China's textile export potential to South Asian countries and its determinants

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ABSTRACT – REZUMAT

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Against the backdrop of the Belt and Road Initiative and the restructuring of the global textile supply chain, this paper analyses textile trade patterns between China and the seven South Asian countries, using China's textile export data to these countries from 2010 to 2023, with a focus on textile exports. It employs a stochastic frontier gravity model for empirical analysis to assess the potential and influencing factors of textile trade between China and the seven South Asian countries, and provides feasible suggestions for the development of textile trade between China and South Asian nations. The study finds that the scale of textile trade between China and South Asian countries has been expanding, with trade relations becoming increasingly close. However, the scale of imports and exports remains relatively small. In terms of influencing factors, the study finds that China's economic size has a significant inhibitory effect on textile exports. In contrast, China's population size, the economic development level and population size of South Asian countries, as well as straight-line distance and whether they share a common border, have a positive impact on textile exports. However, the influence of the Shanghai Cooperation Organisation on China's textile exports is relatively weak, with limited promotional effects; government efficiency indices, free trade agreements, currency flexibility, and economic freedom scores all have a positive promotional effect on textile export efficiency. However, trade freedom has a negative impact on trade efficiency; although China's textile export trade efficiency with the seven South Asian countries remains at a relatively low level, there is significant trade potential and room for expansion, with broad prospects for future development.

Keywords: *China, South Asia, textiles, stochastic frontier gravity model, export trade efficiency*

Potențialul Chinei în materie de exporturi textile către țările din Asia de Sud și factorii determinanți

În contextul Inițiativei „Belt and Road" și al restructurării lanțului global de aprovizionare cu produse textile, lucrarea de față analizează modelele comerțului cu produse textile dintre China și cele șapte țări din Asia de Sud, pe baza datelor privind exporturile de produse textile ale Chinei către aceste țări în perioada 2010-2023, punând accentul pe exporturile de produse textile. Studiul utilizează un model de gravitație stocastică de frontieră pentru analiza empirică, în scopul evaluării potențialului și a factorilor care influențează comerțul cu textile între China și cele șapte țări din Asia de Sud și oferă sugestii fezabile pentru dezvoltarea comerțului de produse textile între China și națiunile din Asia de Sud. Studiul constată că amploarea comerțului cu textile între China și țările din Asia de Sud a crescut, iar relațiile comerciale au devenit din ce în ce mai strânse. Cu toate acestea, amploarea importurilor și a exporturilor rămâne relativ redusă. În ceea ce privește factorii de influență, studiul constată că dimensiunea economică a Chinei are un efect inhibitor semnificativ asupra exporturilor de textile. În schimb, dimensiunea populației Chinei, nivelul de dezvoltare economică și dimensiunea populației țărilor din Asia de Sud, precum și distanța în linie dreaptă și existența unei frontiere comune au un impact pozitiv asupra exporturilor de textile. Cu toate acestea, influența Organizației de Cooperare de la Shanghai asupra exporturilor de textile ale Chinei este relativ redusă, cu efecte de promovare limitate; indicii de eficiență guvernamentală, acordurile de liber schimb, flexibilitatea valutară și scorurile privind libertatea economică au toate un efect pozitiv de promovare asupra eficienței exporturilor de textile. Cu toate acestea, libertatea comercială are un impact negativ asupra eficienței comerțului. Deși eficiența comerțului cu exporturi de textile ale Chinei către cele șapte țări din Asia de Sud rămâne la un nivel relativ scăzut, există un potențial comercial semnificativ și spațiu de expansiune, cu perspective largi de dezvoltare viitoare.

Cuvinte-cheie: *China, Asia de Sud, textile, modelul stocastic de gravitație de frontier, eficiența comerțului de export*

INTRODUCTION

In recent years, China and South Asian countries have deepened trade cooperation in the textile industry through multi-level policy coordination, forming a three-dimensional policy system based on free trade agreements, centred on industrial chain synergy, and driven by technology output. China and the South Asian region have taken the upgrading of free trade agreements as a breakthrough. China and Bangladesh launched free trade agreement negotiations in 2024 and clearly proposed in September 2024 to grant Bangladesh a zero-tariff transition period for 98% of tariff items. According to statistics from the General Administration of Customs of China, since the upgrading of the China-Pakistan Free

Trade Agreement, China's exports of textile yarn to Pakistan reached 1.12 billion USD in 2024, a year-on-year increase of 46.9%, and exports of textile machinery to Pakistan increased by 22%. In terms of in-depth integration of the industrial chain, China has invested in the construction of textile and garment industrial parks in Pakistan, with supporting power projects to solve energy bottlenecks; in Bangladesh, it has promoted the construction of garment accessories factories. According to the 2023 annual report data of the Bangladesh Garment Manufacturers Association, there are 1,200 garment accessories factories in Bangladesh, forming a closed loop of "Chinese raw materials – South Asian processing". In addition, technology output and green transformation have become new highlights. Chinese textile machinery enterprises have promoted Internet of Things spinning equipment in South Asia; at the same time, the 2024 report of the China Textile Industry Federation shows that the Sino-Bangladeshi cooperative environmental protection printing and dyeing project will adopt low-carbon technologies. Moreover, trade facilitation measures have further released potential. After the entry into force of the China-Nepal Transit Transport Agreement, the growth of China's exports of wool products to Nepal stems from the optimisation of cross-border logistics, while Myanmar and other countries under the RCEP framework have implemented tariff reductions, promoting a reduction in the circulation costs of regional textile raw materials. Although India still imposes high tariffs and anti-dumping measures on Chinese textiles, through strategies such as transferring factories to Pakistan and Bangladesh, the scale of China's textile exports to India through third countries has expanded. In the future, the two sides will rely on mechanisms such as the China-Pakistan Economic Corridor and the China-Myanmar-India-Bangladesh Economic Corridor to deepen cooperation in intelligent equipment and green technologies and promote industrial chain upgrading.

The textile trade between China and South Asian countries has seen steady growth. According to statistics from the UN Comtrade database, China's textile export value to South Asia increased from approximately 8.4 billion USD in 2010 to over 18.8 billion USD in 2023. However, a notable trade imbalance persists within the region. India, Pakistan, and Bangladesh account for over 90% of China's textile exports to South Asia, characterised by significant volatility, while markets like Bhutan and the Maldives remain smaller with minimal fluctuations. Meanwhile, Deardorff's trade cost theory manifests prominently in the South Asian context: transportation costs posed by the geographical barrier of the Himalayas, technical trade barriers arising from disparities in animal and plant quarantine standards across nations, and market risks triggered by exchange rate fluctuations in some countries directly impact textile trade [1]. In a specialised study on Sino-Indian textile trade, Karackattu (2013) found that India's non-tariff barriers significantly constrained China's exports of fruits, vegetables, and processed foods, whereas the Bangladeshi market's demand for Chinese grains and aquatic products continued to expand with population growth and income improvement, findings that validate the differential impacts of market scale and institutional factors [2].

In summary, existing studies universally acknowledge the global competitiveness of China's textile trade and the growth potential of Sino-South Asian trade under the Belt and Road Initiative, while also highlighting challenges such as cost pressures, non-tariff barriers, and geoeconomic risks. Future research could further integrate the impacts of the latest regional trade agreements and digital transformation on supply chains to provide more time-sensitive references for policy optimisation. However, bilateral trade still confronts challenges, including geographical barriers, technical trade barriers, and institutional differences, necessitating systematic research to uncover trade potential and key influencing factors. To promote the healthy and sustainable development of bilateral textile trade, it is imperative to remove obstacles to China's textile exports to the seven South Asian countries, enhance China's market share in these markets, expand export volume, and reverse the long-term trade deficit. In short, expanding textile exports to the seven South Asian nations, i.e., achieving export growth, remains China's primary task in the coming period. Regarding whether there is room for growth in China's textile exports to the seven South Asian countries, what major factors hinder export growth, and how to tap export potential, answering these questions requires examining the gap between the current level of China's textile exports to the seven South Asian nations and their potential, measuring export efficiency, and conducting an in-depth analysis of influencing factors.

Existing literature has conducted limited research on the textile trade between China and South Asia, with notable gaps in regional studies and analyses of the textile industry. Most literature applies the gravity model solely in its traditional form, offering insufficient analysis of emerging factors such as institutional elements when introducing inefficiency factors. In response, this paper constructs an extended gravity model based on China's textile export data to seven South Asian countries from 2010 to 2023: Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka. It empirically examines the direction and intensity of traditional factors, including economic scale, geographic distance, and trade facilitation level, alongside emerging variables such as digital trade infrastructure and regional trade agreements. The study estimates each country's trade potential and identifies key constraining factors. Aiming to address: What are the primary driving forces behind China's textile exports to South Asian nations? Has the current trade level reached its potential ceiling? Which structural factors hinder the improvement of trade efficiency? This research not only provides empirical evidence for optimising China's textile export strategies to South Asia but also enriches the application of the gravity model in regional textile trade studies. It offers theoretical references for precision policymaking in international textile cooperation under the Belt and Road Initiative.

