Environmental Governance: A Perspective from Industrial Civilization to Ecological Civilization

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Abstract: *The key of environmental governance is to tackle the environment-development relationship so to achieve sustainability. This paper reveals that the traditional concept of environmental governance that took hold in the industrial era is rooted in the traditional development paradigm and theory that conflict environmental protection with economic development. Dilemmas exist not only between the environment and development, but in the resource distribution between current and future generations and in the sharing of global environmental responsibilities among countries. Consequently, in the traditional industrial era, environmental governance mainly focused on broadening the space of compromise by facilitating technology progress and raising efficiency, which is hard to solve the underlying environment-development conflict. Under the concept of ecological civilization, environmental governance brings about a mutually-beneficial relationship between environmental protection and economic development and thus could turn environmental burden into a shared opportunity among countries, and into a "win-win" relationship between current and future generations.*

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1. Introduction

Since the Industrial Revolution, the traditional development mode of "resource-intensive, high carbon emission, and high environmental costs" has drastically increased productivity and advanced industrial civilization at an unprecedented scale. Yet it has led to a global unsustainability crisis, including climate change. Currently, over 130 countries have promised to go carbon neutral or reach net zero carbon emissions by the mid-21st century. Those countries represent some 90% of global carbon emissions and GDP, and 85% of global population. More importantly, about 70% of them are developing countries. That is to say, developing countries may skip the traditional "emit first, mitigate later" development path that the industrialized countries took and head for a low-carbon takeoff. The global carbon neutrality consensus and initiatives herald an end to the mode of traditional industrialization and the advent of a new era of ecological civilization and green development.

Traditional environmental governance is rooted in the mode of traditional industrialization and

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[1] https://eciu.net/netzerotracker

development concepts. Under the traditional mode, not only environmental protection is at odds with economic development, but countries are engaged in a zero-sum game when it comes to global environmental responsibilities, and dilemmas exist in the interests of current and future generations. Accordingly, environmental governance aims to maximize the space of compromise between environment and development to attain a higher level of economic development. Global environmental governance is more concerned with how the burden of environmental protection is shared among countries. In terms of inter-generational responsibilities, the current generation should be responsible for the posterity and try to avoid occupying resources or damaging the environment. This approach is reflected in the definition of sustainable development in the Brundtland report, i.e. "sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their owns" (WCED, 1987).

As Albert Einstein noted, "we cannot solve problems by using the same kind of thinking when we created them." [2]There is very little space to compromise between the environment and development as long as the two are in conflict. Even if such space can be expanded with better technology and more efficient management practices, this mode will eventually take its toll on the environment. Hence, environmental governance must shift from unsustainable industrial civilization to ecological civilization. The fundamental approach for environmental governance under the concept of ecological civilization is to create benign interactions between the government, enterprises and consumers, and shift the conflicting relationship between the environment and development into a mutually beneficial one, transform development paradigm, and achieve modernization in which man and nature live in harmony and prosperity is shared globally.

This paper aims to provide a conceptual framework to reveal the fundamental differences of environmental governance under traditional industrialization and ecological civilization, as well as their different mechanisms of realization and policy implications. Part 2 reviews the history and research literature on environmental governance and explain the limitations of existing studies and the importance to shift from traditional industrial civilization to ecological civilization. Part 3 discusses the environmental governance approach and limitations under the traditional concepts of industrial civilization, as well as why sustainability problems cannot be resolved under such concepts. Part 4 employs a conceptual framework to reveal the new environmental governance mechanism under ecological civilization. Part 5 offers discussions on related matters. The final section provides brief concluding remarks.

2. Transformation of Environmental Governance Approach

2.1 Conflict between the Environment and Development and Governance Approach under the Traditional Development Mode

Since the mid-20th century, the traditional mode of industrialization has led to an environmental crisis of great concern to all nations. In 1972, the United Nations held the Environment and Development Conference for the first time and adopted the *Declaration of the United Nations Conference on the Human Environment*, which called upon governments and peoples to take joint actions to conserve and improve human habitat for the benefit of future generations. Thereafter, the relationship between the environment and development has become a key item on the global agenda. On September 25, 2015, the United Nations Sustainable Development Summit was held at its headquarters in New York, which officially adopted 17 sustainable development goals (SDGs). Nonetheless, the reasons why these goals have not been achieved are not because their importance were not well-understood, but because they

[2] https://todayinsci.com/E/Einstein_Albert/EinsteinAlbert-Problem-Quotations.htm.

conflicted with each other in the traditional industrialization mode. Without fundamental transition of development mode, it is hard to form a mutually beneficial relationship between the 17 SDGs and overcome daunting difficulties for their achievement.

