生态环境治理：从工业文明到生态文明思维

张永生*

中国社会科学院大学

中国社会科学院生态文明研究所

摘　要：生态环境治理的核心是处理环境与发展之间的关系，以实现可持续发展。本文揭示，传统工业时代形成的生态环境治理思维，更多的是建立在环境保护与发展之间相互冲突的传统工业化发展范式和发展理论基础之上。不仅环境保护与发展之间存在两难关系，当代人与后代人之间在资源分配上，以及国与国之间在分担全球环境责任上，均存在两难关系。这样，传统工业时代的生态环境治理思路，更多的就只能是通过技术进步和提高治理效率来扩大两难冲突的折中空间，难以从根本上解决环境与发展的关系问题。生态文明思维下的生态环境治理，则是通过新发展理念及相应约束条件的改变，促进发展范式的根本转变，形成环境保护与发展之间相互促进的关系，进而实现各国从环境负担分担转向机遇共享的共赢关系，以及实现当代人与后代人的共赢。

关键词：生态环境治理　工业文明　生态文明

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一、导论

工业革命后建立在“高物质资源消耗、高碳排放、高环境代价”基础之上的传统工业化模式，促进了生产力的飞跃，前所未有地推进了工业文明进程，但也带来了包括气候变化在内的不可持续危机。目前，有130多个国家承诺在21世纪中期左右实现碳中和或净零碳排放。这些国家的年排放量和经济总量，占全球碳排放和GDP的比重均为90%左右，占全球人口比重为85%左右。更为重要的是，这些国家中约70%为发展中国家[1]。这意味着，发展中国家的经济不必再像工业化国家那样走一条“先高排放、再减排”的传统发展路径，而是有可能实现低碳起飞。全球范围的碳中和共识与行动，标志着工业革命后建立的传统工业化模式的落幕和一个新的生态文明绿色发展时代的到来。

但是，传统的生态环境治理，很大程度上正是建立在传统工业化模式和发展理念基础之上。在传统工业化模式下，不仅环境保护与发展之间相互冲突，各国之间在全球环境保护责任上也更多的是零和博弈，当代

* 联系人：张永生，邮箱：ys_zhang@cass.org.cn。

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[1] https://eciu.net/netzerotracker。

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人和未来人的利益也存在两难。相应地，生态环境治理的思路，就是如何最大限度地通过技术进步或管理效率提升，来扩大环境与发展之间的折中空间，以实现更高水平的经济发展。在全球环境治理方面，更多的是各国如何公平分担全球环境保护的负担。在代际之间，就是要求当代人对子孙后代负责，减少当代人对资源的占用或对环境的破坏。这一思路体现在Brundtland报告对可持续发展的定义上，即在满足当代人需求的同时，不牺牲后代人满足其自身需求能力的发展。

正如爱因斯坦指出，“我们不能用过去导致问题的思维来解决这些问题”。显然，如果不根本改变环境与发展相互冲突的关系，这种折中空间就会非常有限。而且，即使由于技术进步和管理效率提升一时扩大了折中空间，随着时间的推移，这种模式累积的环境后果也终会爆发。因此，生态环境治理必须从不可持续的传统工业文明转向生态文明思维。生态文明概念下生态环境治理的根本思路是通过在政府、企业、消费者等主体之间建立良性互动，将传统工业化模式下环境与发展之间相互冲突的关系转变成相互促进的关系，以推动发展范式转变，实现“人与自然和谐共生”的现代化，以及全球共享繁荣。

本文旨在提供一个概念性框架，揭示传统工业化思维和生态文明思维下生态环境治理逻辑的本质区别，以及不同实现机制和新的政策含义。接下来的第二部分对生态环境治理的历史及相关研究文献进行评述，揭示其存在的局限，以及为什么要从传统工业文明思维转向生态文明思维；第三部分揭示传统工业文明概念下的生态环境治理思路及其局限，以及在这种概念下为什么无法解决可持续问题；第四部分用一个概念性框架，揭示生态文明下新的生态环境治理机制；第五部分是对相关问题的讨论；最后是简短的结语。

二、生态环境治理的思路演变

（一）传统发展模式下环境与发展的对立关系及治理思路

20世纪中叶开始，传统工业化模式带来的生态环境危机引起广泛重视。1972年，联合国首次召开环境与发展大会，通过了《联合国人类环境会议宣言》，呼吁各国政府和人民为维护和改善人类环境、造福后代而共同努力。此后，环境与发展关系成为主要的世界性议题。2015年9月25日，联合国可持续发展峰会在纽约总部召开，峰会正式通过17个可持续发展目标（SDGs）。但是，这17个目标之所以长期得不到实现，并不是因为人们过去没有意识到这些目标的重要性，而是因为这些目标在传统工业化模式下相互冲突。如果不彻底转变发展模式，就难以建立起17个目标之间相互促进的关系，SDGs目标的解决也就困难重重。

