Reshaping the Relationship between Environment and Development: A Theoretical Framework under the Paradigm of Eco-civilization and Its Policy Implications*

Zhang Yongsheng

University of Chinese Academy of Social Sciences; Research Institute for Eco-civilization, CASS

Abstract

This study investigates the sustainability implications of the theoretical models of industrialization and urbanization pioneered by Dixit and Stiglitz[1] so to open the theoretical "black box" of the unsustainability of the traditional industrialization mode, and shows how to reshape the relationship between the environment and development under the paradigm of ecological civilization. It finds that the theoretical models that "perfectly" simulate the traditional industrialization mode all have the implicit consequence of environmental unsustainability. Nonetheless, this limitation is not due to the problems of the models themselves but is more a result of the limitations of the traditional developmental and neoclassical economics paradigms of the industrial era. Therefore, the consequences of unsustainability cannot simply be avoided through external policies such as technological progress and environmental regulations, nor can they be prevented by simply adjusting some parameters in these theoretical models. Instead, a shift is required in both the developmental and the economics paradigms formed in the traditional industrial era. From an ecological civilization perspective, this study rethinks the basic issues of economics along the two lines of the ends (what) and the means (how) of development; briefly reviews the history of economic thought; and uses a conceptual framework to reorganize the relevant intellectual profundities that are neglected in standard neoclassical economics. The study further formalizes the conceptual framework in a general form model and shows how a paradigm shift in development could shift the trade-offs from the multiple goals of the economy, the environment, and well-being in the traditional industrial era to mutual reinforcement in eco-civilization.

Keywords: environment and development, ecological civilization, paradigm shift of

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1   A. Dixit and J. Stiglitz, "Monopolistic Competition and Optimum Product Diversity," pp. 297-308.

development, Dixit and Stiglitz model, theoretical models of industrialization, theory of urbanization

I. Introduction

The traditional development paradigm established after the Industrial Revolution had as its main goal the mass production and consumption of material wealth. This traditional industrialization mode based on anthropocentrism, economic materialism, and rationalism has unprecedentedly promoted productivity and the liberation of man, while facilitating industrial civilization. However, economic materialism cannot fully represent the human goals of a good life.[2] Anthropocentrism puts people above nature,[3] which inevitably leads to an unprecedented global environmental crisis.[4] Without a paradigm shift in development, this complex systemic crisis cannot be resolved due to bounded rationality.[5] The concepts of ecological civilization and Chinese-style modernization represent China's endeavour to address the unsustainability crisis, which is essentially a redefinition of the unsustainable development paradigm and modernization model established after the Industrial Revolution.[6]

This feature of the traditional development paradigm is also reflected in the economics paradigm. From the rise of neoclassical economics after the Marginal Revolution of the mid- and late 19th century until Robbins defined economics as "the science which studies human behavior as a relationship between ends and scarce means which have alternative uses," the "science of choice" has become the standard neoclassical economics paradigm.[7] in which the objective function of the consumer is a typical embodiment of materialism and consumerism, that is, it aims to maximize the consumer's utility through the consumption of goods. The greater the material consumption, the greater the utility. However, a great volume of studies have shown that materialism and consumerism do not necessarily engender happiness.[8] The production function and its constraints are typically based on anthropocentrism, which entails the unrestrained seizure of tangible resources from nature to satisfy human beings' materialistic needs. The impact of production and consumption activities on the environment falls outside the standard analysis of mainstream neoclassical economics. Environmental economics is more an application of standard economics as a branch or marginal subject

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2   T. Scitovsky, *The Joyless Economy: The Psychology of Human Satisfaction.*
3   S.E. Boslaugh, "Anthropocentrism."
4   M. Rockström *et al.*, "A Safe Operating Space for Humanity," pp. 461, 472-475; IPCC, "Summary for Policymakers."
5   H.A. Simon, "Theories of Bounded Rationality."
6   Xi Jinping, "The Report to the 20th National Congress of the Communist Party of China."
7   Lionel Robbins, *An Essay on the Nature and Significance of Economic Science*. p. 15.
8   Adam Smith, *The Theory of Moral Sentiments*; John Maynard Keynes, "Economic Possibilities for Our Grandchildren"; A. Deaton, "Income, Health, and Well-Being around the World: Evidence from the Gallup World Poll," pp. 53-72; Richard A. Easterlin, "Does Economic Growth Improve the Human Lot?"; Richard A. Easterlin *et al.*, "The Happiness-Income Paradox Revisited."

dealing with environmental issues.

　　Though, at the empirical level, it has become a consensus that the traditional industrialization mode is unsustainable, the theoretical "black box" of unsustainability has yet to be fully revealed, rendering it difficult to find an effective solution to the problem of unsustainability. The current mainstream theories on industrialization and urbanization are all shaped under the paradigm of neoclassical economics.[9] Undoubtedly, these theories made pioneering contributions, but once one looks beyond the traditional industrialization perspective, the implicit consequence of the unsustainability of these models becomes apparent. The common practice has been to treat such issues as externalities to be dealt with separately by environmental economics as a sub-discipline of economics.[10]

　　However, the environmental issue is not so simple.[11] Underlying it requires rethinking of the basic issues of economics. Standard economics was largely a product of the traditional industrial age it served. The problems of unsustainable development and low well-being implicit in these theoretical models are not mainly due to the problems of the theories themselves, but are more a result of the limitations of the economics paradigm of the traditional industrial age. As Albert Einstein famously pointed out, "We cannot solve our problems with the same thinking we used when we created them." When the traditional industrialization model has to undergo a paradigm shift of development due to its unsustainability, the standard economics based on this model also faced a paradigm shift. Therefore, to address the crisis of unsustainability, we cannot simply apply standard economics to the eco-environmental field; rather, we need to rethink the basic issues of economics and even its philosophical foundation, including why we produce (why), what we produce (what), and how to produce it (how), to promote a paradigm shift in development and economics research.

　　The objectives of this study are to open the theoretical "black box" of the unsustainability of the traditional industrialization mode and show how the hitherto unsustainable relationship between the environment and development can be reshaped under the paradigm of eco-civilization, as well as providing new policy implications. Section Two presents a literature review that focuses on the ends and means of development and reveals the paradigm evolution of modern economics, as well as highlighting its limitations and noting the research significance of this paper. Section Three examines the existing mainstream theoretical models of industrialization and urbanization from an ecological civilization perspective and reveals the unsustainable mechanism of the traditional industrialization

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9　A. Dixit and J. Stiglitz, "Monopolistic Competition and Optimum Product Diversity," pp. 297-308; Masahisa Fujita and Paul Krugman, "When Is the Economy Monocentric?: Von Thünen and Chamberlin Unified," pp. 505-528.
10　A.C. Pigou, *The Economics of Welfare*; W.D. Nordhaus, "Climate Change: The Ultimate Challenge for Economics," pp. 1991-2014.
11　H. Demsetz, "The Problem of Social Cost: What Problem? A Critique of the Reasoning of A.C. Pigou and R.H. Coase."

mode. Section Four shows why technological progress and environmental regulations are not sufficient to address unsustainability. Section Five, based on a brief review of the history of economic thought along the two lines of the ends (what) and means (how) of development, establishes a conceptual framework from an eco-civilization perspective and further formalizes it with a general form model. Section Six provides a brief conclusion with new policy implications.

II. Literature Review

The modern economics formed after the Industrial Revolution is largely a product of and serves the traditional industrial age. The dilemma encountered by standard neoclassical economics is exactly the same as that encountered by the traditional development paradigm, making it difficult to explain and solve the unsustainability crisis.