Standard economics, however, has not offered sufficient theoretical insight on how to understand and tackle the relationship between environmental protection and economic development. As the most influential theory, the environmental Kuznets curve (EKC) considers that an inverted U-shaped trend exists between the environment and development, which makes environmental improvement possible after economic development reaches a certain level (Grossman and Kruger, 1995). This has become a major theoretical basis for the "pollute first, clean up later" policy and global environmental governance. Though this theory is widely accepted, it is far from a law of economic development (UNEP, 2011; Stern, 2010).

Although environmental issues have increasingly received attention in economics, as reflected in the creation of economics disciplines such as ecology/environment/natural resources economics, environmental issues are far from being incorporated into mainstream economic analysis. According to Polaski *et al*. (2019), most researchers of sustainable development are natural scientists. Take standard economics as an example. Prof. Esther Duflo was awarded Nobel Prize in Economic Sciences in 2019 for her outstanding contributions to development economics, one of which is an important experimental study on incentivizing farmers to use fertilizer (Duflo, Kremer and Robinson, 2011). Nonetheless, the excesses use of fertilizer is a major cause for unsustainable "modern" agriculture. In the developing world, agricultural development should avoid the old path of "pollute first, clean-up later." Since poverty eradication tops the 17 SDGs, their research is regarded as part of sustainable development research.

Economists tend to treat environmental issues as an application and branch discipline of standard economics. In this regard, the most representative environmental issue is climate change research. A typical approach is to figure out an optimal global level of greenhouse gas emissions (GHGs) through cost and benefit analysis (CBA), and then individual countries negotiate their emissions reduction obligations and pursue international cooperation (Nordhaus, 2019). The benefit of emissions reduction is defined as the reduction of future losses stemming from climate change, i.e. social cost of carbon. This approach is characteristic of the traditional industrial era, i.e. emissions reduction conflicts with economic development, current generation conflicts with future generations, and countries see their interests clash. Under this approach, the optimal global carbon emissions is 3°C increase in global mean temperature (Nordhaus, 2019), which is a far cry from the goal set forth in the Paris Agreement and the estimates of mainstream natural scientists, and their research methodology is also broadly controversial (Stern, 2016; Stern and Stiglitz, 2021; Weitzman, 2011). Such debates are not just a simple question about the value of model parameters but involve basic theoretical questions in economics. In fact, emissions reduction can be a process of creative destruction, which may bring the economy to a new and more competitive structure. The benefit of carbon emissions is not just the reduction of future loss, but more importantly, the emergence of new technologies and sunrise industries, as exemplified in the substitution of fossil fuels with new energy and the substitution of gasoline-fueled vehicles with electric vehicles (Zhang and Shi, 2014; Zhang, 2014).

Many studies on environmental governance are focused on the aspect of mechanism design. The best-known environmental governance problem is "The tragedy of the commons" (Hardin, 1968). According to Hardin (1968), there are two ways to resolve the tragedy of the commons: either to privatize or nationalize the commons. Coase theorem is extensively applied to environmental economics (Coase, 1960), i.e. in the absence of transaction cost, optimal resource allocation is irrelevant to the initial allocation of property ownership. Considering the cost of defining and enforcing property rights, externalities cannot be truly removed. According to Cheung (1970), the degree of optimal externalities is subject to an efficient trade-off between the cost of externalities and the cost of removing externalities. That is to say, with the passage of time, the optimal environmental choice under the narrow economic

perspective will eventually exceed the scientific threshold with disastrous consequences. For instance, even if annual GHGs meet so-called annual optimal level, climate change will accelerate once cumulative emissions exceed a tipping point.

Ostrom (2009) suggested that environmental governance goes beyond the above-mentioned two pathways. "Humans have a more complex motivational structure and more capability to solve social dilemmas than posited in earlier rational-choice theory." As she noted, designing institutions to force (or nudge) entirely self-interested individuals to achieve better outcomes has been the major goal posited by policy analysts for governments to accomplish for much of the past half century. Extensive empirical research leads her to argue that instead, a core goal of public policy should be to facilitate the development of institutions that bring out the best in humans. According to the Institutional Analysis and Development framework put forth by Ostrom (2009), people in those regions tend to self-govern to form an effective governance structure of common pool resources (Schoon and Cox, 2018).