但是，标准经济学似乎并未对如何认识环境与发展之间的关系提供很好的理论和应对方案。影响最深远的是所谓环境库兹涅茨曲线（EKC），认为环境和发展之间呈现倒U型趋势，当经济发展到一定水平，环境就可以得到改善治理（Grossman and Kruger，1995）。这也成为“先污染、后治理”政策以及全球环境治理的主要理论依据。但是，这种被很多人奉为圭臬的理论，并不是经济发展的规律（UNEP，2011；Stern，2010）。

虽然生态环境问题正引起越来越多经济学家的关注，且生态、环境、资源等经济学分支学科也已建立，但生态环境问题远未纳入主流经济学分析范畴。根据Polasky等（2019），目前从事可持续发展研究的主要是自然科学家。以发展经济学为例，2019年Esther Duflo教授因为对发展经济学的突出贡献获得诺贝尔经济学奖，

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其一项重要实验研究就是如何激励农民使用化肥(Duflo，Kremer and Robinson，2011)。化肥农药的大量使用正是造成所谓“现代”农业不可持续的重要原因。发展中国家的农业发展，需要避免“先污染、后治理”的老路。由于消除贫困是联合国17个可持续发展目标(SDGs)的首要目标，其研究也被视为可持续发展研究的一部分。

在处理环境问题时，经济学家更多的是将环境问题作为标准经济学的一个应用和分支领域。这方面最有代表性的是气候变化研究。典型的思路是，通过估算全球应对气候变化的成本与收益(Cost and Benefit Analysis，CBA)，得出一个所谓的最优全球温室气体减排量，然后各国再通过气候谈判决定各自的减排量，并建立相应的国际合作机制(Nordhaus，2019)。减排的好处被定义为因气候变化造成的未来损失的减少(Social Cost of Carbon)。这种思路具有传统工业时代的典型特征，即减排与发展相冲突，当代人与后代人的利益相冲突，各国之间的利益也相互冲突。这种思路下得出全球最优减排度为3℃的结论(Nordhaus，2019)，同《巴黎协定》及主流科学家的意见相去甚远，其研究方法也受到广泛争议(Stern，2016；Stern and Stiglitz，2021；Weitzman，2011)。这种争论不只是一个简单的模型参数大小的问题，背后更是涉及基本的理论问题。实际上，减排是一个“创造性毁灭”过程(Creative Destruction)，有可能使经济从一个结构跃升到一个新的更有竞争力的结构，从而减排的好处就不只是未来损失的减少，更有可能是大量新技术和朝阳产业的出现。比如，新能源替代化石能源、智能电动车替代燃油车等(Zhang and Shi，2014；Zhang，2014)。

现有关于生态环境治理的文献，很多集中在机制设计层面。关于环境治理问题，最有影响的就是“公地悲剧”(Hardin，1968)。根据Hardin(1968)，解决公地悲剧有两个途径，一是将公地的产权清晰或私有化，二是实现国有化。科斯定理被广泛用于环境经济学(Coase，1960)，即在没有交易费用的情形下，资源最优配置与产权的初始分配无关。但是，由于界定和执行产权同样也需要花费成本，外部性不可能真的被消除。根据张五常(Cheung，1970)，最优外部性程度取决于外部性的危害和消除外部性的成本之间的有效折中。这意味着，随着时间的累积，狭隘经济视角下的最优环境选择，终会突破科学意义上的阈值，带来灾难性后果。比如，即使每年温室气体排放都按照所谓最优排放量排放，但累积超过一定阈值，气候变化仍会加速恶化。

Ostrom(2009)的研究则显示，解决环境治理的思路，不只有这两条路线。人类实际上有比标准理论提出的远要复杂的激励结构和能力来解决各种社会困境。她指出，过去可持续环境政策制定的主要目标，是如何设计一套制度来引导自利的个体行为。但是，大量的经验研究显示，公共政策的核心目标，应该是推动那些激发人们最好的一面的制度的发展。Ostrom(2009)提出的Institutional Analysis and Development框架分析表明，这些公共资源区域的人们往往会通过自我组织形成一个有效的公共资源(Common Pool Resources)的治理结构(Schoon and Cox，2018)

由于环境问题背后根本上是发展范式的问题，而工业革命后建立的发展范式和研究范式很大程度上又是传统工业时代的产物，简单地将现有标准理论应用到生态环境领域难以真正解决可持续发展危机。必须从这些危机出发，对经济学包括价值理论和分析视野在内的一些基本问题进行重新反思和拓展。如果不彻底转变发展范式，使环境与发展之间的关系由过去的相互冲突转变为相互促进，就难以从根本上建立起有效的生态环境治理。

