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Digitalization and Dependence: Evaluating the Impact of the Belt and Road Initiative on Achieving Sustainable Development Goals 8 and 9 and Shaping Digital Autonomy

Haisheng Hu+

Faculty of Public Administration, University of Ljubljana, Ljubljana, Slovenia

Abstract This study explores the impact of China's "Belt and Road Initiative" (BRI) on the achievement of United Nations Sustainable Development Goals 8 and 9 in participating developing countries, with a particular focus on the moderating role of digitalization and its long-term effect on the reliance of these countries on Chinese digitalization. Rigorous statistical methods, including parallel trend tests, regression analysis, propensity score matching (PSM), and placebo tests, ensure the reliability of the results. The findings indicate that after implementation, the BRI significantly advanced sustainable development goals in participating countries. Countries with higher levels of digitalization utilized the BRI more effectively to promote sustainable development. Further research suggests that while the initiative may increase digital dependence, higher levels of digitalization can mitigate this reliance. This study highlights the positive impact of the BRI on sustainable development, especially in digitally advanced developing countries, and offers a new perspective on reducing dependence on China.

Keywords: One Belt One Road Initiative, Sustainable Development Goals, Digital Dependence, Digitalization

JEL Classifications: F6, O10

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I. Introduction

In the contemporary era, digital transformation is not just a buzzword but a fundamental change that is redefining the international landscape. It is through this lens that we must view the Belt and Road Initiative (BRI), a collective project under the aegis of China, aimed at forging new economic corridors across Asia, Europe, and Africa. With the BRI, we see a blend of ancient trade routes with modern ambitions, crafting a narrative that intertwines infrastructure development with digital innovation. The implications of the BRI for global power structures are vast, touching upon everything from geopolitical alignments to the socioeconomic uplift of entire regions.

The United Nations Sustainable Development Goals (SDGs) 8 and 9 serve as a template

+Corresponding Author: Haisheng Hu
Ph.D. Candidate, Faculty of Public Administration, University of Ljubljana, Kongresni trg 12, Ljubljana, Slovenia.
E-mail: hh10078@student.uni-lj.si

against which the progress and impact of such initiatives can be measured. SDG 8 promotes inclusive and sustainable economic growth, full and productive employment, and decent work for all, while SDG 9 focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. The intersection of these goals with the BRI's objectives is hence fertile ground for research, especially considering the profound implications for participating nations.

This research aims to delve into the intricate effects of the BRI on the realization of these SDGs. It is an exploration that spans several aspects of socioeconomic development, from macroeconomic outcomes, such as changes in trade flows and foreign investment patterns, to more granular impacts on labor markets, skills development, and technological advancement. At the heart of this investigation are two themes that are both contemporary and timeless: the country's level of digitalization and its digital dependency on other countries. The BRI's ambition is not only to create physical infrastructure but also to catalyze digital connectivity. This raises the question of whether the BRI can be a vector for achieving SDGs 8 and 9 through heightened digital engagement and what the long-term implications of this digital deepening might be. The digitalization brought about by the BRI can be both an opportunity and a challenge. For countries involved, this could mean access to new markets, improved governance through digital platforms, and a boost in technological capabilities. Conversely, it may also result in increased digital dependence, where countries find themselves reliant on foreign technology and expertise, potentially compromising their digital sovereignty. One of the critical questions this research addresses is the extent to which the BRI contributes to digital autonomy or digital dependence among participant countries. Digital autonomy pertains to a country's ability to control and develop its digital infrastructure and services, while digital dependence indicates a reliance on external entities for digital needs. This is particularly important in the context of the BRI, where digital infrastructure is often provided by Chinese companies, potentially leading to a situation where domestic industries and security are influenced by foreign technology.

This study will meticulously assess the current landscape of digital development across BRI countries, analyzing the disparate levels of digital maturity and capacity. It will explore whether digital transformation under the BRI is being leveraged for local capacity building and innovation or if it is merely creating new dependencies. Furthermore, this research will evaluate the diversity of outcomes across different regions and socioeconomic contexts, providing a comprehensive picture of the BRI's digital dimension. Another dimension of this research is the scrutiny of the BRI's influence on employment patterns and labor markets in participating countries. The initiative's infrastructure projects are expected to create millions of jobs, but there is also potential for disruption. The BRI's digital component could lead to increased automation and the need for a more skilled workforce, posing challenges for countries with large unskilled

labor pools. Innovation is another key factor in this equation. The BRI's emphasis on technology and infrastructure could spur innovation within participating countries, but this depends on their ability to absorb and build upon the new technologies introduced. This research will examine cases where the BRI has led to significant technological and industrial advancements and identify the factors that have facilitated these developments. Moreover, this study will provide insights into the delicate balance between fostering economic growth through digital development and ensuring that such growth is sustainable and inclusive. It will evaluate the environmental implications of the BRI's digital projects, their contribution to the creation of smart cities, and their impact on the digital divide within and among countries. By offering a multifaceted analysis of the BRI's impact on SDGs 8 and 9, this research aims to present a nuanced understanding of digital transformation within the ambit of international relations. It will shed light on the intricacies of digital autonomy and how it is being shaped by transnational projects such as the BRI. The findings will hold particular relevance for policymakers, international agencies, and scholars seeking to comprehend the evolving dynamics of digitalization and its implications for sustainable development.

In conclusion, this research provides a comprehensive picture of the role that the BRI could play in advancing SDGs 8 and 9, examining the potential for sustainable economic growth, employment, and innovation. It will critically analyze the nexus of digitalization and dependence within the framework of this monumental initiative, thereby contributing to the broader discourse on sustainable development and international cooperation. Through this endeavor, this study aims to enhance our understanding of the complex dynamics of digital transformation and its multifarious consequences for the international community.

II. Literature Review

The "Belt and Road Initiative" (BRI) is a global development strategy aimed at promoting international cooperation and economic growth through the construction of large-scale infrastructure and extensive trade networks (Zhu, H., 2023; Wang, R., 2023). The BRI plays a particularly important role in advancing Sustainable Development Goals (SDGs) 8 and 9 (Xu, J., 2023; Liu, Y., 2023). SDG 8 focuses on achieving full and productive employment and decent work, while SDG 9 emphasizes the development of resilient infrastructure, inclusive industrialization, and the promotion of innovation (He, R., 2021).

