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A Study on the Integration of Digital Empowerment with Green Development and Sustainable Economic Growth

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Abstract: Digital technologies are profoundly changing how we integrate green development with sustainable economic development at the level of the individual and commercial economy. An effective way to resolve the conflict between the environmental constraints imposed on economic growth and the need for continued economic growth is to coordinate and promote both simultaneously. The advancement of digital technologies is defining the new operations of production, distribution, and consumption, and thus eliminating the endogenous tension between green development and commercial development while enhancing the synergies between green development and commercial development. Studies on the theoretical basis and practical path of the integration of green development and commercial development, exploring the empowerment mechanisms created by the use of digital technologies, proposing recommendations related to institutional arrangements for effective governance of the integrated use of both types of development in order to provide practical examples for facilitating the integration of both types of development and achieving both ecological and commercial development goals at the same time.

Keywords: Digital empowerment; Green development; Commercial economy; Sustainable growth

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1. Introduction

Because of the global ecological constraints and increasing expectations for a premium style of development of the commercial economy, both green development and the transparent and equitable growth or expansion of the commercial economy have become an undeniable necessary support of each other. However, green development does have moments of inherent conflict with the commercial expansion of the economy at this time, so the conventional way of developing is hard-pressed to find a common synergetic process of development between ecological protection and commercial development. Digitalization, as a new factor of production, has the empowerment of physically removing the barriers of technology and machinery that limit the potential for integrating both green development and economic development, introducing the concept of green development throughout and encompassing all economic development processes. For both of these developmental business processes, integrating the two processes of green development and economic development is both an inherent requirement of industrial transformation and the key to fulfilling sustainability goals.

2. The theoretical logic of integrated development

2.1. The intrinsic tensions and synergistic potential between green development and commercial growth

The essential disparity between ecological sustainability and commercial profitability arises from a fundamentally different approach to business. Commercially-oriented growth is simply about achieving positive financial returns; for some companies or producers, this means trying to maximize short-term profits through reducing their green capital investments by choosing to invest in energy-intensive and less environmentally-friendly business operations. The goals of green development's core principles regarding the limits of reduced carbon consumption and sustainable site occupancy are in direct conflict with the profitability drive for most businesses. This disparity is not strictly oppositional; the foundation of the two can be related through their respective inherent usefulness to each other. From an operational perspective, the economic costs of green investment should not be perceived as strictly a cost. Green technological solutions and process efficiencies will ultimately result in less use of company resources and a lower cost of waste disposal, thus indirectly increasing a company's operational efficiency [1].

2.2. The empowerment mechanism of digitalization as a link for integration

The integration of green development and business development is most fully realized with the use of digital technologies, which provide businesses with the essential data they need to develop in both areas. With digital technologies, businesses are able to accurately measure resource usage and the related carbon emissions from the creation, circulation, and consumption of products and services, which are the three stages of production, circulation, and consumption. This solves the problem of fragmentation of data and the inability to implement precise control over the outcome of the previously fragmented data. The availability of real-time data collected from the production processes allows businesses to make accurate decisions based on the results obtained from these processes, thus decreasing costs, enhancing business performance, and maintaining accurate control over carbon emissions and depletion of resources, as requested by today's green development initiatives. In addition to providing businesses with essential data for making operational decisions, digital technologies provide a precise mechanism for matching the demand for green products with the supply of green products available for sale in the market. By analyzing customer profiles to identify the customer's green consumption preferences, digital technologies enable businesses to adjust their product and service offerings to facilitate converting green investments into commercial returns, thereby creating a virtuous cycle of synergistic development from both sides of the transaction process for both businesses and consumers.

3. Key pathways for digital empowerment of integrated development

3.1. Production side: Green energy consumption management and low-carbon process upgrades

Production-based systems will have a full range of energy monitoring systems based on industrial internet technologies, the Internet of Things, and edge computing to provide all of the necessary technology for the integration of green development and commercial economies on the production end of the value chain. Digital services, therefore, focus on providing precise energy management and low-carbon scenarios and processes. When integrated with production equipment, the use of smart sensors will enable real-time collection of energy use, milliseconds transmission to the edge computing node for processing and analysis of the energy use data and using the industrial process control system (IPC) as an integrator of the production's actual output and the production's designed output and to adjust for production load and thereby optimize changes in energy consumption based on the dynamic download of the actual energy cost associated with the production, and to accurately identify major consumers of energy and any hidden loss points. Digital technologies will also serve to enable and promote the deep integration of energy consumption data into the production planning system (MPS) through the development of models that represent statistically reliable estimates of expected performance, so that energy budgets and production schedules can be coordinated through data models and to ensure that the efficiency of the disconnection of energy-saving upgrades is minimized with the efficiency of the actual production performance [2].