Environmental problems essentially stem from development paradigms. Since the development and research paradigms established after the Industrial Revolution largely result from the traditional industrial era, it is hard to addressing the sustainability crises facing the world today by simply applying the existing standard theories to sustainability problems. We must revisit and extend some basic questions in economics, including the value theory and analytical perspective, in light of those crises. Unless the development paradigm is transformed to turn the environment-development relationship from conflicting to mutually reinforcing, it would be hard for effective environmental governance to take hold.

2.2 Journey of China's Environmental Governance

China has experienced an arduous path of understanding and dealing the relationship between the environment and development. Environmental problems were initially thought to be non-existent in socialist countries, and when they started to appear, were believed to be surmountable with the strengths of socialism. It was not until rapid economic development took its toll on the environment in the post-reform era since 1978 that the conflict between the traditional mode of development and environmental protection became apparent. The 17th CPC National Congress put forth the concept of ecological civilization, calling for making environmental protection compatible with economic development under the scientific outlook on development. After the 18th CPC National Congress, the concept of ecological civilization took on new implications and became written into the *Constitution of the People's Republic of China* and the *Constitution of the Communist Party of China (CPC)* as a pillar of the "Five-Pronged Strategy." With refreshed understanding comes great change in action. China has made unprecedented efforts to protect the environment with significant achievements in both environmental and economic endeavors, forming a benign cycle where environmental protection begets economic development (Zhang, 2020a).

In terms of scale and speed, China is the biggest beneficiary of the mode of traditional industrialization. But why does China take the lead to embrace ecological civilization and pursue green development? An underlying reason is that the traditional mode of polluting and resource-intensive industrial development entails hefty external, implicit, long-term costs, opportunity cost, and welfare costs that render economic growth unsustainable. Meanwhile, upsurge in the green economy led by new energy, electric vehicle and 5G communication has opened up vast opportunities that undergird China's shift towards ecological civilization and green development.

Modernization of China's governance system and capabilities for ecological civilization is all about establishing a mutually conducive relationship between the environment and development to achieve sustainable development goals. Specifically, at three levels. First is at the domestic level. The conflict between the environment and development under the mode of traditional industrialization should be transformed into a mutually conducive one to defy the "modernization paradox" under the industrial civilization, so to follow a path of modernization in which man and nature live in harmony, and

pursue sustainable development for the Chinese nation. Second is at the international level. The great rejuvenation of the Chinese nation under this new development philosophy represents an opportunity for the world at large. International environmental obligations can be turned into shared opportunities. Third is at the intergenerational level. A Pareto improvement can be achieved for the welfare of both current and future generations, and the welfare of our posterity may not come at the expense of the current generation.

3. Environmental Governance in the Lens of Traditional Industrial Civilization

3.1 Intrinsic Characteristics and Environmental Governance Dilemmas under the Traditional Mode of Industrialization

The mode of traditional industrialization, by its nature, puts economic development at odds with ecological environment, and, consequently, ecological governance can only broaden the space of compromise between the two. The mode of traditional industrialization is more focused on the mass production and consumption of material wealth and characterized by intensive material resource input, carbon emissions and environmental costs. Meanwhile, little consideration is given to the environmental, social and cultural impacts of economic activities, some of which yield handsome returns at the expense of external, implicit, long-term and opportunity costs and welfare losses. Unlike large-scale and dedicated production for industrialization, social organizations, culture and ecological environment are more dependent on diversity and symbiosis. Hence, there tends to be an intrinsic conflict between the mode of traditional industrialization and ecological environment.

Assuming that an economy consists of two product categories, i.e. (X, Y). Where X is industrial products based on material resources with a higher environmental intensity, i.e. $e_1>0$; Y is service products based on intangible resources, whose production does not damage the ecological environment, $e_2=0$. Condition for sustainable development is that actual environmental emissions E does not exceed the environmental capacity $\overline{E}$, i.e. $E<\overline{E}$. The aggregate environmental footprint of both types of products is:

$$E=e_1X+e_2Y=e_1X \tag{1}$$

We will reveal that without changing what produce and consume, raising the efficiency of environmental management alone can hardly achieve pollution mitigation. As can be learned from equation (1), there are two ways to reduce aggregate environmental footprint E under the mode of traditional industrialization. One is to reduce e_1 through technology progress, i.e. to make X with greener technologies, which tends to raise the cost of production. The other way is to reduce the output of X, which means an economic contraction similar to reaching the limit of growth (Meadows, *et al*., 1972). Both pathways are seen as a burden of economic development.