A. BRI and SDG 8: Promoting inclusive and sustainable economic growth

1. Infrastructure construction and employment opportunities

The essence of the "Belt and Road Initiative" lies in infrastructure projects such as roads, railways, and ports, which directly contribute to the creation of job opportunities and economic growth (Cao, X., 2022; Ullah, A., 2022). For example, in Pakistan, the construction of the China-Pakistan Economic Corridor (CPEC) is expected to create more than 700,000 jobs, greatly promoting local economic development (Li, X.,2021;Li, C., 2023). These projects not only provide a large number of employment opportunities for professionals in construction and engineering but also stimulate the development of related industries such as building materials, logistics, and services.

2. Enhancing skills and productive employment

Beyond direct employment opportunities, regional infrastructure initiatives in Africa also increase the productivity and competitiveness of the workforce through skill training and career development opportunities (Zhao, T.,2022;Zhang, D., 2023). In the Hambantota Port project in Sri Lanka, Chinese companies not only provide employment opportunities but also conduct skill training programs to improve the professional skills of local employees.

B. BRI and SDG 9: Promoting resilient infrastructure and sustainable industrialization

Within the strategic framework of global development, the BRI and the SDGs constitute a crucial multilateral development architecture (Huang, Y., 2022; Umurzakov, U.,2023). The BRI aims to promote infrastructure construction and economic integration on a global scale, while the ninth goal of the SDGs (SDG 9) focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and stimulating innovation activities (Liaqat, I.,2022). These two major development agendas intersect on many levels, particularly in strengthening digital infrastructure and promoting industrialization.

Regarding the development of digital infrastructure, the BRI's investments in this area are significant and have a profound impact on participating countries. These investments align with the objectives of SDG 9, as they strengthen industrialization processes and technological upgrading by providing digital means (Wang, S., 2023). For example, the layout of fiber optic networks allows remote areas to access high-speed internet, which not only improves communication quality but also lays the foundation for the development of online education, remote work, and e-commerce. The construction of data centers has become the core infrastructure that supports the efficient operation of these services. Taking the railway project between China

and Laos as an example, the project integrated advanced communication systems and data center construction during its construction, which are key elements of digital infrastructure. The application of these technologies not only improves the efficiency of railway operations and ensures transportation safety but also promotes the development of the local digital economy, allowing Laos to steadily advance in the global digitalization process.

In terms of industrialization and technology transfer, the BRI facilitates technology transfer and the industrialization process through project execution. Infrastructure projects introduce advanced technologies and equipment to participating countries, which significantly improves local industrial capabilities and accelerates the pace of industrialization. In the railway project in East Africa, the introduction of Chinese technology and standards not only improved the modernization level of the railway system but also provided local personnel with training and skill development opportunities, enabling them to maintain and operate these advanced systems. Technology transfer also plays a decisive role in promoting the industrialization process of participating countries (Wang, B., 2023). Through cooperation with Chinese companies, local enterprises have learned new production methods and management techniques, accelerating their transition to more efficient and environmentally friendly production models. Knowledge sharing and personnel training have equipped the local workforce with the necessary skills, further catalyzing the diversification of the economy and sustainable development (Brauteseth, 2023). This technological cooperation and transfer not only promotes economic growth but also helps to reduce inequality, as it fosters skill enhancement and the creation of high-quality job opportunities. In these ways, the BRI closely aligns with the objectives of SDG 9, which are to jointly promote economic growth and social inclusiveness.

In summary, the contributions of the BRI to digital infrastructure and industrialization have opened up new paths to sustainable development for participating countries. The construction of digital infrastructure such as fiber optic networks and data centers has enhanced the proliferation of information and communication technologies, accelerating the flow of information and the spread of knowledge. This not only benefits the transportation, telecommunications, and financial services industries but also significantly boosts broader economic activity and social development.

As the BRI promotes regional trade and investment cooperation, it creates a favorable environment for achieving the eighth and ninth Sustainable Development Goals (SDGs). The construction of infrastructure networks helps reduce trade costs and widens market access, thereby generating more employment and business opportunities. Additionally, this transnational collaboration attracts a significant amount of foreign direct investment, further catalyzing the development of local industries and technologies. The infrastructure projects of the BRI not only provide numerous employment opportunities but also promote comprehensive and productive employment through skill training and industrial development. In terms of digital infrastructure and technology transfer, the BRI's efforts significantly enhance the industrialization

and innovation capacities of participating countries. As such, the implementation of the Belt and Road Initiative is highly important for promoting the achievement of sustainable development goals. It brings new opportunities for economic growth and social progress to participating countries by building resilient infrastructure, promoting inclusive industrialization, and nurturing innovation.

Based on the above analysis, this article proposes Hypothesis 1: The BRI can promote the achievement of Sustainable Development Goals 8 and 9.

One of the core components of the BRI is to promote the development of digital infrastructure and technology, which has different impacts on participating countries depending on their existing level of digital preparedness. Countries such as Singapore and Malaysia, which already have strong digital infrastructure, benefit greatly from participating in the BRI. For example, Singapore aligns its cooperation in the BRI with its "Smart Nation" vision, attempting to use this initiative to further enhance its digital capabilities (Bian, J., 2022; Yu, S., 2023). This cooperation could lead to significant progress in e-government, smart city solutions, and digital innovation, simplifying city life and governance. These advancements extend not only to improving government services but also to fostering a more connected, technologically advanced society, in line with global trends toward digitization. Similarly, Malaysia could leverage BRI investments to strengthen its digital ecosystem. By focusing on enhancing digital infrastructure, such as broadband connectivity and data centers, Malaysia can strengthen its technological prowess. This growth can drive the development of various industries, including e-commerce, digital education and healthcare, thereby contributing to overall economic growth and development.

