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An Empirical Study of the Impact of the Digital Silk Road on Foreign Trade between China and Countries along the Route - A Quasi-Natural Experiment Based on Silk Road E-Commerce International Cooperation

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Abstract. The Digital Silk Road, as the digital extension of the Belt and Road Initiative, aims to enhance international trade and infrastructure development. This study is based on data from 190 countries from 2002 to 2022, using the PSM-DID model and the quasi-natural experimental environment of Silk Road e-commerce international cooperation, to conduct an in-depth study of the impact of the Digital Silk Road (DSR) initiative on trade between China and the countries along the route (countries that have signed the DSR initiative with China). This study draws the following conclusions. First, the DSR initiative has a positive effect on trade between China and the countries along the route, with China's import effect on these countries being more significant than the export effect. Second, digital infrastructure has a positive impact on the effectiveness of the DSR initiative. Third, the DSR initiative is more effective when the countries along the route are Asian countries or high-income countries.

Keywords: Digital Silk Road, trade, digital infrastructure

1. Introduction

In September and October 2013, during his visits abroad, Chinese President Xi Jinping proposed the construction of the "New Silk Road Economic Belt" and the "21st Century Maritime Silk Road" cooperation initiatives, which together form the "Belt and Road Initiative" (BRI). The purpose of this initiative is to establish interconnected, friendly, and open cooperative relationships with BRI trade partner countries (regions), and to strengthen political, economic, and cultural cooperation and exchanges. This laid a solid foundation for the development of the "Digital Silk Road" (DSR) initiative. In December 2015, at the Second World Internet Conference, the concept of the prototype for the DSR initiative was proposed[1]. In his speech, President Xi Jinping called for accelerating the construction of global network infrastructure and promoting innovative development of the network economy. Subsequently, in May 2016, at the "Belt and Road Space Cognition International Conference", Conference Chairman Guo Huadong proposed the "Digital Belt and Road" (DBAR) plan based on space observation[2]. The formulation of this plan aims to promote scientific and comprehensive cooperation between China and BRI trade partner countries, serving the construction of the BRI initiative. Finally, in May 2017, in his speech at the opening ceremony of the Belt and Road Forum for International Cooperation, President Xi Jinping officially proposed the DSR initiative, emphasizing the importance[3] of enhancing innovation capabilities and developing cooperation in frontier fields such as the digital economy, artificial intelligence, and smart cities.

Since the Belt and Road Initiative (BRI) was proposed in 2013, it has achieved significant results. According to statistics from the General Administration of Customs of China, in 2023, China's imports and exports with countries participating in the BRI reached 19.47 trillion yuan, an increase of 2.8%, accounting for 46.6% of the total import and export value, an increase of 1.2 percentage points. This accounts for 46.6% of China's total foreign trade value, with both the scale and proportion reaching the

[1] Cyberspace Administration of China publishes. Source: https://www.cac.gov.cn/2015-12/16/c_1117481112.htm.

[2] Chinese Academic of Sciences publishes.
Source: https://www.cas.cn/cm/201605/t20160518_4557600.shtml?from=singlemessage.

[3] BELT and Road Portal publishes. Source: https://www.yidaiyilu.gov.cn/p/306542.html.

highest levels[4] since the initiative was proposed. As the digital extension of the BRI, the Digital Silk Road (DSR) aims to enhance international trade and infrastructure development. According to the Report on China's Development of Digital Trade (2022), in 2022, the proportion of China's imports and exports with BRI countries exceeded 50%, and the growth rate of cross-border e-commerce imports and exports with these countries was higher than the overall growth rate of China's cross-border e-commerce imports and exports during the same period. Additionally, the transaction volume of countries that have signed e-commerce cooperation memoranda with China, such as Cambodia, Kuwait, the UAE, and Austria, has increased by more than 100% year-on-year[5]. This shows that the DSR initiative has injected new vitality into the development of international trade, significantly expanding the trade scale between China and the countries along the route.

The remainder of this paper is structured as follows. Section 2 provides a summary of the literature related to the DSR. Section 3 presents the research hypotheses based on existing theoretical analysis. Section 4 discusses the research design, including the data sources and sample selection, methods, and variables. Section 5 presents the main empirical results, including baseline regression results, mechanism analysis, heterogeneity analysis, and robustness checks. Section 6 concludes the paper, provides recommendations, and offers prospects for future research.

2. Literature Review

In recent years, with the advancement of the DSR initiative, the benefits it brings to the countries along the route are multifaceted, and different scholars have explored this issue from various perspectives. Among them, some scholars believe that the DSR initiative can help the invested countries achieve sustainable development goals, with its main contributions including enhancing connectivity and supplementing physical infrastructure construction (Gong & Li, 2019) [1]. Ho et al., (2023) further found that the economies participating in the DSR saw significant improvements in information and communication technology (ICT) development [2]. In addition, the DSR initiative has a significant positive impact on digital economic development (Jiang & Duan, 2021; Ghimire et al., 2024), digital inclusion (Eguegu, 2022), and digital industry policies (Naughton, 2020) [3-6]. Moreover, the DSR initiative can better assist the Chinese government in supporting the development of Chinese technology companies, thus providing these companies with more opportunities to obtain preferential loans through the DSR initiative (Shen, 2018) and enhance their global status (Hinane El-Kadi, 2024) [7-8].

