3. AN ANALYSIS OF THE IMPACT OF US-CHINA TRADE FRICTIONS ON CHINESE MANUFACTURING INDUSTRIES FROM THE PERSPECTIVE OF TRADE GAINS

Yanfang LYU[1]*
Linhui ZHAO[2]
Dong WANG[3]

Abstract

Economies are under the influence of global macroeconomic variables as well as national This paper shows that the impact of US-China trade frictions on the trade gains of Chinese manufacturing industries is a nonlinear effect. The trade gains in the Chinese manufacturing industries exhibit an increasing trend when the average anti-dumping and anti-subsidy duties imposed by the United States on China are relatively low. However, the trade gains decrease as the average anti-dumping and anti-subsidy duties reach higher levels. On the one hand, US-China trade frictions directly undermine trade gains in the Chinese manufacturing industries by elevating its trade costs. On the other hand, trade frictions compel Chinese manufacturing companies to phase out outdated production methods and transform their trade structures. These measures result in long-term improvements and contribute to an increase in the trade gains in the Chinese manufacturing industries. We establish a dynamic semi-parametric panel model to quantify the nonlinear effect of US-China trade frictions. We find that the trade gains of Chinese manufacturing industries can either increase, decrease or remain constant with average anti-dumping and anti-subsidy duties imposed by the United States on China.

Keyword: US-China trade frictions; manufacturing industries; the trade gains; nonlinear effect

JEL Classification: F10

1. Introduction

We show that the relationship between US-China trade frictions and the trade gains in the Chinese manufacturing industries is characterized by a nonlinear effect. When the average levels of anti-dumping and anti-subsidy duties imposed by the United States on China are low, it leads to an increase in the trade gains in the Chinese manufacturing industries. Conversely, if these average duties become excessively high, it results in a decrease in the trade gains in the Chinese manufacturing industries.

[1] *Institute of Quantitative Economics, Huaqiao University; Email: yanfang902@sina.com.* ***Corresponding author****.*

[2] *Institute of Quantitative Economics, Huaqiao University; Email: linhui.z@foxmail.com.*

[3] *School of Business, Minnan Normal University; Email: wangrichard72@sina.com.*

Recently, the protectionist policies of major countries have been on the rise, triggering concerns about a global trade war. The dramatic escalation of tariffs between the United States and China in 2018, and more recently the emergence of domestic protectionism in U.S. legislation, point to a growing breakdown in the system of rules-based international trading arrangements (Auray *et al*., 2023). In the global trade war, countries tend to impose anti-subsidy and anti-dumping duties to protect their own industries, but will such protection measures really weaken the trade gains of manufacturing industries of sanctioned countries?

In this paper, a new perspective is presented for illustrating the mechanism of trade frictions on the trade gains of manufacturing industries. On the one hand, the trade gains in the Chinese manufacturing industries are adversely affected by US-China trade frictions due to the escalation of trade costs. A number of scholars show that US-China trade frictions seriously damage the welfare of consumers and economic growth in the two countries (Ossa, 2014; Rosyadi and Widodo, 2018; Doifode and Gopalakrishnan, 2020). The US-China trade war also reduces sector-level import and output (Itakura, 2020) and firm-level profits (Benguria *et al*., 2022) in China. It is related to the changes in the supply chain network and the rising costs caused by trade frictions (Amiti *et al*., 2019; Waugh, 2019; Handfield *et al*., 2020). In addition, US-China trade frictions cause trade diversion (Carvalho *et al*., 2019; Nantembelele *et al*., 2023). Trade diversion indirectly damages the trade gains of Chinese manufacturing industries. These phenomena are called the disruptive effect of trade frictions.

On the other hand, trade frictions compel Chinese manufacturing companies to eliminate outdated production methods and adjust their trade structures. These measures contribute to long-term improvements and have the potential to increase the trade gains in the Chinese manufacturing industries. The phenomena can be referred to as the incentive effect of trade frictions. The incentive effect lead to the transformation of production structure and trade structure in Chinese manufacturing industries (Xu *et al*., 2022). It will increase the trade gains of Chinese manufacturing industries.