Low carbon process transformation's digital deployment principally consists of adapting new technologies with cost effectiveness through the digital simulation of the low carbon process. Digital twin technology enables an enterprise to develop a digital model of an entire production process, which can simulate the effect of implementing different low-carbon processes at the enterprise level. Once an enterprise has created a digital model of their actual production process, it can choose which low-carbon procedures are most adaptable and cost-effective to implement based on the size and type of products they manufacture. High energy-consuming manufacturing industries can optimize their production processes through the use of numerical modeling, allowing for improved recycling of raw materials as well as reducing waste and traditional high-energy-consuming and high-emission processes. This resolves the barriers to traditional transformations, ensuring that low-carbon process upgrades both meet green development goals.

3.2. Distribution side: Smart logistics and carbon efficiency optimization in supply chains

One of the main challenges to improving carbon efficiency at the endpoint of distribution is the lack of information sharing across supply chain components and ineffective allocation of resources. Improving carbon efficiency will primarily be accomplished by using big data, blockchain technology, and Geographic Information Systems (GIS), which will allow for the creation of a smart system of "coordinated, end-to-end supply chain + accurate carbon efficiency management." Unlike a traditional logistics model that optimizes supply chain component(s) at a single point, the use of digital technology offers an integrated approach to data across warehousing, transportation, delivery, and sorting, and builds a common supply chain carbon efficiency management platform. The use of blockchain technology provides visibility into the carbon impacts associated with the cargo movement process, ensures that carbon footprints can be traced through the entire process, and offers tamper-proof, quantitative accounting to accurately measure inefficiencies associated with empty vehicles, congested warehouses, redundant routes, etc., providing the basis for accurate data-based carbon efficiency improvement strategies.

The global supply chain's long-term optimization of carbon efficiency relies fundamentally upon the coordinated digital interface between upstream and downstream participants, with the integration of supply chain management (SCM) systems and IoT technologies serving as a fundamental demonstration of the new way to innovate and differentiate from traditional methods of optimizing circulation. The impact of digitalization provides a means for breaking down the barriers of information between supply chain entities through access to SCM systems that allow the sharing of data between manufacturers, logistics providers, and retailers. This collaboration enables participants in production planning, inventory management, and logistical distribution to coordinate collaboratively and thus avoid wasting resources or increasing carbon emissions through "blind" production and excess inventory. At the same time, the use of IoT enables participants to obtain carbon efficiency data throughout the supply chain, facilitating the establishment of a carbon efficiency evaluation system. Measures at the same time promote the use of green packaging and new energy vehicles; therefore, creating a virtuous cycle of "collaborative carbon reduction and shared value."

3.3. Consumption side: Data-driven incentives for green consumption and behavioral guidance

The ultimate development of green consumer end-products will be achieved by the energy revolution and economic transformation through green development. Using digital technologies, such as user-generated behavior data collection technology, machine learning algorithms (MLA), and customer relationship management (CRM) systems, businesses can deliver personalized products that match the consumer's precise needs and offer them long-term behavior-based suggestions. Existing consumer methods for promoting green consumption typically rely on formalizing consumption and efficiency through various methods. Green consumption habits and preferences are identified by collecting consumer transactional and behavioral data via various consumer terminal devices or through consumer platform interfaces. Using MLA techniques, such as decision trees and K-means clustering, to develop best-fit user profiles and alternative methods helps businesses to identify the different green consumption preferences (e.g., beliefs, opinions, etc.), abilities, and habits of different types of consumer groups (i.e., high income vs low income), and eliminate the guesswork of green product promotion and incentive creation. Taking these identified groups into account, differentiated guidance and recommendations for green products based on the needs of each of these groups would be delivered to help build the awareness of each of these groups regarding their own green consumption practices through scenario-based guidance and incremental incentive programs. The result would be greater targeting and effectiveness of green consumption guidance.