LITERATURE REVIEW

The gravity model of trade, as a classic tool for analysing bilateral trade flows, has undergone a developmental process from empirical hypotheses to a systematic theory. Tinbergen was the first to introduce Newton's law of universal gravitation into trade research, proposing the core hypothesis that trade flows are positively correlated with economic size and negatively correlated with distance [3]. Anderson provided a micro-theoretical foundation for the model from the perspective of maximising consumer utility, emphasising the impact of product differentiation on trade [4]. Anderson and Van Wincoop solved the "border puzzle" by introducing the "multilateral resistance term", enabling the model to more accurately reflect the structural impact of trade costs, while Egger (2000) revised the econometric specification of the model, emphasising the importance of panel data and fixed effects [5, 6]. In research on the textile trade, the application of the gravity model has become relatively mature. Chen et al. used the gravity model to analyse the factors influencing exports of major global textile-producing countries, finding that economic size, trade agreements, and logistics efficiency are key variables [7]. Shekhawat and Shastri, in their study on India's textile exports, showed that per capita income, trade freedom, and regional trade arrangements significantly enhance export potential [8]. Rahman et al., in their analysis of Bangladesh's textile industry, pointed out that exchange rate fluctuations and infrastructure levels are important factors restricting exports [9]. It is worth noting that Wen et al. used a time-varying coefficient stochastic frontier gravity model to measure export efficiency, providing a methodological reference for the dynamic evaluation of trade potential [10]. This is highly consistent with the analysis of "trade potential and influencing factors" focused on in this paper, and is particularly suitable for capturing efficiency losses and room for improvement in textile trade between China and South Asian countries.

As a vital segment of the global textile trade, South Asia's bilateral trade relations with China have become a focus of academic attention. From a historical perspective, Janaway and Coningham's research on archaeological evidence of South Asian textiles revealed the region's long-standing textile traditions and trade networks [11]. Riello and Roy noted that South Asian textiles dominated the global market between 1500 and 1850, and contemporary textile trade between China and South Asia can be seen as a continuation and transformation of this historical context [12]. Although Maxwell focused on Southeast Asia, his analytical framework of "trade-tradition-transformation" in textiles provides insights for understanding the cultural attributes and economic functions of South Asian textiles [13]. In studies specifically on China-South Asia trade practices, existing research exhibits multi-perspective characteristics. Karackattu analysed the challenges and opportunities in Sino-Indian border trade, identifying insufficient policy coordination as the main obstacle [2]. Tsang and Au compared the textile export competitiveness of South Asian and Southeast Asian countries, finding that China holds significant advantages in mid-to-high-end markets, while South Asian countries have greater potential in labour costs [14]. Guan et al.'s research based on the diamond model showed that the international competitiveness of China's textile industry stems from its complete industrial chain and technological innovation capabilities, which have laid the foundation for exploring the South Asian market [15]. At the regional cooperation level, Zhou et al. studied the Belt and Road Initiative's role in promoting China-South Asia trade, finding that infrastructure connectivity and trade facilitation measures have achieved significant effects [16]. Dastgeer et al.'s analysis of the China-Pakistan Free Trade Agreement, Razzaque et al.'s discussion on China-Bangladesh trade, and Sikder and Dou's research on China-Bangladesh export structures all confirmed the positive impact of free trade agreements on bilateral trade [17–19]. Additionally, Jain pointed out that the textile trade serves as an important carrier in China's economic expansion in South Asia [20]. The rapid growth of China's textile exports to South Asia since the 21st century not only reflects complementarity but also implies the complex dynamics of regional competition and cooperation.

Research on the influencing factors of textile trade has expanded from traditional variables to institutions, policies, and emerging issues. In terms of human factors, the roles of government efficiency, economic freedom, and regional organisations have become increasingly prominent. For example, Shekhawat and Shastri incorporated trade freedom into the gravity model and found that its elasticity coefficient for India's textile exports reached 0.32 [8]. Li et al.'s research on ESG performance and enterprise growth showed that environmental compliance and social responsibility can enhance enterprises' competitiveness in the international market, which is enlightening for Chinese textile enterprises to explore the South Asian market, especially in the context where South Asian countries are paying increasing attention to green trade barriers [21]. Ma and Appolloni pointed out that financial flexibility can improve enterprises' green innovation performance, implying that Chinese textile enterprises can break through trade restrictions through technological upgrading, such as the research and development of environmentally friendly fabrics [22]. In addition, the role of digital transformation in promoting trade efficiency has been verified. Liu et al. found that the digitalisation of construction enterprises can improve innovation efficiency, and this logic is equally applicable to supply chain optimisation and cross-border e-commerce development in the textile industry [23]. The impact of environmental and policy factors cannot be ignored either. Zhang et al.'s research on the impact of air pollution control on enterprises' green innovation revealed the forcing effect of environmental regulations on industrial upgrading, which may affect the export structure of Chinese textiles [24]. In addition, Zhang et al.'s research on the impact of carbon emissions, green energy, and high-tech policy uncertainty on financial markets uncovered the complex transmission paths of policy variables through market expectations, indicating the potential impact of the macro policy environment on the development of the textile industry [25]. Ma et al.'s analysis of climate change and human activities suggested that differences in natural resource endowments may indirectly affect textile trade through raw material costs [26]. Moreover, Ma et al.'s research on the impact of agricultural mechanisation on agricultural carbon emission intensity analysed, from the upstream of the industrial chain, the mechanism by which agricultural production methods affect carbon emissions, providing an important supplement to understanding the carbon emission reduction path across the entire industrial chain [27]. These studies collectively construct a multi-dimensional analytical framework ranging from micro-enterprises to macro-ecology, and from technological innovation to policy regulations, offering rich theoretical and empirical support for exploring industrial transformation and ecological governance under the goal of sustainable development. Overall, these multi-dimensional factors together constitute the complex influence mechanism of China's textile export potential to South Asia, providing a theoretical and empirical basis for this study to include variables such as government efficiency and economic freedom.

In summary, existing studies have laid the foundation for this paper in terms of the application of the gravity model, regional trade characteristics, and influencing factors, but there are still two shortcomings: first, there are few specialized studies on textile trade between China and South Asian countries, especially a lack of potential measurement based on the stochastic frontier model; second, the analysis of institutional factors such as government efficiency and economic freedom is not systematic. The scarcity of studies on the South Asian region stems from the following factors: geographically, due to the barrier of the Himalayas, transportation costs in South Asia are higher than those in Southeast Asia, and the land transportation cycle is longer than that of maritime transportation in Southeast Asia, while Central Asia has reduced railway transportation costs through the China-Europe Railway Express. Institutionally, the intensity of non-tariff barriers in South Asian countries is much higher than that in Southeast Asia, and India conducts anti-dumping investigations against Chinese textiles more frequently than Southeast Asian countries; Southeast Asia has achieved textile tariff reductions relying on RCEP, and Central Asia has simplified customs clearance procedures through the Shanghai Cooperation Organization, while the role of South Asian regional cooperation mechanisms in promoting trade is significantly weaker. This paper takes textiles as the research object of trade, with the following innovations: first, methodological innovation. This paper applies the time-varying stochastic frontier gravity model to the study of China's textile exports to South Asia, breaking through the "constant trade cost" assumption of the traditional gravity model. Second, expansion of core variables. This paper introduces emerging variables such as digital trade, regional trade agreements, and regional policies, changing the impact of traditional human factors on trade efficiency in the past. Third, a breakthrough in research scope. This paper systematically measures the trade efficiency of the seven South Asian countries for the first time and subdivides the trade efficiency and expansion space of each country in the South Asian region. The study breaks through the "one-size-fits-all" analytical framework of existing literature on the South Asian region, provides a quantitative basis for China to formulate country-specific textile export strategies under the Belt and Road Initiative, and enriches the application scenarios of the gravity model in populous regions. This paper will combine data from 2010 to 2023 and use the stochastic frontier gravity model to fill the above gaps, providing policy references for the development of bilateral trade.

CHINA'S TEXTILE EXPORTS TO THE SEVEN SOUTH ASIAN COUNTRIES

With the deepening of cross-regional economic and trade cooperation, trade between China and the seven South Asian countries has developed rapidly, especially since the deepening of textile trade cooperation through multi-level policy coordination between China and South Asia, and the scale of textile trade has grown rapidly. Figures 1 and 2, respectively, show the scale of China's textile trade with South Asia and the scale of textile exports. Due to data availability, China's import data of textiles from Bhutan and the Maldives are missing in some years, and the total import and export trade data are calculated using estimated values. Overall, between 2020 and 2023, textile trade between China and South Asia showed a growing trend with a good development scenario. From 2010 to 2019, the total textile trade volume between China and the seven South Asian countries increased from 8.466 billion USD to 16.631 billion USD, with an average annual growth rate of 6.34%, showing a significant growth trend, indicating that the scale of textile trade between China and South Asia is gradually expanding. Affected by the new epidemic in 2020, the textile trade volume decreased, but it recovered rapidly and continued to grow from 2021 to 2023, reaching 18.825 billion USD in 2023. From 2010 to 2023, exports increased from 8.412 billion USD to 18.727 billion USD, accounting for more than 99%, while

Fig. 1. China's Total import and export of textile products to 7 South Asian countries, 2010–2023 (based on UN Comtrade data)

imports increased from 54 million USD to 98 million USD, reflecting that China occupies a dominant position in the textile trade with South Asia.

