CAPACITY FOR DEVELOPING INNOVATIVE PRODUCTION TECHNOLOGIES

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Summary

In modern society, a large part of human economic activity still relies on the extraction and utilization of natural resources. Natural resources, including nonrenewable and renewable resources, have two opposite properties—infiniteness and finiteness—just like two sides of a coin. What really matters in the focus of rational resources use is what is called sustainability. A technological innovation base in scientific advance would be an important contribution to overcoming the global resources crisis and moving towards sustainable development. The concept of technological innovation, and its expansion, is briefly introduced in this article. According to technological innovation theory, the interactions between resources allocation and technological innovation can be summarized as a circular process—"equilibrium–disequilibrium–equilibrium." Institutional arrangements are critical in promoting scientific advances and technological innovation. A knowledge innovation system on two levels—national and enterprise—are

introduced with emphasis on strategies and measures developing countries should pay attention to in establishing their own knowledge innovation systems.

1. Finite, Infinite, and Sustainability of Resources

Rapid growth of population and expansion of industrialization has led to accelerated over consumption of natural resources, which have supported human society for hundreds of thousands years. Inappropriate exploitation, utilization, and management of environmental and natural resources has brought about an energy crisis, water crisis, and food crisis—a global crisis—since the 1970s. In modern industrial/urban societies it is sometimes easy to overlook the fact that a large part of total economic activity still relies on the extraction and utilization of natural resources.

1.2. Two Sides of the Coin: Finiteness and Infiniteness

Natural resources, according to the definition of the United Nations Development Programme (UNDP), are environmental and natural factors that can be converted, at certain times and spaces and under certain conditions, into economic value to improve human life at present or in the future. Natural resources are preserved in the form of either materials or energy that can be utilized at present or in the foreseeable future.

A fundamental distinction in natural resources economics is that between renewable and nonrenewable resources. The use of *nonrenewable resources* is a problem with a strong time dimension; it involves trade-off between the present and the future. Complicated temporal trade-offs also exist with *renewable resources*. Biological and ecological processes create connections between the rates of resource use in the present and the quantity and quality of resources available to future generations. Both nonrenewable and renewable resources are characterized by two opposite properties: infiniteness and finiteness.

Finiteness. The finiteness of resources is obvious from their absolute scarcity since for nonrenewable resources there are no processes of replenishment (for example, if more oil is pumped out of an underground deposit this year, less will be available to extract in future years). For non-living renewable resources, such as solar and wind energy, commercial utilization is limited by cost-effectiveness of technologies. Even renewable resources with replenishment functions are also finite; harvesting rates should be no more than growing rates in the long run, otherwise the stocks of resources will decline to below specific thresholds leading to irreversible depletion of resources or even the extinction of species.

Infiniteness. The finiteness of resources should not lead to a pessimistic conclusion. Development of human society could go beyond the limitations currently predicted. For nonrenewable resources, additional reserves could be explored to increase the amount of resources for exploitation. Unconventional reserves could be commercially utilized with reduction of extraction costs, which is expected to be many times the amount of current reserves in total. Artificial synthesized material could functionally replace some scarce resources: a typical example is synthesized diamonds. For renewable resources, they could be continuously used far into the future under effective management. Some resources also can be seen as infinite due to their huge reserves on the planet or in the universe, such as energy from the sun and tides.

1.2. Sustainability Is What Really Matters

Finiteness and infiniteness of resources are two sides of a coin. What really matters in the focus of rational resources use is what is called sustainability. A resources use rate that is “sustainable” is one that can be maintained over the long term without impairing the fundamental ability of the natural resource base to support future generations. Sustainability does not mean that resources must remain untouched; rather, it means that their rates of use should be chosen so as not to risk future generations. In the case of nonrenewable resources, this implies using the extracted resource in such a way that it contributes to the long-run economic and social health of the population. For renewable resources, it means establishing rates of use that are coordinated with the natural productivity rates affecting the way the resources grow and decline.

Not only natural resources are affected by sustainability; sustainability of environmental resources deserves even more attention. Environmental resources refer to the assimilative capacity of the environment, the ability of the natural system to accept certain pollutants and render them benign or inoffensive. Pollutants tend to accumulate in the environment rather than to dissipate and disappear. For example, heavy metals can accumulate in water and soil. Carbon dioxide emissions over many decades have accumulated in the earth’s atmosphere. What is in fact being depleted here is the earth’s assimilative capacity. In this sense, assimilative capacity is a natural resource akin to traditional resources such as oil deposits and forests. Thus, some theoretical ideas about the depletion of natural resources are also useful in understanding environmental pollution.

