied Powers did not help resolve the dilemma either. The postwar Japan has seen a large number of conflicts, occasionally serious, between the State and citizens, mostly farmers, in the processes of land expropriation for the construction of infrastructure facilities.

The Narita Airport Problem is probably one of the thorniest problems Japan has faced since the end of the Second World War involving infrastructure construction, and brought with it a far more extensive damage to the society than the scope and magnitude of the infrastructure facilities originally planned would deserve. It began on July 4, 1966, when the Cabinet meeting decided to construct the New Tokyo International Airport at Sanrizuka in Narita, without prior consultation with the inhabitants in the community or the local authorities, and the thirty years of the conflict claimed close to ten thousand casualties on both sides, leading to a large number of human tragedies, unprecedented in peacetime Japan. The conflict was peacefully brought to an end on May 24, 1993, when the Minister of Transportation and the representatives of the Airport Opposition Alliance jointly declared that neither side would resort to any forceful measures and instead would cooperate in devising a comprehensive regional development plan, including the completion of the Airport, that would be acceptable to all those involved. As part of the peaceful resolution of the Narita Conflict, a commission was appointed to draw a blueprint for the Sanrizuka Agricultural Commons that would serve not only as the core organization for the comprehensive regional development plan, but also as the prototype of the organizational renovation to vitalize the Japanese agriculture.

Medical Care as Social Common Capital

When medical care is regarded as social common capital, every member of the society is entitled, as basic human rights, to receive the best available medical care that the society can provide, regardless of the economic, social, and regional circumstances, even though this does not necessarily imply that medical care is provided free of charge. The government then is required to compose the overall plan for the regional distribution of various types of medical institutions and the schooling system to train physicians, nurses, technical experts, and other co-medical staff to meet the demand for medical care that would result in the management of the medical care component of social common capital that is socially optimum. It is then required to devise institutional and financial arrangements under which the construction and maintenance of the necessary medical institutions are realized and the required number of medical professionals are trained without social or bureaucratic coercion. It should be emphasized that all medical institutions and schools basically are private and the management is supervised by qualified medical professionals.

The fees for medical care then are determined based on the principle of marginal social costs pricing, not through merely market mechanism. It may be noted that, the smaller the capacity of the medical component of social common capital, the higher are the fees charged to various types of medical care services. Hence, in composing the overall plan for the medical care component of social common capital, we must explicitly take into account the relationships between the capacity of the medical care component of social common capital and the imputed prices of medical care services. The socially optimum plan for the medical care component of social common capital then is one where the resulting system of imputed prices of various types of medical care services leads to the allocation of scarce resources, privately appropriated or otherwise, and the accompanying distribution of real income that are socially optimum, in the sense as will be in detail discussed in this chapter.

When, however, physicians provide medical care services to those whose health is impaired due to diseases or injuries, the very nature of medical care necessarily implies that the processes of diagnosis and curative treatment may occasionally involve the impairment, physical or mental, of patients, whereas the curative effects are not necessarily absolutely guaranteed. If an ordinary person were to perform such conduct, he or she would certainly be criminally prosecuted. Only qualified physicians and co-medical staff are immune from such prosecution, because not only are they licensed to practice medical care, but also they are supposed, as being trusted on a fiduciary basis the management of the medical care component of social common capital, to obey professional codes of conduct truthfully and to take care of patients with the best scientific knowledge and the highest available technical proficiency of the medical sciences today. For such presuppositions to be fulfilled, it is not only necessary that arrangements are institutionalized whereby the provision of medical care and the conduct of each physician are properly monitored, in terms of peers' review or some other means, but also it is required that an overall system of incentive mechanisms, in terms of social esteem and compensatory scheme, must be established whereby it becomes physicians' own self-interest to obey professional codes of conduct truthfully and to seek for the best scientific knowledge and the highest available technical proficiency of the medical profession.

Under such utopian presuppositions, total expenditures for the construction and maintenance of the socially optimum medical care component of social common capital then exceed, generally by a large amount, the total fees paid by the patients under the principle of marginal social cost pricing. The resulting pattern of resource allocation and real income distribution, however, is optimum from the social point of view. The magnitude of the deficits with

respect to the management of the socially optimum medical care component of social common capital then may appropriately be regarded as an index to measure the relative importance of medical care from the social point of view.