Between 2010 and 2023, China's textile exports to South Asian countries demonstrated an overall characteristic of "fluctuating growth with market divergence", though significant variations existed in market performance across different nations. By 2023, the total textile export volume from China to the seven South Asian countries had more than tripled compared to 2010. Except for Bhutan and the Maldives, where export growth was slow, the other five countries experienced relatively satisfactory export growth, as shown in figure 2. From 2010 to 2019, the export value increased from 8.412 billion USD to 16.528 billion USD, doubling in size. However, in 2020, exports declined rapidly, dropping by 23.14% compared to 2019. Following 2020, exports recovered and grew, reaching their peak in 2022 with the total export value exceeding 20 billion USD amid fluctuations. Nevertheless, market divergence intensified across South Asian countries. The textile imports of Bangladesh, India, and Pakistan were severely impacted due to the combined effects of multiple factors in 2020, including supply-demand imbalances caused by the pandemic, heightened trade barriers, and short-term industrial chain restructuring. Bangladesh's export value plummeted from 6.963 billion USD in 2018 to 5.46 billion USD in 2020, a 27.53% decrease from 2018. India's export value fell by 38.55% year-on-year in 2019, while Pakistan's textile import volume decreased by 1.212 billion USD compared to 2019. In contrast, Sri Lanka and Nepal experienced relatively stable export performances with only short-term declines during the pandemic. Post-2020, countries gradually recovered.

Bangladesh, India, and Pakistan reached their export peaks in 2022, with values of 9.369 billion USD, 6.677 billion USD, and 4.367 billion USD, respectively, while the other four countries showed steady recovery.

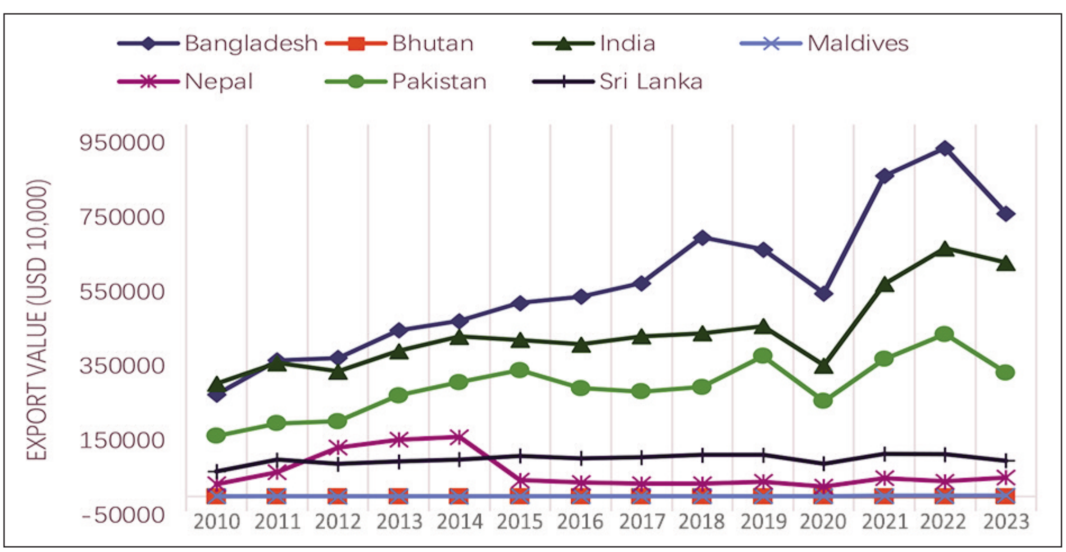

Fig. 2. China's Textile exports to 7 South Asian countries, 2010–2023 (based on UN Comtrade data)

China's textile exports to the seven South Asian countries exhibit significant market concentration, with Bangladesh, India and Pakistan accounting for the largest shares, followed by Sri Lanka and Nepal, whilst exports to Bhutan and the Maldives are relatively small, as shown in table 1. In terms of export share, Bangladesh is China's largest textile export market in South Asia, and its market position continues to strengthen. Between 2010 and 2023, the share of China's textile exports to Bangladesh rose from 25.66% to 34.04%, an increase of 8.38 percentage points, demonstrating the sustained expansion of the country's demand for Chinese textiles. India's market share, however, has shown a fluctuating downward trend. In 2010, China's share of textile exports to India stood at 31.57%, falling to 27.95% by 2023, a decrease of 3.62 percentage points. Despite this decline, India remains one of China's key export markets in South Asia. It is worth noting that, as shown in figure 2, the value of China's textile exports to India has not decreased but has, in fact, increased. This indicates that the overall growth rate of India's textile imports has outpaced the growth rate of imports from China. The change in market share was most pronounced in Pakistan. In 2010, China's share of textile exports to Pakistan stood at 29.52 per cent, falling sharply to 19.36 per cent by 2023, a decline of 10.16 percentage points. This downward trend reflects the diversification of Pakistan's textile import sources or a relative weakening of China's export competitiveness in this market. China's market share in Sri Lanka remained stable, whilst its share in the Nepalese market showed an overall upward trend. Between 2010 and 2023, China's share of textile exports to Sri Lanka fluctuated between 9.39% and 7.79%, whereas its share in Nepal rose from 3.56% to 10.30%, indicating a marked increase in demand for Chinese textiles in the Nepalese market.

THEORETICAL MODEL AND DATA SOURCES

Theoretical model

In the field of international trade research, the gravity model is widely used by most scholars. Tin Bergen was the first scholar to apply the gravity model to international trade research [28]. The basic theory of this model is that the total trade volume between two countries is directly proportional to their economic scale and inversely proportional to the distance between them. However, over time, the gravity model has gradually developed from its original traditional form to the stochastic frontier gravity model, and its theory has been continuously improved. The traditional trade gravity model, while canonical in trade potential estimation, harbours an inherent limitation: it overlooks endogenous trade resistances stemming from institutional frictions, policy barriers, and logistical inefficiencies. In contrast, the SFG model incorporates a trade inefficiency term, a construct rooted in Meeusen and van den Broeck's technical inefficiency formulation, that explicitly accounts for such anthropogenic resistances [29]. Compared with the traditional gravity model, the stochastic frontier gravity model decomposes trade resistance into random errors and optimizable artificial factors by introducing the trade inefficiency term. This not only allows for the quantification of the boundaries of trade potential but also identifies the time-varying characteristics of remediable resistances, such as institutional and logistical factors. Therefore, this paper uses the stochastic frontier gravity model to analyse how the development level of digital service trade in countries along the route affects China's exports.

The stochastic frontier gravity model was formulated as follows:

$$T_{ijt} = f(X_{ijt}, \beta)\exp(v_{ijt})\exp(-u_{ijt}), \quad u_{ijt} \geq 0 \qquad (1)$$

It is obtained after taking the logarithm:

Table 1

PROPORTION OF CHINA'S TEXTILE EXPORTS TO THE SEVEN SOUTH ASIAN COUNTRIES FROM 2010 TO 2023

Year	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
2010	25.66%	0.03%	31.57%	0.29%	3.56%	29.52%	9.39%
2011	23.61%	0.01%	31.95%	0.42%	5.29%	27.99%	10.72%
2012	21.09%	0.03%	36.45%	0.29%	4.57%	25.40%	12.17%
2013	22.70%	0.03%	37.57%	0.33%	5.19%	21.62%	12.57%
2014	23.93%	0.01%	34.22%	0.31%	3.60%	23.01%	14.92%
2015	22.66%	0.05%	26.80%	0.34%	3.53%	24.97%	21.65%
2016	22.30%	0.03%	30.10%	0.47%	4.76%	23.01%	19.33%
2017	21.33%	0.02%	31.86%	0.44%	5.33%	24.62%	16.40%
2018	28.90%	0.02%	27.56%	0.42%	6.58%	23.59%	12.93%
2019	37.37%	0.01%	20.74%	0.45%	5.91%	22.65%	12.87%
2020	40.93%	0.01%	18.22%	0.26%	4.61%	23.92%	12.04%
2021	39.67%	0.01%	19.03%	0.41%	9.17%	22.19%	9.52%
2022	36.64%	0.00%	24.33%	0.51%	7.76%	23.90%	6.85%
2023	34.04%	0.01%	27.95%	0.55%	10.30%	19.36%	7.79%

$$\ln T_{ijt} = \ln f(X_{ijt}, \beta) + v_{ijt} - u_{ijt}\,, \;\; u_{ijt} \geq 0 \tag{2}$$