The first pathway alone, i.e. to reduce e_1 with new production technologies, may not reduce the aggregate environmental footprint E since X may increase at a faster pace, so that growth in X will cause an environmental footprint that outweighs what decreasing environmental intensity e_1 helps to reduce. Even if it is the other way around, i.e. decreasing environmental intensity e_1 does more to shrink environmental footprint than the increasing output of X expands it, the cumulative environmental impact will eventually exceed the environmental threshold over time, i.e. $\int_0^t E(s)\cdot ds>\overline{E}$, thus triggering an environmental crisis. The second pathway, i.e. protecting the environment at the expense of economic growth, is hard to be embraced either.

Due to the environment-development conflict under the mode of traditional industrialization, environmental governance relies more on technology progress, management efficiency or economic slowdown or contraction to postpone the exceedance of environmental threshold. None of these measures may fundamentally resolve environmental problems or avoid the Malthusian trap. If

development is based on the production and consumption of material wealth, the limitation of resources, e.g. space for further global carbon emissions, presents a dilemma in the distribution of limited resources between current and future generations. To realize sustainability, therefore, economic development must be decoupled from environmental degradation and resource consumption as much as possible, i.e. to move from the traditional economy (X, Y) to the green economy (X', Y'). Where, $X'<X$, $Y'>Y$. Only in this manner will the sustainability condition $E<\overline{E}$ be satisfied and economic growth occur at the same time.

3.2 Dilemma Facing Global Environmental Governance under the Traditional Mode of Development

Lack of sustainability due to the environment-development conflict will present a dilemma between nations. The mode of traditional industrialization highly dependent on the input of material resources and fossil fuels since the Industrial Revolution has brought material abundance to a minority of people in certain parts of the world, but once this mode is scaled up on a global scale or a longer timeframe, a crisis of unsustainable development will ensue.

We assume that two types of countries exist, i.e. developed and developing countries. Condition for global sustainability is: $E_{global}=e_1x_1M_1+e_2x_2M_2<\overline{E}_{global}$, where, $e_i,x_i,M_i,i=1,2$ which respectively denote the environmental intensity of unit output from developed and developing countries, per capita output and population size; E_{global} is the degree of global environmental degradation; $\overline{E}_{global}$ is global environmental capacity, e.g. total global carbon emissions that correspond to an increase in global mean temperature by 1.5°C. When the gap between the global North and South is large enough and the per capita output x_2 of developing countries is sufficiently below x_1 of developed countries, the condition for global environmental crisis $E_{global}=e_1x_1M_1+e_2x_2M_2<\overline{E}_{global}$ can be satisfied to the extent that no major global environmental crisis will occur. At this moment, the mode of modernization in the developed world appears replicable in the rest of the world, and its intrinsic attribute of environmental unsustainability becomes concealed due to the global North-South divide.

As such, the modernization mode of the developed world is seen as a template for modernization in the developing world. The concept of modernization accepted by most countries is modernization based on the production and consumption of material wealth with industrialized countries as the benchmark. In exploring their own paths to modernization, late-moving countries are obsessed with how to achieve the sort of modernization in the developed world based on their national conditions, i.e. how to raise per capita output from x_2 to x_1, without questioning what modernization should be, i.e. whether X is sustainable and may improve people's welfare. When emerging countries attain rapid development following the trail of industrialized nations, the global environmental crisis led by climate change will erupt, and the unsustainability of such a path to modernization is laid bare (Zhang, 2020b).

How to deal with the global environmental crisis? Under the mode of traditional industrialization, environmental protection is in conflict with economic development, and a typical approach to solving global environmental problems is for all countries to "fairly" share their environmental responsibilities. Take climate change as an example. A typical practice is to first estimate the volume of carbon emissions that needs to be cut to keep global warming within 2°C or 1.5°C, and then bringing countries to the negotiation table to divide the burden. This old approach of sharing the burden has made it hard to find a real solution to global environmental problems (Zhang and Shi, 2014). A new approach should be to view emissions reduction as an opportunity for green development and create and share such an opportunity through international cooperation.

3.3 Environmental Governance Trap under the Mode of Traditional Industrialization

Coming back to Hardin's (1968) tragedy of the commons, this section will reveal why the mode of traditional industrialization cannot achieve sustainable development goals at the microscopic level

of institutional design. In the lens of ecological civilization, the so-called tragedy of the commons or development trap falls into three categories (Zhang, 2021a).

The first type of development trap is the tragedy of the commons such as overfishing and overgrazing. According to Ostrom's (2009) research, stakeholders may form effective incentives through cheap talk to avoid overfishing and overgrazing and control output X within a certain range, i.e. $X<\overline{X}$, to avoid overfishing or overgrazing and satisfy the sustainability condition $E=e\overline{X}<\overline{E}$. While the avoidance of overfishing or overgrazing may sustain output at a level above overfishing or overgrazing, such "sustainability" remains at a low level, and the upper limit of sustainable fishing or grazing $\overline{X}$ becomes the ceiling of development.