Education as Social Common Capital

Education, together with medical care, constitutes the most important components of social common capital and, as such, may require the institutional arrangements substantially different from those for the standard economic activities that are generally pursued from the view point of profit maximization and subject to transactions on the market. Whereas medical care is provided for those who are not able to perform ordinary human functions due to impaired health or injuries, education is provided to help young people develop their human abilities, both innate and acquired, as fully as possible. Both activities play a crucial role in enabling every member of the society in concern to maintain his or her human dignity and to enjoy basic human rights as fully as possible. If either medical care or education is subject to market transactions based merely on profit motives or under the bureaucratic control by state authorities, their effectiveness may be seriously impaired and the resulting distribution of real income may tend to become extremely unfair and unequal. Thus the economics of education and medical care may better be carefully analyzed within the theoretical framework of social common capital. The role of education as social common capital within the analytical framework of the theory of social common capital may be effectively analyzed.

In describing the behavior of educational institutions, we occasionally talk about the maximization of net value, it is used in the sense that the optimum level of education and the most efficient pattern of resource allocation in the provision of education are sought, strictly in accordance with professional disciplines and ethics.

We consider a society which consists of a finite number of individuals and two types of the institutions; private firms that are specialized in producing goods that are transacted on the market, on the one hand, and social institutions that are concerned with the provision of education as services of social common capital, on the other.

All social institutions are characterized by the properties that all factors of production that are needed for the professional provision of education are either privately owned, or if not, they are managed as if privately owned. However, the social institutions in charge of education are managed strictly in accordance with professional discipline and expertise knowledge.

Subsidy payments are made for the provision of education, with the rate to be administratively determined by the government and announced prior to the opening of the market. The fees paid to social institutions for the provision of education exceed, by the subsidy rate, those charged for the attainment of education. Given the subsidy rate for the provision of education, the two levels of fees are so determined that the general level of education provided by all educational institutions in the society is precisely equal to the total level of education attained by all individuals of the society. One of the crucial roles of the government is to determine the subsidy rate for education in such a manner that the ensuing pattern of resource allocation and income distribution is optimum in a certain well-defined, socially acceptable sense.

Global Warming and Sustainable Development

The atmospheric concentration of greenhouse gases, particularly of carbon dioxide, has been increasing since the times of the Industrial Revolution, with an accelerated rate in the last three decades. According to the IPCC reports, it is estimated that, if the emission of carbon dioxide and other greenhouse gases and the disruption of tropical rain forests were to continue at the present pace, global average air surface temperature toward the end of the twenty-first century would be 3 - 6 C higher than the level prevailing before the Industrial Revolution, resulting in drastic changes in climatic conditions and accompanying disruption of the biological and ecological environments.

The problems of global warming are genuinely dynamic. From past human activities we inherit an excess concentration of atmospheric carbon dioxide, and the choices we make today concerning the use of fossil fuels and related activities significantly affect all future generations through the phenomenon of global warming that is brought about by the atmospheric concentrations of carbon dioxide due to the combustion of fossil fuels today. Thus, we have to take into account explicitly the changes in the welfare levels of all future generations caused by the increases in the atmospheric accumulations of carbon dioxide.

In Uzawa (2005), we are primarily concerned with the economic analysis of global warming within the theoretical framework of dynamic analysis of global warming, as introduced in Uzawa (1991b, 2003). We are particularly concerned with the policy arrangements of the proportional carbon tax scheme under which the tax rate is made proportional either to the level of the per capita national income of the countries where greenhouse gases are emitted or to the sum of the national incomes of all countries in the world. We first consider the case where the oceans are the only reservoir of CO₂ on the earth, and then we explicitly take into consideration the role of the terrestrial forests in moderating processes of global warming by absorbing the atmospheric accumulation of CO₂, on the one hand, and in affecting the level of the welfare of people in the society by providing a decent and cultural environment, on the other.

The rate of anthropogenic change in the atmospheric level of CO₂ is determined by the combustion of fossil fuels and is closely related to the levels of production and consumption activities conducted during the year observed.