On the other hand, countries where digital infrastructure is just beginning, such as Cambodia and Laos, face challenges in fully utilizing the digital component of the BRI. While these countries have received much-needed digital infrastructure development through the BRI, they face the risk of falling into digital dependency (Huang, J., 2021). This dependency may occur when countries overly rely on external support to meet their digital needs, potentially compromising their digital sovereignty. This could lead to decision-making and control over digital infrastructure and policies being largely influenced or even controlled by external entities. This digital dependency could affect these countries' long-term sustainable growth. If they lack independent digital capabilities and expertise, they may struggle to maintain and upgrade their infrastructure, and their economies may become overly reliant on external tech solutions. This situation may hinder the development of local digital industries and expertise, impeding innovation and domestic economic growth.

Therefore, this paper posits that the level of digital readiness among BRI countries greatly influences their ability to effectively use the initiative to achieve Sustainable Development Goals (SDGs) 8 (Decent Work and Economic Growth) and 9 (Industry, Innovation, and Infrastructure). Countries with a greater degree of digitization can more effectively utilize the digital components

of the BRI. These countries can not only seamlessly integrate new technologies into their existing digital ecosystems but also handle the challenges brought about by rapid digitization, such as cybersecurity threats, data privacy issues, and the demands of their workforce for digital skills development. Furthermore, digitally mature countries can serve as models for other countries in the BRI network, demonstrating how to use digital technology to achieve sustainable economic growth and innovation (Yang, L.,2022). They can become centers of digital innovation within the BRI framework, contributing to regional technological advancement and knowledge sharing. Conversely, countries with lower digital readiness need strategic planning and support to avoid the trap of digital dependency (Xu, L. 2023). For these countries, the key is to develop comprehensive digital strategies that focus not only on infrastructure construction but also on building local digital capabilities, fostering digital literacy, and encouraging local technological innovation. As part of the BRI, international cooperation should include technology transfer, skills development programs, and support for local digital industries to ensure that the benefits of digital transformation are inclusive and sustainable (Yang, A.,2023).

In conclusion, the BRI offers participating countries a unique opportunity to accelerate their journey to the digital future. However, the extent to which these benefits are realized depends on the level of digital readiness in each country. Countries such as Singapore and Malaysia can expect to further enhance their already advanced digital backgrounds, while countries such as Cambodia and Laos must take a more cautious approach to the challenges of digital integration. The key to fully utilizing the digital component of the BRI is a balanced approach that promotes the development of digital infrastructure while also fostering digital autonomy and local capacity building.

Based on the above analysis, this paper proposes research Hypothesis 2: Countries with a greater degree of digitization can better leverage the "Belt and Road Initiative" to achieve Sustainable Development Goals 8 and 9.

Since China proposed the Belt and Road Initiative (BRI) in 2013, the BRI has become a focal point of global attention. The significance of the initiative lies not only in its infrastructure projects, such as the construction of transportation and energy facilities but also in its participation in digital cooperation. However, the initiative has also raised concerns about digital dependency, which is becoming a key issue worthy of in-depth discussion (Ali, M., 2022; Wang, B., 2023).

The technological expertise of Chinese enterprises primarily stems from sustained investment in research and development and a broad global network. For decades, companies such as Huawei have been intensifying their R&D efforts, creating a global R&D network aimed at achieving autonomous innovation in key areas of technology. Researchers at Huawei have worked with top global experts to continuously explore and design new technological solutions.

Under the BRI, Chinese enterprises have been bringing their technology and expertise to countries along the route, playing a crucial role. Digital infrastructure solutions provided by

Chinese companies, such as Huawei's assistance in building Kenya's 4G network and participating in the upgrade of the M-PESA mobile payment system, have undoubtedly promoted the digitalization process in these countries. However, the introduction of these external technologies has also raised concerns (Ullah, A., 2021; Wang, C.,2021). Overreliance on a single foreign supplier could expose these countries to risks in terms of technological sovereignty and information security. Therefore, while adopting external technologies, these countries must establish their technological research and review mechanisms to ensure their technological sovereignty and information security.

Within the framework of the BRI, China's digital policies and practices are also spreading globally and having an impact. China's experience in data governance and cyberspace security provides a reference for BRICS countries in formulating digital policies. However, such emulation is not always positive (Cao, X.,2023; Anwar,2023). In Central Asia, some countries have begun to emulate China's internet censorship and surveillance models, imposing stricter controls on the internet. This could compromise information freedom in these countries and impact citizens' rights. Therefore, while referencing China's digital policy, these countries must also develop corresponding policies based on their specific national conditions and societal needs (Fang, Y., 2021; Senadjki, 2022). Hence, while the BRI may stimulate local digital economic development, it could also exacerbate participating countries' economic dependence on China. For instance, Pakistan's "Digital Pakistan" initiative relies heavily on Chinese investment and technology, including optical fiber networks and digital service platforms built by Chinese companies. This dependency makes Pakistan more vulnerable to global supply chain disruptions or geopolitical tensions. Thus, developing countries such as Pakistan should seek diversified partnerships while accepting Chinese investment and technology to reduce their reliance on any single country and strengthen their ability to withstand risks.

The impact of the BRI on participating countries' capacity for autonomous innovation is a double-edged sword. Chinese technology and capital have had a positive impact on resource-limited countries, helping them to rapidly establish a foundation for the digital economy (Zhang, J., 2022; Zhang, Y., 2022). However, overreliance could stifle local enterprises' innovative drive and capacity building. The Hambantota Port project in Sri Lanka, for example, stimulated local economic development but also led to a deep dependency on Chinese investments. This signals to participating countries that they must cultivate their capacities, especially in innovation, to avoid the trap of overreliance (Geng, Z., 2021;Li, F., 2023).

In summary, the BRI's role in advancing digitalization has both positive aspects and potential issues. It has improved infrastructure, spread technology, and fostered the development of the digital economy. However, the issue of technological dependency cannot be ignored. Participating countries must strengthen their legal frameworks, policies, and technological foundations while deepening cooperation to ensure national security and stability. The international community

also needs to continuously monitor and assess the impact of the BRI to safeguard the healthy development of the global digital economy.