The second type of development trap is environmental degradation under the mode of traditional industrialization. Although overfishing can be disincentivized, fish farmers are tempted to use excessive fertilizers that pollute lakes. Even if chemical fishing is abandoned, pollution from chemical agriculture and industrial activities in surrounding areas will still pollute lakes. Environmental damages wrought by human activity have already penetrated into uninhabited areas including deep oceans through the Earth's complex circulatory systems. Without transforming the mode of economic development on a broader scale, microscopic design to avoid the tragedy of the commons is of limited effects to achieving global sustainability.

The third type of development trap is that the economy is locked-in the mode of traditional industrialization and cannot leap to a more competitive green development structure, i.e. from (X, Y) to (X', Y'). Green transition is similar to the structural leap from 0 to 1. This leap is similar to the chicken or egg paradox. Risk-averse decision-makers refrain from taking emissions reduction initiatives unless enough green evidences are seen; but in the absence of emissions reduction initiatives, green evidences will not appear anyway. To break through this "evidence-action" dilemma, it takes new theories to foresee new outcomes that would appear under certain circumstances (Zhang and Shi, 2014). Without a fundamental transformation of the development model, the economy will be locked-in a traditional structure due to path dependence and cannot unlock the potential benefits of green transition.

The global unsustainability crisis facing mankind is not just an externality problem of the tragedy of the commons, but involves a paradigm shift of values, the matter and mode of development, and systems and institutions. Only by extricating ourselves from the traditional mode of industrialization and embracing the concept of ecological civilization will we establish a mutually conducive relationship between environment and development (Zhang, 2019, 2021).

4. Environmental Governance under Ecological Civilization: A Conceptual Framework

President Xi Jinping called for "two win-win results" at the Paris Climate Conference in 2015, which underpin China's approach for environmental governance under the concept of ecological civilization. First, win-win results between the environment and development; second, win-win results between countries. As discussed before, it is hard to achieve sustainable development goals under the mode of traditional industrialization. Next, we will focus on ecological governance under the concept of ecological civilization and how those win-win results could be achieved.

4.1 Mechanism of Behavior for Environmental Governance Stakeholders

The fundamental solution to environmental problems is to ditch the traditional mentality of industrial civilization and decouple economic development from environmental degradation under the concept of ecological civilization . That is to say, we should try to reduce the production and consumption of high-environmental-footprint product X and increase the production and consumption of green product Y to transform the economy from (X, Y) to (X', Y'). Where, $X'<X$, $Y'>Y$.

The question is how to realize such a transition? Here, we use a simple general equilibrium model to reveal the interactions between the environmental governance stakeholders of the government, enterprises and consumers, as well as how they change their behaviors under the new concepts and constraints and embrace green transition.

It is assumed that consumers consume two types of products X and Y, whose utility functions and constraints are:

$$max\ U=x^{\alpha}y^{1-\alpha} \tag{2}$$

$$s.t.p_x x+p_y y=I \tag{3}$$

Where U is utility, and α and $(1-\alpha)$ are the preference parameters of X and Y, respectively. I is income (wage), and P_x and P_y are the prices of X and Y, respectively. Demand functions of the two types of products are solved as:

$$x=\frac{\alpha I}{P_x}, y=\frac{(1-\alpha)I}{P_y} \tag{4}$$

For the simplicity of analysis, it is assumed that only labor input exists for Firm X and Firm Y. It can be understood that the production of X requires the application of labor to material resources while the production of Y is more dependent on intangible resources such as knowledge, culture and environment, and the production functions are $X=AL_x$, $Y=BL_y$. Where, A and B are technical parameters, and L_x and L_y are labor inputs. In most cases since the 1970s, there has been only input of labor in the production functions of the new trade theory, the new growth theory and industrialization and new economic geography models based on Dixit and Stiglitz's (1977) model.

We introduce a new environmental constraint into the firm decision-making system to assess its impact on firm behaviors and general equilibrium result. The objective function for the profit maximization of Firm X is: $\pi_x=kP_xX-\omega L_x$. Where, $0<k<1$ is the effective output coefficient. Since the government follows a "polluter pays" principle, the firm must consume $(1-k)$ of its output for the treatment of environmental pollution for the emissions of its products to stay below environmental standard e_x (compliance with environmental standard does not mean zero pollution). The firm's net revenue after deducting the cost of environmental treatment is kP_xX, and ω is wage. Due to market competition and free entry, Firms X and Y offer equal wages. For the simplicity of analysis, we make wage ω a price numeraire and have $\omega=1$, and all prices in the model are relative prices. Green product Y has no environmental cleaning-up problem, and the objective function of its profit maximization is $\pi_y=P_yY-\omega L_y$.