Furthermore, since the original intention of establishing the DSR was to expand trade with the countries along the route, the positive impact of the DSR initiative on trade has received considerable attention from scholars. Research has found that the DSR has had a positive impact on foreign trade and that it has played a positive moderating role through human capital and innovation levels (Wang et al., 2024) [9]. Liang & Qin (2024) discovered that the DSR can effectively reduce the trade costs of the countries along the route and ultimately decrease the demand for imported intermediate goods while increasing the demand for exported intermediate goods, enhancing the depth and breadth of each country's participation in the global value chain [10]. Moreover, the DSR initiative can enhance the trade vitality of the countries along the route, providing strong impetus for China's cross-border trade (Wang et al., 2023) [11]. Since the DSR initiative was proposed seven years ago, the construction of the DSR has achieved significant results. By the end of 2023, China had signed e-commerce cooperation memoranda with 30 countries, making 'Silk Road e-commerce' a new path and trend for cooperation between China and its trade partners[6]. Cross-border e-commerce, as a new type of trade interaction that combines elements of e-commerce and cross-border trade (Sibanda & Yin, 2020), has rapidly developed within the context of the DSR [12]. Scholars have found that the DSR initiative can expand global trade through cross-border e-commerce and improve the quality of the network in the participating countries (Lazanyuk & Revinova, 2019) [13]. This shows that the construction of the DSR has brought a large number of export markets to China, increased import demand, and further expanded the trade scale.

Today, the development of international trade cannot be separated from the support of robust digital infrastructure. Digital infrastructure can be regarded as a tool for facilitating trade and a guarantee for the development of the digital economy cooperation under the BRI (Rukanova et al., 2017; Li & Zhai, 2023) [14-15]. As an important component and central hub of new infrastructure construction, digital infrastructure has received much attention for its positive role in promoting economic growth, boosting export trade, upgrading industrial structures, enhancing innovation capabilities, and improving total factor productivity (Zhou et al., 2022) [16]. One of the original intentions of the DSR initiative is to establish a China-centric digital infrastructure (Shen, 2018) [7]. If the digital infrastructures of various countries can achieve connectivity as much as possible, it will effectively promote trade and cooperation among nations. Through empirical research, Zhou et al. (2022) found that broadband infrastructure can promote the growth of China's export trade. Moreover, they believe that digital infrastructure provides opportunities for developing countries to compete in the international market [16]. Additionally, some studies have found that digital infrastructure is conducive to the innovation of high-tech industries, expansion of scale, and transnational investment (Tranos and Mack, 2016; Rippa and Secundo, 2019; DeStefano et al., 2023) [17-19]. Digital infrastructure also contributes to the construction of the digital economy market.

[4] The State Council Information Office. P.R.C. publishes.
Source: https://www.gov.cn/lianbo/fabu/202401/content_6925700.htm.
[5] Ministry of Commerce of the People's Republic of China publishes.
Source: http://images.mofcom.gov.cn/fms/202312/20231205112658867.pdf.
[6] Ministry of Commerce People's Republic of China publishes.
Source: https://dzswgf.mofcom.gov.cn/slds.html#Kuwait.

For example, in response to the challenges of digital cities, Eastern and Western European countries have expanded the digital services market by upgrading local digital infrastructure to build digital platforms and digital ecosystems (Komninos et al., 2021) [20]. However, despite the significant growth in the digitalization of the countries along the route, their insufficient digital infrastructure still limits their trade growth potential (Kere & Zongo, 2023) [21]. Scholars have found that Vietnam, as one of the signatories of the DSR e-commerce cooperation memorandum, has limited China-Vietnam digital economy cooperation due to a lack of adequate network information security (Jin & Du, 2020) [22]. Therefore, the development of digital infrastructure in the countries along the route may affect their trade growth.

It is worth noting that the 'digital divide' caused by the layout of digital infrastructure may constrain the effectiveness of the DSR initiative. The digital divide refers to the differences between groups and societies in the adoption and dissemination of electronic information, communication technology, and e-commerce practices (Genus et al., 2005) [23]. Therefore, the inadequacy of digital infrastructure in the countries along the route can also lead to the phenomenon of the 'digital divide.' Existing research has found that the primary cause of the digital divide is the lack of necessary, knowledgeable human capital (Alyoubi and Adel, 2015) [24]. Since 5G network coverage can indirectly reflect the gap in digital infrastructure between high-income and low-income economies, according to the International Telecommunication Union's 'Facts and Figures 2023,' the global distribution of 5G networks is currently uneven[7]. In high-income countries, 89% of the population is covered by 5G networks, whereas in many low-income countries, 4G networks cover only 39% of the population, with 3G often being the only way to connect to the internet. Currently, among the trade countries engaging in digital economy cooperation with China, there are also inequalities in digital infrastructure development, which increase international trade costs and reduce cooperation efficiency. Specifically, high-income countries invested in digital development early, making their digital economy levels globally advanced, whereas low-income countries, facing issues like funding shortages, outdated technology, and lack of professionals, have low digital economy levels (Li & Zhang, 2023) [25]. Han (2022) further pointed out that the digital divide in the Middle East is a major obstacle to the high-quality development of the DSR (Han, 2022) [26]. Therefore, the existence of the digital divide will weaken the depth and breadth of cooperation between China and the countries along the route.