   —*Development goals and their consequences.* The consumer objective function in standard neoclassical economics corresponds to materialism and cannot fully reflect the real objectives of consumer behavior. After the Marginal Revolution, the concept of utility as the consumer goal lost its original meaning of satisfaction or well-being, being adapted to a concept of preference.[12] The consumer's objective function in economics, a function corresponding to development ends and development content, is to maximize utility from material consumption for a given preference. Intangible or non-material and non-market content, such as environmental services, are not reflected in the standard utility function, so it is hard to reveal their influence on consumer behavior in terms of theory.[13] As Weber points out when discussing the spirit of capitalism, capital appreciation is not a means but an end in itself; making money is not a means but an end in itself.[14] However, maximizing wealth does not necessarily translate to maximizing well-being, which is the fundamental purpose of development.[15] Consequently, this leads to a divergence between the ends and means of development.

   —*Means of development and their consequences.* The production function and its economic constraints are based on anthropocentrism: man is above nature and sees nature as the object of resource grabbing.[16] Human beings with materialistic-based values seize or mass produce resources in a complex natural ecological system that they consider to be in line with their

12   William S. Jevons, *The Theory of Political Economy*; C, Menger, *Principles of Economics*; Léon Walras, *Éléments d'économie politique pure.*
13   Frank H. Knight, "The Limitations of Scientific Method in Economics."
14   Max Weber, *The Protestant Ethic and the Spirit of Capitalism.*
15   Adam Smith, *The Theory of Moral Sentiments*; John Maynard Keynes, "Economic Possibilities for Our Grandchildren"; A. Deaton, "Income, Health, and Well-Being around the World: Evidence from the Gallup World Poll"; R.A. Easterlin, "Does Economic Growth Improve the Human Lot?"; Richard A. Easterlin *et al*., "The Happiness-Income Paradox Revisited"; A. Etzioni, "The Good Life: An International Perspective."
16   S.E. Boslaugh, "Anthropocentrism."

own value preferences. This economic logic often conflicts with environmental and social logic.[17] Meanwhile, the waste generated in industrial production and consumption processes pollutes and destroys the environment. Accordingly, intangible ecological and environmental services not only find it difficult to play a role within the traditional industrialization mode, but to some extent are destroyed by this mode. This kind of damage to nature is bound to meet with a backlash from nature. Technological determinism is then seen as a way out of the conflict between environment and development.[18]

The standard development economics that emerged after World War II is the application of neoclassical economics in developing countries. Development is defined as the process of industrialization, urbanization, and agricultural modernization.[19] The early mainstream neoclassical development economics was the dual sector theory represented by Lewis.[20] Development economics in the 1940s and 1950s, such as circular cumulative causation, industrial linkages, and the big push theory, contained many profound ideas.[21] However, due to Marshall's Dilemma of the incompatibility of internal economies of scale and competition, the general equilibrium theory of the time could not deal with economies of scale. Consequently, these profound ideas were once silent after the 1950s and 1960s.[22]

This situation did not change until the late 1970s when Dixit and Stiglitz first introduced increasing returns into the general equilibrium model (hereafter referred to as the DS model),[23] thereby triggering an upsurge in economies of scale; new theories were born, including the new trade theory,[24] endogenous growth theory,[25] industrialization, new economic geography, urbanization theory,[26] and high development theory.[27]

With the continuous advancement of industrialization, environmental crises have become

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17   K. Polanyi, *The Great Transformation: The Political and Economic Origins of Our Time*.
18   D. Acemoglu *et al*., "The Environment and Directed Technical Change," pp. 131-166.
19   Zhang Peigang, *Agriculture and Industrialization: The Adjustments that Take Place as an Agricultural Country Is Industrialized*; Simon Kuznets, *Modern Economic Growth*.
20   W. Lewis, *The Theory of Economic Growth*.
21   Paul Rosenstein-Rodan, "Problem of Industrialization of Eastern and South-Eastern Europe"; Marcus Fleming, "External Economies and the Doctrine of Balanced Growth," pp. 241-256; R. Nurkse, *Problems of Capital Formation in Underdeveloped Countries*; T. Scitovsky, *The Joyless Economy: The Psychology of Human Satisfaction*; G. Myrdal, *Economic Theory and the Underdeveloped Regions*; Albert Hirschman, *The Strategy of Economic Development*.
22   Paul Krugman, "The Fall and Rise of Development Economics."
23   A. Dixit and J. Stiglitz, "Monopolistic Competition and Optimum Product Diversity."
24   Paul Krugman, "Increasing Returns, Monopolistic Competition, and International Trade." G. Grossman and E. Helpman, "Product Development and International Trade," [1989] "Trade, Innovation and Growth" AND/OR "Comparative Advantage and Long-run Growth" [both 1990].
25   Paul Romer, "Increasing Returns and Long-run Growth" and "Endogenous Technological Change"; K. Judd, "On the Performance of Patents."
26   W. Ethier, "National and International Returns to Scale in the Modern Theory of International Trade"; Masahisa Fujita and Paul Krugman, "When Is the Economy Monocentric?: von Thünen and Chamberlin Unified."
27   K. Murphy, A. Shleifer and R. Vishny, "Industrialization and the Big Push."

increasingly severe. Although Pigou's "welfare economics" had laid the theoretical foundation for environmental economics as early as 1920, environmental economics has basically been regarded as the application of standard mainstream economics to environmental issues.[28] Its central issue principally entails dealing with the externalities of different stakeholders to seek a so-called Pareto optimal pollution level in an economic sense, rather than to understand and resolve the unsustainable development crisis from the perspective of the relationship between "man and nature."[29]

To a large extent, standard neoclassical economics believes in solving environmental problems under the model of "pollute first, clean up later." On the relationship between environment and development, the most influential hypothesis is the so-called inverted U-shaped environmental Kuznets curve (EKC).[30] This hypothesis is the basis of the "pollute first, clean up later" rationale, which is essentially contrary to environmental protection. The EKC hypothesis is a defence of neoclassical economics' traditional development model. It believes that there is no need to worry about environmental issues because when the economy grows to a certain level, the cost of environmental cleaning up will then become affordable. Current research on environmental issues focuses on how to pass through or lower the peak of the EKC curve as early as possible. However, this theory, regarded as the standard by many people, is not a law of economic development and is somehow misleading.[31]

Although ecological and environmental issues are attracting increasing attention from economics, and ecological economics, environmental economics, and resource economics have been established as sub-disciplines of economics, ecological and environmental issues are far from being integrated into mainstream economic analysis.[32] According to Polasky et al.,[33] the current research on sustainable development is mainly carried out by natural scientists. If we take development economics as an example, one could say that mainstream development economics does not seem to reflect deeply on development issues from a sustainable perspective.[34] The existing research on ecological and environmental issues is mostly carried out on the premise that the environment and development are in conflict, with a focus on how to internalize external costs (environmental economics), impose ecological and environmental capacity constraints on economic growth (ecological economics), or seek greater room for compromise through technological or governance efficiency improvements (resource economics). For example, the core content of ecological economics is the scale of growth, efficiency, and distribution. As the

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28   A.C. Pigou, *The Economics of Welfare*.
29   R. Coase, "The Problem of Social Cost," pp. 1-44; A.C. Pigou, *The Economics of Welfare*.
30   G. Grossman and A.B. Kreuger, "Economic Growth and the Environment," pp. 353-377.
31   UNEP, "Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication"; D.I. Stern, "The Rise and Fall of the Environmental Kuznets Curve."
32   K. Arrow *et al.*, "Economic Growth, Carrying Capacity, and the Environment," pp. 91-95.
33   S. Polasky *et al.*, "Role of Economics in Analyzing the Environment and Sustainable Development."
34   E. Duflo, M. Kremer and J. Robinson, "Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya."

scale of growth is limited by the carrying capacity of the eco-environment, attention is given to the efficiency of resource allocation and fair distribution.[35]

In short, environmental issues are not within the mainstream framework of the standard neoclassical economics paradigm. The study of environmental issues is merely an application of standard economics in the environmental field. However, as standard neoclassical economics is largely a product of the development paradigm of the traditional industrial age, when the unsustainability of that development paradigm necessitates a shift, the economics paradigm on which it is based must also shift.