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（二）中国生态环境治理的历程

在环境与发展之间关系的认识和实践上，中国走过了一条艰辛的探索道路。早期认为，社会主义国家没有环境问题。后来发现，社会主义也有环境问题，但认为社会主义的优越性可以解决环境问题。改革开放后，在经历了经济高速发展带来的环境全面持续恶化后，认识到传统发展模式同环境难以两全。党的十七大提出生态文明概念，强调以科学发展观实现环境与发展的兼容。十八大后，不仅生态文明概念被赋予新的内涵，还被写入宪法、党章，成为“五位一体”总体布局的一部分。认识的重大转变带来行动上的重大变化。中国环境保护力度空前加大，并在环境和发展两方面都取得显著成效，初步形成“越保护、越发展”的发展方式（张永生，2020a）。

从规模和速度而言，中国可以称得上是传统工业化模式最大的受益者。但是，为什么中国却率先提出生态文明，并坚定不移地走绿色发展之路？背后的原因在于，建立在“高碳排放、高资源消耗、高生态环境破坏”基础之上的传统工业化模式，其外部成本、隐性成本、长期成本、机会成本、福祉成本高昂，经济增长不可持续。与此同时，以新能源、电动汽车、5G等为代表的新兴绿色经济的快速发展，带来了大量的绿色机遇。这使得中国坚定不移地转向生态文明和绿色发展。

中国生态文明治理体系和治理能力现代化，就是建立环境与发展之间相互促进的关系，以实现可持续发展目标。具体表现在三个层面。一是国内层面。就是将传统工业化模式下环境与发展之间相互冲突的关系转变成相互促进的关系，以走出工业文明下的“现代化悖论”，实现“人与自然和谐共生”的现代化和中华民族的永续发展。二是国际层面。实现“人与自然和谐共生”的现代化，中华民族的伟大复兴就不只是中华民族的复兴，也是全世界的一个重大发展机遇。各国在国际环境治理上，就可以从过去的各国负担分担转变为机遇分享。三是在代际层面，当代人与后代人福祉提升可以做到帕累托改进，后代人福祉的改进不一定要以降低当代人福祉为代价。

三、传统工业文明视角下的生态环境治理

（一）传统工业化模式的本质特征及其环境治理困境

传统工业化模式的本质特征，决定经济发展与生态环境在一定程度上相互冲突，故生态环境治理的思路，更多的就是扩大两难折中的空间。传统工业化模式更多集中在物质财富的大规模生产和消费，以高物质资源投入、高碳排放、高生态环境代价为特征，经济活动对生态环境、社会、文化等方面的影响则未得到充分考虑。一些经济上投入产出效益很高的经济活动，往往以破坏生态环境和文化社会为代价，具有高外部成本、隐性成本、长期成本、机会成本和福祉损失。而且，工业化的组织逻辑，更多的是依靠大规模和单一生产，而社会组织、文化和生态环境则更多地依靠多样性和共生效应。因此，传统工业化模式同生态环境之间往往有着内在的冲突。

假定一个经济体由两大类产品组成，即(X, Y)。其中，X为基于物质资源的工业类产品，其生产的环境强度较高，即$e_1>0$；Y为基于非物质资源的服务类产品，其生产不破坏生态环境，$e_2=0$。可持续发展的条件为实

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际环境排放 E 不超过环境容量 $\overline{E}$，即 $E<\overline{E}$。两类产品总的环境足迹为：

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

我们将揭示，在不转变生产和消费内容的条件下，通过提高生态环境治理效率很难从根本上降低环境污染。由公式(1)可知，在传统工业化模式下，有两个途径可以降低总的环境足迹 E。一是通过技术进步降低 e_1，即用更绿色的技术生产 X。这往往会提高生产成本。二是降低 X 的产出。这意味着经济收缩，类似增长的极限(Meadows，et al，1972)。这两个途径，都被视为经济发展的负担。

如果只是简单地通过第一种途径，即使用新的生产技术降低 e_1，也并不一定能够降低总的环境足迹 E，因为 X 可能会更快地增加，从而 X 增长带来的环境足迹超过环境强度 e_1 下降而减缓的环境足迹。而且，即使环境强度 e_1 下降对环境足迹改善的效果超过 X 产出增加对环境足迹增加的效果，则随着时间的推移，环境影响效果的累积仍也会超过环境阈值，即 $\int_0^t E(s)\cdot ds>\overline{E}$，导致环境危机爆发。第二种途径，即通过降低经济增长来实现环境保护，更难以被人们接受。