In summary, since the DSR initiative was proposed relatively recently (in 2017), the literature on the DSR initiative is not yet fully developed. Considering that the policy implementation period has not been long, the impact of the DSR initiative on trade is mostly described qualitatively, with a lack of quantitative analysis. Additionally, few studies have considered digital infrastructure as an influencing mechanism to discuss its impact on the effectiveness of the DSR initiative. Therefore, the marginal contributions of this study are mainly threefold. Firstly, this paper enriches the empirical research on the DSR initiative. Since the DSR initiative, based on the BRI initiative, was proposed in 2017, most existing studies focus on the BRI initiative, with few studies using the DSR initiative as the background, and there is a lack of quantitative evidence. This study uses quantitative analysis to empirically test the policy effects of the DSR initiative on trade between China and the countries along the route. Secondly, this paper helps explore the marginal contributions of the DSR initiative to trade between China and the countries along the route. Based on the import and export data of China and 190 countries from 2002 to 2022, this study explores the role of the DSR in promoting trade between China and the countries along the route and the channels through which the DSR initiative promotes trade, further proving that the DSR initiative has expanded the welfare of the countries along the route. Finally, this study explores the heterogeneous effects of the DSR initiative by analyzing its impact on high-income and low-income countries along the route, and on different continents (Asia, Europe, Africa), enriching the conclusions of the evaluation of the DSR initiative's policy effects.

3. Theoretical Analysis and Hypotheses

In the context of the rapid development of the digital economy, the DSR initiative serves as a digital extension of the BRI initiative. This study posits that the DSR initiative benefits the development of trade between China and countries along the route. The main reasons are as follows:

Firstly, the DSR initiative promotes the development of digital trade. Cross-border e-commerce, as a trade mode that effectively combines digital and trade elements, represents a significant form of digital trade. Even before the formal proposal of the DSR initiative, scholars had observed that the BRI digital strategy greatly broadened the prospects for cross-border e-commerce development (Liu & Zhang, 2016) [27]. Moreover, there is close cooperation in trade between BRI partner countries and China in cross-border e-commerce. Intelligent communication platforms have enhanced the efficiency of China's cross-border e-commerce exports, promoting China's exports to BRI partner countries (Wang & Sheng, 2024) [28]. Furthermore, Wu et al. (2023), through analyzing recent digital trade data between China and BRI partner countries, found that the efficiency of digital trade between China and these countries has shown a yearly increasing trend [29]. China and its trading partners can leverage the digital BRI framework to advance digital trade cooperation, enhancing the country's level of digital trade through mutually beneficial trade (Gao, 2022) [30]. Thus, it is evident that the DSR initiative promotes the development of digital trade between China and its trading partners.

Secondly, the DSR initiative can promote the upgrading of countries in the global value chain. Existing literature has found that DSR construction enables countries along the route to develop towards a more refined direction in the global production network, enhancing resource allocation efficiency (Zhao et al., 2023) [31]. Furthermore, Liang & Jiao (2022) found that the construction and development of Digital BRI (equivalent to DSR) can promote digital connectivity and interoperability among

[7] International Telecommunication Union(ITU) publishes. Source: https://www.itu.int/pub/D-IND-ICT_MDD-2023-1.

trading partner countries, accelerating the flow of data elements, thereby facilitating cross-industry and cross-enterprise cooperation both online and offline [32]. In addition, scholars have found that Digital BRI benefits in enhancing the global value chain position of host countries along the BRI route, with the most pronounced impact on influencing the international environment of digital economic development (Qin et al., 2023) [33]. Liang & Qin (2024) further observed that the DSR initiative has a significant enhancing effect on the optimization of the global value chain, especially evident for countries along the route and BRI trading partner countries [34]. Therefore, the upgrading of the global supply chain for countries along the route and other BRI trading partners enhances the flow of factors and resource allocation, creating favorable conditions for foreign trade.