III. Examining the Relationship between the Environment and Development in Mainstream Industrialization Theories

Undoubtedly, the existing theoretical models of industrialization pioneered by the DS model have "perfectly" simulated the traditional industrialization process. This has laid the foundation for us to open the theoretical "black box" of unsustainability in the traditional industrialization model. This section examines the series of industrialization and urbanization theories based on economies of scale that emerged in the late 1970s and reveals the ecological and environmental consequences implied by these models. We first use a simplified version of the DS model to reveal the mechanism of the traditional industrialization model, examine its environmental and well-being consequences from the new perspective of eco-civilization, and then apply this analysis to related derivative theoretical models.

1. Standard industrialization theoretical model

Industrialization is a process in which a variety of industrial final products (horizontal) and roundabout production chains (vertical) constantly increases or enlarges. The DS model first introduced increasing returns to scale into the general equilibrium model to endogenize the number of industrial final products, thereby triggering an upsurge in economies of scale. Ethier used the basic method of the DS model to endogenize the number of intermediate products.[36] Together, these two models can be used to provide a comprehensive analysis of the microeconomic mechanisms of the industrialization process. As the DS model is the basis of such models, we mainly examine the environmental consequences implied by the DS model and then extend the analysis to a series of models based on the DS model and other related theories.

The story of the DS model is as follows: the consumption of industrial products has a constant elasticity of substitution (CES) utility function; the more industrial varieties consumers consume, the greater their utility. There are economies of scale in production; the larger the size of the firm, the higher the productivity. However, the more numerous the varieties of industrial products, the smaller is the production scale of each firm, and the higher

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35   B. Czech, "The Neoclassical Production Function as a Relic of Anti-George Politics: Implications for Ecological Economics," pp. 2193-2197.

36   W. Ethier, "National and International Returns to Scale in the Modern Theory of International Trade."

the unit product cost and price. This has the effect of decreasing utility for consumers. This trade-off can be used to endogenize the number of consumer goods. Therefore, the expansion of population size (or through regional economic integration or international trade) can expand the space for the trade-off, thereby bringing about simultaneous improvements in productivity, firm size, utility, and product variety. Because the purpose of this study is to reveal the microeconomic mechanism of industrialization and its environmental consequences, we skip the technical details of the DS model and present its basic ideas in a simplified version.[37]

Consumers have the following CES utility function with a love of variety among industrial products, and the decision problem is:

$$Max \; u = (\sum_{i=1}^{n} x_i^{\rho})^{1/\rho} \tag{1}$$

$$\text{s.t.} \; \sum_{i=1}^{n} p_{xi} x_i = I \tag{2}$$

where x_i is the different industrial products consumed, p_{xi} is the price, n is the number of endogenous product variety, and I is income. Assume the model is symmetric so all x_i are the same.

Suppose the production function of x_i has economies of scale. There is monopolistic competition, and one firm produces one type of product:

$$x_i = (L_i - a)/b \tag{3}$$

where L_i is labor, a is fixed cost, and b is variable cost. This means that the larger the production scale of the firm, the lower the cost. Owing to monopolistic competition and free entry, firms make zero profits. The zero-profit condition makes it easy to solve the supply function.

As the objective of this study is to reveal the implications of this model for sustainability, we will not repeat the specific results of the general equilibrium solution but only give the results of a comparative statics analysis of the equilibrium solution to illustrate how different parameter changes affect the environment.[38]

$$\frac{\partial n}{\partial M} > 0, \frac{\partial u}{\partial M} > 0, \frac{\partial x_i}{\partial M} > 0, \frac{\partial L_i}{\partial M} > 0, \frac{\partial p_{xi}}{\partial M} < 0 \tag{4}$$

where M represents the population size. Equation (4) means that with the expansion of population size, the equilibrium variety of industrial consumer goods, utility, output, average firm size, per capita income, and so on, all increase while prices decrease. The following points are particularly important for revealing the relationship between growth, the environment, and well-being.

First, the increasing returns to scale in the DS model are based on economies of scale to population, but this does not necessarily mean that the premise of economic development is the absolute expansion of a country's population size. It can also be achieved through

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37   Yang X.K., *Economics: New Classical versus Neoclassical Frameworks*.

38   For the results of the simplified version of the DS model, see Yang X.K., *Economics: New Classical versus Neoclassical Frameworks*, Ch. 11.

economic integration or international trade through the improvement of transaction conditions. For example, the benefits of economies of scale can be shared when formerly separate economies integrate into a single large market. Therefore, the traditional industrialization model is highly dependent on globalization.

Second, in the DS model, there is no limit to the expansion of total output, and the impact of expansion on the environment is not included in the analysis. As long as the population size M or the degree of economic integration increases, and/or technology continues to advance, total output $X = \sum^{x_i}$ will continue to expand, and consequently the impact of the continuous expansion of X on the environment will inevitably continue to increase.

Third, the DS model adopts the standard neoclassical concept of utility. Since utility is a function of goods consumption and cannot really represent consumers' objective of a "good life," high growth or high utility does not necessarily mean high well-being.

2. Consequences of unsustainability

Next, we show that once environmental constraints are introduced, the implicit consequences of unsustainability in the model will emerge, and such consequences cannot be eliminated simply through technological progress and environmental regulations but must be solved via the transformation of development content. This, in turn, involves rethinking the basic issues of economics, such as value theory and preference, and thus a re-specification of the utility function and the production function is required, as well as constraint conditions in the model. In sum, we cannot simply leave environmental consequences to environmental economics without changing the theoretical model of industrialization.

Assume that the environmental carrying capacity for sustainable development is $\bar{E}$. If the environmental footprint of economic development is within this capacity, then the environmental footprint can be purified and adjusted by nature itself, so development is sustainable in this case. Otherwise, it is unsustainable.[39] The relationship between economic development and environmental sustainability is

$$E = e \cdot X < \bar{E}, \frac{\partial E}{\partial e} > 0, \frac{\partial E}{\partial X} > 0 \tag{5}$$

where E is the environmental footprint, e is the environmental intensity of unit output, X is the total economic output, and $\bar{E}$ is the environmental capacity. Once the environmental footprint E of economic activities exceeds the environmental capacity $\bar{E}$, that is, $E \geq \bar{E}$, the eco-environment system will collapse. $\frac{\partial E}{\partial e} > 0, \frac{\partial E}{\partial X} > 0$ means that when other conditions remain unchanged, the environmental footprint E decreases as environmental intensity e decreases, while it increases as output X increases.

From Equation (5), we can obtain the upper limit $\bar{X}$ of X output under environmental carrying capacity, that is

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39   Zhang Y.S., "Why Should Carbon Neutrality Be Integrated into the Construction of Ecological Civilization: A Theoretical Explanation and Policy Implications."

$$\bar{X} = \frac{\bar{E}}{e} \qquad\qquad\qquad (6)$$

This means that if the content of growth is not transformed, the improvement in the upper limit of economic growth $\bar{X}$ can only be achieved through a decrease in e, that is, technological progress. However, in the DS model, there is no limit to the expansion of the aggregate output of X: the more, the better. As long as the population size continues to expand (or the market becomes more integrated), transaction efficiency continues to increase (transaction efficiency can be introduced into the model), and production technology continues to progress (a decrease of a and b in the production function), the total output X will continue to increase. If the content of economic growth is only based on X without green transformation, the scope of e to decline will be limited, and the output of X will eventually exceed the upper limit of environmental unsustainability.

3. Examination of a series of theoretical models of industrialization, urbanization, and trade theory

Other models with economies of scale emerged after 1977, including theoretical industrialization models, urbanization and economic geography models, and trade theory, have all been developed based on the DS model. Therefore, the conclusions drawn from the examination of the unsustainability consequences of the DS model are also applicable to these derived models.