The impact index function $\phi(V)$ of the following form is postulated:

$$\phi(V) = (\hat{V} - V)^\beta, \quad 0 < V < \hat{V},$$

Where \hat{V} is the critical level of the atmospheric accumulation of CO₂ and β is the sensitivity parameter ($0 < \beta < 1$). The critical level \hat{V} of the atmospheric accumulation of CO₂ is usually assumed to be twice the level prevailing before the Industrial Revolution; that is, $\hat{V} = 600$ GtC. The impact coefficient $\tau(V)$ is given by

$$\tau(V) = \frac{\beta}{\hat{V} - V}.$$

Proposition. Sustainable time-paths (V_t) of the atmospheric accumulations of CO₂ are obtained as the competitive market equilibrium under the following system of proportional carbon taxes for the emission of CO₂ and tax-subsidy measures for the reforestation and depletion of resources of forests:

- (i) In each country v , the carbon taxes are levied with the rate θ^v that is proportional to the per capita national income y^v :

$$\theta^v = \frac{\tau(V)}{\delta + \mu} y^v,$$

where $\tau(V)$ is the impact coefficient of global warming, δ is the social rate of discount, and μ is the rate at which atmospheric CO₂ is annually absorbed by the oceans.

(ii) In each country v , tax-subsidy arrangements are made for the depletion of resources and reforestation of forests with the rate π^v that is proportional to the national income y^v , to be given by

$$\pi^v = \frac{1}{\delta} \left[\tau^v(R^v) + \gamma^v \frac{\tau(V)}{\delta + \mu} \right] y^v,$$

where $\tau^v(R^v)$, γ^v are, respectively, the impact coefficient and carbon sequester rate for forests in country v .

International Fund for Atmospheric Stabilization

The divergence in economic performance between developed countries and developing countries has steadily widened in the last several decades, and various institutional and policy measures that have been devised internationally or bilaterally have not had much impact in narrowing the gap between these two groups of countries. The introduction of the proportional carbon tax system as envisioned here, in spite of the implicit recognition of the equity aspect in its design, may tend to worsen the relative position of developing countries, at least in the short-run. It would be desirable, therefore, to supplement the carbon tax system with the international redistributive scheme that would have significant impact in narrowing the gap between the stages of economic development of various countries involved.

The International Fund for Atmospheric Stabilization is an institutional framework in which it is possible to combine an international arrangement to stabilize atmospheric equilibrium with a redistributive scheme to help developing countries to accelerate processes of economic development.

The International Fund for Atmospheric Stabilization presupposes that each country adopts the proportional carbon tax system under which emissions of carbon dioxide and other greenhouse gases are charged a levy evaluated at the imputed prices proportional to the per capita level of national income and a charge (or a subsidiary payment) is made for the depletion (or the afforestation) of terrestrial forests, again based upon the evaluation at the imputed prices of terrestrial forests that are proportional to the per capita level of national income, as in detail discussed in Uzawa (2003, 2005).

The tax revenues from the proportional carbon tax system are principally put into the general revenue account of each government, preferably to be partly earmarked for the purposes of restoring the natural and ecological environments, and for encouraging private economic agents to develop those technological and institutional knowledge that are crucial in restoring equilibrium conditions in the global environment.

Each country then transfers a fixed portion, say 5%, of the net revenue from the carbon tax system to the International Fund for Atmospheric Stabilization. The total amount transferred to the International Fund for Atmospheric Stabilization from individual countries then would be allocated to developing countries according to a certain predetermined schedule, properly taking into account the per capita levels of national income and the size of population. Developing countries may use the amounts transferred from the International Fund for Atmospheric

Stabilization for the purposes which they think appropriate, preferably for compensating those who would suffer from the phenomena of global environmental disequilibrium and incur the hardships by the implementation of the carbon tax system, for restructuring industrial organizations and social infrastructure, and for introducing substitutional energy sources and energy-saving technologies.