Thirdly, the DSR initiative can optimize the trade environment of countries along the route. Currently, various countries and local governments are actively promoting trade optimization policies, creating a more convenient and harmonious trade environment. Wang et al. (2024) believe that the promotion of the DSR initiative has created favorable institutional conditions for the development of trade between countries [9]. Lu et al. (2021) found that the BRI has improved the policy environment of cities along the BRI route, enhanced local government support for enterprise innovation policies, and ultimately promoted high-quality exports by Chinese companies [35]. Zeng et al. (2023) found that the DSR initiative can help promote the development of digital economy in countries along the route and the transformation of the global economic governance system, forming a comprehensive regional community of shared destiny [36]. In addition, DSR construction promotes the digital transformation of industries in countries along the route, breaking the traditional resource flow mechanisms between regions and promoting efficient resource allocation mechanisms (Qin et al., 2023) [33]. These activities have laid a solid foundation for trade cooperation and exchanges between China and countries along the route.

In summary, the DSR initiative may have a positive impact on trade between China and countries along the route due to its positive effects on digital trade, global value chains, and trade environment. Based on this, Hypothesis 1 is proposed in this study:

H1: The DSR initiative benefits the development of trade between China and countries along the route.

Furthermore, combined with the analysis from the literature review above, it can be seen that the digital divide constrains the effectiveness of the DSR initiative. Therefore, this study mainly discusses the role of digital infrastructure in influencing trade between China and countries along the DSR initiative. And proposes the following mechanism analysis and research hypothesis: digital infrastructure and trade between China and countries along the route.

With the implementation of the DSR initiative, countries along the route have accelerated data transmission and sharing, strengthened legislation on digital trade, and maintained network information, effectively ensuring the secure operation of digital currency and financial systems. Gao (2023) found that the construction of new digital infrastructure helps countries along the route develop distinctive advantageous industries, and also facilitates the exploration of potential trade cooperation between China and BRI partner countries and other regions, contributing to the joint construction of the BRI initiative [37]. Currently, projects such as China-ASEAN Information Harbor and the China-Arab Silk Road online employ technical exchanges and infrastructure construction as auxiliary measures, which optimize the regional digital business environment, enabling BRI partner countries to achieve efficient connectivity through digital technology (Wang et al., 2023; Luo, 2023) [11;38]. Ismail (2021) mentioned that digital technology, as a means to promote trade, has gained attention from many scholars [39]. Simultaneously, he used digital infrastructure as an indicator of facilitating digital trade and empirically tested its role in promoting bilateral trade among Asian countries. Based on this, this study believes that the construction of digital infrastructure plays a positive role in the impact of the DSR initiative on trade between China and countries along the route. Therefore, this study proposes Hypothesis H2:

H2: Digital infrastructure plays a positive moderating role in the impact of the DSR initiative on trade between China and countries along the route.

4. Research Design

4.1. Data Sources and Sample Selection

This study constructs its sample data from 190 countries over a span of 20 years from 2002 to 2022. Based on the list published by the Chinese Ministry of Commerce and under the Silk-Road E-commerce initiative - E-commerce international cooperation of the DSR initiative, this study found that by the end of 2023, a total of 30 countries had signed memoranda of understanding on e-commerce cooperation. Since the other data in this study are updated only until 2022, two countries that signed e-commerce cooperation agreements in 2023 (the Philippines and Indonesia) have been excluded from the analysis. The remaining 28 countries are considered the treatment group, while the other countries serve as the control group (Table 1). Among these, China's import and export data with 190 countries come from the United Nations Comtrade Database, while geographical distance data come from the National Platform for Common GeoSpatial Information Service. Data at the country level for other countries are sourced from the World Bank database. Subsequently, this study matches these data according to year and country codes. Additionally, to maintain high data consistency, this study excluded countries and regional data with significant missing data and used linear interpolation to handle some missing data.

Table 1[8]. The time and countries of signing the memorandum of understanding on e-commerce cooperation

Year	Countries
2016	Chile
2017	New Zealand, Vietnam, Brazil, Australia, Cambodia, Estonia, Hungary
2018	Austria, Kazakhstan, Russia, Kuwait, the UAE, Rwanda, Iceland, Argentina, Panama
2019	Italy, Colombia, Samoa, Vanuatu, Uzbekistan
2021	Senegal
2022	Belarus, Singapore, Pakistan, Thailand, Laos

4.2. Methods and Variables

4.2.1. Propensity Score Matching (PSM)

In employing the Difference-in-Difference (DID) method, it is crucial to maintain similar trends between the treatment group and the control group. However, due to real-world circumstances and national characteristics, the countries along the Belt and Road Initiative (BRI) that signed memoranda of understanding on e-commerce cooperation with China were not randomly selected; their selection was based on specific criteria. Therefore, the development trends of the treatment and control groups may not satisfy the essential precondition of DID.

To address this issue, this study utilizes the PSM-DID model. The basic approach of this method involves using the control group, assigning weights to each country within the control group, and constructing a weighted average that mirrors the treatment group. In doing so, the trends of the treatment group and control group become more similar, thereby meeting the assumptions of the DID method. Figure 1, a kernel density comparison graph, illustrates that prior to matching, there is significant dispersion in the trends between the treatment and control groups; post-matching, their trends converge closely, thereby maximizing adherence to the parallel trends assumption required by DID.