(1) Etheir's model endogenizes the number of intermediate products[40]

Assume that the economy has two final consumer goods, food y and industrial good z. The industrial product Z is produced by labor and compound intermediate products composed of all x_i, and the production of Z displays constant returns to scale, that is, $Z = [\sum_{i=1}^{n} (kx_i)^{\rho}]^{\beta/\rho} Lz^{1-\beta}$, where the composite intermediate product is a CES function of many intermediate products x_i. The greater the variety number n of x_i, the greater the complementary effect in Z production. k is the transaction efficiency of x_i. The production function of the intermediate product is $x_i = (L_{xi} - a)/b$ with economies of scale. The larger the production scale of x_i, the higher the productivity of the final product Z. However, for a given population size, the larger the production scale of each intermediate product x_i, the smaller the number n of endogenous intermediate products, which will reduce the complementary effect in Z production. Therefore, the trade-off can endogenize the number n of intermediate products. The expansion of population (or regional or global economic integration) and the improvement of transaction efficiency will expand the space for this trade-off. As the technical essence of Ethier's model is the same as that of the DS model, the examination results of the environmental effects of the DS model are also applicable to it.

(2) Big push industrialization model[41]

This model was to formalize the big push industrialization theory of Rosenstein-Rodan in

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40   W. Ethier, "National and International Returns to Scale in the Modern Theory of International Trade."

41   K. Murphy, A. Shleifer and R. Vishny, "Industrialization and the Big Push."

order to explain the coordination problem in the industrialization process. It is assumed that each product can be produced either by traditional technology with constant returns to scale or by modern enterprises with economies of scale. In the absence of the coordination of a big push, multiple equilibrium outcomes would occur. This big push industrialization process is reflected in the equilibrium of the jump from the low-level cottage industry to modern industry. As the size of the population increases, the equilibrium level of industrialization increases discontinuously. This indicates a substantial increase in output X. Evidently, once we consider the ecological and environmental impact of economic activities in the model, the impact of industrialization on the environment will increase discontinuously.

(3) Urbanization model[42]

The production and consumption functions of industrial products in this model are the same as those in the DS model. The basic idea of a simplified version is that consumers consume an agricultural product z and n types of industrial products x_i, and the consumption of industrial products is a CES function. Assume that industrial production does not require land, and that its production has economies of scale, that is, $X_i = (L_{xi} - a)/b$. All manufacturers reside in cities, and agricultural production requires land. It is assumed that there is no transaction cost within the agricultural or industrial sector, but there is a transaction cost between the urban and rural sectors. Therefore, as the population size and/or the trading conditions of agricultural products improve, the number of industrial varieties and their physical output will expand, and the level of urbanization will also increase (to a certain degree). Therefore, the results of the unsustainability in the DS model are also applicable to the Fujita-Krugman model.

(4) International trade model[43]

Krugman's international trade theory is the application of the DS model in the field of international trade, so the examination results of the DS model are also applicable to it. International trade is equivalent to expanding the population size of the trading country, which makes the scale of the firm in the trading country expand, thereby resulting in internal economies of scale. The international trade theory based on economies of scale differs from the previous trade theories based on absolute[44] and comparative (technology, endowment) advantages.[45] Even when all conditions of the two countries are exactly the same, they can be better off from international trade due to economies of scale. Hence, globalization is a driving force for economic growth in the traditional industrialization model.

Although the models examined above all appeared after 1977, in fact, as the standard neoclassical economic analysis does not include environmental issues, either neoclassical

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42   Masahisa Fujita and Paul Krugman, "When Is the Economy Monocentric?: von Thünen and Chamberlin Unified," pp. 505-528.

43   Paul Krugman, "Increasing Returns, Monopolistic Competition, and International Trade."

44   Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*.

45   D. Ricardo, *The Principle of Political Economy and Taxation*; E. Heckscher, "The Effect of Foreign Trade on the Distribution of Income"; B. Ohlin, *Interregional and International Trade*.

industrialization, urbanization theories before 1977,[46] or theories that differ from the neoclassical approach mostly imply unsustainability problems.[47]

IV. Can Technological Progress and Environmental Regulations Solve Unsustainability Problems

So, can the unsustainability problem implied by the DS model and its derived models be solved? The standard neoclassical thinking is that without changing both the developmental and economics paradigms, environmental problems can be solved by relying on technological progress and environmental regulations, and the abovementioned series of theories based on standard neoclassical economics do not need to be changed because the environmental issues engendered by industrialization can be dealt with separately via environmental economics. In this section, we show that although technological progress and environmental regulations can achieve Pareto improvements in environmental protection and economic growth to a certain extent, they cannot fundamentally solve the environmental crisis, and profound changes in the development paradigm and research paradigm are required.

1. Technological progress is not sufficient to solve the environmental crisis

We use the environmental intensity e to represent the green technology level of output X. It can be seen from Equation (6) $\bar{X} = \frac{\bar{E}}{e}$ that when technological progress leads to a decline in environmental intensity e, it will expand the space for the trade-off between the environment and development, thereby increasing the output upper limit value $\bar{X}$. However, technological progress does not necessarily guarantee meeting the conditions for sustainable development.[48] Here, we use superscripts to denote the environmental footprint E', environmental intensity e', and output X' after technological progress; thus, the environmental consequences before and after technological progress are $E = e \cdot X$ and $E' = e'X'$, respectively. We have

$$E' < E, \text{ if and only if } \frac{e'}{e} < \frac{X}{X'} \tag{7}$$

In the DS model, since $\frac{\partial x}{\partial M} > 0$, it means that as long as the population M increases or economic integration is sufficiently fast, the increase of X would be sufficiently fast as well, the condition $\frac{e'}{e} < \frac{X(M)}{X'(M')}$ would become difficult to meet, and an unsustainability crisis would would arise. That is to say, if the environmental damage caused by output expansion exceeds the environmental improvement effect from technological progress, the environment would continue to deteriorate.

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46   For example, W. Lewis, *The Theory of Economic Growth.*
47   For example, Shi H-L. and Yang, X., "A New Theory of Industrialization"; Yang X.K., "Development, Structure and Urbanization."
48   Zhang Y.S., "Why Should Carbon Neutrality Be Integrated into the Construction of Ecological Civilization: A Theoretical Explanation and Policy Implications."

Then, is it true that growth would be sustainable as long as Formula (7) $\frac{e'}{e} < \frac{X}{X'}$ is satisfied? The answer is no. Assume that the government imposes strict environmental technical standards to ensure that the condition of $\frac{e'}{e} < \frac{X}{X'}$ is satisfied at any point in time, so there is $E' < E$. However, once the time dimension is introduced, the cumulative environmental consequences of economic activities will eventually exceed the environmental capacity at a certain point, that is,

$$\int_0^t E(s) \cdot ds > \bar{E} \tag{8}$$

Much research has been done on the paradox of technological progress in solving environmental problems. Technological progress does not always lead to sustainable outcomes, and, in some cases, it may even exacerbate environmental crises.[49] Jevons revealed the counter-intuitive phenomenon that the improvement in the efficiency of the British coal industry led to an increase in coal consumption, which was a universal law in the economy.[50]

2. Environmental regulations are not sufficient to solve the environmental crisis

As environmental issues are not usually considered in the standard neoclassical economics analysis and the concept of standard neoclassical utility is inconsistent with the concept of well-being, the market equilibrium consumption bundle (x, y) that is simply obtained according to the utility maximization objective often deviates from the goals of environmental optimization and welfare maximization. On the indifference curve representing the same level of utility, there are an infinite number of consumption combinations. Although these consumption combinations all have the same utility, their environmental effects $E = e_x X + e_y Y$ differ. For simplicity, we herein randomly select four consumption combinations, $u_1(2,10) = u_2(4,5) = u_3(5,4) = u_4(10,2)$. We assume that $u_3(5,4)$ is the market equilibrium that satisfies the goals of consumer utility maximization and producer profit maximization. However, this economically optimal consumption combination $(5,4)$ is one of the combinations with the greatest environmental consequences among the four. Suppose x is a type of non-green product and y is a type of green product, and their environmental intensities are $e_x = 2$ and $e_y = 0$, respectively. The environmental consequences of the above four consumption combinations are as follows: $E_1(2,10) < E_2(4,5) < E_3(5,4) < E_4(10,2)$.