The results of general equilibrium are:

Price: $p_x=\frac{1}{kA}$, $p_y=\frac{1}{B}$ (4.1)

Per capita consumption: $x=\alpha kA$, $y=(1-\alpha)B$ (4.2)

Labor allocation: $L_x=\alpha kM$, $L_y=(1-\alpha k)M$ (4.3)

Total output: $X=\alpha AkM$, $Y=(1-\alpha k)BM$ (4.4)

Utility: $U=(\alpha kA)^{\alpha}[(1-\alpha)B]^{1-\alpha}$ (4.5)

How to transform the economy from a traditional economy (X, Y) into a green economy (X', Y'), where $X'<X$, $Y'>Y$, to reduce the environmental impact of the economy as a whole? This requires a step change in the behaviors of government, businesses and consumers. In performing a comparative static analysis of $X=\alpha AkM$ and $Y=(1-\alpha k)BM$, we have:

$$\frac{\partial X}{\partial k}>0, \frac{\partial Y}{\partial k}<0, \frac{\partial X}{\partial \alpha}>0, \frac{\partial Y}{\partial \alpha}<0 \tag{5}$$

As can be learned from equation (5), there are two basic pathways for the economy to transform

from traditional economy (X, Y) into a green economy (X', Y'):

The first pathway is to enforce stricter environmental constraints upon firms to change the relative prices of green and non-green products, i.e. raise p_x and decrease p_y. As can be learned from $p_x=\frac{1}{kA}$, $x=\alpha kA$ and $X=\alpha AkM$, the relative prices of X and Y will change with their costs of environmental regulation. The more environmental cost $(1-k)$ polluting firms pay, the higher the relative price p_x of polluting product X becomes, and the more the market will reduce demand for X and raise demand for Y. The share of X in the economy decreases, and the share of green product Y increases. In the absence of environmental constraint, i.e. if $k=1$ or $1-k=0$, it becomes difficult to raise the relative price of non-green products p_x, and it is hard for the green transition to occur.

The second pathway is the transformation of consumption mode. The first pathway primarily deals with the internalization of external cost in standard economics, which alone cannot solve environmental problems without transforming the underlying value system and development mode. As can be learned from $x=\alpha kA$ and $y=(1-\alpha)B$, when α decreases, there will be less demand for X and more demand for green product Y. Notably, standard economics has a different attitude from other disciplines on the change of consumer preferences. In such disciplines as psychology, marketing, anthropology and sociology, changing preferences are a normalcy, but standard economics is more concerned with resource allocation analysis under given preferences. The reason is that changing preferences will present numerous difficulties to "science-based analysis" and affect the scientificity of economics (Bruni and Sugden, 2007). Yet many challenges facing economics derive from problems arising from such an assumption. Without evolving preferences, many changes in economic structure may not even occur. Judging by economic history and behavioral and experimental economics, people's preferences are not constant as assumed in standard economics. On the contrary, preferences keep evolving (Stern and Stiglitz, 2021; Grune-Yanoff and Hanson, 2000; Becker, 1996). Massive changes in social psychology and consumer habits form the premise of transition from agricultural to industrial society (Rostow, 1960). High productivity in the modern industrial society needs to transform "frugal men" into "hungry consumers" to create market demand (Atkinsson, 2012).

4.2 Green Transition and Ecological Civilization

The above basic pathways correspond to two core concepts of ecological civilization, i.e. man and nature living in harmony and "green is gold", while the former has to do with constraints under different analytical perspective, the latter has to do with the concept of values (Zhang, 2021b).

The first represents a broader perspective of "man and nature." The mode of traditional industrialization is confined to the narrow perspective of man and goods and cares little about the environmental impact of human activity. In various standard economics textbook models, ecology and environment plays a marginal role (Smith, 1776; Marshal, 1890; Samuelson, 1948; Keynes, 1948). So-called optimal human behavior of single-mindedly maximizing material wealth production and consumption inevitably brings destruction to the relationship between man and nature. A broader perspective of "man and nature" corresponds to the increasing environmental cleaning-up cost of $(1-K)$ for firm X in the model. Such a new constraint will change relative product price and push up demand for green goods while reducing demand for non-green goods.