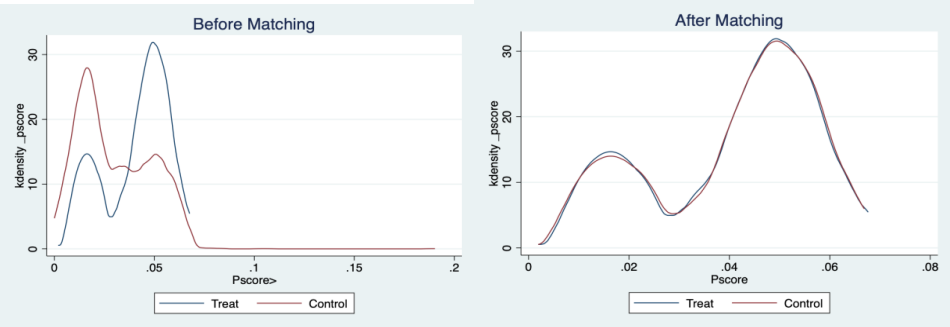

Figure 1. Comparison of kernel density before and after PSM

4.2.2. Difference-in-Difference (DID) Method

This study uses data from 190 countries over a 20-year period (2002-2022) to construct a multi-period DID model. In this model, *i* and *t* represent individual countries and years, respectively. $Trade_{it}$ denotes the trade between China and country *i* in year t. $Treat_i \times Post_t$ is a dummy variable indicating whether a country participated in the Digital Silk Road (DSR) initiative. $\mathbf{X_{it}}$ represents a set of control variables influencing trade outcomes. μ_i captures country-specific fixed effects, ϑ_t captures year-specific fixed effects, and ε_{it} represents the error term. Following the methodologies of Atanassov (2013) and Wang et al. (2024) [40;9], the baseline regression equation of the DID model is defined as Eq. (1):

$$Trade_{it} = \beta_0 + \beta_1 Treat_i \times Post_t + \beta_2 X_{it} + \mu_i + \vartheta_t + \varepsilon_{it} \quad (1)$$

To test hypothesis 2, this study employs the moderation analysis method as per Wei & Wang (2023), examining the moderating effect of digital infrastructure [41]. Here, M_{it} represents the moderating variable, specifically digital infrastructure. The

[8] Ministry of Commerce People's Republic of China publishes. The time and countries of signing the memorandum of understanding on e-commerce cooperation.
Source: https://dzswgf.mofcom.gov.cn/slds.html#Kuwait.

coefficient γ_3 of the interaction term in Eq. (2) explores the moderating effect of digital infrastructure on the trade between China and countries along the Belt and Road Initiative under the DSR:

$$Trade_{it} = \gamma_0 + \gamma_1 Treat_i \times Post_t + \gamma_2 M_{it} + \gamma_3 M_{it} \times Treat_i \times Post_t + \gamma_4 X_{it} + \mu_i + \vartheta_t + \varepsilon_{it} \quad (2)$$

4.2.3. Variables

Dependent Variable: The dependent variable in this study is the import and export values sourced from the United Nations Comtrade Database.

Key Independent Variable: In this study, whether a country has engaged in the Digital Silk Road (DSR) initiative with China ($Treat_i \times Post_t$) serves as a proxy variable to assess the impact of the DSR policy. Here, $Treat_i$ identifies whether a country has signed a memorandum of e-commerce cooperation with China: it takes a value of 1 if signed, and 0 if not. Variable $Post_t$ indicates the years from which a country is considered to have signed the memorandum. For example, if China and Vietnam signed such a memorandum in 2017, Vietnam would be coded as 1 from 2017 onwards (refer to Table 1).

Control Variables: This study controls for variables that potentially affect national-level trade, drawing from existing literature: gross domestic product (GDP), inflation rate (Inflation), Total tax and contribution rate (Tax), official exchange rate (Oer), taxable items (Ti), population density (Pop_density), and the geographical distance between Beijing and other capitals (Distance).

Moderating Variables: To characterize digital infrastructure as a mechanism variable, this study employs fixed telephone subscriptions, fixed broadband subscriptions, mobile cellular subscriptions, individuals using the Internet, and secure Internet servers. The entropy method is then utilized to determine weights and composite scores for these indicators, assessing their combined impact on the moderation effect of digital infrastructure in the context of the DSR initiative's influence on trade between China and countries along the Silk Road. Detailed explanations and descriptive statistics for these variables can be found in Table 2 and Table 3.