Indeed, we can improve the environment without reducing utility through environmental regulations. As long as x and y are normal goods, the relative price P_x / P_y can be increased by punishing the non-green X manufacturers and compensating the green Y manufacturers for their ecological services, so that the equilibrium (x, y) could approach to $(2,10)$ with a more

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49   See J.M. Polimeni *et al.*, *The Myth of Resource Efficiency: The Jevons Paradox*; M.H. Huesemann, "Can Pollution Problems Be Effectively Solved by Environmental Science and Technology? An Analysis of Critical Limitations"; M.H. Huesemann and Joyce Huesemann, *Techno-Fix: Why Technology Won't Save Us or the Environment*.
50   William S. Jevons, *The Coal Question: An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal Mines*.

optimal environment from (5,4).

However, the Pareto improvement between utility, the environment and well-being brought about by environmental regulations is insufficient to fundamentally shift the divergence to synergy among the three goals, since as long as the economy expands over the level of Equation (6) $\bar{X} = \dfrac{\bar{E}}{e}$, even for the consumption combination (2,10) with least environmental impact, the environmental impact will eventually exceed the environmental threshold.[51]

3. The deviation between growth and well-being under the traditional industrialization model

We further examine the well-being effects of traditional industrialization models. The fundamental purpose of development is to improve people's well-being. However, in neoclassical economics, utility has been adapted to a concept that only represents the order of preference among a set of goods bundles, and it cannot represent the good life of the consumer.[52] Therefore, it becomes normal that economic growth under the objective of maximizing utility deviates from the objective of maximizing well-being.

As utility is based on materialism, and the content of production and consumption corresponding to the gross domestic product (GDP) is also material, high per capita GDP does not necessarily represent high well-being. Although in these models, the utility U will increase with X and M, $\partial u / \partial X > 0$, $\partial u / \partial M > 0$, real well-being does not necessarily increase with output X and population M.[53] Consequently, so authors Stiglitz, Sen, and Fitouss have urged that the measurement of development performance should shift from GDP to well-being.[54] However, as the budget constraint corresponding to GDP is built into consumers' decision problem system, it is far from sufficient to simply change the measurement of development performance from GDP to well-being. It is necessary to rethink the underlying theory of value.

In short, from the perspective of sustainability and well-being, in both of the traditional developmental and the economics paradigms established after the Industrial Revolution, the objectives (what) of development cannot fully represent the "good life," and the means (how) to achieve this goal are based on anthropocentrism. The objective and the means reinforce

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51   Some authors have very different viewpoints on this and think that there is no need for a paradigm shift as long as tax or charges on pollution is sufficiently high. For instance, Y.K. Ng, "Optimal Environmental Charges/Taxes: Easy to Estimate and Surplus-yielding," pp. 395-408.
52   Antoine P.J. Artiganave, "The Good Life in the History of Economic Thought."
53   R.A. Easterlin, "Does Economic Growth Improve the Human Lot?"; R.A. Easterlin *et al*., "The Happiness-income Paradox Revisited"; Y.K. Ng, "From Preference to Happiness: Towards a More Complete Welfare Economics," pp. 307-350; T. Scitovsky, *The Joyless Economy: The Psychology of Human Satisfaction*; E. Skidelsky and R. Skidelsky, *How Much Is Enough?: Money and the Good Life*; N. Goodwin *et al*., "Consumption and the Consumer Society"; Chandra Mukerji, "The Birth of a Consumer Society"; A. AtKisson, *Life beyond Growth: Alternatives and Complements to GDP-measured Growth as a Framing Concept for Social Progress (2012 Annual Survey Report)*; Thorstein Veblen, *The Theory of the Leisure Class*.
54   J. Stiglitz, "GDP Is a Wrong Tool for Measuring What Matters"; J. Stiglitz, A. Sen and J. Fitouss, "Report by the Commission on the Measurement of Economic Performance and Social Progress, Paris."

each other, leading not only to a deviation in the ends and means of development but also to environmental unsustainability.

V. A New Relationship between the Environment and Development under the Paradigm of Ecological Civilization

To solve the ecological and environmental crises, we cannot simply apply standard neoclassical economics to the problems, but should rethink the basic issues of economics from the perspective of ecological civilization. This kind of reflection can be carried out along "one perspective, two lines, and three sources." The "one perspective" concept refers to the perspective of eco-civilization. The "two lines" are two basic issues of economics, that is, the ends of development (what) and the means of development (how). Outside the standard neoclassical economics paradigm, profound ideas exist vis-à-vis "what" and "how" in "the three sources": 1) the profound economic thought neglected in standard neoclassical economics, 2) emerging ideas that challenge standard neoclassical economics, and 3) the relevant ancient Chinese and Western philosophical thoughts prior to the Industrial Revolution. However, these scattered and profound ideas need to be reorganized under a new paradigm that would enable them to converge into a new river of thoughts. This new inclusive paradigm is eco-civilization. This section first establishes a conceptual framework and subsequently formalizes the framework with a general form model.

1. Rethinking the ends and means of development: a conceptual framework

In fact, "outside the box" of neoclassical mainstream economics, profound thinking on the basic issues of economics, such as the ends and means of development, shines like stars. As it is hard to deal with these ideas under the framework of and with the tools of mainstream economics, or if they are inconsistent with mainstream theories, they are often ignored (un)-intentionally. We do not aim to comprehensively review these ideas but to briefly outline "three sources" for "thinking outside the box" of mainstream standard economics.

The first is the profound thinking neglected in the history of economic thought. This includes the ideas of Adam Smith, known as the father of modern economics, and John Maynard Keynes, the father of macroeconomics. Smith's and Keynes' insights on the good life in *The Theory of Moral Sentiments* (1759) and "The Economic Possibilities of Our Grandchildren" (1930) were each overshadowed by their later masterpieces, *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776) and *The General Theory of Employment, Interest and Money* (1936), and hence were ignored.

—*On the ends and means of development*. Smith points out in *The Theory of Moral Sentiments* that the productivity of the market economy is driven by the misguided belief that wealth brings happiness. "It is this deception which rouses and keeps in continual motion the industry of mankind...which have entirely changed the whole face of the globe." However, modern economics focuses more on how to increase national material wealth within the

framework of *An Inquiry into the Nature and Causes of the Wealth of Nations*, and does not pay much attention to Smith's thoughts on the good life for the purpose of development. Keynes paid much attention to "the real value of life" and did not think that solving economic problems was the ultimate goal of human beings, pointing out that "If the economic problem is solved, mankind will be deprived of its traditional purpose." "We shall once more value ends above means and prefer the good to the useful," "but, chiefly, do not let us overestimate the importance of the economic problem, or sacrifice to its supposed necessities other matters of greater and more permanent significance."[55] Keynes' idea is actually about a new paradigm of development.

—*On the relationship between man and nature*. This relationship is essentially an issue of whether man is part of or above nature. The former is the idea of eco-civilization, while the latter is the idea of industrial civilization. Mill, a representative figure of classical economics, points out that the unlimited industrial expansion of human beings will destroy the natural environment.[56] He sees the "stationary state" as a desirable outcome. However, "It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. There would be as much scope as ever for all kinds of mental culture, and moral and social progress, as much room for improving the Art of Living, and much more likelihood of its being improved, when minds ceased to be engrossed by the art of getting on." Mill's idea is actually about a paradigm shift of development.