在传统工业化模式下，由于环境保护和发展之间的两难冲突，生态环境治理更多的就只能依靠技术进步、管理效率提升或降低经济增长速度或总量，以推迟突破环境阈值的时间。这些都难以从根本上解决环境问题，最终难以避免马尔萨斯陷阱。如果发展是基于物质财富的生产和消费，由于资源的有限性(比如全球碳排放空间)，当代人和后代人之间如何分配有限的资源就成为一个两难。因此，实现可持续发展，经济发展就必须尽可能地同环境破坏资源消耗脱钩，即从传统经济 $(X,\ Y)$ 转型到绿色经济 $(X',\ Y')$。其中，$X'<X$，$Y'>Y$。这样，可持续条件 $E<\overline{E}$ 的满足与经济增长才能同时实现。

(二)传统发展模式下全球环境治理的困境

环境与发展之间冲突导致的不可持续，会导致国与国之间的两难冲突。工业革命后建立的高度依赖物质资源和化石能源投入的传统工业化模式，虽然可以让世界上少数人口过上物质丰裕的生活，但是一旦这种模式扩大到全球范围，或者在一个更长的时间尺度上，就必然会带来发展不可持续的危机。

假定世界上有两类国家，发达国家与发展中国家。全球可持续的条件是：$E_{global}=e_1x_1M_1+e_2x_2M_2<\overline{E}_{global}$，其中，$e_i$，$x_i$，$M_i$，$i$=1,2，分别代表发达国家和发展中国家的单位产出环境强度、人均产出和人口规模，E_{global} 为全球环境破坏程度，$\overline{E}_{global}$ 为全球环境容量，比如温升1.5℃对应的全球碳排放总量。当全球南北差距足够大，发展中国家的人均产出 x_2 足够低于发达国家的 x_1 时，$E_{global}=e_1x_1M_1+e_2x_2M_2<\overline{E}_{global}$ 的条件暂时可以满足，不至于出现全球性环境危机。此时，发达国家的现代化模式看似可以在全球复制，其环境不可持续的内在特征因为全球南北差距而被掩盖。

这样，发达国家的现代化模式，就被广大发展中国家视为现代化的模板。目前全球广为接受的现代化概念，正是以发达工业化国家为标准的、以物质财富的生产和消费为中心的现代化。后发国家对现代化的探索，更多的是将发达国家经济内容和发展水平作为默认标准，主要集中在如何根据本国国情“实现发达国家那样的现代化”(即how)，即如何将产出从 x_2 提高到 x_1 的水平，而对“什么是现代化”(即what)，也就是 X 的内容是否可持续，以及是否能够提高人们福祉，则缺少深刻反思和质疑。当越来越多的新兴国家也按照工业化国

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家的模式快速发展，以气候变化为代表的全球环境危机爆发，这种现代化模式不可持续的弊端也就暴露无遗（张永生，2020b）。

那么，如何处理全球环境危机？由于在传统工业化模式下，环境保护和发展之间相互冲突，解决全球环境问题的典型思路，就是各国如何“公平地”分担全球环境保护责任。以气候变化为例，典型的做法是先测算实现2℃或1.5℃全球温升控制目标全球需要减少多少排放，然后各国谈判如何公平地承担各自的份额，而不是将减排视作一种机遇，然后各国讨论如何通过合作创造并共享绿色发展的机遇。在这种负担分担的发展思路下，全球环境问题的解决就十分困难（Zhang and Shi，2014）。

（三）传统工业化模式下的生态环境治理陷阱

我们再回到Hardin(1968)的公地悲剧，揭示为什么在传统工业化模式下，仅仅在微观制度设计的层面并不足以实现可持续发展目标。从生态文明视角看所谓公地的悲剧或发展的陷阱，实际上存在三类悲剧或发展陷阱（张永生，2021a）。

第一类发展陷阱是类似过度捕捞、过度放牧等的公地悲剧。Ostrom(2009)的研究显示，利益相关者通过沟通（cheap talk）形成有效的激励机制设计，可以避免过度捕捞、过度放牧，从而将产出 X 控制在一定范围，即 $X<\overline{X}$，避免“过度捕捞”或“过度放牧”的发生，以满足可持续条件 $E=e\overline{X}<\overline{E}$。但是，避免“过度捕捞”或“过度放牧”虽然可以实现“可持续”，并使产出高于过度捕捞导致的低产量，但只是一种低水平的“可持续”，无法以此实现更高水平的“发展”目标，因为可持续捕捞或放牧的上限 $\overline{X}$ 就成为发展的上限。