Digital innovation in green consumption incentives relies on blockchain and a point management system to break the "single incentive + short-term effect" paradigm and create a long-term "incentive feedback optimization" mechanism. This approach differs from the traditional model of point exchange in that it more closely links green consumption behavior to personal carbon accounts, commercial discounts, and social recognition. Carbon points generated by consumers can be traced and circulated through the use of blockchain technology as consumers earn carbon points for each instance of green consumption. In addition to being used to reduce the cost of future consumption, these carbon points can also be used to support various green public welfare initiatives and acquire green services, increasing the attractiveness and sustainability of incentives [3].

4. Institutional safeguards and governance optimization for integrated development

4.1. Mechanisms for green data collection, mutual recognition, and sharing

The main participants in developing the mechanism for green data collection, recognition, and sharing are the Government, Enterprises, and third-party service agencies. Through cooperation, these three parties will remove the current confusion surrounding green data and create a smooth flow of green data. The government must spearhead the establishment of uniform green data collection standards, including defining the scope of green data collection (e.g., enterprise production energy consumption, carbon footprint of product/transportation, and consumer green behaviors). Enterprises must use standardized collection tools so as not to create confusion and to enhance interoperability of green data. Based on the above, the government should establish an open public green data-sharing platform, which will define the data-sharing process and permissions granted to each party, as well as differentiate between sensitive and non-sensitive data for each enterprise, and ensure the safe transfer of green data by means of encryption, so that enterprises will not be concerned with any leakage of green data when sharing green data. Third-party service providers must authenticate, cross-reference green data submitted by enterprises, detect fraudulent green data, correct bias or errors included within the green data, and verify the authenticity and usability of the green data.

4.2. Research and development orientation and incentives for commercialization of digital green technologies

Research and development as well as successful transformation in digital green technology are typically focused on enterprises. Currently, technology research & development has become disconnected from practical application, and there are challenges for small and medium-sized enterprises in securing funding or grants for basic green transformation. Thus, enterprises should establish differentiated research & development as well as a transformation strategy based upon their green transformation reality. Enterprises must conduct a thorough analysis of pain points associated with producing and operating at high energy consumption and emissions and create a detailed list of requirements for technologies. Enterprises must then actively partner with research institutions to conduct targeted research and development on acceptable technologies and focus on technologies that have low costs, are easy to operate, and can be adapted [4]. Additionally, enterprises should establish a pilot trial mechanism for technologies being developed to confirm/apply technologies within production, assign personnel who will track/record the effectiveness of the application, and provide timely feedback to research institutions regarding operational suitability and cost management, and further promote technology improvements.

4.3. Corporate collaboration and cross-departmental governance capacity building

The situation requires the enterprise management to exercise top leadership in building the governance system that is "clear in responsibility and authority, dynamic in collaboration, and closed-loop management," in contrast to the traditional administrative control mode. It would not be muscularly buttressing a rigid organizational structure, it is generalized as a green collaboration team that will be called upon to promote cross-departmental collaboration, not the reconstruction of the existing departments. The collaborative teams must create a problem ledger system for departments, after the completion of the task in the PDCA cycle of "discovery solution review optimization," that covers resource allocation and inconsistency in the implementation of standards among Production, Finance, and Environmental Protection departments. The enterprise's management must also include the effectiveness of green collaboration in the primary evaluation metrics for departments and individuals, instead of merely using them as supports for other assessments. They should use positive incentives and negative constraints to motivate departments to work collaboratively and remove barriers in order to advance green development and business growth [5].

5. Conclusion

Digitally empowering green development and the commercial economy's sustainable development is a systematic effort; it requires guidance from the logic of theory, critical path support, and institutional safeguards. The implementation of digitization addresses the existing contradictions between production, circulation, consumption, and the allocation of resources through the empowerment of these systems, demonstrating the unique advantages of collaborative development. By enhancing green data sharing, developing technology advancement, standard certification, and intensifying collaboration among businesses and teams, the possibilities of integrated development will be explored, a new sustainable development pattern will be established that is environmentally friendly and has positive impacts, and lasting green momentum will be created for the high-quality development of the commercial economy.

Disclosure statement

The author declares no conflict of interest.

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