—*On the limitations of the traditional industrialization mechanism*. As a representative figure of the Marginal Revolution and neoclassical economics, Jevons proposed the Jevons paradox: counter-intuitively, the improvement of energy efficiency actually leads to an increase in energy consumption, which implies the intrinsic mechanism underlying the way technological progress in the traditional industrialization model leads to unsustainability.[57] Despite this, the current focus on the Jevons paradox is more on the narrow energy rebound effect.

The second is the idea of challenging standard neoclassical mainstream economics, including several streams of the literature on behavioral economics, experimental economics, happiness economics, economics of the division of labor and specialization, and so on. These studies show that, for instance, because the standard utility function fails to describe the real goals of individuals, in many cases behavior does not conform to the behavioral patterns predicted by standard economics.[58] These research works provide important theoretical sources and empirical support for developing a new line of research under the eco-civilization

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55   John Maynard Keynes, "Economic Possibilities for our Grandchildren."
56   J.S. Mill, *Principles of Political Economy, with Some of Their Applications to Social Philosophy* (2 vols).
57   William S. Jevons, *The Coal Question: An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal Mines*.
58   A. Sen, "Rational Fools: A Critique of the Behavioral Foundations of Economic Theory," pp. 317-344; V. Smith, "Constructivist and Ecological Rationality in Economics"; Daniel Kahneman and Amos Tversky eds., *Choices, Values, and Frames*; Richard H. Thaler, "Behavioral Economics: Past, Present,

paradigm.

The third is philosophical thought prior to the Industrial Revolution. Eco-civilization represents a new form of civilization that differs from industrial civilization. The developmental paradigm and modern economics established after the Industrial Revolutionare based on the philosophy of anthropocentrism, materialism, consumerism, and rationalism, which emerged after the Renaissance and the Enlightenment. Therefore, to get out of the crisis of unsustainability, we must rethink the philosophical foundation of traditional development and economics paradigms. Prior to the Industrial Revolution, the dominant Western philosophy about the relationship between man and nature and about the good life was quite different from the anthropocentrism and materialism of the industrial era.[59] Traditional Chinese philosophy, in particular, emphasizes "harmony between man and nature," "the Tao follows nature," and "self-cultivation." This relationship between man and nature and its values were very different from Western materialism and anthropocentrism.[60] The idea of an eco-civilization formed on the basis of China's 5,000 years of fine cultural traditions provides a new direction for getting out of the unsustainability crisis of the traditional industrialization model.[61]

The different answers above to the questions of why, what, and how to develop can thus constitute a conceptual framework different from that of standard neoclassical economics. As different development purposes correspond to different development contents, so different contents correspond to different resource concepts. Different resources have different physical properties, which require different firm organization models, business models, and spatial forms; thus the above re-reflection and answering of questions mean a systematic shift in the developmental and economics paradigms. This rethinking on why, what, and how to develop are specifically reflected in the re-specification of the consumers' objective and production functions and their respective economic constraints, resulting in changes in the concepts of cost, benefit, well-being, utility, optimality, and so on. According to Kuhn's standard, such a systemic shift is a paradigm shift.[62] Next, we formalize the aforementioned conceptual framework. Because it is hard for a single specific functional form to fit into different situations, we use a more general functional form here.

2. *Reshaping the relationship between the environment and development: a general theoretical framework*

(1) Transition of the consumer decision system

As the standard neoclassical concept of utility cannot fully represent the objective of

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and Future," pp. 1577-1600; Elinor Ostrom, "Beyond Markets and States: Polycentric Governance of Complex Economic Systems," pp. 641-672; Yang X.K., *Economics: New Classical versus Neoclassical Frameworks*.
59　A. Kenny, *A New History of Western Philosophy*.
60　Fung Y-L, *A Short History of Chinese Philosophy*.
61　Xi Jinping, "The Report to the 20th National Congress of the Communist Party of China."
62　Thomas Kuhn, "The Structure of Scientific Revolutions."

consumers' behavior, it has received many criticisms and is at odds with the evidence.[63] Therefore, economics should somehow return to the concept of Marshall from that of Robbins' "science of choice," that is, "Economics is a study of man in the ordinary business of life."[64] This means that economics should study not only wealth maximization but also, more importantly, human behavior.

Accordingly, the standard neoclassical consumer decision system needs to undergo the following changes: first, the standard utility function should be redefined and expanded so that the concept of utility can shift from the neoclassical concept of pure preference to its original meaning of well-being.[65] The utility function should include not only the consumption of standard goods (x, y) but also the satisfaction of non-market and non-material needs N_c. In this case, the utility function is no longer a mere reflection of materialism and consumerism but is more representative of the overall needs of consumers for a "good life." Second, preference a is no longer just exogenously given but rather endogenously changing with income, identity, knowledge, education, culture, beliefs, institutions, policies, and so on.[66] This provides conditions for the green transformation of development content. Third is the introduction of environmental constraints in the consumer decision system. Thus, we have

$$Max \ U_{wb} = f(x, y, N_c, a) \tag{9}$$
$$s.t. \ p_x x + p_y y \leq 1 \tag{10}$$

where U_{wb} is the redefined utility concept, which is closer to the original concept of satisfaction or subjective well-being in economics. The utility function includes not only the two types of composite products, x and y, but also N_c, the abbreviation of nature or non-market, which represents non-market contents, such as the eco-environment and culture, or in a broader sense, security, social justice and fairness, and so on. N_c is non-rivalrous by nature and can be consumed by everyone in a particular region. It is "the most inclusive livelihood and well-being." Consumers do not need to pay directly for N_c, but it has a shadow price or opportunity cost; when consumers choose the level of x and y consumption, they consider the total satisfaction brought by (x, y, N_c, a), not just utility from consumption of goods (x, y). As

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63   Y.K. Ng, "From Preference to Happiness: Towards a More Complete Welfare Economics"; N. Stern, J. Stiglitz and C. Taylor, "The Economics of Immense Risk, Urgent Action and Radical Change: Towards New Approaches to the Economics of Climate Change"; J. Stiglitz, A. Sen and J. Fitouss, "Report by the Commission on the Measurement of Economic Performance and Social Progress, Paris"; M. Karacuka and A. Zaman, "The Empirical Evidence against Neoclassical Utility Theory: A Review of the Literature." OECD, "Better Life Initiative: Measuring Well-Being and Progress"; European Commission, "Beyond GDP Measuring Progress, True Wealth, and Well-being."
64   Alfred Marshall, *Principles of Economics* (8th Edition); L. Robbins, *Essay on the Nature and Significance of Economic Science.*
65   Y.K. Ng, "From Preference to Happiness: Towards a More Complete Welfare Economics." Also, there are various studies introducing more factors into the standard utility function, which suggests a wide consensus that standard utility function has its limitation.
66   G. Akerlof and R. Kranton, "Economics and Identity," pp. 715-753; Joan Robinson, *Economic Philosophy.*

the level of N_c is not directly determined by the individual consumer's behavior but by the sum of all consumers' behaviors, the introduction of environmental constraints to individual consumers then becomes a new function of government. N_c has a trade-off relationship with the growth of non-green product *X*, while it is mutually beneficial with the increase of green product *Y*. *a* is the preference parameter; p_x and p_y are prices of *x* and *y* respectively; and *I* is income, consisting of wages, resource income, and profit.

The redefinition of the utility function has a significant meaning. It can make the utility function more accurately reflect the objective of consumers' behaviors. If N_c is low, consuming more *x* and *y* does not necessarily mean higher utility U_{wb} than is the case with a higher N_c but less *x* and *y*. At present, economics has many skills to deal with N_c, including revealed preference, stated preference, or indirect pricing methods.