The second is the concepts that "green is gold" and "a beautiful environment is the most inclusive wellbeing." Such new development concepts mean new preferences and redefinition of a good life. It corresponds to change in consumer preference parameter α in the utility function, as well as such factors as intangible ecology and environment in the standard utility function. Since standard utility function $U=x^{\alpha}y^{1-\alpha}$ does not consider the adverse impact of intangible factors such as environmental degradation, real consumer utility is not as high as what the nominal goods consumption reveals, i.e. "high GDP and low wellbeing." This has been extensively verified by happiness economics (Easterlin, 1974; 1979).

Once the social wellbeing loss from environmental degradation ($1-k_s$) is taken into account, the real utility function would become $U=k_s x^{\alpha} y^{1-\alpha}$, where, $0<k_s \leqslant 1$. As the preference parameter α for Product X decreases and environmental cleaning-up intensifies, environmental quality would improve and so would k_s in the utility function and real utility. For instance, consumption of goods worth 1,000 yuan would create different wellbeing in a clean environment as opposed to a heavily polluted one. Just like that the transition from an agrarian society to an industrial society is conditioned upon a mass transformation of social psyche and consumer habits, the shift from unsustainable mode of traditional industrialization to green development also entails a systematic and profound transformation of social psyche, consumer mentality and lifestyle. Otherwise, the green transition could not be achieved with technology progress alone.

The intrinsic difference between traditional industrial civilization and ecological civilization means different definitions of cost, benefit, wellbeing and optimality, as well as different implications to ecology, environment, society and culture. Under the mode of traditional industrialization, economic development somehow conflicts with ecology, environment, society and culture; the green development mode of ecological civilization offers the prospect for a mutually conducive relationship between economic development and ecological environment, society and culture (Zhang, 2021b, 2019).

5. Discussions on Relevant Matters and Policy Implications

5.1 Shift in the Role of Ecological Governance Stakeholders

Environmental governance is the result of joint actions by the government, enterprises and consumers. As can be seen from the changing constraints of consumer and producer decision-making system, transition from the traditionally economy (X, Y) to the green economy (X', Y') involves change in key parameters such as preference α, environmental regulation k, and technologies A and B. Among them, the most critical is government support.

First, transition in development philosophy and strategy. As far as governance is concerned, the key to the green transition is to refresh development concepts and replace the GDP-oriented development objectives with wellbeing-centric ones. New strategic development concepts and objectives are self-fulfilling and will transform development pattern, business model and institutional systems and policymaking.

Second, changing role of the government. According to Stern and Stiglitz (2021), environmental crisis is a typical market failure. In establishing the governance system for ecological civilization, some fundamental questions need to be revisited, including the redefinition of market and government functions. From the supreme ruler in *Leviathan* (Hobbes, 1651) to the contractual relationship between the government and citizens in *The Social Contract* (Rousseau, 1762), the night-watchman state in the *Wealth of Nations* (Smith, 1776) and new government functions of the modern market economy (Keynes, 1936), the perception of government functions has experienced a substantive evolution. The Third Plenum of the 18th CPC Central Committee called for "fully leveraging the decisive role of the market in allocating resources and giving better play to the role of government," and the Fourth Plenum of the 19th CPC Central Committee made a decision on the modernization of national governance system and capabilities. These policy initiatives will redefine market and government functions. For instance, tight environmental regulation will change the relative price of products, and government support to green technology will lower the price of green products.

Third, change in the role of enterprises. In the past, the goal of firms was to maximize shareholder profits with little consideration over externalities. Under the mode of traditional industrialization, corporate governance put shareholder interests above everything else. Under the principles of ecological civilization, considerations should be given to the social, environmental and cultural impacts of economic activities, and shareholder's profit can only be maximized subject to the condition with the key

stakeholders to be included into corporate governance in various forms. The objective function of Firm X is then transformed from $\pi_x=P_xX-\omega L_x$ in the past to $\pi_x=kP_xX-\omega L_x$ at the present.

Fourth, change in consumer behaviors. Aside from the factor of relative price, consumer preferences are a key impetus of economic transition. Change in consumer behaviors can be driven by (i) perception of how environmental pollution affects their own interests; (ii) deepening experience of the benefits of environmental improvement; and (iii) education and public awareness. According to Zhang and Ilan (2020), "green knowledge" is vital to changing consumer preferences and behaviors, and education is an important way to increase such knowledge. Notably, the government should create a negative list of unsustainable consumer behaviors so the consumer can have freedom of choice, rather than imposing certain preferences upon consumers.