With the refinement of the division of labour in global value chains, vertical specialization (Hummels *et al*., 2001), the VAX ratio (Johnson and Noguera, 2012), the degree of upstreamness (Antràs *et al*., 2012) are proposed to measure the characteristic of production linkage. Among them, the concept of trade value added has become increasingly important. As trade in intermediate goods increases, it is not appropriate to use total trade volume to measure the trade gains of Chinese manufacturing industries. Especially in the bilateral trade relation between China and the United States. As a developed country, the United States has comparative advantages in high-end production links such as R&D, authorization, and design. While as a developing country, China only participates in low-end links such as processing and assembly. Therefore, despite China's large total export volume, a significant portion of the trade value added is generated outside of China.

We quantify the trade gains in China using the trade value added. Several scholars have developed accounting frameworks to analyze the sources of added value in gross exports. Koopman *et al.* (2010) introduce the KPWW method, dividing a country's gross exports into five parts based on different sources of added value. Building upon this, Koopman *et al.* (2014) refine the framework into the KWW method, decomposing aggregate exports into nine parts. However, the KWW method is still based on a national-level analysis. Wang *et al.* (2013) further decomposed the total trade value at the sectoral level within a country, revealing the changing trends of value-added at the industry level. This method is referred to as the WWZ method. Under the WWZ accounting framework, we investigate the impact of US-China trade frictions on the trade gains in the Chinese manufacturing industries.

In addition, we establish a dynamic semi-parametric panel model to quantify the nonlinear effect of US-China trade frictions. Consistent with our theoretical analysis, we observe that the average anti-dumping and anti-subsidy duties imposed by the United States on China have varying effects on the trade gains in the Chinese manufacturing industries, which can result in either an increase, decrease, or no change.

2. Materials and Methods

In this section, we will use a mathematical model to demonstrate the impact of the United States' imposition of tariffs on Chinese export value-added in the context of US-China trade friction.

To simplify the analysis, we divide the world into the United States (U), China (C), and other countries (O). Referring to Wang *et al.* (2013), the input-output table of the three countries (C, U, O) is shown in Table 1.

Table 1. Three Countries N Sectors' Input-Output Table

Input \ Output		Intermediate demand			Final demand			Total output
		C	U	O	C	U	O	
Intermediate input	C	Z^{cc}	Z^{cu}	Z^{co}	Y^{cc}	Y^{cu}	Y^{co}	X^{c}
	U	Z^{uc}	Z^{uu}	Z^{uo}	Z^{uo}	Y^{uu}	Y^{uo}	X^{u}
	O	Z^{oc}	Z^{ou}	Z^{oo}	Y^{oc}	Y^{ou}	Y^{oo}	X^{o}
Value added		VA^{c}	VA^{u}	VA^{o}				
Total input		$(X^{c})'$	$(X^{u})'$	$(X^{o})'$				

Note: The superscripts C, U, and O denote country C, country U, and country O, respectively. VA^{c} *represents the added value of country C, and* X^{c} *represents the output of country C. The superscript " ' " indicates transpose. Assuming there are N departments, Z is an N × N square matrix, and* X, Y, *and* VA *are N ×1, N×1, and 1 × N vectors, respectively.*

First, the horizontal balance relationship in Table 1 is shown in Eq. (1).