It is difficult to imagine that the International Fund for Atmospheric Stabilization or similar international arrangements on the global scale may be instituted in any immediate future. Whether such international arrangements may be effectively implemented or not depends to a significant extent upon the degree of awareness on the part of the general public concerning the enormous burden and costs future generations will have to suffer from the phenomena of global warming and other global environmental disequilibrium.

The strenuous effort by a large number of geo-scientists, ecologists, and other scientists to clarify the mechanism of global warming and to identify the specific implications of global warming and other environmental issues for ecological, biological, social, and cultural life on Earth has had a significant impact to the awareness and consciousness of the general public and the national governments. The numerous conferences and symposia organized by various international organizations, such as the 1991 Rio Conference and the Intergovernmental Panel on Climate Change, particularly the Kyoto Protocol of 1997, have substantially altered the perception of the international community as regards the plausibility and danger of global warming and other atmospheric disequilibria.

All these help the national governments involved to search for those policy and institutional arrangements that will make the practical implementation of the International Fund for Atmospheric Stabilization or similar international agreements feasible from economic, social, and political points of view. It would not be too optimistic to expect to have the International Fund for Atmospheric Stabilization or a similar framework to be instituted within a foreseeable period, though not in the immediate future.

A Hypothetical Case

A hypothetical case of the incidences of the proportional carbon taxes under the system of proportional carbon taxes for the emission of CO₂ and tax-subsidy measures for the reforestation and depletion of resources of forests are presented, all in terms of the statistical data of 2005 (in US\$).

Table 1 Incidences of proportional carbon taxes (2005) with the coefficient of proportion 0.01 including all radiative forcing agents (RFA)

Countries	National Income per capita [Dollars]	RFA Increase per capita (Ct)	Imputed Price [Dollars / ct]	Carbon Taxes per capita [Dollars]
USA	42,000	5.90	420	2,500
Canada	34,000	6.20	340	2,100
UK	32,000	3.00	320	950
France	31,000	2.20	310	680
Germany	31,000	3.20	310	980
Italy	28,000	2.20	280	600
The Netherland	35,000	3.60	350	1,200
Sweden	32,000	1.90	320	610
Norway	48,000	1.60	480	760
Finland	31,000	2.00	310	610
Denmark	34,000	3.20	340	1,100
Indonesia	3,100	1.70	30	50
Japan	31,000	2.70	310	840
Korea	21,000	2.60	210	560
Malaysia	11,000	1.90	110	210
Philippine	3,200	0.30	30	8
Singapore	40,000	3.20	400	1,300
Thailand	6,900	1.20	70	80
India	2,200	0.30	20	7
China	4,100	1.10	40	40
Australia	33,000	7.10	330	2,300
New Zealand	23,000	3.50	230	790

Sources: UNFCCC, World Development Indicators, etc

Table 2 Incidences of Tax-Subsidy Measures for the Reforestation and Depletion of Resources of Forests (2005)

Country	Forest and Woodlands [Million ha]	Net Annual Reforestation [1000 ha]	Imputed Price [Per ha]	Assessment	
				Total [Million Dollars]	Per Capita [Dollars]
USA	303	159	42,000	6,627	22
Canada	310	0	34,000	0	0
UK	3	10	32,000	321	5
France	16	41	31,000	1,264	21
Germany	11	0	31,000	0	0
Italy	10	106	28,000	2,929	50
The Netherland	0	1	35,000	35	2
Sweden	28	11	32,000	351	39
Norway	9	17	48,000	808	175
Finland	23	5	31,000	153	29
Denmark	1	3	34,000	102	19
Indonesia	88	- 1,871	9,300	- 17,120	- 77
Japan	25	- 2	31,000	- 62	0
Korea	6	- 7	21,000	- 149	- 3
Malaysia	21	- 140	33,000	- 4,679	- 179
Philippine	7	- 157	9,600	- 1,507	- 18
Singapore	0	0	40,000	0	0
Thailand	15	- 59	20,700	- 1,220	- 19
India	68	29	2,200	64	0
China	197	4,058	4,100	16,678	13
Australia	164	- 193	33,000	- 6,319	- 310
New Zealand	8	17	23,000	388	94

Tropical rain forest states: Indonesia, Malaysia, Philippine, and Thai

Source: World Resources Institute, etc.

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