2. Contributions of Technological Innovation to Sustainable Development

Advances in science and technology play an important role in economic growth as well as resources conservation. Many new techniques have been developed and widely deployed in exploration, exploitation, recovery, and utilization of resources to increase efficiency and reduce cost of production, greatly reducing the elasticity of economic growth to natural resources demands since World War II. Although we cannot predict precisely the impacts on environmental and natural resources that technological advancement could have in the future, there are many reasons to believe that technological innovation will be an important contributor to overcoming the global resources crisis as we move toward sustainable development.

2.1. How Can Technological Innovation Contribute?

Besides institutional guarantees, such as environmental laws, regulations, and policies, technological innovation contributes in ensuring sustainable use of environmental and natural resources in several ways:

- Deployment of advanced techniques with high efficiency increases yield and reduces waste discharge. For example, clean generation techniques of clean coal technologies (CCT) such as integrated gasification of combined cycle (IGCC) and pressed fluidized bed combustion-combined cycle (PFBC-CC) may increase the efficiency of power stations from 33% to 45% and greatly reduce emissions of pollutants, such as nitrogen oxides (NOx), sulfur dioxide (SO_2), and carbon dioxide (CO_2).
- Advanced regeneration technologies improve resources recovery, reuse, and recycling. In the USA, 70% of steel and 32% of aluminum are recycled from used material.
- Alternative processes are developed to replace rare materials with abundant substances, providing opportunities for resources conservation. For example, composite materials with higher chemical and mechanical properties have been produced on a large scale to replace steel and iron, and carbon fibers have been used in making aircraft, ships, and automobiles.
- The ecological industry presents another way for resources conservation whereby production processes are well integrated and life cycles of products are well designed and organized to maximize efficiency of resources utilization and minimize waste discharge.
- Besides economic capacity, military forces, political influence, and level of scientific and technological development have already been recognized as some important factors in determining the comprehensive power of a nation and its civilization. It may also lead to structural change of the global political configuration, which used to be determined by the redistribution of political power between large countries.

2.2. The Concept of Technological Innovation and Expanding It

What is technological innovation? From a comprehensive view, technological innovation leads to efficiency improvement of natural resources use.

- Technological innovation changes production tools and processes. Introduction of new techniques, new materials, and new energy expand the range and usage of resources.
- Technological innovation advances the evolution of industrial structures and improves organization and management production. Although it does not directly change resources, it indirectly saves resources through optimum allocation of resources.

Overall, technological innovation makes it possible to expand the range of resource, produce more goods with limited resources, improve total productivity of society, promote rational utilization of resources, and reduce environmental pollution. All of these contribute to a better ecological environment on the earth.

By its nature, innovation is creation but more than creation. What is emphasized by creation is invention or bringing something about for the first time. Innovation, however, is an endless process of refining or improvement. Creation may be a new thing emerging that has no relation to the original one, but innovation is usually built on previous foundations. To some extent, the sprit of innovation is the inexhaustible driving force for the evolution of a nation, and the key to a nation's culture and economic prosperity.

In the 1960s and 1970s, a linear/chain model of technological innovation was widely accepted by developed countries. The innovation process is described as a sort of teamwork. Firstly, a new idea is produced at a laboratory then it is the turn of the design department to establish a flow chart of production. The manufacturing department produces products according to technical documents provided by the design department and finally products are put on the market for sale.

It was not until the 1980s that Western scholars noticed long-term uncertainty characteristics of technological innovation. Many successive studies have revealed that the technological innovation process and spatial distribution are much more complicated than previously realized. There are complicated interactions among research and development, production, marketing, and sales through information exchanges between different departments. Technological innovation is not a one-way process; from invention to diffusion, it may have different starting points. Opportunities of innovation may exist in each section of all activities in the chain of valuation of a factory or a company, such as raw materials supply, manufacturing, and sales. Innovation begins in the practicalities of production. The concept of technological innovation has been expanded to a comprehensive process with increasingly complicated interactions.

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Biographical Sketch

Dr. Ying Chen was born in April 1969 and is now an associate researcher with the Institute of World Economics and Politics, Chinese Academy of Social Sciences. Dr. Chen graduated from the Chemical Engineering Department of Tsinghua University, Beijing, in July 1997 and she is now engaged in research of environmental and natural economics. Her areas of interest include global environmental problems, climate change economics, and sustainable development indicators.