$$X = Z + Y \tag{1}$$

We define $A = Z(\hat{X})^{-1}$ is a matrix of input coefficients, AX is a matrix of the intermediate demand. Y is a matrix of the final demand. Given these definitions, output can be computed as:

$$X = AX + Y = (I - A)^{-1}Y = BY \tag{2}$$

In Eq. (2), B is Leontief inverse matrix. The world direct added value coefficient matrix is defined as 1 × 3N matrix $V = [V^{c}, V^{u}, V^{o}]$. And $V^{c} = VA^{c}(X^{c})^{-1}$, V^{u} and V^{o} have the same meaning as V^{c}. The world added value coefficient matrix can be calculated as:

$$VB = [V^{c}\ V^{u}\ V^{o}]\begin{bmatrix} B^{cc} & B^{cu} & B^{co} \\ B^{uc} & B^{uu} & B^{uo} \\ B^{oc} & B^{ou} & B^{oo} \end{bmatrix}$$
$$= [V^{c}B^{cc} + V^{u}B^{uc} + V^{o}B^{oc} \quad V^{c}B^{cu} + V^{u}B^{uu} + V^{o}B^{ou} \quad V^{c}B^{co} + V^{u}B^{uo} + V^{o}B^{oo}] \tag{3}$$

In VB matrix, taking $V^{c}B^{cc} + V^{u}B^{uc} + V^{o}B^{oc}$ as an example, define:

$$D = V^{c}B^{cc} + V^{u}B^{uc} + V^{o}B^{oc} \tag{4}$$

The 1×N vector D represents the combined value-added shares of the domestic and foreign sectors (country U and country O) in the total output of country C, with all elements equal to 1. Let F^{cu} represent the export value from country C to country U , then the export from country C to country U can be computed as:

$$F^{cu} = (V^{c}B^{cc})'\sharp F^{cu} + (V^{u}B^{uc})'\sharp F^{cu} + (V^{o}B^{oc})'\sharp F^{cu} \tag{5}$$

Therefore, F^{cu} can be expressed as:

$$F^{cu} = A^{cu}X^{u} + Y^{cu} \quad (6)$$

Let $Z^{cu} = A^{cu}X^{u}$. Z^{cu} represents the intermediate export from country C to Country U. Y^{cu} represents the final export from country C to country U. Then the total export of country C can be expressed as:

$$E^{c} = E^{cu} + E^{co} = A^{cu}X^{u} + A^{co}X^{o} + Y^{cu} + Y^{co} \quad (7)$$

Then Eq. (2) can be changed to:

$$\begin{bmatrix} X^{c} \\ X^{u} \\ X^{o} \end{bmatrix} = \begin{bmatrix} A^{cc} & 0 & 0 \\ 0 & A^{uu} & 0 \\ 0 & 0 & A^{oo} \end{bmatrix} \begin{bmatrix} X^{c} \\ X^{u} \\ X^{o} \end{bmatrix} + \begin{bmatrix} Y^{cc} + E^{c} \\ Y^{uu} + E^{u} \\ Y^{oo} + E^{o} \end{bmatrix} = \begin{bmatrix} L^{cc}Y^{cc} + L^{cc}E^{c} \\ L^{uu}Y^{uu} + L^{uu}E^{u} \\ L^{oo}Y^{oo} + L^{oo}E^{o} \end{bmatrix} \quad (8)$$

In Eq. (8), the matrix $L^{cc} = (I - A^{cc})^{-1}$ is the Leontief inverse matrix in country C. The intermediate export Z^{cu} can be expressed as:

$$Z^{cu} = A^{cu}X^{u} = A^{cu}L^{uu}Y^{uu} + A^{cu}L^{uu}E^{u} \quad (9)$$

Taking Eq. (5) and Eq. (9) into Eq. (6). The export from country C to country U can be broken down into 16 parts, that is WWZ trade accounting framework. According to the WWZ Trade Accounting Framework, F^{cu} can be represented as:

$$F^{cu} = TVA + VS = DVA + RDV + VS = DVA\_FIN + DVA\_INT + DVA\_INTREX + RDV + VS \quad (10)$$

Where TVA represents export value-added, VS represents vertical specialization, DVA represents domestic value added absorbed abroad, RDV represents Value added first exported but eventually returned home, DVA_FIN represents DVA in final goods exports, DVA_INT represents intermediates exports absorbed by direct importers, DVA_INTREX represents intermediates re-exported to third countries.