In the above equation, T_{ijt} represents the total trade volume between country i and country j in period t; X_{ijt} represents the natural factors such as economic size, population size, straight-line distance between the capitals, whether there is a border and language that affect the trade volume between the two sides in period t; β is a parameter; v_{ijt} represents the random error, which obeys the normal distribution with a mean value of 0 and a variance of σ^2, and is independent of the trade inefficiency term u_{ijt}; u_{ijt} obeys a kinked normal or half-normal distribution and contains the human factors that affect the trade volume between the two parties. The trade inefficiency term adds human resistance factors when the trade inefficiency term u_{ijt} = 0, that is, there is no trade inefficiency term, the two countries maximise the trade size, and at this time, the two countries reach the trade potential T_{ijt}*, expressed as:

$$T_{ijt}^* = f(X_{ijt}, \beta)\exp(v_{ijt}) \tag{3}$$

The efficiency of trade between the two sides is indicated as:

$$TE_{ijt} = \frac{T_{ijt}}{T_{ijt}^*} = \exp(-u_{ijt}) \tag{4}$$

When there are artificial resistance factors, i.e., $u_{ijt} > 0$, $T_{ijt}^* < 1$, the trade volume of the two countries is less than the trade potential; when there are no artificial resistance factors, i.e., $u_{ijt} = 0$, $T_{ijt}^* = 1$, the trade volume of the two countries reaches the trade potential. Based on researchers' observations of the mean value of trade inefficiency terms changing over time, the gravity model can be classified into the time-varying stochastic frontier gravity model and the time-invariant stochastic frontier gravity model. Initially, most scholars believed that the trade inefficiency term remained constant over time, thus adopting the time-invariant stochastic frontier gravity model to estimate trade efficiency. However, this assumption was clearly unreasonable. Battese and Coelli pointed out that with the increase in the time dimension, the trade inefficiency term might change, and its expression is as follows [30]:

$$u_{ijt} = \{\exp[-\eta(t - T)]\}\, u_{ij} \tag{5}$$

The time-varying model posits that u_{ijt} is nonlinearly related to time. The time variable t and the base period T constitute the temporal framework for dynamic analysis. When t approaches T, the "stubborn resistance" not intervened by policies becomes prominent. The inefficiency term u_{ijt} reflects the inherent trade resistance at the initial stage of the sample period, and u_{ijt} follows a truncated normal distribution. η is the parameter to be estimated, characterising the decay rate of trade inefficiency over time.

Specifically, η indicates that u_{ijt} does not change with time; η implies that the trade inefficiency term, increasing with time, can reduce trade resistance; η signifies that the trade inefficiency term escalating over time leads to an increase in trade resistance.

The analysis of the impact of human resistance factors in trade inefficiency models involves two approaches: the "one-step method" and the "two-step method". The one-step method integrates the trade inefficiency model into the stochastic frontier gravity model for analysis, whereas the two-step method constructs an independent model using the trade inefficiency term as the dependent variable.

However, the two-step method assumes that the trade inefficiency term remains constant, which contradicts the premise of treating it as a dependent variable in an independent model. Therefore, this study draws on Battese and Coelli's (1995) application of the one-step method for trade efficiency research, simultaneously conducting regression on both the stochastic frontier gravity model and the trade inefficiency term [31].

The expression for the trade inefficiency term u_{ijt} was as follows:

$$u_{ijt} = \alpha' z_{ijt} + \varepsilon_{ijt} \tag{6}$$

In the above equation, α' is the parameter to be estimated, and $\alpha' > 0$ indicates that the exogenous variable z_{ijt} is positively correlated with the trade inefficiency term; z_{ijt} is the exogenous variable affecting u_{ijt}; ε_{ijt} indicates the random error term obeying the normal truncated-tailed distribution with a mean of 0 and a variance of σ^2, and it is assumed that $u_{ijt} > 0$. According to the "one-step method, equation 6 can be obtained by substituting equation 2:

$$\ln T_{ijt} = \ln f(X_{ijt}, \beta) + v_{ijt} - (\alpha' z_{ijt} + \varepsilon_{ijt}) \tag{7}$$

Model construction and variable selection

Time-varying stochastic frontier gravity model

This paper referenced Armstrong's suggestions, introducing natural factors affecting trade volume into the stochastic frontier gravity model, such as economic scale, population size, and whether there is a common language [32]. In the trade inefficiency model, artificial factors were introduced, including the government efficiency index, economic freedom score, monetary freedom, trade freedom, and whether a free trade agreement was signed between the trading parties or whether they belonged to the Shanghai Cooperation Organisation. On this basis, this paper constructed a time-varying stochastic frontier gravity model to study the trade potential and influencing factors of China's textile exports to South Asia.

The specific equation setting is as follows:

$$\begin{aligned} \ln EXP_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \\ + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln DIS_{ij} + \\ + \beta_6 \ln LANG_{ij} + v_{ijt} - u_{ijt} \end{aligned} \tag{8}$$

In the model, i denoted China, while j represented one of the seven South Asian countries. The dependent variable EXP_{ijt} referred to the actual level of textile exports from country i to country j in period t, measured by the real value of textile exports. The explanatory variables were primarily derived from factors that influenced export volumes, including characteristics of the exporting country, the importing country, and bilateral features. The economic meanings of these variables were explained as follows: GDP_{it} and POP_{it} denoted China's total GDP and population size in the period *t*, respectively. These variables represented China's level of economic development and demographic scale. Generally, a country's economic development determined its position in the international market and was positively correlated with its export volume. The higher the total GDP of the exporting country, the higher the level of economic development, and the stronger its production capacity and supply capacity for the international market. Therefore, GDP_{it} was expected to have a positive effect on EXP_{ijt}. The population size of a country was typically proportional to its domestic demand for textiles. Given China's relatively large population, a considerable portion of textile production was allocated to meeting domestic demand, potentially limiting its external supply capacity. Hence, POP_{it} was expected to have a negative impact on EXP_{ijt}.

GDP_{jt} and POP_{jt} were characteristics of the importing countries, representing, respectively, the GDP and population size of the country *j* in period *t*. GDP_{jt} reflected the economic development level of the importing country, while POP_{jt} indicated its population size. Higher economic development and a larger population typically implied stronger purchasing power and greater market demand for textiles, which, in turn, promoted exports from China. Therefore, both GDP_{jt} and POP_{jt} were expected to have a positive influence on China's textile export trade.

DIS_{ij} referred to a bilateral characteristic variable representing the geographical distance between countries *i* and *j*, serving as a proxy for transportation costs between the exporting and importing countries. In general, the greater the geographical distance, the higher the transportation costs, thereby reducing trade feasibility. Thus, DIS_{ij} was expected to have a negative effect on EXP_{ijt}.

$LANG_{ij}$ was a dummy variable indicating whether a common language was shared between the two countries. A value of 1 was assigned if a common language existed, and 0 otherwise. The presence of a common language facilitated communication and reduced trade information costs, thereby providing a natural advantage in conducting export trade. Accordingly, $LANG_{ij}$ was expected to have a positive impact on EXP_{ijt}.

Model of export trade inefficiency

To further explore the trade potential of China's textile exports to the seven South Asian countries, this paper refers to the research by Wen Liqin et al. on the impact of the development level of digital service trade in Belt and Road countries on China's green building commodity exports [25]. It introduces human factors affecting bilateral trade – the government efficiency index, economic freedom score, monetary freedom, trade freedom, whether a free trade agreement is signed between the trading parties, and whether they are members of the Shanghai Cooperation Organization – into the inefficiency term, and further constructs a trade inefficiency model. The specific equation is as follows:

$$u_{ijt} = \alpha_0 + \alpha_1 GEI_{jt} + \alpha_2 EFI_{jt} + \alpha_3 TRA_{jt} + \alpha_4 MON_{jt} + \alpha_5 FTA_{ijt} + \alpha_5 SCO_{ijt} + \varepsilon_{ijt} \quad (9)$$

In this model, the dependent variable u_{ijt} represented export trade inefficiency, while α_0 denoted the parameter to be estimated. The explanatory variables were defined as follows: GEI_{jt} represented policy communication and was measured by the Government Effectiveness Index. This index reflected the government's capacity and efficiency in policy implementation. A higher value of this index indicated lower administrative communication costs and, consequently, greater efficiency in textile exports. Thus, GEI_{jt} was expected to be positively correlated with export efficiency and negatively associated with the inefficiency term.

Trade facilitation was measured by trade freedom, denoted as TRA_{jt}. A higher value indicated fewer institutional restrictions on international trade, such as lower tariffs and non-tariff barriers. Therefore, TRA_{jt} was anticipated to be negatively related to trade inefficiency.

Financial integration was proxied by monetary freedom, represented by MON_{jt}, which measured the degree of currency circulation freedom and price stability. A higher score suggested greater monetary stability and liberalisation, which was expected to be positively related to trade efficiency, and thus negatively related to inefficiency.

Economic mobility was assessed using the Economic Freedom Index EFI_{jt}, which captured a country's reliance on market mechanisms and the degree to which the government had transitioned from being an economic participant to a rule-setter. Higher levels of economic freedom were associated with greater international trade openness and capital flow liberalisation. Countries with greater economic freedom typically exhibited stronger export competitiveness and greater appeal to foreign investment. Therefore, EFI_{jt} was expected to reduce export inefficiency.