5.2 Implications of Green Transition to Productivity, Wellbeing and Sustainability

It should be noted that X and Y mentioned above refer to a set of products of two types, which respectively contain a series of products, i.e. $X=(x_1, x_2,\ldots, x_n)$, $Y=(y_1, y_2,\ldots, y_n)$. In this manner, change in the relative share of X and Y may be construed as a process in which non-green sunset industries vanish and green industries emerge. Such a green transition is a Schumpeterian creative destruction process. As Zhang and Shi (2014) revealed, emissions reduction may drive economic structure to a more competitive one, so that emissions reduction turns into an impetus rather than a burden of economic development. For instance, strict emissions reduction policy propels the transition of economic structure from "gasoline-fueled vehicles and gasoline stations" to a more competitive one featuring "electric vehicles and charging points", as well as increasingly deepened division of labor and lowering costs. China's booming new energy vehicle industry is a vivid reflection of creative destruction.

Green transition will not impede economic growth as some fear. Instead, it may serve as a path to better and faster growth. At the heart of green transition lies a shift from GDP-centric development to a focus on people's wellbeing. Under the model of green economy, Category-Y goods and services are based more on non-rivalrous intangible resources such as knowledge, ecological environment and culture, and compared with Category-X goods dependent on the input of material resources, Category-Y production has higher increasing returns since the marginal costs of knowledge, ecological environment and culture, once formed, are extremely low and even zero. Unlike traditional economy (X, Y) dependent on exhaustible material resources with damaging effects on the ecology and environment, the new green economy (X', Y') is largely based on intangible resources that are inexhaustible. The key problem is that those products and services based on intangible resources often require new business models for the realization of their value. Admittedly, it is a tall order to transform existing business models that took hold in the traditional industrial era.

Take the management of common pool resources, under the traditional concept of industrialization, the function of lakes or forests is to farm fishes or graze cattle, which is a standard definition in traditional development economics centered around material wealth production and consumption. But apart from fish farming, lakes also have various ecological and cultural functions such as ecotourism, sports, recreation, culture and education. Intangible ecological resources like lakes are non-rivalrous and offer value (such as landscapes) to the masses. Those functions of lakes, if fully utilized, will endow the ecological protection of lakes with new implications to development, so that polluting fish farming is no longer the only way to make more profits. Once development is redefined, Ostrom's (2009) IAD framework will take on new development implications, and the development traps discussed before will vanish.

Furthermore, a plausible illusion needs to be clarified. A key reason that the mode of traditional industrialization appears more efficient than the green economy is the non-inclusion of its exorbitant social costs into the economic analysis and evaluation systems. For instance, if the medical cost $C_{medical}$

of environmental pollution is taken into account, the budget constraint of consumers will decrease, i.e. from $p_x x+p_y y=I$ to $p_x x+p_y y=I-C_{medical}$. For the simplicity of analysis, we can introduce a coefficient of social cost k_s into the utility function to transform it from $U=x^{\alpha}y^{1-\alpha}$ to $U=k_s x^{\alpha}y^{1-\alpha}$, where $0<k_s\leqslant 1$. When polluting enterprises step up environmental control, the society as a whole will benefit from non-rivalrous environmental improvement, and at this moment, k_s in the utility function will increase for everyone. In this sense, tight environmental regulation will enhance society-wide real wellbeing level.

6. Brief Concluding Remarks

Since the Industrial Revolution, the mode of traditional industrialization has vastly increased productivity but has also led to unsustainability crises globally. Not only is the environment conflicted with economic development, but dilemmas exist between the present and future generations and between countries. This paper reveals that environmental governance in the traditional industrial era could only expand the space of compromise for those dilemmas by advancing technology progress and raising governance efficiency. At the fundamental level, it cannot harmonize the conflicting relationship between environmental protection and economic development. Under ecological civilization, the goal of environmental governance is to foster a mutually conducive relationship between environmental protection and economic development, so that countries will share the opportunities rather than burden of environmental protection, and it can benefit both the current and future generations.

The transition from traditional industrial civilization to ecological civilization represents a systematic change of development and research paradigms. Consideration of environmental governance under this paradigm requires redefining such concepts as the objective function, cost, benefit, wellbeing and optimization, as well as changes in the behavior and modes of government, enterprises and consumers with different environmental consequences. Put forth at the Fourth Plenum of the 19th CPC Central Committee, ecological civilization underscores environmental protection, resource utilization, ecological conservation and restoration, as well as environmental accountability. Under the concept of ecological civilization, those priorities assume different policy implications compared with the traditional industrial era. Once we free ourselves from the mindset of the industrial era, some firmly believed theories may have to be revisited.

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