Table 2. Explanation of variables

Variable classification	Variable name	Variable symbol	Variable explanation
Dependent variable	Total trade of import and export	Trade	External trade indicators (10 trillion USA$) measured and published by the UN Comtrade Database
	Export trade	Export	
	Import trade	Import	
Key independent variable	Countries participating in the DSR initiative	Treat x Post	Treat is 1 for countries who have signed the memorandum of understanding on e-commerce cooperation and 0 for the remaining countries; Post is 1 in the year of signing and thereafter; Otherwise, it is 0
Control variable	Gross domestic product	GDP	GDP (10 trillion USA$) of each country
	Total tax and contribution rate	Tax	Total tax and contribution rate
	Inflation rate	Inflation	Inflation rate measure by consumer prices
	Population density	Pop_density	Persons per 1000 square kilometer of land area
	Taxable items	Ti	The number of tax items
	Official exchange rate	Oer	Local Currency Units per 1000 US$, period average
	Geographical distance	Distance	The geographical distance between the capitals of two countries
Moderator variable	Digital infrastructure	Infra	It is composed of fixed telephone subscriptions, fixed broadband subscriptions, mobile cellular subscriptions, individuals using the Internet and secure Internet servers

Table 3. Descriptive statistics

Variable	N	Mean	Standard deviation	Min.	Max.
Trade	3990	1.5900	5.1989	0.0001	7.6171
Export	3990	0.9327	3.5279	0.0001	58.2756

Table 3. (continued).

Import	3990	0.6573	2.1453	0.0000	21.3217
Treat x Post	3990	0.0303	0.1715	0.0000	1.0000
GDP	3990	32.0121	137.9333	0.0001	2543.9700
Tax	3990	0.4036	0.3246	0.0000	0.6386
Inflation	3990	0.0730	0.3459	0.0001	10.5421
Pop_density	3990	0.3410	1.5681	0.0001	21.0568
Ti	3990	26.1255	20.9020	3.0000	191.0000
Oer	3990	0.7005	3.2817	0.0001	42.0000
Distance	3990	8964.6820	3813.2260	0.0001	19261.9300
Infra	3990	0.0702	0.0618	0.0002	0.8063

5. Empirical Results

5.1. Baseline Regression Results

Table 4. Baseline regression results

	DID				PSM-DID			
Variable	Trade (1)	Trade (2)	Export (3)	Import (4)	Trade (5)	Trade (6)	Export (7)	Import (8)
Treat x Post	2.472***	1.370***	0.514***	0.855***	2.462***	1.362***	0.507***	0.856***
	(5.17)	(8.78)	(5.02)	(10.23)	(5.09)	(8.68)	(5.01)	(10.07)
GDP		0.0503***	0.0359***	0.0144***		0.0505***	0.0361***	0.0144***
		(68.21)	(74.00)	(36.49)		(68.30)	(75.71)	(36.02)
Tax		0.305**	0.134*	0.172***		0.499***	0.256***	0.243***
		(2.53)	(1.69)	(2.65)		(3.27)	(2.60)	(2.93)
Inflation		-0.606***	-0.360***	-0.246***		-0.300	-0.0346	-0.265**
		(-7.50)	(-6.78)	(-5.67)		(-1.50)	(-0.27)	(-2.45)
Pop_density		0.652***	0.786***	-0.134		4.243***	5.098***	-0.855***
		(3.41)	(6.26)	(-1.31)		(8.38)	(15.61)	(-3.12)
Ti		0.00349*	0.000957	0.00253**		-0.000202	-0.00262	0.00241
		(1.76)	(0.73)	(2.38)		(-0.07)	(-1.39)	(1.53)
Oer		0.0615***	0.0447***	0.0168		0.0820***	0.0597***	0.0223*
		(3.17)	(3.51)	(1.62)		(3.34)	(3.77)	(1.68)
cons.	1.515***	-0.999***	-0.765***	-0.234***	1.525***	-1.705***	-1.557***	-0.148
	(18.18)	(-7.01)	(-8.16)	(-3.06)	(17.88)	(-9.57)	(-13.56)	(-1.54)
Year FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
N	3990	3990	3990	3990	3886	3886	3886	3886
R^2	0.0066	0.6112	0.6325	0.3630	0.0066	0.6203	0.6549	0.3659

t statistics in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

Table 4 presents the baseline regression results of this study. Firstly, columns (1) to (4) represent the multi-period Difference-in-Difference (DID), which is the ordinary fixed-effects regression without Propensity Score Matching (PSM). Column (1) uses the ordinary least squares method without including control variables and fixed effects to examine the impact of the Digital Silk Road (DSR) initiative on trade between China and countries along the Silk Road. Column (2) employs a fixed-effects model, adding control variables and fixed effects for countries and years. Columns (3) to (4) show results using China's trade exports and imports to countries along the Silk Road as dependent variables. In these four regression results, the coefficients of the key independent variable are significant at the 1% level.

Secondly, columns (5) to (8) present the PSM-DID regression results. According to Table 4, the coefficients of the key independent variable in columns (5) to (8) are positive and statistically significant, proving a significant promotional effect of the

DSR initiative on trade between China and countries along the Silk Road. Therefore, H1 is validated. In column (6), the coefficient of the second interaction term is 1.362, which is positive and significant, indicating a policy effect of $13.62 billion (the average trade is $15.9 billion, as shown in Table 3). Furthermore, at the same level of significance, the coefficient for imports is greater than that for exports. This suggests that the effect of China's imports from countries along the Silk Road is more significant, implying an increase in exports from these countries to China. This could be attributed to the DSR initiative facilitating the optimization of products from countries along the Silk Road, thereby prompting China to import more high-quality products from these countries.