FTA_{ijt} and SCO_{ijt} were both dummy variables. FTA_{ijt} indicated whether a free trade agreement had been signed between countries *i* and *j* in period *t*; SCO_{ijt} denoted whether both countries were members of the Shanghai Cooperation Organisation during the same period. Each variable equalled 1 if the condition was satisfied, and 0 otherwise. Free trade agreements played a key role in reducing trade barriers and uncertainty, while regional cooperation frameworks such as the SCO facilitated institutional arrangements and trade among member states. Both mechanisms contributed to improving export efficiency.

The freedom indices used in this study were developed by the Heritage Foundation and provided a comprehensive assessment of a country's economic institutional environment. These indices were scored on a scale of 0 to 100, with higher scores indicating better institutional quality, greater market orientation, and reduced export barriers for exporting countries. As such, MON_{jt}, EFI_{jt}, FTA_{ijt}, and SCO_{ijt} were all expected to exert a negative influence on u_{ijt}.

Sample selection and data sources

To avoid the adverse effects of heteroscedasticity and autocorrelation, and considering the reliability of regression results and data availability, this paper selected sample data from China and seven South Asian countries for empirical analysis. The seven South Asian countries include Bangladesh, Bhutan, India, the Maldives, Pakistan, Nepal, and Sri Lanka. Empirical analysis of panel data from 2010 to 2023 was conducted using Frontier 4.1 software.

Data on China's textile exports to partner countries (*ExPit*) are sourced from the UN Comtrade database. The scope of textiles includes various fabrics made from natural fibres and chemical fibres, with specific HS codes for textiles as follows: 5601-5604, 5607-5609, 57, 5807-5808, 5810-5811, 59, 63, 6501-6502. Data on GDP and population (GDP_{it} and POP_{it}) for both China and its trading partners, data were sourced from the World Bank. The geographic distance (DIS_{ij}) between China and its trading partners was derived from the CEPII database. Information on the Shanghai Cooperation Organisation (SCO_{ijt}) was retrieved from the official website of the SCO. Within the trade inefficiency model, the Government Effectiveness Index (GEI_{jt}) was sourced from the World Development Indicators (WDI), while the Trade Freedom Index (TRA_{jt}) and Monetary Freedom Index (MON_{jt}) were obtained from the Index of Economic Freedom. Where data were missing, interpolation methods were used to supplement the dataset.

EMPIRICAL TESTING AND RESULT ANALYSIS

Before estimating the model using the stochastic frontier gravity approach, it was necessary to conduct likelihood ratio (LR) tests to ensure model validity. These tests included assessments of whether trade inefficiency existed and whether the inefficiency term varied over time. By comparing the log-likelihood values of the restricted and unrestricted models, the LR statistic was calculated and compared against the 1% critical value. The results are presented in table 2. At the 1% significance level, the LR statistics were greater than the critical values from the chi-squared distribution. Therefore, the null hypothesis H_0: $\gamma = 0$, which suggested the absence of inefficiency, was rejected. Similarly, the null hypothesis H_0: $\eta = 0$, which assumed time-invariant inefficiency, was also rejected. These results indicated that trade inefficiency did exist and varied over time. Accordingly, the time-varying stochastic frontier model was adopted for estimation. This confirmed the presence of export trade inefficiencies between China and the seven South Asian countries and demonstrated that such inefficiencies exhibited time variation over the period 2010–2023.

Analysis of results from the stochastic frontier gravity model

According to the estimation results presented in table 3, China's total economic output (ln GDP_{it}) exhibited a statistically significant negative impact on textile exports, passing the 1% significance level. This finding was contrary to expectations. Several possible explanations may account for this result.

The growth of China's total economic output was accompanied by an increase in per capita income, causing the domestic textile demand structure to shift from "quantity-oriented" to "quality-oriented". The surging demand for high-protein products and characteristic organic textiles led to partial textiles prioritising domestic market satisfaction, demonstrating the adverse selection of "domestic demand crowding out exports" (Deaton and Muellbauer, 1980) [33]. From the perspective of industrial structure adjustment, the expansion of China's total economic output promoted the transformation of industrial structure toward high-end and service-oriented sectors [34, 35]. As a traditional manufacturing industry, the textile industry, under the dual influence of rising factor costs and optimised resource allocation, had part of its production capacity reallocated to emerging industries with higher added value, such as information technology and high-end equipment manufacturing [36]. This squeezed the raw material supply, labour resources, and capital investment of textile export enterprises, correspondingly weakening their export capabilities [37, 38]. Meanwhile, economic growth prompted the continuous improvement of domestic environmental protection standards and labour rights

Table 2

STOCHASTIC FRONTIER GRAVITY MODEL APPLICABILITY RESULTS

Original hypothesis	Constrained model log-likelihood	Unconstrained model log-likelihood	LR statistic	1% critical value	Test result
Absence of the trade inefficiency term	–69.847	–38.536	62.622	14.325	Rejection
Trade inefficiency term is non-time varying	–38.536	–29.854	17.346	12.483	Rejection

Table 3

REGRESSION RESULTS OF THE STOCHASTIC FRONTIER GRAVITY MODEL				
Variable	**Time-invariant model**		**Time-varying model**	
	Coefficient value	**T value**	**Coefficient value**	**T value**
Constant	–501.238***	–93.298	–476.500***	–14.135
ln GDP_{it}	–1.736***	–9.902	–1.283***	–6.055
ln GDP_{jt}	0.950***	4.323	0.998***	4.154
ln POP_{it}	24.879***	62.640	24.386***	15.958
ln POP_{jt}	0.328*	1.857	0.055	0.263
ln DIS_{ij}	2.305***	5.722	0.610	0.452
ln $LANG_{ij}$	1.983***	7.614	0.831**	2.367
σ^2	2.709	1.506	12.969	1.110
γ	0.962***	33.941	0.994***	168.390
μ	–3.229**	–2.433	–7.181**	–2.059
η	-	-	–0.039***	–4.344
Log-likelihood value	–38.536		–29.854	
LR test	62.621		79.985	

protection regulations [39, 40]. Textile production enterprises needed to invest more costs in energy conservation, emission reduction, and compliant operations, further compressing export profit margins and inhibiting enterprises' export enthusiasm [41, 42].

In addition, China's population size (ln POP_{it}) exerted a statistically significant positive effect on textile exports to South Asia, also passing the 1% significance threshold. This result contradicted traditional theoretical expectations, which suggest that population growth generally increases domestic consumption demand and suppresses exports. On one hand, the labour-intensive nature of China's textile processing sector allowed population growth to enhance production through increased labour supply elasticity and industrial clustering effects. On the other hand, the rigid demand for mid- to low-end textiles in South Asia was well-aligned with China's economies of scale and competitive pricing, indicating that population growth facilitated textile development and promoted textile exports to the region.

The economic scale of the seven South Asian countries (ln GDP_{jt}) had a significant and positive effect on China's textile exports, with results significant at the 1% level. That is, GDP growth was positively correlated with import demand elasticity: a 1% increase in GDP led to a 0.998% growth in textile import demand. When the economic consumption capacity of South Asian countries improved, Chinese enterprises had greater motivation to break through trade barriers and enhance export efficiency, with such investment decisions directly related to local GDP growth rates. Moreover, countries with higher economic levels typically have more complete infrastructure and lower trade costs. The population size of South Asian countries (ln POP_{jt}) had a positive impact on textile exports but failed to pass the significance test, indicating that an increase in the total population of South Asian countries might promote China's textile exports.

Geographical distance between China and South Asian countries (ln DIS_{ij}) had a positive influence on textile exports, but the effect was statistically insignificant. This could be attributed to the diminishing role of spatial distance as regional integration efforts advanced.

Whether the trading partners shared a common language under the Shanghai Cooperation Organisation framework ($LANG_{ij}$) had a positive and statistically significant effect on Chinese textile exports, at the 5% level. This outcome highlighted the role of linguistic and cultural connections in reducing transaction costs and fostering trust in international trade. From the perspective of transaction cost theory, a shared language could reduce information asymmetry and lower communication costs associated with business negotiations, contract enforcement, and market research. Culturally, linguistic similarities often correlated with converging consumer preferences. This also demonstrates the indispensable role of shared language in facilitating textile trade between China and the seven South Asian nations.

Analysis of results from the trade inefficiency model

The estimation results in table 4 indicate that the γ value (0.999) was significant at the 1% level, and the LR value reached 105.703. This suggests that the overall estimation effect was good, and the presence of the trade inefficiency term in the model was an important factor hindering smooth trade. Analysing the empirical results, the government efficiency index (GEI_{jt}) had a negative impact on trade inefficiency, with a coefficient of –2.931, which promoted the textile trade exports of the exporting country. This indicates that strengthening policy coordination and communication among partner countries is conducive to improving the export efficiency of China's textiles to South Asian countries. Therefore, with the full support of various government departments, the export efficiency of China's textiles to South Asian countries would naturally be enhanced.

