



Natural capital depreciation, pollution damage and total factor productivity

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Abstract: Green transition and digitalization help to address some of the key market failures that are hindering the transition to a circular economy, improving total factor productivity and resource efficiency. Green transition, digitalization, data, information and knowledge help improve the existing circular economy model and enable the development of new circular business models and best practices. The Government needs to establish a policy framework that supports promoting digital circular activities while minimizing the risks that these activities bring.

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1. Green transformation, digital transformation and inclusive green total factor productivity

Productivity is defined as the ratio between output and input. Productivity gains are a key determinant of the ability to supply adequate, nutritious food from available land, capital and labour. Productivity involves using available resources in the best possible manner to produce something more efficiently. Total factor productivity (TFP) is a ratio of a measure of total output to a measure of multiple inputs. Partial factor productivity (PFP) is a ratio of a measure of total output to a measure of a single input. Increases in TFP play an essential role in economic growth and raising incomes. TFP calculations include inputs and outputs that have methodological and data challenges. Important productivity factors include the nature and quality of materials and natural resources; the basic nature of the processes/procedures employed; the amount of plant and equipment employed within the process; the efficiency of the plant and equipment; the volume, continuity and uniformity of production operation; utilization of a labor force. Technical progress is the essential determinant of growth. Technological change and technical efficiency improvements reallocate resources across sectors, contribute to economic growth, generate extra real income and employment, raise living standards, avoid pressure on natural resources and address social goals, including environmental problems. The circular economy involves the requirements of de-

signing out wastes through improving the basic processes via research and development, providing additional and improved physical means of production, equipment and product, methods of operation, organization, planning, and control, manpower effectiveness at all levels.

Traditional TFP only considers the contribution of capital and labor input to economic growth, ignoring the natural capital and the pollution that damages the environment. Inclusive green total factor productivity (IGTFP) places a high priority on climate change mitigation, taking the input of natural capital and the output of pollutants into account. Productivity and carbon sequestration can be achieved through enhanced husbandry management and practices, cutting emissions by possibly 20 - 30%. Robert Gordon (2000) stressed the important of TFP growth in improving American well-being as the combined influence of globalization, global warming, and pollution constitutes an important drag on future growth. Extreme weather events caused by climate change will decelerate future economic growth. Weitzman (1976) pointed out that the maximum attainable level of consumption could be maintained forever without running down capital stocks. Solow (1986) handles Hartwick's rule as a way of maintaining the capital stock intact to keep real consumption constant over time. A measure of Net National Product (NNP) should take into account the value of natural capital depreciation, pollution damage and account for nonmarket amenities such as parks, landscape, nature, and recreational access (green NNP = NNP - natural capital depreciation - pollution damage + nonmarket amenities). Genuine savings contain gross and net saving/investment, depreciation of natural capital, education expenditure, TFP and pollutants such as CO₂ emissions. Positive or Negative changes in inclusive (comprehensive) wealth are indicators of sustainable or unsustainable economic activity.



The standard producer theory can define the technical link between inputs and outputs using production technology. Productivity of complex farming systems can be measured by biomass (agronomic) yield or income as a simple productivity or TFP because a large number of crops are grown simultaneously on the same piece of land and often harvested at different times. Conventional technology can manage the desired outputs. Productivity of mixed cropping systems can be measured by land equivalent ratio (LER), area \times time equivalency ratio (ATER), resource-use efficiency or carbon dynamics. Undesired outputs, on the other hand, require special attention in efficiency analysis. The set of environmental production technologies can be included as climate change and weather risks are more likely to be greater in coming years. Green TFP was not quantified in previous studies. Existing studies have overlooked the intertemporal element of agricultural emissions. Environmental issues, such as air pollutants (CO_2 , CH_4 , N_2O , SO_2 , NO_x , PM_{10} , $\text{PM}_{2.5}$, NMVOC, CO) can be explored. Green resources and green technologies are limited by geographical distance, market segmentation, and information asymmetry. Green productivity would improve through interventions and technology use. The new digital infrastructure breaks through the geographical constraints of green resource allocation and green technology flow, connects the supply and demand sides via AI, IoT, big data, cloud and other information technologies. Producers should design new farming methods to cope with extreme weather events, such as prolonged drought, excessive moisture, or extreme heat, or even to change crops produced on their farms.

The Labor Party Manifesto (2019) lays out a plan to transform Britain's society and economy to tackle climate change through the Green Industrial Revolution on the basis of investments in the circular economy, renewable energy and low-carbon infrastructure while rethinking agricultural subsidies to prioritize conservation and recovery natural habitat. The European Commission has announced the focus of its strategy to lead the green industrial revolution through a circular economy in the creation of clean technology products and access to raw materials needed for the green transition. Global investment in green transition will triple by 2030 from US\$ 1 trillion in 2022.

The world's consumption of raw materials is expected to nearly double by 2060. This is especially alarming because the extraction, processing, use and management of natural resources and natural resources lead to considerable pressure on the environment. The circular economy aims to convert the current linear economy to a circular model to reduce the consumption of finite natural resources by recovering materials from the waste streams. Deposit return systems (DRS), supplemented by mandatory extended manufacturer liability (EPR) policy tools, can encourage eco-design and improve the quality and quantity of reuse and recycling.