Based on the above analysis, this paper proposes research Hypothesis 3: The Belt and Road Initiative will lead to participating countries' digital dependency on China.

Digitalization is not merely a process of introducing and applying technology; it also involves enhancing local capacity building through policy design, education and training, and capital investment, thereby increasing the self-development capabilities of participating countries (Yan Z, 2020). Take Cambodia as an example. As one of the participants of the Belt and Road Initiative, Cambodia is committed to improving its level of digitalization. With the introduction of Chinese technology and capital, Cambodia is gradually advancing technologically while also enhancing the digital skills of local talent through training and education. As the degree of digitalization increases, local Cambodian businesses have begun to develop their own technology and services, thereby reducing their reliance on the outside, especially on China. Similarly, Sri Lanka was another participant in the Belt and Road Initiative. In recent years, the Sri Lankan government has been actively promoting the digitalization process, not only by introducing external technology but also by strongly supporting the development of digital technology and services by local enterprises. As local enterprises grow and digital skills improve, Sri Lanka's autonomy in the digital field has gradually increased, and its dependence on China has relatively decreased (Ozturk, I., 2022). This change not only strengthens the autonomy of domestic digital services and infrastructure but also may enhance these countries' positions in the international digital supply chain. This indicates that digitalization can serve as a tool to assist Belt and Road participating countries in enhancing their economic competitiveness while potentially restructuring the existing international trade and industry patterns. According to the literature, enhancing digital skills and expanding the local digital economy can drive industrial upgrading and strengthen the competitiveness of the domestic market (Maulana, 2023), thereby promoting innovation and improving the technology and services of local businesses and gradually reducing reliance on external entities, particularly Chinese enterprises (Ho, C. Y., 2023; Wang, A., 2023).

Based on the above analysis, Research Hypothesis 4: As the digitalization level of countries along the Belt and Road Initiative increases, these countries may gradually reduce their dependence on China in the digital field.

III. Empirical Model and Methodology

A. Difference-in-differences model

In recent years, difference-in-differences (DID) models based on quasinatural experiments

have been widely used in academic research to estimate the effects of policy implementation (Rothbard et al., 2023; Huang and Chen, 2022; Wang and Jv, 2022; Shen et al., 2023; Feng and Wang, 2021). These models effectively mitigate the influence of nonpolicy factors on the estimation results by utilizing two differences. When using DID models for estimation, the most critical aspects are determining the timing of policy shocks and the selection of treatment and control groups. Regarding the timing of policy shocks, considering that the Belt and Road Initiative was proposed in 2013 but officially launched in 2014, countries have been participating in the initiative since 2014. Therefore, 2014 is chosen as the policy shock time point, with 1 representing the time after 2014 and 0 representing the time before 2014. The selection of the treatment and control groups is shown in Table 1. The implementation of the Belt and Road Initiative can be seen as a quasinatural experiment, with developing countries that have joined the Belt and Road Cooperative considered the treatment group, while those that have not joined the Belt and Road Cooperative are considered the control group. In the design of the baseline model, this study designed the following models according to the principles of the DID model to identify the impact of the BRI on the sustainable development of developing countries.

Table 1. *Experimental Group and Control Group*

Experimental group	Control group
Pakistan	India
Vietnam	Bhutan
Philippines	North Korea
Thailand	Mauritius
Bangladesh	Eswatini (Also known as Swaziland)
Myanmar	Marshall Islands
Egypt	Palau
Jordan	Tuvalu
Iran	Mexico
Turkey	Bahamas
Saudi Arabia	Haiti
Kenya	Brazil
Nigeria	Colombia
Ethiopia	Paraguay
Tanzania	
Mozambique	
South Africa	
Kazakhstan	
Uzbekistan	
Serbia	
Venezuela	
Argentina	

$$SDGs = \alpha_0 + \alpha_1(treat \times time) + X_{control}\alpha_2 + C_i + \lambda_t + trend_{it} + \epsilon_{it}$$

Here, $SDGs_{it}$ represents the explained variable indicating the Sustainable Development Goals; $treat_{it}$ represents the grouping variable at the national level, where $treat_{it}$=0 denotes the control group and $treat_{it}$=1 denotes the experimental group, and is the time grouping variable, with $time$=0 representing before the policy shock and $time$=1 representing after the policy shock.

$X_{control}$ denotes the control variables. Referring to (Cheng et al, 2018; Wuet al, 2020a,b; Yuan et al, 2020), GDP per capita (PGDP) and financial support (FS) are chosen to measure the scale effect, research and development (R&D) investment (RD) and foreign direct investment (FDI) are used to measure the technological effect, and industrial structure (INS) and energy consumption structure (ES) are used to measure the structural effect.

λ_t denotes time fixed effects (TFE), while C_i denotes country-level fixed effects that remain constant over time. Considering the potential impact of country-level unobservables that may change over time and affect the sustainable performance of the country, this paper incorporates country-specific time trends (denoted by $treat_{it}$) to control for changes in these unobservable country-level factors. ϵ_{it} denotes the random disturbance term. In line with the principles of the DID model, this paper emphasizes the coefficients α_1 of the interaction term treat × post.i Representing the country, t symbolizing the time.

A crucial assumption of the difference-in-differences (DID) model is the parallel trends hypothesis. For this study, the differences between the treatment group and the control group should not significantly change over time before the "Belt and Road Initiative" was proposed. The reason to ensure the fulfillment of the parallel trends hypothesis is that before the proposition of the "Belt and Road Initiative", some countries in the treatment group might have been preinformed about future policies through various channels, thus adjusting their related national policies in advance. This policy adjustment will also impact the level of national sustainable development, causing systematic bias in the DID estimation results. This paper refers to the Event Study method for the parallel trends hypothesis test and constructs the econometric model as follows:

$$SDGs = \beta_0 + \sum_{k=2011}^{k=2021} \beta_k(treat_{it} \times D_k) + X_{control}\beta_2 + C_i + \lambda_t + trend_{it} + \epsilon_{it}$$

In the formula, D_k is a time dummy variable, taking the value of 1 when the sample belongs to year k and 0 otherwise. The interpretations of the other variables remain the same as in

formula (1). Figure 1 illustrates the magnitude and significance of coefficient β_k when $SDGs_{it}$ is the dependent variable in equation (2).