The result shows whether China has signed a Free Trade Agreement (FTA_{jt}) with the seven South Asian countries passed the significance test at the 10% level and had a negative impact on trade inefficiency, which was in line with the theoretical expectation of the gravity model that "institutional arrangements reduce trade costs". This indicates that the signing of free trade agreements between China and South Asian countries can promote China's textile exports to South Asian countries to a certain extent. The main reason is that free trade agreements remove trade barriers and release policy dividends through a multidimensional mechanism: first, tariff reduction directly reduces the market access cost of Chinese textiles; second, the transparency and simplification of non-tariff barriers reduce compliance costs, shorten customs clearance time and reduce enterprise testing fees; third, trade facilitation measures directly improve cross-border circulation efficiency; fourth, the enhancement of policy stability reduces market risks. The clear rules of origin, dispute settlement mechanism and other provisions in the agreement provide enterprises with a predictable trade environment and stimulate long-term export investment.

The Shanghai Cooperation Organisation (SCO_{jt}) exhibited an inhibitory effect on the trade inefficiency term of China's textile exports to the seven South Asian countries, i.e., it promoted textile exports, but failed to pass the significance test. This indicates that the role of the Shanghai Cooperation Organisation in textile trade between China and the seven South Asian countries was not particularly prominent. The possible reasons are as follows: the focus of SCO cooperation has been more concentrated on areas such as security and energy, with fewer implemented mechanisms and arrangements related to textile trade, leading to weak direct policy impacts. Additionally, within the data time frame, some cooperation initiatives might not have been fully translated into trade effectiveness, or were interfered with by factors such as geopolitics and other trade agreements, causing the promotion effect of this variable on textile exports to fail to be statistically significant.

The Economic Freedom Index (EFI_{jt}) of the seven South Asian countries exhibited an inhibitory effect on the inefficiency of China's textile trade and passed the significance test at the 1% level. That is, economic freedom was directly proportional to China's textile exports to South Asia. The main reason is that countries with higher economic freedom have lower trade barriers and a more stable and transparent policy environment, reducing the institutional costs for Chinese textiles to enter local markets.

Simultaneously, economies with a higher degree of marketisation have more elastic demand for textiles, and their private sectors are more dynamic, making it easier to form stable import demands and supply chain collaborations. This aligns with the logic in the gravity model that "institutional quality enhances trade flows".

The Monetary Freedom Index (MON_{jt}) exerted a negative impact on trade inefficiency, with a coefficient of –0.039, and passed the significance test at the 10% level. This indicates that the free flow of currency can effectively enhance the export efficiency of Chinese textiles. The primary reasons are as follows: fewer currency exchange restrictions and relaxed foreign exchange controls reduce cross-border settlement costs and exchange rate risks, enabling Chinese exporters to more easily determine prices and receive payments. Simultaneously, countries with a higher degree of monetary freedom have more open financial environments, facilitating the establishment of flexible trade settlement mechanisms, improving transaction efficiency, and strengthening enterprises' willingness to export. This reflects the positive impact of financial institutional convenience on textile trade.

Table 4

REGRESSION RESULTS OF THE TRADE INEFFICIENCY TERM MODEL

Function	Variable	Coefficients	T-value
Stochastic front function	Constant	–458.004	–458.243
	ln GDP_{it}	–1.315	–15.767
	ln GDP_{jt}	0.658	8.730
	ln POP_{it}	22.380	183.047
	ln POP_{jt}	0.533	9.187
	ln DIS_{ij}	2.383	26.630
	ln $LANG_{ij}$	1.035	14.256
Trade inefficiency function	Constant	13.061	8.055
	GEi_{jt}	–2.931	–11.240
	FTA_{jt}	–0.545	–1.733
	SCO_{jt}	–0.064	–0.098
	EFI_{jt}	–0.244	–6.630
	MON_{jt}	–0.039	–1.708
	TRA_{jt}	0.071	4.721
	σ^2	0.706	5.869
	γ	0.999	154.626
Log-likelihood value	–74.031		
LR test	105.703		

The Trade Freedom Index (TRA_{jt}) exerted a significant positive impact on trade inefficiency at the 1% level, which contradicted expectations. This indicates that increasing trade freedom did not promote China's textile exports. Possible reasons include: countries with high trade freedom might rely more on protective policies for their domestic textile industries, setting implicit barriers to textiles despite overall openness; high trade freedom was accompanied by fierce international competition, and Chinese textiles might face squeezing from similar products in regions such as Southeast Asia and Australia, leading to a diversion of market share; the indicator measurement might not have accurately distinguished the characteristics of the textile sector, as overall trade freedom did not necessarily equate to textile trade facilitation, causing the results to deviate from theoretical expectations.

Export trade efficiency and potential

Tables 5 and 6 present the textile export efficiency and expansion potential of China to the seven South Asian countries from 2010 to 2023. As shown in table 5, the average export efficiency of China to South Asia demonstrated a steady growth trend during 2010–2023. The average efficiency of China's textile exports to South Asian countries was 0.3864 in 2010, rising to 0.5403 by 2023. After the Belt and Road Initiative was proposed in 2013, the average textile export efficiency reached a peak of 0.5767 in 2015, followed by a slight decline from 2016 to 2018, dropping to 0.3784 in 2018. The direct cause of the recent decline in average export efficiency to the seven South Asian countries was the significant reduction in textile imports from China by India and Pakistan. For example, India's textile imports from China decreased by $9.5123 million in 2018 compared to 2017, and Pakistan's imports decreased by $4.5261 million, with the import reduction from these two countries accounting for over 80% of the total decline. Overall, China's textile export efficiency to South Asia showed an upward trend but with large fluctuations. Except for Bhutan, India, and Pakistan, the annual average export efficiency exceeded 0.5. The highest annual average efficiency was observed in exports to Bangladesh at 0.7633, followed by the Maldives, Sri Lanka, and Nepal at 0.7360, 0.5845, and 0.5303, respectively, while the efficiency of exports to India was the lowest at 0.0973.

China and the seven South Asian countries demonstrated substantial potential in textile export trade, and this potential showed a steady upward trend, as presented in table 6. An in-depth analysis of trade potential differences across countries revealed that China's textile export potential to Bangladesh, India, Pakistan, and Sri Lanka was at a relatively high level, while that to Bhutan and the Maldives was relatively low. In terms of specific trade potential values, under the ideal assumption of no trade resistance or frictions, the average textile export potential from China to the seven South Asian countries in 2023 was approximately 2.1 billion USD. In the same year, China's export potential to India reached about 12.6 billion USD, which was closely related to India's huge population base, strong demand for textiles, and the long-standing good cooperation foundation between the two countries in the textile industry. As the most populous and largest economy in South Asia, India has a huge demand for textiles. China's wide variety of textile products can meet the diversified needs of the Indian market, ranging from grains to various textile products. In 2023, the export potentials of Bangladesh and Pakistan were approximately 0.6 billion USD and 1.1 billion USD respectively. These two countries have vast textile markets and growing consumption capacity, and China has strong complementarity with them in textile trade.

Meanwhile, Sri Lanka's export potential was about 0.2 billion USD. Although its market size was relatively small, the demand for some speciality textiles was stable. In contrast, China's textile export potential to Bhutan and the Maldives was low, at about 1.09 million USD and 8.35 million USD, respectively. This was mainly because Bhutan, located in the Himalayan mountains, had a relatively closed geographical environment, a small-scale textile industry, and limited domestic market demand.

The Maldives, an archipelagic country with scarce land resources, faced significant constraints in textile industry development and mainly relied on imports. However, restricted by its own economic scale and market capacity, its import demand for textiles was relatively small. Such differences in trade potential reflected the disparities between China and South Asian countries in terms of textile resource endowments, market demand structures, and trade cooperation foundations. With the in-depth advancement of the Belt and Road Initiative, cooperation between China and South Asian countries in infrastructure construction and trade facilitation has been continuously strengthened, which will help further unleash trade potential, reduce trade resistance, and promote the development of textile export trade between China and the seven South Asian countries to a higher level. In the future, through measures such as strengthening scientific and technological exchanges

Table 5

EFFICIENCY OF CHINA'S EXPORTS TO SEVEN SOUTH ASIAN COUNTRIES, 2010–2023

Year	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka	Mean (USD)
2010	0.7989	0.3043	0.0324	0.5658	0.3270	0.3082	0.3681	0.3864
2011	0.8522	0.1259	0.0385	0.9731	0.4994	0.3256	0.4769	0.4702
2012	0.7184	0.3444	0.0423	0.6199	0.4168	0.2693	0.5101	0.4173
2013	0.7650	0.3485	0.0461	0.6912	0.5006	0.2388	0.5423	0.4475
2014	0.7894	0.1614	0.0423	0.6348	0.3681	0.2639	0.6610	0.4173
2015	0.7345	0.6232	0.3452	0.6815	0.3679	0.2846	0.9998	0.5767
2016	0.5954	0.3794	0.0368	0.8915	0.4990	0.2561	0.8794	0.5054
2017	0.5042	0.1698	0.0335	0.7440	0.4755	0.2456	0.6733	0.4066
2018	0.6115	0.1602	0.0271	0.6193	0.5120	0.2155	0.5034	0.3784
2019	0.8696	0.1411	0.2306	0.7241	0.5243	0.2573	0.6083	0.4793
2020	0.8632	0.1389	0.1987	0.5266	0.3899	0.2667	0.5579	0.4203
2021	0.9607	0.1135	0.2288	0.8080	0.8905	0.2749	0.5255	0.5431
2022	0.7810	0.0469	0.0265	0.8447	0.6601	0.2643	0.4015	0.4321
2023	0.8425	0.1984	0.0329	0.9798	0.9954	0.2570	0.4759	0.5403
Mean	0.7633	0.2326	0.0973	0.7360	0.5305	0.2663	0.5845	0.4586