第二类发展陷阱是传统工业化模式导致的生态环境破坏。比如，尽管一个湖泊可以通过有效的激励机制设计避免过度捕捞，但由于避免过度捕捞并不能带来更大的“发展”，湖泊可能不得不走上“投肥养鱼”的高污染道路。而且，即使湖泊不用化学方式养殖，但是其周围的化学农业、工业生产活动都是传统工业化模式，也同样会对湖泊产生污染。实际上，人类活动对生态环境的破坏，早已通过复杂的地球循环系统深入到包括深海在内的无人区。如果不在更大范围转变经济发展模式，小范围内通过微观机制设计避免公地悲剧对解决全球可持续发展而言效果有限。

第三类发展陷阱是经济被锁定在传统工业化模式，难以跳跃到一个新的更有竞争力的绿色发展结构，即从 (X, Y) 跳到 (X', Y')。绿色转型类似从0到1的结构跳跃。这个跳跃的过程，类似“鸡生蛋、蛋生鸡”的困境。由于风险厌恶，决策者在没有看到足够的“绿色”证据时，往往不会采取减排行动，而如果不采取减排行动，绿色证据就不会出现。这就形成一个“证据-行动”困境。打破这个困境，就需要新的理论，能够预见到在何种条件下会出现新的结果（Zhang and Shi，2014）。如果没有发展模式的根本转变，经济就会因为路径依赖而锁定在一个传统的结构，难以实现绿色转型的潜在好处。

因此，人类当前面临的全球不可持续危机，不只是一个公地悲剧的所谓外部性问题，而是从价值观念到发展内容、发展方式、体制机制等的发展范式转型问题。只有跳出传统工业化模式，在生态文明思维下才能建立环境与发展之间相互促进的关系（张永生，2019，2021）。

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四、生态文明下的生态环境治理：一个概念性框架

习近平主席在巴黎气候大会上提出“两个共赢”，正是中国在生态文明思维下的生态环境治理以及全球环境治理思路。一是环境与发展之间的共赢；二是各国之间的共赢。前面揭示了在传统工业化模式下很难实现可持续发展目标。接下来揭示生态文明思维下的生态环境治理何以实现这些共赢。

（一）生态环境治理主体的作用机制

解决环境问题的根本出路是跳出传统工业文明思维，在生态文明思维下尽可能地实现经济发展同环境破坏的脱钩(Decoupling)。也就是，尽可能地降低高环境足迹的产品 X 的生产和消费，扩大绿色产品 Y 的生产和消费，将经济从 (X, Y) 转型为绿色经济 (X', Y')。其中，$X'<X, Y'>Y$。

那么，如何实现这种转型？我们用一个简单的一般均衡模型揭示政府、企业、消费者等生态环境治理主体的相互作用机制，以及他们如何在新的理念和约束条件下改变行为模式，实现绿色转型。

假定消费者消费两类产品 X 和 Y，其效用函数和约束条件为：

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

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

其中，U 为效用，α 和 $(1-\alpha)$ 分别为 X 和 Y 的偏好参数，x 和 y 为消费者的个人消费量。I 为收入（即工资），P_x 和 P_y 分别为 x 和 y 的价格。求解两类产品的需求函数为：

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

为简便分析，假定 X 生产企业和 Y 生产企业只有劳动一种投入（可以理解为 X 的生产需要劳动作用于有形的物质资源，Y 的生产更多地依赖知识、文化、环境等无形资源。20世纪70年代后基于Dixit and Stiglitz (1977)模型的新贸易理论、新增长理论、工业化、新经济地理模型，其生产函数大都只有劳动一种投入。生产函数分别为 $X=AL_x$, $Y=BL_y$，其中，A 和 B 为技术参数，L_x 和 L_y 为劳动投入。

我们在企业决策系统中增加一个新的环境约束条件，考察其对企业行为及一般均衡结果的影响。X 生产企业的利润最大化目标函数为：$\pi_x=kP_x X-\omega L_x$。其中，$0<k<1$ 为有效产出系数，因为由于政府实施“谁污染、谁治理”政策，企业必须消耗掉其产出的(1−k)部分治理环境污染，以使其产品排放不高于环保标准 e_x（符合环保标准不意味污染为零）。企业支付治理环境成本后的净收入为 $kP_x X$，ω 为工资。由于市场竞争和行业自由进入，X 生产企业和 Y 生产企业工资均等。为简便分析，令工资 ω 为计价物(numeraire)，$\omega=1$。模型中所有价格均为相对价格。绿色产品 Y 没有环境治理问题，其利润最大化目标函数为 $\pi_y=P_y Y-\omega L_y$。

解出如下一般均衡：

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

人均消费：$x=\alpha kA, y=(1-\alpha)B$ (4.2)

劳动力配置：$L_x=\alpha kM, L_y=(1-\alpha k)M$ (4.3)