To verify hypothesis 2, this paper constructs the following model:

$$\begin{cases} SDGs = \beta_0 + \beta_1(treat_{it} \times time_{it}) + X_{control}\beta_2 + C_i + \lambda_t + trend_{it} + \epsilon_{jt}, \\ \qquad\qquad i \in Highly\ digitized\ countries \\ SDGs_{jt} = \gamma_0 + \gamma_1(treat_{jt} \times time_{it}) + X_{control}\gamma_2 + C_j + \lambda_t + trend_{jt} + \epsilon_{jt}, \\ \qquad\qquad j \in Less\ digitized\ countries \end{cases}$$

The level of digitization is measured by individuals using the internet (% of population). Countries above the sample median are highly digitized countries.

Hypothesis 2 is true if the core regression coefficients β_1 and γ_1 are both significantly positive and β_1 is greater than γ_1.

To verify Hypothesis 3 and Hypothesis 4, this paper constructs the following model:

$$Dependency = \delta_0 + \delta_1(treat_{it} \times time_{it}) + X_{control}\delta_2 + C_i + \lambda_t + trend_j + \epsilon_{it}$$

Digital dependence on China ($Dependency$) was assessed using the share of imported Chinese digital goods and services in total goods and services.

Hypothesis 3 holds if the core regression coefficient δ_1 is significantly positive.

$$\begin{aligned} Dependency = {} & \zeta_0 + \zeta_1(treat_{it} \times time_{it} \times Digitization) + \zeta_2(treat_{it} \times time_{it}) \\ & + X_{control}\zeta_3 + C_i + \lambda_t + trend_j + \epsilon_{it} \end{aligned}$$

Hypothesis 4 is true if the core regression coefficient ζ_1 is significantly negative and the coefficient ζ_2 is significantly positive.

B. Variable description

The following quantitative indicators can be designed for measurement in relation to sustainable development goals ($SDGs$) 8 and 9:

- Goal 8: Promote sustained, inclusive and sustainable economic growth; achieve full and productive employment; and ensure decent work for all.
  - National Income Level: The level of national income reflects the degree of economic growth and development and is important for the promotion of sustained, inclusive and sustainable economic growth under Goal 8. Higher levels of national income are generally associated with greater economic opportunities and better employment

conditions. (Adjusted net national income (annual % growth)).

- Poverty rate: The poverty rate is an important social indicator that is crucial for poverty eradication under Goal 8. Monitoring the poverty rate can help assess the impact of economic growth on poverty reduction and whether people are able to move out of poverty and gain access to decent work. (Multidimensional poverty headcount ratio (% of total population)).

• Goal 9: Build risk-resilient infrastructure, promote inclusive and sustainable industries, and foster innovation.

- Infrastructure coverage: Infrastructure coverage reflects the achievement of Goal 9 in building risk-resilient infrastructure and promoting inclusive and sustainable industries. High coverage means that more people have access to basic transportation, energy, communications and other services, which is conducive to fostering inclusive industrial development and economic growth. (Logistics performance index: Quality of trade and transport-related infrastructure (1=low to 5=high)).
- Industrial growth rate: The industrial growth rate is an important indicator for assessing sustainable industrial development in Goal 9, reflecting the sustained growth of the industrial sector. Monitoring the industrial growth rate provides insights into the extent to which the industrial sector contributes to economic growth. (Industry (including construction), value added (annual % growth)).
- STI inputs: STI inputs are a key indicator in the assessment of the ability of Goal 9 to drive innovation, reflecting the country's investment and development in the field of science and technology. Monitoring STI inputs allows for an assessment of a country's innovation capacity and level of scientific and technological development, which is essential for promoting sustainable industrial development. (Research and development expenditure (% of GDP)).

The SDGs can be measured using the entropy method. Compared to the subjective assignment method, the entropy assignment analysis method is more credible. The construction of the indicator system for the Sustainable Development Goals Index is shown in Table 2.

Table 2. *Sustainable Development Goal Measurement*

Level 1 indicators	Level 2 indicators	Level 3 indicators	Indicator properties
SDGs	SDGs8	National Income Level	+
		Poverty rate	-
	SDGs9	Infrastructure coverage	+
		Industrial growth rate	+
		STI inputs	+

(1) The original data were standardized using the polar deviation method to create a data matrix of m rows × n columns $X^* = \left(x^*_{i\ j}\right)_{m \times n}$, where m is the number of countries in the sample and n is the number of evaluation indicators.

(2) Positive indicators:

$$x^*_{i\ j} = (x_{ij} - \min(x_j))/(\max(x_j) - \min(x_j))$$

x_{ij} is the raw data for the j[th] indicator for the i[th] country, $x^*_{i\ j}$ is the standardized indicator value, and $\max(x_j)$ and $\min(x_j)$ are the maximum and minimum values of the indicator in column j, respectively.

(3) The weight of each indicator was calculated:

$$p_{ij} = \frac{x^*_{i\ j}}{\Sigma^{m}_{i=1} x^*_{i\ j}}$$

(4) Calculate the information entropy of each indicator:

$$e_j = -\frac{1}{\ln m}\sum_{i=1}^{m} p_{ij} \ln p_{ij}$$

(5) Calculation of the weights of the indicators

$$\omega_j = \frac{(1 - e_j)}{\Sigma^{m}_{i=1}(1 - e_j)}$$

where $(1 - e_j)$ is the information redundancy of the j[th] indicator; the larger the indicator is, the more important the indicator.