Meanwhile, the preference parameter *a* is no longer fixed but changes with income, culture, education, and other conditions, shifting from basic material consumption to more non-material consumption. Preference change is essential for the transformation of economic content.[67] In fact, the assumption of given preferences in neoclassical economics is more a result of the division of labor between economics, sociology, and psychology in order to make economics more like a science.[68] In psychology, sociology, anthropology, and marketing, preference change is a normal situation.[69] For simplicity, N_c and *a* can be deemed as exogenous parameters first and then treated as variables to be endogenized.

Note that the effective introduction of environmental constraints (climate, pollution, ecology and resources) into the consumer decision system requires further discussion. Whether to impose environmental constraints on the consumption or production side depends on which has the lowest transaction costs. For example, the government can establish an environmental account for all individuals, but if consumers' environmental footprint exceeds their environmental quota, they would need to purchase a quota from the market.[70]

(2) Transition of producer decision system

Accordingly, the producer's decision system should undergo the following transition: first, the transition of production content (what). Not only does the share of material products need to decline, but also the share of material inputs in the value of products. Second, the transition of production function (how): the non-rivalrous ecological services provided by nature should enter the value creation process, and become an important source of increasing

67   N. Stern, J. Stiglitz and C. Taylor, "The Economics of Immense Risk, Urgent Action and Radical Change: Towards New Approaches to the Economics of Climate Change."
68   L. Robbins, *Essay on the Nature and Significance of Economic Science.*
69   E. Dekel, J.C. Ely and O. Yilankaya, "Evolution of Preferences"; G.S. Becker, "Altruism, Egoism, and Genetic Fitness," pp. 817-826; J. Hirshleifer, "Economics from a Biological Viewpoint," pp. 1-52; P. Rubin and C. Paul, "An Evolutionary Model of Taste for Risk," pp. 585-596; R.H. Frank, "If Homo Economicus Could Choose His Own Utility Function, Would He Want One with a Conscience?", pp. 593-604; W. Rostow, *Stages of Economic Growth*; Till Grüne-Yanoff and Sven Ove Hanson, eds., *Preference Change: Approaches From Philosophy, Economics and Psychology.*
70   Liu Shijin, ed., "Introduction."

returns for economic growth. Third, the transition of firm and corporate governance: corporate governance needs to shift from shareholder to stakeholder governance, including environmental and social stakeholders (or ESG). Fourth, a shift in corporate organizational forms and business models: because of the tradability of intangible inputs and services that differ from material resources and products, as well as their non-rivalrous characteristics, they require different business models. Fifth, the market structure should change from the impersonal market under traditional mass production to also emphasizing the personal market, which is crucial for realizing such intangible value as customized products.

Assume that the economy consists of two categories of products (X_i, Y_j), where X_i is industrial or material products and Y_j is new green service products. $i = 1, 2, ..., m; j = 1, 2, ..., n$. Here m and n represent the endogenous variety number of X_i and Y_j, respectively. The continuous expansion process of m and n is the continuous evolution process of the division of labour. At the same time, the government collects environmental fees from the polluting firms X_i and rewards the green firms Y_j.

1) The transition of the production mode of material products x_i. Both the objective function of the firm and its constraints are re-specified. The government collects an environmental fee of t per unit of output from x_i firms, which is used to compensate green y_j firms. An environmental cost tx_i is introduced into the objective function of the firm to maximize the profit of shareholders while satisfying the interests of other stakeholders. Therefore, the relative prices of resources, labor, and products will change, as will the optimal decision of the firm.

Assume that the production of x_i requires inputs of exhaustible natural resources N_{x_i} (including minerals, raw materials, etc.) and labour l_{x_i}. Production has monopolistic competition and each x_i product is produced by one firm. Therefore, the production function of each x_i firm is $x_i = f(N_{x_i}, l_{x_i})$. To further introduce the production function with intermediate products, one can refer to Ethier (1982).

$$Max \ \pi_x = p_{xi}x_i - \omega l_{x_i} - p_{N_{x_i}}N_{x_i} - tx_i \tag{11}$$
$$s.t. \ x_i = f(N_{x_i}, l_{x_i}) \qquad \text{(production function)} \tag{12}$$

where N_{x_i}, l_{x_i}, ω and $p_{N_{x_i}}$ represent natural resources, labor, wage, and resource price, respectively.

The production of x_i has internal economies of scale. As the input increases to m times, the output is greater than m times, that is, $f(mN_{x_i}, ml_{x_i}) > mf(N_{x_i}, l_{x_i})$. As there is free entry under monopolistic competition, the firm's decision problem can be solved with the zero-profit condition.[71]

2) The production of emerging green products y_j: the industry-level increasing returns effect and the transition of organizational form. Assume that the production of y_j needs two types of

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71   See Dixit and Stiglitz's assumptions and method. A. Dixit and J. Stiglitz, "Monopolistic Competition and Optimum Product Diversity."

input, intangible green ecological resources N_y and labour l_{y_j}, to translate "green" into "gold."

$$Max\ \pi_y = p_{y_j} y_j - \omega l_{y_j} + \frac{tX}{n} \tag{13}$$

$$s.t.\ y_j = f(N_y, l_{y_j}) \tag{14}$$

where N_y provides intangible ecological services in value creation and is non-rivalrous. N_y is essentially the same as N_c in the utility function, with different subscripts representing whether it is in production or consumption. Each firm of y_j can use all N_y for free. For example, a good eco-environment can improve the quality of all health, sports, catering, education, hotels, agricultural products, and other products in the region. ω is the wage, and $\frac{tX}{n}$ is the environmental compensation to each firm of y_j.

Interestingly, as N_y is exogenously given to the individual firm, the firm y_j can only increase its output by increasing its labour input l_{y_j} with diminishing returns to scale. However, the total productivity of industry Y has the effect of "1+1>2" because the non-rivalrous factor N_y can be repeatedly used by all firms of y_i, which is an important source of increasing returns in industry Y. Assuming that the input of l_{y_j} in a firm of y_j increases to n times, that is, from l_{y_j} to L_y, the output is $y_j = f(N_y, nl_{y_j}) = f(N_y, L_y)$. However, since N_y can be repeatedly used by all firms simultaneously, the total productivity of all y_j firm $nf(N_y, l_{y_j})$ is greater than the output $y_j = f(N_y, L_y)$ of a single firm increased to n times, that is, $nf(N_y, l_{y_j}) > f(N_y, nl_{y_j})$.

The increasing returns effect of the non-rivalrous resource N_y here differs from that of Romer's study on the nonrivalry of "ideas."[72] First, Romer's study uses increasing returns of non-rivalrous ideas to more effectively produce the same kinds of products as before, while this study uses increasing returns of non-rivalrous ecological resources and services to produce different green final products, that is, use N_y for y_j. The former can be classified as the direction for a "green industrial civilization" relying on improving "how" via technological innovation without changing "what"; this will eventually lead to unsustainability. The latter is the direction of sustainable ecological civilization.[73] Second, non-rivalrous resources (i.e., N_y or N_c) have not only an increasing returns effect in production but also an increasing returns effect for improving well-being through the utility function.

The feature of the individual firm having diminishing returns to scale while the whole industry has increasing returns means that green transition is not only a transition of the content of development ("what") but also a new economic forms, organizational forms, and business models ("how"). It can be used to explain many emerging economic forms and decentralization phenomena such as the distributed economy, the ecological economy, the platform economy, chain operations, franchise business, and Industry 4.0 in the digital green era. For example, in the platform and franchise business, the productivity of each joined firm or individual is greatly improved due to the non-rivalrous services provided by the platform (or headquarters).

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72   Paul Romer, "Endogenous Technological Change."
73   Zhang Y.S., "Ecological Civilization Is Not Equal to Green Industrial Civilization."