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

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

如何将经济从传统经济(X, Y)转型为绿色经济(X', Y')，其中$X'<X$, $Y'>Y$，以降低整个经济的环境强度？这就需要政府、企业、消费者等主体改变其行为。对$X=\alpha AkM$和$Y=(1-\alpha k)BM$进行比较静态分析，有：

$$\frac{\partial X}{\partial k}>0, \frac{\partial Y}{\partial k}<0, \frac{\partial X}{\partial \alpha}>0, \frac{\partial Y}{\partial \alpha}<0 \quad (5)$$

由公式(5)可知，经济从传统经济(X, Y)转型为绿色经济(X', Y')有两个基本途径：

第一个途径是对企业施加更严格的环境约束条件，以改变绿色产品和非绿色产品的相对价格，即提高p_x，降低p_y。从$p_x=\frac{1}{kA}$，$x=\alpha kA$，$X=\alpha AkM$可知，在市场竞争和自由进入的条件下，X和Y的相对价格会随着其环境规制成本的变化而变化。污染企业付出的环境成本$(1-k)$越大，污染产品X的相对价格p_x就越高，市场会自发地降低对X的需求，提高对Y的需求。X在经济中的比重就越低，绿色产品Y在经济中的比重就越高。如果没有环境约束，即如果$k=1$或$1-k=0$，则非绿色产品的相对价格p_x就难以提高，绿色转型也就难以发生。

第二个途径是转变消费模式。第一个途径更多的还只是标准经济学中的环境外部成本内部化问题，仅此还不足以解决环境问题，必须从价值观念到发展模式进行系统性转变。从$x=\alpha kA$和$y=(1-\alpha)B$可知，当α下降时，对X的需求就下降，对绿色产品Y的需求上升。需要特别指出的是，对于消费者偏好改变，标准经济学同其他学科持有不同的态度。在心理学、营销学、人类学、社会学等学科中，偏好变化是一个常态，而标准经济学更多的是在偏好给定条件下进行资源配置的分析。原因在于，偏好变动会给经济学“科学分析”带来很多困难，影响经济学的“科学化”(Bruni and Sugden, 2007)。但是，经济学面临的很多挑战，正是来自这种假定引起的问题。如果没有偏好的演进，很多经济结构的变化甚至不可能发生。从经济史，以及行为经济学、实验经济学来看，人们的偏好并不是标准经济学假定的一成不变。相反，偏好一直在不断演进(Stern and Stiglitz, 2021；Grune-Yanoff and Hanson, 2009；Becker, 1996)。大规模社会心理及消费习惯的改变，是从农业社会到工业社会转变的前提(Rostow, 1960)。现代工业社会的高生产力，需要通过将过去“节俭的人”变成“消费动物”来创造市场需求(Atkisson, 2012)。

(二)绿色转型与生态文明

上面两个基本途径，分别对应着生态文明思想的两个最核心概念，即人与自然和谐共生，以及“绿水青山就是金山银山”理念。前者与不同分析视野下的约束条件有关，后者同价值理念有关(张永生，2021b)。

第一个是“人与自然”更宏大的视野。传统工业化模式更多地局限于“人与商品”的狭隘视野下，并不太关心人类活动对生态环境的影响。在各种经济学标准教材模型中，生态环境处于一个非常次要的角色(Smith，1776；Marshall, 1890；Samuelson, 1948；Keynes，1948)。这种一味追求物质财富生产和消费最大化的所谓人类最优行为，必然带来“人与自然”关系的破坏。“人与自然”更宏大视野在模型中对应的是X生产企业环境治理成本$(1-k)$的加大。这种新的约束条件会改变产品的相对价格，从而提高对绿色产品的需求，减少对非绿色产品的需求。

第二个是“绿水青山就是金山银山”和“良好的生态环境是最普惠的民生福祉”理念。这种新发展理念意

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味着新的偏好，以及对美好生活的重新定义。与之相对应的，是效用函数中消费者的偏好参数α的变化，以及在标准效用函数中考虑无形的生态环境等因素。标准的效用函数 $U=x^{\alpha}y^{1-\alpha}$ 由于没有考虑环境破坏等无形因素对福祉的负效应，消费者的真实效用并不如名义商品消费水平显示的高，即“高GDP、低福祉”。这已为大量福祉经济学的研究证实(Easterlin， 1974；1979)。因此，一旦考虑环境破坏带来的社会福祉损失效果$(1-k_s)$，真实效用函数就成为 $U=k_sx^{\alpha}y^{1-\alpha}$。其中，$0<k_s\leqslant 1$。随着$X$产品偏好参数$\alpha$的降低和环境治理力度加大，生态环境质量得以改善，效用函数中的k_s亦会提高，真实效用随之提高。比如，同样是消费1000元的商品，在生态环境良好的环境下或在环境严重污染的环境下，各自产生的效用就大不同。就正如从传统农业社会向工业社会转变的前提是社会心理和消费习惯的大规模转变一样，从不可持续的传统工业化模式转变到绿色发展，也需要社会心理、消费心理、生活方式的系统而深刻的转变。否则，仅仅依靠技术进步难以实现绿色转型。