5.2. Mechanism Analysis

Table 5. Mechanism

Variable	Trade (1)	Export (2)	Import (3)
Treat x Post	0.204	0.274	-0.0696
	(0.59)	(1.22)	(-0.37)
Infra x Treat x Post	10.280***	2.051	8.226***
	(3.70)	(1.14)	(5.49)
Infra	3.747***	1.376	2.371***
	(2.89)	(1.64)	(3.38)
cons.	-1.811***	-1.598***	-0.213**
	(-9.94)	(-13.57)	(-2.17)
Control variables	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
N	3886	3886	3886
R^2	0.7235	0.7622	0.3738

t statistics in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

According to previous theoretical analysis, digital infrastructure may positively moderate the impact of the DSR initiative on trade between China and countries along the Silk Road. This study uses entropy-weighted scores of various countries' fixed telephone subscriptions, fixed broadband subscriptions, mobile cellular subscriptions, individuals using the Internet, and secure Internet servers as proxy variables for digital infrastructure. The higher the score, the more developed the digital infrastructure of the country. As shown in Table 5, columns (1) and (3), the coefficients of the triple interaction terms are positive and statistically significant. Therefore, countries with more advanced digital infrastructure along the Silk Road experience a greater positive impact of the DSR initiative on trade, supporting H2. However, when using China's exports to these countries as the dependent variable, the coefficient of the triple interaction term is not significant. This may be because improved digital infrastructure in these countries enables them to explore alternative overseas markets that may be more suitable than the Chinese market in terms of products, prices, and other factors. Thus, they may prefer importing products and services from these other markets rather than from China.

5.3. Heterogeneity Analysis

5.3.1. Different Continents

In this study, among the 28 countries that have entered into the Digital Silk Road (DSR) initiative with China, they are predominantly distributed across Asia, Europe, and Africa. To further distinguish the impact of the DSR initiative across different continents, the study categorizes a sample of 190 countries into Asia, Europe, and Africa. As shown in Table 6, columns (1)-(3) present the regression results of the DSR initiative on trade between China and Asian, European, and African countries along the Belt and Road. Columns (1) and (2) indicate that the coefficients of the interaction terms between China and Asian as well as European countries are positive and significant. Particularly, the coefficient for trade between China and Asian countries is larger, indicating a more pronounced promoting effect. This could be attributed to China's geographical proximity and historical trade relations with other Asian countries along the Belt and Road. However, as shown in column (3), the regression results for the DSR initiative on trade between China and African countries along the Belt and Road are not significant. This may be due to the generally lower economic development and inadequate digital infrastructure in African countries. Since the effectiveness of the DSR initiative largely depends on the development of digital technology, its promoting effect on trade between China and African countries along the Belt and Road is not significant.

5.3.2. Income Level

Differences in income levels among countries also contribute to variations in their trade activities. This study uses GDP per capita as a metric, classifying countries above the average as high-income and those below as low-income. Table 6, columns (4) and (5), respectively present the regression results of the DSR initiative on trade between China and high-income countries along the route, and between China and low-income countries along the route. According to Table 6, although the coefficients of the core explanatory variables are statistically significant at the 1% level for both China's trade with high-income and low-income countries along the route, the coefficient is larger for trade between China and high-income countries along the route. This indicates that the DSR initiative has a more pronounced promotion effect on trade between China and high-income countries along the route. This could be attributed to the generally higher economic development and stable political and economic conditions in high-income countries along the route, which facilitate favorable conditions for trade activities between China and these countries.

Table 6. Heterogeneity analysis

	Continent			Income level	
Variable	Trade (1)	Trade (2)	Trade (3)	Trade (4)	Trade (5)
Treat x Post	1.838***	0.643***	0.0679	1.395***	1.090***
	(3.76)	(3.50)	(0.69)	(10.36)	(5.01)
cons.	-2.174***	-1.483***	0.0904	-0.00139	-8.419***
	(-3.74)	(-4.49)	(0.92)	(-0.01)	(-10.81)
Control variables	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
N	906	916	1009	2742	1144
R^2	0.6618	0.7210	0.4595	0.5310	0.7752

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

5.4. Robustness Tests

5.4.1. Parallel Trend Test

This study uses the event study method to examine pre-treatment parallel trends. The method involves multiplying the Treat variable by pre-policy time dummy variables Post (Before 1-Before 8). As shown in Table 7, when using the years before the actual signing of the electronic commerce cooperation memoranda as the Post variable for the treatment group, the coefficient of Treat x Post is not significant. This demonstrates that there were no significant differences in trade trends between China and the treatment group compared to the control group before the implementation of the DSR initiative. Therefore, the parallel trends assumption is validated. This result further confirms that the DSR initiative contributes to enhancing trade between China and countries along the route.