(6) Calculation of the composite score

$$\mu_{ij} = \sum_{i=1}^{n} \omega_j \times x^*_{i\ j}$$

Table 3. *Variable Description*

Variable type	Variable symbol	description
Explained variables of hypotheses 1 and 2	SDGs	Calculate using the entropy method
Explanatory variable	TP	Treat× *Post*
Control variable	PGDP	GDP per capita
	FS	financial support
	R&D	research and development investment
	FDI	foreign direct investment
	INS	industrial structure
	ES	energy consumption
Moderating variable	Digitization	Individuals using the internet (% of population)
Explained variables of hypotheses 3 and 4	Dependency	The share of imported Chinese digital goods and services in total goods and services.

The data in this article primarily come from the World Bank and the WIND database. These data sources cover a wide range of fields, providing information for analyzing and interpreting research problems. Before starting the data analysis, this research carried out a series of preprocessing and cleaning steps on the initial data to ensure its accuracy and stability. First, to reduce the effects of dimensional differences among different indicators, the initial data were normalized. This study refers to the research of Han et al. (2018) and He et al. (2019), where normalization was performed on the raw data. Normalization is a common data preprocessing method that eliminates the impact of dimensions on the results by converting each indicator to the same scale range, thus allowing different indicators to be compared. The processed data are then more convenient for subsequent statistical analysis and modeling.

$$X_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})}$$

After the above preprocessing and cleaning steps, comprehensive data were obtained, and missing values were removed. This article obtained a strongly balanced panel dataset spanning 36 developing countries and the time period from 2011 to 2021. This dataset includes 396 observations covering the relevant index information of various countries during different time periods. The selection of variables is shown in Table 3. These data provide valuable information resources for this article, which is conducive to delving into the inherent laws and characteristics of the research issue. It is worth noting that in the data cleaning process, this article has always followed best practice principles in the field of data science, striving to ensure the authenticity, completeness, and reliability of the data.

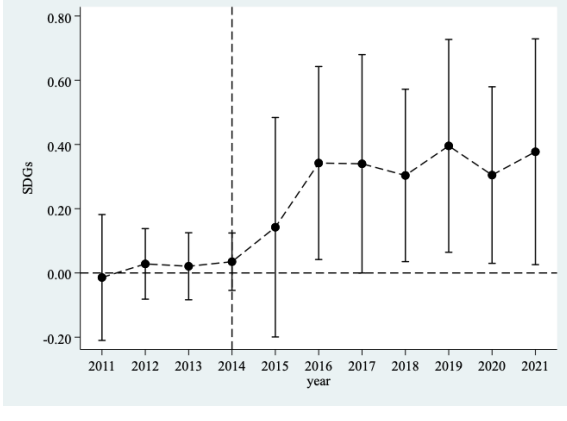
In conclusion, the data used in this study are sourced from various authoritative channels and have undergone rigorous preprocessing and cleaning operations, providing a high-quality, strongly balanced panel dataset for subsequent research. These data will offer robust support for future studies.

IV. Empirical Findings

A. Parallel trends assumption test

The coefficient β_k of the interaction term is not significantly different from 0 before 2014. This suggests that before the implementation of the policy, the difference in sustainable development levels between the test group and the control group did not vary over time, thereby verifying the parallel trend hypothesis. Meanwhile, for the interaction term coefficients after 2014, their estimated values increase year by year, indicating a more noticeable progression of sustainable development in the test group relative to the control group, and the policy's impact intensifies each year. This also implies that the sustainable development level of the test group continued to improve, at least within seven years after policy implementation.

Figure 1. Parallel trends assumption test



*The graph was drawn using Stata

B. Baseline regression

Table 4 reports the estimated results of the baseline regression model, where the dependent variables in columns (1)-(4) are all sustainable development goals. All regression equations controlled for control variables and individual and year fixed effects. Taking the results of

the first column in Table 4 as an example, the coefficient of the core explanatory variable TP is significantly positive at the 1% statistical level. This implies that after the proposal of the "Belt and Road Initiative", the level of sustainable development in developing countries that have joined the "Belt and Road Initiative" (experimental group) significantly improved compared to that in developing countries that have not joined (control group). To ensure the robustness of the results, in columns (2) and (3), the dependent variables were replaced with the comprehensive indicators of SDGs 8 and 9, respectively. The results remain significant, indicating that the conclusions are robust.

Table 4. *Baseline Regression*

	(1) DID	(2) DID(SDGs8)	(3) DID(SDGs9)	(4) PSM-DID
TP	0.4689*** [4.3952]	0.2720*** [2.6201]	0.2485** [2.5476]	0.4522*** [2.6972]
PGDP	0.2121 [1.5034]	-0.8065*** [-2.9164]	-0.5407*** [-2.7934]	-0.6035*** [-2.9478]
FS	-0.1048 [-1.5540]	0.0791 [0.9245]	0.0642 [0.9312]	0.0662 [0.9242]
R&D	-0.2610*** [-2.7109]	-0.1638 [-1.5526]	-0.1354* [-1.8741]	-0.1192 [-1.5483]
FDI	0.366 [1.6011]	0.6904** [2.4745]	0.5261** [2.4641]	0.5617** [2.4976]
INS	0.1705** [2.1047]	-0.2667* [-1.7617]	-0.1504 [-1.5993]	-0.1700* [-1.7716]
ES	-0.096 [-0.7438]	-0.0133 [-0.1000]	0.0147 [0.1870]	0.0006 [0.0074]
trend	0.0131 [0.2030]	0.022 [0.3659]	0.0166 [0.4925]	0.0137 [0.4189]
_cons	0.1215*** [3.3075]	0.1598*** [3.7307]	0.1381*** [3.8572]	0.1343*** [3.7151]
N	396	396	396	396
r2	0.7141	0.7256	0.7725	0.7454
F	104.5601	119.7771	96.2215	88.4109
p	0.0000	0.0000	0.0000	0.0000
Control	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Time Trend	YES	YES	YES	YES
Individual clustering	YES	YES	YES	YES
Time clustering	YES	YES	YES	YES