传统工业文明和生态文明发展模式的这两个本质区别，意味着对成本、收益、福祉、最优化等概念的不同定义，从而生态环境、社会、文化等也有了不同含义。在传统工业化模式下，经济发展同生态环境、社会、文化等方面，则是一种相互冲突关系；在生态文明绿色发展模式下，经济发展同生态环境、社会、文化等方面，就有望形成相互促进的关系(张永生，2021b，2019)。

五、相关问题的讨论及其政策含义

(一)生态环境治理主体的角色转变

生态环境治理是政府、企业、消费者等主体共同行动的结果。从前面消费者和生产者决策系统约束条件的变化可以看出，经济从传统经济 (X, Y) 转型为绿色经济 (X', Y')，涉及偏好α、环境规制k、技术A和B等关键参数条件的变化。其中，最为关键的是政府的推动。

第一，发展理念和发展战略的转变。对于政府治理而言，绿色转型的关键是用新发展理念替代传统发展理念，用“人民福祉为中心”的发展目标替代长期以来GDP导向的发展目标。这种发展理念和发展目标的战略性具有“自我实现”(Self-fulfilling)的功能，会带来发展内容、商业模式、体制政策等的系统性转变。

第二，政府角色变化。根据Stern和 Stiglitz (2021)，环境危机是典型的市场失败。建立生态文明治理体系涉及对一些根本问题的重新思考，包括对市场职能和政府职能的重新定位。从《利维坦》中至高无上的统治者(霍布斯，1651)到《契约论》中政府与公民的契约关系(卢梭，1762)、到《国富论》中守夜人政府(Smith，1776)，再到现代市场经济下政府新的职能(Keynes， 1936)，人们对政府职能的认识也经历了实质性演变过程。中共十八届三中全会提出“更好地发挥市场的决定性作用，更好地发挥政府的作用”，以及十九届四中全会关于国家治理体系和治理能力现代化的决定，实质是对市场的功能和政府职能进行重新定义。比如，政府采取严格的环境措施会改变产品的相对价格，对绿色产品技术的扶持会促进绿色技术进步，降低绿色产品的价格。

第三，企业角色的变化。企业原先是在较少考虑外部性的条件下，实现股东利润最大化。现在则要在考虑更多利益相关者利益的条件下，实现股东利润最大化。在传统工业化模式下，企业治理更多的只是单一强调股东利益至上。在生态文明视角下，则要充分考虑经济活动的社会环境文化等后果，将主要利益相关者(以各

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种方式）均纳入公司治理结构，在此前提下实现股东利益最大化。X生产企业的目标函数从过去的$\pi_x=P_xX-\omega L_x$转变为$\pi_x=kP_xX-\omega L_x$。

第四，消费者消费习惯的变化。除了相对价格的因素外，消费者偏好是经济转型的重要推动力。改变的动力来自于：第一，对环境污染之于自身利益真实影响的了解；第二，消费者对良好生态环境好处的感受加深；第三，教育引导。Zhang和Chabay（2020）的研究显示，“绿色知识”对于改变消费偏好和消费行为十分关键，教育应该成为重要的途径。需要特别指出，政府引导偏好转变，并不是将特定的偏好强加给消费者，而是为那些不可持续的消费行为建立负面清单，让消费者自由选择。

（二）绿色转型对生产力、福祉和可持续的含义

需要强调的是，上面讨论的X和Y是指两种类型的产品集合，它们各自包含一系列产品，即$X=(x_1, x_2, \ldots, x_n)$，$Y=(y_1, y_2, \ldots, y_n)$。这样，可以将$X$和$Y$相对比重的变化理解为大量非绿色的夕阳产业不断消失，新的绿色产业不断涌现的过程。这个绿色转型过程，就是一个熊彼特的“创造性毁灭”（Creative Destruction）过程。Zhang和Shi（2014）的研究显示，减排有可能驱动经济结构跃升到一个更有竞争力的新结构，从而减排就不再是经济发展的负担，而可以成为经济增长的动力。比如，政府严格的减排政策驱使经济结构从传统“燃油车－加油站”的结构，跃升到“电动汽车－充电桩”更有竞争力的结构，同时后者的分工链条又不断细分，成本不断下降。目前，中国新能源、智能电动车的产业分工体系正在经历的井喷式增长，就是“创造性毁灭”的生动体现。