Table 6

ESTIMATED EXPORT TRADE POTENTIAL OF SEVEN SOUTH ASIAN COUNTRIES, 2010–2023								
Year	**Bangladesh**	**Bhutan**	**India**	**Maldives**	**Nepal**	**Pakistan**	**Sri Lanka**	**Mean**
2010	292237604	879648	8865652994	4607047	98975040	871531204	232114789	1480856904
2011	268622695	828832	8044682182	4181548	102790288	833514189	217965024	1353226394
2012	274037553	825494	8043498132	4333588	102440917	880529740	222623292	1361184102
2013	297049179	820660	8159251649	4804657	103774586	906329012	232082318	1386301723
2014	335117326	884758	8942739480	5394625	108066582	964147806	249595502	1515135154
2015	386673003	972378	9733979900	6265680	120267043	1099831859	271474990	408411849
2016	529605339	1143919	11569697935	7425328	134896172	1270679520	310961701	1974915702
2017	577616244	1241137	12982879821	8131220	152984414	1368740428	332452243	2203435072
2018	582866481	1177428	12538856753	8447802	158384750	1349893838	316828802	2136636551
2019	648310657	1281545	1357245317	9314411	169994850	1328233964	319194588	547653618.8
2020	689814403	1218474	1334193659	7229070	172019787	1304898950	313910645	546183569.7
2021	588135369	1046652	1184976543	7292621	146638056	1149812710	258102700	476572093
2022	626987041	1073390	12270693811	8120471	157063562	1208702694	227977758	2071516961
2023	600199742	1091351	12618677720	8348898	153722194	1119121374	243178132	2106334202
Mean	478376617	1034690	8403358993	6706926	134429874	1118283378	267747320	-

in the textile industry, optimising the textile trade structure, and improving trade service levels, textile trade between China and South Asian countries is expected to achieve greater growth, bringing more opportunities for the development of the textile industry and economic cooperation between both sides.

According to the level of trade potential, South Asian countries can be categorised into “high-potential low-efficiency countries”, “medium-potential high-efficiency countries”, “medium-potential medium-efficiency countries”, and “small-scale markets”. The high-potential low-efficiency group includes India and Pakistan. From 2010 to 2023, their textile export efficiencies were 0.0973 and 0.2663, respectively, significantly lower than the South Asian average (0.4586), but their trade potentials reached 7.7 billion USD and 1.1 billion USD, ranking top two in South Asia. India’s high potential stems from the consumption demand of its 1.4 billion population, while Pakistan relies on its textile processing industry foundation. However, trade inefficiencies in both countries are primarily constrained by non-tariff barriers and infrastructure bottlenecks, necessitating breakthroughs in inefficiency bottlenecks to unleash trade potential. Medium-potential high-efficiency countries such as Bangladesh and Sri Lanka have export efficiencies of 0.7633 and 0.5845, respectively, significantly higher than the South Asian average, with trade potentials of 480 million USD and 270 million USD, classifying them as “mature markets”. Bangladesh, relying on its garment processing industry, has become a major importer of Chinese fabrics, while Sri Lanka demonstrates stable demand for speciality textiles but faces competition from Southeast Asian products, requiring deepened industrial collaboration to enhance trade quality. Small-scale markets include the Maldives and Bhutan, where strategies should focus on precise demand positioning and niche potential exploration. Nepal, a medium-potential medium-efficiency country with an export efficiency of 0.5305 (slightly above the South Asian average) and a trade potential of 0.134 billion USD, is a “growth market” that can activate its regional hub value through infrastructure connectivity. The final category, small-scale markets (Maldives and Bhutan), has export efficiencies of 0.7360 and 0.2326, with trade potentials of only 6.7 million USD and 1.03 million USD. The Maldives, constrained by its island economy, primarily demands tourism-related textiles, while Bhutan, geographically isolated with a weak textile foundation, shows growing demand for environmental products.

The export expansion space of Chinese textiles to South Asian countries showed significant country-specific differentiation, as presented in table 7, which was closely related to export efficiency. The largest expansion spaces were observed in Bhutan and India, reaching 2132.20% and 3773.58%, respectively. Although China’s textile export efficiency to these countries was low, the expandable space released was the largest, indicating broad cooperation prospects for future textile trade. The formation of such high expansion space stemmed from both the high logistics costs caused by Bhutan’s geographical isolation and India’s textile industry protection policies. In contrast, the smallest expansion spaces were in Bangladesh, the Maldives, and Sri Lanka, at 134.77%, 140.72%, and 183.36%, respectively. While the import expansion space in these countries was limited, the low expansion space did not imply exhausted trade potential but directly reflected market maturity. From 2010 to 2023, the overall export expansion space of Chinese textiles to South Asia

Table 7

EXPORT EXPANSION POTENTIAL OF THE SEVEN SOUTH ASIAN COUNTRIES, 2010–2023								
Year	**Bangladesh**	**Bhutan**	**India**	**Maldives**	**Nepal**	**Pakistan**	**Sri Lanka**	**Mean**
2010	125.17%	328.62%	3086.42%	176.74%	305.81%	324.46%	271.67%	659.84%
2011	117.34%	794.28%	2597.40%	102.76%	200.24%	307.13%	209.69%	618.41%
2012	139.20%	290.36%	2364.07%	161.32%	239.92%	371.33%	196.04%	537.46%
2013	130.72%	286.94%	2169.20%	144.68%	199.76%	418.76%	184.40%	504.92%
2014	126.68%	619.58%	2364.07%	157.53%	271.67%	378.93%	151.29%	581.39%
2015	136.15%	160.46%	289.69%	146.74%	271.81%	351.37%	100.02%	208.03%
2016	167.95%	263.57%	2717.39%	112.17%	200.40%	390.47%	113.71%	566.53%
2017	198.33%	588.93%	2985.07%	134.41%	210.30%	407.17%	148.52%	667.53%
2018	163.53%	624.22%	3690.04%	161.47%	195.31%	464.04%	198.65%	785.32%
2019	115.00%	708.72%	433.65%	138.10%	190.73%	388.65%	164.39%	305.61%
2020	115.85%	719.94%	503.27%	189.90%	256.48%	374.95%	179.24%	334.23%
2021	104.09%	881.06%	437.06%	123.76%	112.30%	363.77%	190.29%	316.05%
2022	128.04%	2132.20%	3773.58%	118.39%	151.49%	378.36%	249.07%	990.16%
2023	118.69%	504.03%	3039.51%	102.06%	100.46%	389.11%	210.13%	637.71%
Mean	134.77%	635.92%	2175.03%	140.72%	207.62%	379.18%	183.36%	550.94%

decreased from 659.84% to 550.94%, indicating a gradual improvement in the prospects of textile trade between China and South Asia. Despite short-term fluctuations due to external shocks such as India's trade policy adjustment in 2014 and the COVID-19 pandemic in 2020, the continuous convergence trend was of clear positive significance. The decline in expansion space essentially represented the process of actual trade volume approaching trade potential, reflecting the effectiveness of policy tools such as the second-phase implementation of the China-Pakistan Free Trade Agreement and the launch of the China-Bangladesh cross-border textile industrial park. The improvement of regional trade facilitation gradually dismantled tariff and non-tariff barriers.

CONCLUSION AND POLICY RECOMMENDATIONS

Conclusion

Expansion of textile trade and efficiency trends (2010–2023)

Between 2010 and 2023, China's textile exports to South Asian countries experienced significant growth, enhancing China's position within the regional textile trade. Overall, trade efficiency exhibited an upward trajectory; however, export volumes remained relatively modest, and efficiency levels were generally low, with notable disparities among countries. While there was substantial room for improvement in trade potential and expansion capacity, these opportunities varied considerably across different nations.

Impact of objective factors on export efficiency

China's domestic economic development level imposed certain constraints on textile exports, indicating that it was no longer a primary driver for exports to South Asia and, in some respects, may have acted as a limiting factor. Conversely, the growth in China's textile exports to South Asian countries was primarily attributed to China's large population, the economic advancement of South Asian nations, and the influence of shared languages. Although the expansion of South Asian populations and the geographical proximity between capitals somewhat facilitated textile trade, their impact was not pronounced. Therefore, it was imperative for China and South Asian countries to enhance the role of common languages and for South Asian nations to focus on economic development to further elevate bilateral textile trade cooperation.

Influence of institutional and policy factors

Key institutional factors, such as government effectiveness, free trade agreements, participation in the Shanghai Cooperation Organisation (SCO), and monetary freedom, played significant roles in reducing inefficiencies in China's textile exports to South Asia. These elements substantially promoted export efficiency. However, trade freedom exerted a positive effect on export inefficiency, potentially hindering the development of textile trade between China and South Asian countries. This phenomenon might be attributed to the strong protective measures for domestic textile industries within South Asian nations, which adversely affected China's export markets. Consequently, both parties needed to implement measures to reduce tariff and non-tariff barriers, thereby expanding marketing flexibility and mitigating inefficiencies.