t statistics in brackets
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

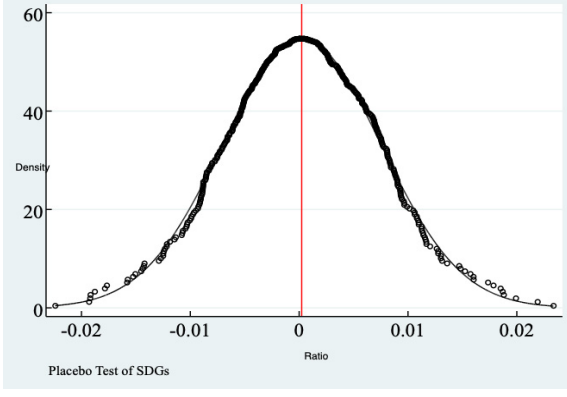
When using the DID model for policy effect evaluation, the ideal scenario should be that

the individual characteristics of the experimental group and the control group are the same before the policy, but the experimental group and the control group in this paper cover many countries and cannot fully meet these conditions, such as geopolitical issues. Therefore, there may be a "selection bias". To mitigate this issue, this paper further uses the propensity score matching (PSM) method to rematch the control group for estimation analysis to ensure the robustness of the conclusions of the paper. The regression results show that the coefficient of the interaction term treat×post(TP) is significant at the 1% level in the regression of $SDGs_{it}$, which is consistent with previous research conclusions.

C. Placebo test

A real-world scenario exists wherein some unobservable redundant factors that share a high degree of similarity and synchrony with the "Belt and Road Initiative" could lead to mixed superimposed effects, as reflected in the results of Table 4. This paper conducts placebo tests on the benchmark model based on the counterfactual analysis framework. Specifically, by setting the number of sample individuals and policy-action years randomly according to a certain sampling rule, if the estimated coefficients derived from such grouping arrangements and time settings deviate significantly from the "true" coefficients of the benchmark model, it suggests that the baseline regression results are not driven by unobservable redundant factors. Figure 2 shows the distribution of the estimated TP coefficients after 500 random samplings. The mean values of the coefficients (vertical line on the horizontal axis) are distributed closely approximately 0. Meanwhile, considering that the coefficient of the interaction term in the baseline regression is 0.4689 (first column), the "true" estimated coefficient of the benchmark model appears as a low-probability event in Figures 2. This finding further substantiates the basic discoveries of this paper.

Figure 2. Placebo test



To conclude, the research findings are robust; thus, Hypothesis 1 is supported.

D. Heterogeneity analysis

Based on the regression results, we can see that the "Belt and Road Initiative" has a significant impact on achieving Sustainable Development Goals 8 and 9 in two different types of countries (highly digitized countries and less digitized countries). In all the models, the initiative's impact (TP) is significant and has a positive effect. Further observations reveal that in highly digitized countries, both the regression coefficients and their significance levels are greater than those in less digitized countries. This reaffirms our hypothesis that countries with a greater degree of digitization can better utilize the "Belt and Road Initiative" to achieve sustainable development goals. In highly digitized countries, the coefficients of the "Belt and Road Initiative" in the DID and PSM-DID models are 0.5324 (significant at the 1% level) and 0.4788 (significant at the 1% level), respectively. In low-digitization countries, these two coefficients are 0.1805 and 0.1372, both of which are significant at the 10% level. However, this comparison does not establish the statistical significance of the differences between these coefficients. In other words, it is still unclear how to determine whether the "TP" coefficient for highly digitized countries is significantly greater than that for less digitized countries. Therefore, this paper refers to the study by Gregory C. Chow (1960) to conduct an intergroup difference test. When using the DID method for regression, the Chow Test = 53.99, P value > F(1, 454) = 0.0000; when using the PSM-DID method for regression, the Chow Test = 30.17, P value > F(1, 454) = 0.0000.

These results are consistent with our theoretical expectation that highly digitized countries are more likely to achieve their sustainable development goals through the "Belt and Road" initiative. Hypothesis 2 is validated.

Table 5. *Heterogeneity Analysis*

	(1)	(2)	(3)	(4)
	DID		PSM-DID	
	Highly digitalized countries	Low-digitalization countries	Highly digitalized countries	Low-digitalization countries
TP	0.5324*** [8.7905]	0.1805* [1.7095]	0.4788*** [3.1651]	0.1372* [1.6944]
PGDP	-0.0878 [-1.0932]	0.0956 [1.4393]	0.6066*** [3.4485]	-0.1139 [-1.5421]
FS	0.0112 [0.3881]	-0.1376*** [-6.2817]	-0.3976** [-2.2399]	0.0766 [0.9957]
R&D	-0.0337 [-0.7128]	-0.1038*** [-4.3057]	-0.0417 [-1.0291]	-0.0011 [-0.1184]
FDI	-0.0882 [-0.9276]	0.2013** [2.1682]	0.0295 [0.3439]	0.0319 [0.7908]
INS	-0.0938 [-1.5560]	0.0205 [0.5236]	4.1536*** [3.4896]	-2.0037*** [-3.6121]

Table 5. *Continued*

	(1)	(2)	(3)	(4)
	DID		PSM-DID	
	Highly digitalized countries	Low-digitalization countries	Highly digitalized countries	Low-digitalization countries
ES	-0.1953*** [-5.3803]	0.1866*** [5.5900]	0.0381 [0.2340]	-0.0172 [-0.2705]
trend	0.1103*** [3.3340]	0.1542*** [8.8575]	0.022 [0.7906]	0.013 [1.0350]
_cons	0.0270* [1.9290]	0.0999*** [9.6008]	0.0188 [0.2402]	0.0706*** [3.2757]
chowtest	Chow Test = 53.99 P Value > F(1 , 454) = 0.0000		Chow Test = 30.17 P Value > F(1 , 454) = 0.0000	
N	396	396	396	396
r2	0.7621	0.7904	0.8115	0.8261
F	96.0259	2.10E+03	90.0498	1.90E+03
p	0.0000	0.0000	0.0000	0.0000
Control	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Time Trend	YES	YES	YES	YES
Individual clustering	YES	YES	YES	YES
Time clustering	YES	YES	YES	YES

t statistics in brackets
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

E. Further analysis

The regression results are shown in Table 6. According to the regression results in Table 6, in Model (1) and Model (2), the regression coefficients for the variable TP are 0.5821 and 0.4441, respectively, which are statistically significant at the 1% level. This finding supports our third hypothesis; that is, the "Belt and Road Initiative" may exacerbate the digital dependence of developing countries along the route to China. Looking again at Model (3) and Model (4), we find that the regression coefficients of the variables TP×Digitization and TP show opposite trends, where the coefficient of TP×Digitization is significantly negative, while the coefficient of TP is significantly positive. This result reveals an important perspective: the digitization level (digitization) of developing countries along the route can generate a reverse regulatory effect on the relationship between the Belt and Road Initiative and digital dependence. Specifically, improving the digitization level of countries along the route may help to alleviate their digital dependence on China, which fully confirms our fourth hypothesis.