绿色转型并不像一些人担心的会影响经济增长，而是有可能实现更好更快的增长。绿色转型的核心要义是GDP内容的转变，以让发展回归到提高人民福祉这个初心。在新的绿色经济模式下，Y类产品和服务更多地基于知识、生态环境、文化等具有非竞争性（Nonrivalry）的无形资源，相较于高度依赖有形的物质资源投入的X类产品，Y的生产具有更高的递增报酬（Increasing Returns），因为知识、生态环境、文化一旦形成，其边际成本很低甚至为零。而且，新的绿色经济（X', Y'）很大程度上基于无形资源，这些资源会越用越多，不像传统经济（X, Y）依赖的有形资源会枯竭并破坏生态环境。只不过这种基于无形资源的产品和服务往往需要新的商业模式来实现其价值。但是，现有商业模式很大程度上又是在传统工业时代形成的，要实现这种转变殊为不易。

以前面讨论的公共资源治理为例。在传统工业化思维下，湖泊或林地的功能主要是养鱼或放牧。这是传统发展经济学以物质财富生产和消费为中心的标准定义。实际上，湖泊除了养鱼，还有大量的生态文化功能。比如，生态旅游、体育休闲、文化教育等。湖泊的这种无形生态资源，具有非竞争性的特性，其价值（比如景观）可以同时满足很多人的需求。如果湖泊的这些价值得到充分开发，则湖泊生态保护就有了新的发展含义，不再需要依赖“投肥养鱼”污染环境来获得更高的收益。因此，一旦对发展进行重新定义，Ostrom（2009）的IAD框架，就会有更新的发展含义。前面讨论的几类发展陷阱就会消失。

此外，需要澄清一个假象。传统工业化模式之所以看起来比绿色经济更有效率，一个重要原因就是长期以来其高社会成本没有被纳入经济分析和评估体系。比如，如果考虑环境污染的医疗支出$C_{medical}$，则所有消费

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者的预算约束就会降低，由$p_x x+p_y y=I$降低为$p_x x+p_y y=I-C_{medical}$。或者，为简便分析，我们可以在效用函数中引入一个社会成本相关的系数k_s，效用函数从$U=x^{\alpha}y^{1-\alpha}$变为$U=k_s x^{\alpha}y^{1-\alpha}$，其中，$0<k_s\leqslant 1$。当对那些污染企业采取严格环境措施时，由于环境改善具有非竞争性的性质，全社会均会从环境改善中受益，此时效用函数中的k_s均会提高。因此，严格环境政策反而会提高全社会的真实福祉水平。

六、简短的结语

工业革命后建立的传统工业化模式，在大幅提高物质生产力的同时，也带来全球范围的不可持续危机。在传统工业化模式下，不仅环境与发展之间存在两难冲突，当代人和后代人之间以及国与国之间，也存在两难关系。本文揭示，在传统工业时代形成的生态环境治理思维，更多的只能是通过技术进步和提高治理效率来扩大这种两难冲突的折中空间，难以从根本上解决环境与发展之间的矛盾。生态文明思维下的生态环境治理，则是通过促进发展范式的根本转变，形成环境保护与发展之间相互促进的关系，进而实现各国从环境负担分担转向机遇共享的共赢关系以及当代人与后代人的共赢。

从传统工业文明转向生态文明，是一个发展范式和研究范式的系统性转变。一旦在这个新的范式下思考生态环境治理问题，则关于目标函数、成本、收益、福祉、最优化等概念就需要进行重新定义，政府、企业、消费者的行为模式都会改变，带来非常不同的生态环境后果。中共十九届四中全会提出的生态文明治理，重点强调生态环境保护、资源利用、生态保护与修复、生态环境责任制度。在生态文明思维下，这些都具有不同于传统工业时代的政策含义。同时，一旦跳出传统工业时代的思维，对一些长期被奉为圭臬的理论，可能就需要重新思考。

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Environmental Governance: A Perspective from Industrial Civilization to Ecological Civilization

Zhang Yongsheng*
University of Chinese Academy of Social Sciences (UCASS), Beijing, China
Research Institute for Eco-civilization(RIEco), CASS

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.*

Keywords: *Environmental governance, industrial civilization, ecological civilization*
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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

* CONTACT: Zhang Yongsheng, email: ys_zhang@cass.org.cn.
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[1] https://eciu.net/netzerotracker

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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.

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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

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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

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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

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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

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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, $X'<X, Y'>Y$.

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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: $\pi_x=kP_x X-\omega L_x$. 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 $kP_x X$, 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 $\pi_y=P_y Y-\omega L_y$.

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

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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).

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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

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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 $C_{medical}$

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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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