The circular economy provides the backbone for public policy to support industrial development in the context of environmental and social concerns. The final challenge for sustainable development is to decouple economic growth from the exploitation and depletion of natural resources. The Green Industrial Revolution promotes industrial progress, economic growth and diversification in a socially inclusive and environmentally friendly manner. Resolution of the 13th National Congress of the Party identifies building a circular economy as one of the country's development orientations for the period 2021 - 2030 to achieve the goals of sustainable production and consumption development. The Law on Environmental Protection in 2020 has institutionalized a number of mechanisms and policies to promote the circular economy, such as in the use of economic tools and policies such as natural resource taxes, environmental protection fees; green procurement, green credit, green bonds, carbon market development, environmental industry development, environmental services; segregation of waste at source, collection of waste fees based on volume, recycling and reuse of waste; extended producer responsibilities...

2. Green transformation, digital transformation is an opportunity to improve the IGTFP in Vietnam

A circular economy is a sustainable consumption and production model that promotes sharing, renting, reusing, remodeling, refurbishing and recycling existing materials and products for as long as possible. The circular economy reduces the use of materials, redesigns materials, products and services to use less resources, and reuses "waste" as a resource to produce materials and products. Unlike the linear economy, the circular economy circulates resources throughout the entire value chain from investigation, exploration, exploitation, processing, and manufacturing to distribution, consumption, classification, collection, transportation, storage, reuse, recycling, remanufacturing and recycling of waste. With a circular economy, the value of resources is preserved, the raw materials needed to create new products are maintained. The circular economy directly impacts total factor productivity through improving productivity, increasing value added and reducing costs, and replacing intermediate inputs, including raw materials (primary or secondary), energy (fossil or renewable) and other goods and services necessary for sustainable production and consumption.



The circular economy's greatest contribution to IGTFP is the redesign of industrial processes at an early stage.

Applying green transformation, digital transformation to design, share data, connect and communicate in order to realize industrial symbiosis based on the circular economy model in ecological industrial parks. Circular economy models often rely on reverse supply chains and reverse logistics to close material loops, such as recycling waste while extending product life by promoting reuse, repair, refurbishment. Such activities can extend beyond borders and require cross-border movement of end-of-life products to deliver economies of scale. Digital transformation is a tool to help increase TFP, increase output value faster than inputs. Digital transformation provides access to large volumes of data and community resources allowing policymakers to identify priority areas and make policy decisions based on big data. Digital transformation supports policy design and reshapes government-citizen interactions. Digitization offers new tools for governments to more effectively test design and evaluate policy. Smart waste segregation and collection system, powered by IoT and sensors, help increase efficiency and improve the quality of waste segregation and collection services. The synergy of real-time systems, machine learning and artificial intelligence is the basis for improving the IGTFP through reducing time and human resources, management costs.

3. Solutions to promote IGTFP in Vietnam

At the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26), Vietnam pledged to bring net emissions to “zero” by 2050. In the Nationally determined contributions (NDCs) updated in 2022, Vietnam aims to reduce its total greenhouse gas emissions by 43.5% compared to the BAU scenario by 2030 with international support, a remarkable increase compared to the NDCs 2020 (27%). At the fifteenth meeting of the UN Biodiversity Conference of the Parties (COP15) held in Kunming, China and Montreal, Canada, Vietnam and 190 countries approved the historical “Kunming-Montreal Global Biodiversity Framework”. Vietnam is the third country to reach an agreement to establish a Just Energy Transition Partnership (JETP).

IGTFP is crucial to improving environmental quality and sustainable development. Green transition and digitalization have a significant improvement effect on IGTFP. Green technology innovation and factor allocation optimization help reduce environmental and resource problems and enhance rapid economic growth. Ecological crises and environmental problems can only be addressed through green transition and digitalization to achieve the coordinated development of the economy, resources and the environment. IGTFP can only be achieved by green technology innovation and green resource allocation optimization.

Green transformation and digitization help transforming the current linear economy to circular economy, by transforming circular value chains, changing market structures and operations, enabling the creation of platforms and ecosystems, adjusting the consumer behavior and raising public awareness about climate actions and protecting environment, increasing the likelihood of value retention and mitigating negative environmental externalities. Combining physical and virtual assets, digital transformation acts as a driving force for creating value, improving labor productivity, and aggregating factors through the establishment of digital and operating platforms, integration and sharing of data among ministries, localities, helping improve the quality of public service delivery.

Digital transformation helps reduce transaction costs, traceability, of products and goods, materials, waste streams of plastic, metal, oil and lubricants, rubber, glass, wood, paper and other biomass...; the quality of secondary materials for reusability and recycling of goods and materials in the value chain can be improved; Component and product tracking for maintenance, repair, reuse, recycle and remanufacture can be made easy. Besides playing an important role in circular business models, digital transformation, digital innovation and the adoption of digital solutions help improve circular economy policymaking. To make this linkage a reality, Central and local governments need to research and explore data-driven approaches to better predict environmental and social trends and needs, integrate circular economy model into strategies, master plans and plans of ministries, sectors, localities and enterprises to make circular economy policies towards the goal of improving the IGTFP ■

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