Table 7. Parallel trend test

Variable	Trade (1)
Treat x Before 8	-0.123
	(-0.62)
Treat x Before 7	-0.170
	(-0.82)
Treat x Before 6	-0.158
	(-0.76)
Treat x Before 5	-0.148
	(-0.72)
Treat x Before 4	0.0662
	(0.33)

Table 3. (continued).

Treat x Before 3	0.213 (1.05)
Treat x Before 2	0.0244 (0.12)
Treat x Before 1	-0.0199 (-0.10)
cons.	-0.914***
Control variables	Yes
Year FE	Yes
Country FE	Yes
N	3665
R^2	0.5014

t statistics in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

5.4.2. Placebo Test

Following Chetty et al. (2009) [42], this study randomly selects 28 countries from the sample of 190 countries, assuming they have signed electronic commerce cooperation memoranda with China, to create a new treatment group. The baseline regression is repeated 500 times. As shown in Figure 2, the estimated coefficients of the baseline regression from the 500 repetitions are distributed around zero, far from the PSM-DID baseline regression coefficient of 1.362 (Table 4). Therefore, this indicates that the policy effect of the DSR initiative is significant in enhancing trade between China and countries along the route, and the policy impact of the DSR initiative is not significantly affected by other unobservable factors.

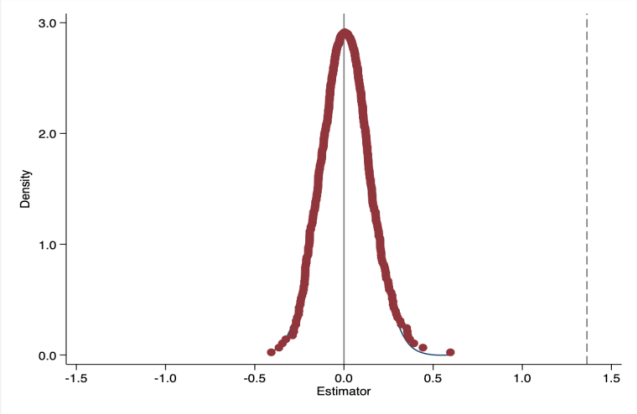

Figure 2. Placebo test

6. Conclusions and Policy Implications

The DSR initiative is a significant component of the BRI and plays a positive role in promoting cooperation and development between China and countries along its route. Based on data from 190 countries spanning from 2002 to 2022, this study utilizes the quasi-natural experimental environment of electronic commerce cooperation under the DSR initiative and the PSM-DID model to explore its impact on trade between China and countries along the route. The empirical results demonstrate the following: Firstly, the DSR initiative significantly promotes trade between China and countries along the route, with a more pronounced effect on imports to China from these countries. Secondly, through mechanism analysis, the study finds that the DSR initiative positively influences trade between China and countries along the route through the enhancement of digital infrastructure. Thirdly, heterogeneous analysis reveals that the DSR initiative has a more significant positive impact on trade between China and countries in Asia or high-income countries along the route. Fourthly, robustness tests including parallel trend and placebo tests confirm the effectiveness of the policy impact of the DSR initiative. Based on these empirical findings, this paper proposes the following policy recommendations:

Firstly, further unleash the policy dividends of the DSR initiative and actively respond to its calls. The study results demonstrate that the DSR initiative can promote trade development between China and countries along the route. Therefore, future efforts should encourage more countries to join the DSR initiative, share the mutual benefits brought by the initiative with China, and

establish a more efficient and open international trade environment in the digital realm. Moreover, China should deepen digital integration with countries along the route that have already signed DSR initiatives, by enhancing exchanges in digital talents, smart city construction, and integrating upgrades of e-commerce platforms, thereby jointly promoting digital innovation and development and laying a solid foundation for realizing the dividends of the DSR initiative.

Secondly, countries along the route should strengthen the construction of digital infrastructure. Mechanism analysis in this paper shows that digital infrastructure can effectively enhance the effects of the DSR initiative. Currently, the development of digital infrastructure varies among countries, with many African countries lagging behind due to low levels of digital infrastructure construction and inadequate resilience of digital communication enterprises (Huang, 2019) [43]. The heterogeneous analysis in this paper indicates that the DSR initiative does not significantly promote trade between China and African countries along the route, likely due to the imbalance in digital infrastructure hindering interaction and trade between countries. Therefore, countries should narrow the digital divide by improving signal coverage, increasing internet speed, and enhancing internet penetration rates.

Lastly, future research can expand the scope of mechanism analysis. While this paper explores digital infrastructure as a mechanism variable, future studies can investigate additional mechanism variables that may influence the effectiveness of the DSR initiative. Additionally, future research can focus on the impact of the DSR initiative on other related dependent variables in the digital domain, such as digital trade rules and developments, which would be highly meaningful.

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