Table 6. *Further Analysis*

	(1)	(2)	(3)	(4)
	Dependency		Dependency	
	DID	PSM-DID	DID	PSM-DID
TP×Digitization			-0.4802** [-2.0194]	-0.4322*** [-6.1133]
TP	0.5821*** [9.5873]	0.4441*** [4.8583]	0.0178*** [3.2078]	0.1030*** [3.4725]
PGDP	-0.4599*** [-2.6360]	0.3461 [1.4898]	0.4931*** [6.5741]	-0.3375 [-1.2456]
FS	0.0038 [0.0677]	-0.3627*** [-5.5247]	0.0357* [1.7544]	0.0778 [1.1647]
R&D	-0.0125 [-0.1239]	0.3126* [1.9192]	0.0075 [0.3610]	-0.1368** [-2.3760]
FDI	-0.0391 [-0.2474]	0.2166 [0.8841]	-0.0522 [-0.7226]	0.6270** [2.2486]
INS	0.0831 [0.7431]	0.1494* [1.7805]	0.1186*** [3.2390]	-0.2099* [-1.6830]
ES	0.0954 [1.0733]	0.1491 [1.2538]	0.1067*** [2.7178]	-0.0647 [-0.5389]
trend	0.1438*** [3.7496]	-0.0579 [-0.8427]	0.0516*** [3.0698]	-0.0657 [-1.2442]
_cons	-0.1018*** [-3.9034]	0.0369 [1.3320]	-0.0391*** [-3.5119]	-0.0905** [-2.5050]
N	396	396	396	396
r2	0.7541	0.8169	0.8263	0.8215
F	82.0382	1.60E+03	93.0381	1.90E+03
p	0.0000	0.0000	0.0000	0.0000
Control	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Time Trend	YES	YES	YES	YES
Individual clustering	YES	YES	YES	YES
Time clustering	YES	YES	YES	YES

t statistics in brackets
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

This study, through an empirical analysis of the "Belt and Road Initiative" and sustainable development goals 8 and 9, reached the following conclusions:

1. The "Belt and Road Initiative" has had a significant positive impact on the achievement of sustainable development goals 8 and 9. Within seven years following the implementation of the policy, the sustainable development levels of developing countries that joined the "Belt and Road" were significantly greater than those of developing countries that did not.

2. The degree of digitalization has a significant effect on the effectiveness of the "Belt and Road Initiative". The greater the degree of digitalization in a country is, the better the outcomes it achieves through the "Belt and Road Initiative" in terms of sustainable development goals. Therefore, the degree of digitalization can be used as an important indicator of whether a country can effectively utilize the "Belt and Road Initiative" to achieve its sustainable development goals.
3. The "Belt and Road Initiative" may exacerbate the digital dependency of developing countries along its route to China. However, the level of digitalization in these developing countries can have a reverse moderating effect on the relationship between the "Belt and Road Initiative" and digital dependency. Specifically, improving the level of digitalization in countries along the route may help to mitigate their digital dependency on China.

In summary, all four hypotheses of this study have been verified. This not only provides a basis for policymakers but also offers theoretical and empirical foundations for subsequent research. In the future, policymakers and researchers can continue to investigate how the degree of digitalization affects the implementation outcomes of the "Belt and Road Initiative" and how to reduce the digital dependency of countries along the route on China by enhancing their level of digitalization.

V. Conclusion

A. Policy recommendations

1. Strengthening digital infrastructure construction: Given that an increase in the degree of digitalization can promote the better realization of sustainable development goals in countries along the Belt and Road Initiative, it is recommended to prioritize investments in improving their digital infrastructure. This includes but is not limited to network communication, data centers, digital technology education, and skill training.
2. Promoting the application of digital technology in sustainable development: Encourage countries along the Belt and Road Initiative to adopt advanced digital technologies to optimize industrial production, urban planning, energy management, and other fields to achieve sustainable development goals 8 and 9.
3. Promote the independent development of digital technology: Considering that the BRI may exacerbate the digital dependence of countries along the route on China, it is recommended that countries invest in local technology R&D and innovation capabilities, reducing dependencies on external resources. At the same time, intellectual property protection

and technological exchange should be strengthened, and technological sharing and cooperation should be encouraged.

4. Cultivating digital talent: To cope with the impact of digitalization on the labor market, vocational training and education programs, especially in information technology and data management, are recommended to improve the labor skills and adaptability of countries along the Belt and Road Initiative.
5. Improving policy transparency and participation: Ensure that countries along the Belt and Road Initiative have a thorough understanding of and participation in the digital project of the initiative, avoid unequal or opaque practices, and ensure that the projects meet local needs and development goals.
6. Monitoring and Evaluation: Regularly monitor and evaluate the impact of the Belt and Road Initiative, especially its effects on digital dependence. This will aid in the timely adjustment of strategies, ensuring the continuous effectiveness and sustainability of projects.

By implementing these policy recommendations, the Belt and Road countries will be able to enhance their digitalization level and sustainable development capacity while maintaining good cooperation with China, reducing dependence on external forces, and achieving more independent and autonomous development.

B. Research limitations

Due to the limited impact of the BRI on developed countries and the presence of various confounding factors, this paper focuses on developing countries as the research subjects. This constitutes a limitation of this study, and future researchers can build upon this work for further research.

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