(3) Market equilibrium and its comparative statics

The abovementioned re-specification of consumer and producer objective functions and constraints, based as it is on the rethinking of the ends and means of development, still satisfies Arrow-Debreu's conditions for the existence of general equilibrium.[74] Whether it is the internal scale economy of X sector under monopolistic competition or the industry-level increasing returns of Y, they are all compatible with market competition. The government's introduction of environmental constraints in terms of intensity and cap would change the relative prices of different inputs and outputs, but it would not change the nature of market competition. The natural resources market is cleared under the condition of $Nx = \sum_{i=1}^{n_x} N_{x_i} \le \bar{N}_x$, where $\bar{N}_x$ is the resource use limit set by the government (e.g. total carbon emissions, etc.). The products market x_i and y_i and the labor markets l_{xi} and l_{yi} can be cleared. In a model with specific form, the equilibrium of the variables U_{wb}, p_{xi}, p_{yj}, $p_{N_{x_i}}$, ω, x_i, y_j, l_{xi}, l_{yj}, m, n can be solved according to Walras's law, and N_c and preference parameter a can be further endogenized.

However, due to changes in the concepts of cost, benefit, utility, well-being, optimality, and so on, the general equilibrium results will change accordingly. The discontinuous leap of the economic system and development paradigm requires inframarginal analysis.[75] The original Pareto optimal results of standard neoclassical economics would no longer be necessarily optimal under the new paradigm, and the optimal results under the new paradigm would not be necessarily considered optimal in the standard neoclassical paradigm. Among them, the biggest change in equilibrium results is that owing to changes in relative prices, utility functions, endogenous preferences, and so on, the relationship between the Pareto optimal economic goal, the environmental goal, and the well-being goal could shift from deviation into synergy.

1) Economic growth effect

As there are $\partial X / \partial M > 0$, $\partial Y / \partial M > 0$, $\partial Y / \partial N_y > 0$, $\partial Y / \partial n > 0$, the green transformation will not affect economic growth, but the content and source of growth will shift. As the population size increases (or through greater economic integration), total output (X', Y') will continue to increase, but $X' < \bar{X}$ subject to Equation (6) $\bar{X} < \dfrac{\bar{E}}{e}$ and the economy will be more dematerialized and growth will be more reliant on Y. In particular, non-rivalrous green resources N_y, such as intangible eco-environment and culture, not only generate increasing returns but many N_y resources will "grow with use" (e.g. cultural resources "grow with use"), and environmental protection and development can then reinforce each other. In particular, as consumers' endogenous preferences for green products and services increases continuously, the proportion of Y in employment and value will also increase. In contrast, under the traditional industrialization model that is dominated by material products X, there is always a

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74   K.J. Arrow and G. Debreu, "Existence of an Equilibrium for a Competitive Economy," pp. 265-290.

75   Yang X.K., *Economics: New Classical versus Neoclassical Frameworks*.

conflicting relationship between environmental protection and growth.

2) Environmental and resource effects

On environmental effects, as the economy shifts from (X, Y) to (X', Y'), where $X' < \bar{X}$, $Y' > Y$, the environmental sustainability conditions $E = e \cdot X < \bar{E}$ and $\int_0^t E(s) \cdot ds < \bar{E}$ can be met. On resource effects, material demands would be subject to $Nx = \sum_{i=1}^{n_x} N_{x_i} \leq \bar{N}_x$ as the economy becomes more dematerialized through the following channels. First, the development content shifts from (X, Y) to (X', Y'). Second, planned obsolescence is regulated, products become more durable, and many hardware products can be upgraded through software updates. Third, material resource recycling. Unlike depletable material resources, the intangible resources represented by the eco-environment, culture, art, knowledge, and so on have the nature of "growing with use," and the current generation could create and accumulate more intangible resources for future generations.

3) Well-being effect

The expanded utility function $U_{wb} = f(x, y, N_c, a)$, including non-market content N_c and endogenous preference a is closer to the concept of the "good life." Since the level of well-being relies not only on the consumption of goods x and y but also on the level of N_c and endogenous preference a, high economic growth (or high consumption of x and y) does not necessarily connote high well-being if N_c and a decrease. Meanwhile, the non-rivalrous nature of N_c has increasing returns in improving well-being. Under the same or even a lower (x, y) consumption level, the improvement of N_c not only improves well-being but also benefits all consumers. This means that even if the potential for future economic growth is exhausted, it will merely indicate that the traditional utility $U(x, y)$ no longer increases, but the level of well-being $U_{wb} = f(x, y, N_c, a)$ can still improve. As Mill points out, "A stationary condition of capital and population implies no stationary state of human improvement."[76]

VI.　Brief Conclusion and Policy Implications

This study aims to show theoretically how the ecological civilization paradigm can reshape the unsustainable relationship between the environment and development under the traditional industrialization model and reveals its new policy implications. It examines a series of mainstream theoretical models on industrialization and urbanization pioneered by Dixit and Stiglitz and reveals their hidden consequences of environmental unsustainability. These consequences are not due to the problems of the models themselves but more to the limitations of the traditional development and standard economics paradigms of the industrial age. Therefore, such consequences can neither be avoided simply through external policies such as technological progress and environmental regulations, nor can they be prevented by simply adjusting the parameters of the theoretical models. Instead, what is required is to shift

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76　J.S Mill, *Principles of Political Economy, with Some of Their Applications to Social Philosophy* (2 vols).

the development and economics paradigms formed in the traditional industrial age.

From the perspective of eco-civilization, this paper reviews the history of economic thought along the two major lines of developmental ends ("what") and means ("how") and, in a new conceptual framework, reorganizes relevant in-depth ideas that have been neglected by mainstream neoclassical economics. Consequently, this paper further formalizes the framework in a general form and shows that under the new development paradigm, the economy, the environment and well-being can shift from a trade-off to a mutually beneficial relationship and finally realize modernization with harmonious coexistence between man and nature. Eco-civilization and Chinese-style modernization represent China's endeavour to address the unsustainability crisis; they are essentially a profound transformation of the traditional development paradigm and a redefinition of the concept of modernization established after the Industrial Revolution.

The paradigm shift from the traditional industrialization model to green development under eco-civilization has new policy implications. An essential implication is that the relationship between the environment and development can be reshaped from a trade-off to a mutually beneficial relationship. This mutually beneficial relationship lays the foundation for the establishment of new win-win relationships between countries and between present and future generations.[77] The mechanism of this paradigm shift is, to some extent, a self-fulfilling process led by expectation, wherein the new development concepts and vision play a decisive role. But in any case, the challenges of this paradigm shift are extremely daunting. This paper is more to show a new direction of research under the paradigm of eco-civilization. More topics and technical issues under this paradigm are yet to be tackled in details separately.

Note on Author

Zhang Yongsheng, PhD in Economics, is Professor, Senior Research Fellow and Director of the Research Institute for Eco-civilization (RIEco) at the Chinese Academy of Social Sciences (CASS). He conducts theoretical and policy research from the perspective of eco-civilization. He is Professor at the University of the Chinese Academy of Social Sciences (UCASS) where he teaches "Economics: Perspectives of Eco-civilization versus Industrial Civilization." He is the co-author of *New Classical Economics and Inframarginal Analysis* (Beijing: Social Sciences Academic Press [China], 2019), and the author of *Irrelevance of the Size of the Firm: Theory and Evidence* (Beijing: China Renmin University Press, 2003). He is also the author of numerous policy reports, including "The New Era of Green Development: China's Transition to 2050," a flagship report of CCICED, and "Seizing the Opportunity of Green Development in China," a pillar report of the joint project between DRC and the World Bank, "China 2030." E-mail: ys_zhang@cass.org.cn.

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77   Zhang Y.S., "Environmental Governance: A Perspective from Industrial Civilization to Ecological Civilization."

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