Tracing Carbon Emissions Driven by Chinaâ€™s Digital Economy through Input-Output Analysis

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While the digital economy is recognized globally as a driver for production efficiency and economic growth, it may also boost CO2 emissions, which remain inadequately quantified. Existing studies primarily centered on estimating emissions from some pure digital sectors, such as the information and communication technology (ICT) industry, employing inputâ€“output methods to analyze their driving factors and transmission paths. However, the impact of the digital economy is not limited to pure digital sectors. It also increasingly permeates non-digital industries, in particular manufacturing, and reshapes the production and emission structure of the entire economic system through supply chains. Therefore, it is necessary to adopt a broader supply-chain perspective to examine the emission changes driven by the digital economy and to reveal their driving factors and transmission mechanisms, while also exploring its role in promoting economic growth.

In this study, we take China as a case to conduct a comprehensive assessment of emissions driven by digital economy. We start by accounting for the production-based emissions driven by digital economy across sectors from 2000 to 2020 based on our sectoral level emission inventories (CEADs.net) and our newly compiled Chinaâ€™s digital use tables. We then estimate embodied digital emissions along supply chains from a consumption-based accounting approach. Subsequently, we apply the Structural Decomposition Analysis (SDA) to analyze the drivers of both economy-wide emissions and digital-economy emissions, respectively. Ultimately, Structural Path Analysis (SPA) is used to identify the most crucial intersectoral emission transfer pathways associated with the digital economy.

Results reveal a pronounced disparity between the direct and embodied emissions of the digital economy. To be exact, production-based emissions constitute a mere 0.13-0.43% of total national emissions, whereas embodied emissions are substantially larger and increase markedly over time, rising from 6.63% in 2000 to 12.1% in 2020. Moreover, the digital economy represents a cleaner pathway for economic growth. Although digital-economy-related sectors contribute 8.05%-22.62% of national total output, their embodied emission share (6.63%-12.1%) remains substantially lower. In particular, the output share was approximately twice the embodied emission share in 2020. Furthermore, digital-economy emissions exhibit highly sectoral concentration.

The SDA results further indicate that economic growth and emission-reducing technological progress are the dominant upward and downward drivers of both economy-wide and digital-economy emissions, respectively. Economic growth contributes 8.22-25.05% and 12.97-37.91% annually at the two levels, while technological progress offsets emissions by 6.51-12.10% and 6.51-13.26%, respectively. Changes in production- and consumption-side digital structures both exhibit emission-mitigating effects, although their contributions remain relatively limited, generally below 1%. SPA results demonstrate that the embodied emissions of the digital economy are primarily driven by distant upstream layers rather than direct suppliers. Tier 1 suppliers contribute only about 18.85-20.61% of total embodied emissions, whereas Tier 2 and subsequent upstream layers account for roughly 77.26-79.68%. Moreover, power generation and metal-related sectors are the most critical upstream nodes determining the embodied emissions driven by digital economy. Specifically, among hundreds of millions of potential supply-chain paths, the top ten emission pathways alone account for 13.02-14.08% of the total annually, and these paths are generally characterized by inputs from electricity and heat supply, basic metals, and non-metallic mineral product sectors, highlighting their central role in emission transmission.

In summary, our study has three main contributions. First, we provide the first comprehensive accounting of production- and consumption-based emissions driven by digital economy using our newly developed digital inputâ€“output tables. Our method extends existing ICT-focused research from narrowly defined digital sectors to the broader digital economy. Second, we identify the key drivers and critical transmission pathways of embodied emissions. These findings can improve understanding of how digitalization shapes emission flows and provide actionable policy insights for designing more effective mitigation strategies tailored to the digital economy. Third, we find that developing digital economy is a cleaner growth pathway for China, where the share of output generated by the digital-economy sector is consistently higher than its share of COâ‚‚ emissions over the period 2000-2020. Therefore, our study offers evidence support for the ongoing development of the digital economy as part of Chinaâ€™s low-carbon transition.