From the empirical results, the promoting effect of human factors is significantly greater than that of natural factors, which answers the question in the introduction: the main driving force for China's textile exports to South Asian countries is human factors, and the current trade level has not reached the upper limit of potential.

Policy recommendations and future outlook

Policy recommendations

(1) At the national level

China and South Asian countries need to establish a long-term intergovernmental cooperation framework for the textile industry, focusing on promoting institutional coordination in three aspects. First, establish the "China-South Asia Textile Standards Joint Committee" to unify textile safety certifications, testing methods, and labelling specifications, reducing trade barriers caused by standard discrepancies. For example, in major markets such as Bangladesh and Pakistan, pilot mechanisms for mutual recognition of indicators like formaldehyde content and colour fastness in textile fabrics can be prioritised to lower corporate compliance costs. Second, accelerate the upgrading negotiations of free trade agreements (FTAs). In the second-phase implementation of the China-Pakistan Free Trade Agreement, expand the coverage of textile items with zero tariffs, and launch feasibility studies on FTAs with countries such as India and Sri Lanka to directly reduce the market access costs for Chinese textiles through tariff reductions. Third, establish a "Textile Industry Policy Communication Platform" to regularly release trade policy updates of South Asian countries and provide policy risk assessment services for enterprises.

Relying on the Belt and Road Initiative, a multidimensional infrastructure network should be constructed. Accelerate the construction of the main line of the China-Nepal Railway, the Gwadar Port section of the China-Pakistan Railway, and the extension of the China-Laos Railway to form a three-dimensional transportation system of "railway-highway-port", shortening the transportation cycle and reducing costs for textiles from China to South Asia. Meanwhile, launch intermodal routes for the "China-South Asia Railway Express", establish bonded logistics centres in Kathmandu (Nepal) and Lahore (Pakistan), and achieve "one inspection, full-domain clearance" for textiles. Additionally, promote South Asian countries' access to China's cross-border e-commerce comprehensive pilot zones, establish online textile trading markets via platforms such as Alibaba.com and AliExpress, and compress customs clearance time for small and medium orders through digital technologies to enhance trade efficiency.

(2) At the enterprise level

Chinese textile enterprises need to adjust their strategies according to the characteristics of South Asian markets. On the one hand, strengthen the industrial chain collaboration model of "Chinese raw materials, South Asian processing", such as expanding investment in Pakistan's Sahiwal Textile and Garment Industrial Park and constructing supporting chemical fibre raw material production lines to meet local garment manufacturers' demand for high-elasticity fabrics. On the other hand, develop a cost-effective product matrix for the rigid demand of mid-to-low-end textiles in South Asia. Meanwhile, establish a Southeast Asia-South Asia entrepot trade network by setting up distribution centres in Yangon (Myanmar) and Colombo (Sri Lanka) to evade India's anti-dumping restrictions on Chinese polyester fibres.

Furthermore, promote digital transformation and green production reforms to accelerate textile technology export and standard upgrading. Popularise IoT spinning equipment to help South Asian enterprises improve production efficiency while reducing energy consumption. Deploy intelligent printing and dyeing factories in Bangladesh and Nepal, adopt zero-emission technologies, obtain EU eco-labels, and break through green trade barriers in developed countries. Additionally, develop products compliant with South Asian environmental standards: launch degradable textile packaging materials in response to India's "Clean India" initiative, and research and develop plant fibre-based textiles to meet the Maldives' plastic ban, thereby enhancing product premium.

(3) At the international cooperation level

China should strengthen multilateral mechanisms and cultural integration bonds, activate the trade promotion function of the Shanghai Cooperation Organisation (SCO), and build a textile trade coordination system with the SCO as the platform. Establish an "SCO Textile Trade Working Group" including members from India, Pakistan, China, etc., focus on formulating regional rules of origin mutual recognition schemes, and promote the establishment of a "South Asian Textile Trade Database" to share supply and demand information among countries. Meanwhile, jointly issue a "White Paper on South Asian Textile Trade Facilitation" to unify customs codes and inspection and quarantine procedures, reducing corporate customs clearance costs. In response to the SCO's current focus on security-related cooperation, initiate an "SCO Textile Industry Innovation Forum" focusing on topics such as green textiles and digital technology applications to enhance the direct impact of policies on trade.

Moreover, construct a language-culture-trade integration ecosystem to promote deep trade integration through language interoperability. Establish "China-Pakistan Bilingual Talent Training Bases for the Textile Industry" in Lahore (Pakistan) and Kathmandu (Nepal), collaborate with local universities to offer specialised courses in Urdu, Nepali, and textile engineering, cultivate interdisciplinary talent, and reduce business negotiation costs. Meanwhile, carry out "Chinese Textile Culture Exhibition Tours" through Confucius Institutes, display traditional craftsmanship such as Su embroidery and Xiang embroidery in Sri Lanka and Bhutan, promote the integration of Chinese embroidery with local clothing cultures, develop "Belt and Road"-themed textiles, and enhance product premium derived from cultural identity. Additionally, leverage the advantage of common languages to optimise trade negotiation efficiency: form bilingual negotiation teams in the upgrading negotiations of the China-Pakistan Free Trade Agreement, shorten the consultation cycle for technical trade barriers, and promote the implementation of the China-Bangladesh textile fast-track customs clearance agreement.

Research limitations and future directions

This study reveals the potential landscape of textile trade between China and South Asia, covering only seven South Asian countries and excluding Central Asia or Southeast Asia, so the conclusions do not apply to other regions. The stochastic frontier model is used to reveal the multidimensional influencing factors of trade potential, but there are still many limitations. The policy recommendations proposed in this paper aim to promote textile trade between China and South Asia, but their effectiveness may be constrained by practical obstacles, especially trade protectionism and geopolitical risks in the region. These limitations highlight the necessity of adjusting policies according to local conditions and formulating risk mitigation strategies. Moreover, due to the limitations of data dimensions and availability, this paper does not include domestic logistics costs and consumer preference data of South Asian countries, which may lead to incomplete identification of trade inefficiency factors. The trade characteristics of textile subcategories differ significantly, but the model does not conduct category-specific estimations, making it difficult to accurately locate the potential release paths of different products. In addition, this paper fails to consider spatial spillover effects; for example, the competitive relationship between India and Pakistan may affect China's export decisions through third-country markets, thus requiring the introduction of spatial econometric models to analyse the interactive effects of intra-regional trade. Future research could explore and promote practices from the following dimensions:

(1) Inclusion of emerging variables and dynamic mechanism analysis

Due to data constraints, variables such as domestic logistics costs and consumer preferences in South Asian countries were not incorporated, potentially leading to an incomplete identification of trade inefficiency factors. Additionally, significant differences existed in the trade characteristics of various textile subcategories, but the model did not estimate these separately, hindering the precise identification of potential release pathways for different products. Future research could introduce emerging variables, such as a "Digital Trade Intensity Index", to quantitatively assess the marginal contributions of innovations like live-streaming e-commerce and smart logistics to trade efficiency, particularly in countries like the Maldives and Bhutan, which were in the early stages of digital development. Furthermore, climate change impacts, such as monsoon anomalies in India leading to reduced grain production, could reshape trade structures, necessitating the inclusion of climate risk indices to dynamically evaluate the effects of extreme weather on export potential.

(2) Deepening regional institutional coordination

The positive impact of the SCO on trade efficiency had not yet been fully realised. Future studies could focus on the synergistic mechanisms between the Belt and Road Initiative and the SCO, such as examining the effects of textile tariffs within the SCO framework on trade dynamics. Additionally, the policy spillover effects of the Regional Comprehensive Economic Partnership (RCEP) on South Asian countries warranted investigation, with analyses of its long-term influence on textile trade volumes and structures.

(3) Expanding research from a microenterprise perspective

Current analyses were based on macro-level data, lacking in-depth insights into enterprise behaviours. Future research could employ surveys or case studies to explore the practical challenges faced by small and medium-sized export enterprises in South Asian markets, particularly strategies to navigate non-tariff barriers in India. Moreover, examining how the supply chain configurations of multinational textile enterprises influenced trade efficiency could provide valuable empirical insights at the enterprise level.

(4) Integrating green trade and sustainable development:

The rising demand for environmentally friendly products in South Asian countries, such as the Maldives' plastic ban, highlighted the need to incorporate variables like green certifications and carbon footprints into analyses. Future studies could develop a "Textile Green Trade Index" to assess the impact of organic certification, mutual recognition, and low-carbon packaging technologies on export premiums.

Additionally, evaluating the trade creation effects of China's promotion of green technologies, such as photovoltaic irrigation and smart greenhouses, in South Asia would offer theoretical support for "climate-smart agricultural cooperation".

This study provided a quantitative analysis framework based on the gravity model for examining China's textile trade with South Asia. Future research should aim to enhance data richness, model sophistication, and policy relevance to comprehensively elucidate the dynamic evolution of regional trade patterns and offer targeted theoretical support for precise policy formulation within the context of Belt and Road textile cooperation.

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