Let q^{cu} denote the export quantity from country C to country U. In the scenario where country U imposes tariffs on country C, the change in export value from country C to country U is given by:

$$\Delta F^{cu} = F_{1}^{cu} - F_{0}^{cu} = (p + \Delta \mathrm{p})(q^{cu} + \Delta q^{cu}) - p \cdot q^{cu} = p \cdot \Delta q^{cu} + q^{cu} \cdot \Delta \mathrm{p} + \Delta \mathrm{p} \cdot \Delta q^{cu} \quad (11)$$

Due to the small magnitude of the change in $\Delta \mathrm{p} \cdot \Delta q^{cu}$, it can be neglected. Therefore, Eq. (11) can be rewritten as:

$$\Delta F^{cu} = p \cdot \Delta q^{cu} + q^{cu} \cdot \Delta \mathrm{p} \quad (12)$$

According to Eq. (10), ΔF^{cu} can be represented as:

$$\Delta F^{cu} = \Delta TVA + \Delta VS = \Delta \mathrm{DVA} + \Delta \mathrm{RDV} + \Delta VS \quad (13)$$

By substituting Eq. (12) into Eq. (13), we obtain:

$$\Delta TVA + \Delta VS = p \cdot \Delta q^{cu} + q^{cu} \cdot \Delta \mathrm{p} \quad (14)$$

By rearranging Eq. (14), we can derive the formula for the change in Chinese export value-added (TVA) as follows:

$$\Delta TVA = p \cdot \Delta q^{cu} + q^{cu} \cdot \Delta \mathrm{p} - \Delta VS \quad (15)$$

In Eq. (15), ΔVS can be expressed as:

$$\Delta VS = VS_{1} - VS_{0} \quad (16)$$

Therefore, the percentage change in the share of VS in total exports can be expressed as:

$$\Delta VSS = \frac{VS_{1}}{F_{1}^{cu}} - \frac{VS_{0}}{F_{0}^{cu}} = \frac{VS_{1} - VS_{0} \cdot (F_{1}^{cu}/F_{0}^{cu})}{F_{1}^{cu}} \quad (17)$$

When $F_{1}^{cu} > F_{0}^{cu}, \frac{F_{1}^{cu}}{F_{0}^{cu}} > 1$ and $\Delta F^{cu} > 0$. Assuming that when $\Delta F^{cu} > 0$, $\Delta VS > 0$, it means that the export behavior of country C can continuously enhance its vertical specialization. Therefore, when $\Delta VS > 0$, according to Eq. (17), $\Delta VSS < 0$. Consequently, $\Delta VS = -\Delta VSS$. Therefore, Eq. (15) can be expressed as:

$$\Delta TVA = p \cdot \Delta q^{cu} + q^{cu} \cdot \Delta \mathrm{p} + \Delta VSS \tag{18}$$

When the tariffs imposed by country U on country C are specific tariffs, $\Delta p = t$, and Δq^{cu} is a function of t, i.e., $\Delta q^{cu} = f(t)$, therefore:

$$\Delta TVA = p \cdot f(t) + t \cdot q^{cu} + \Delta VSS \tag{19}$$

In Eq. (19), under the scenario of imposed tariffs, $t > 0$, and assuming the base period export quantity Δq^{cu}, then $t \cdot q^{cu} > 0$. Therefore, the direction of change in ΔTVAdepends on $p \cdot f(t) + t \cdot q^{cu}$.

When Chinese export products lack competitiveness, leading to a decrease in export quantity ($\Delta q^{cu} < 0$), the disruptive effect of tariff imposition exceeds $t \cdot q^{cu}$. In this case, the US-China trade friction damages China's trade benefits in manufacturing, resulting in $\Delta TVA < 0$. However, when the manufacturing and trade structure in China improves, the detrimental impact of trade friction on exports weakens. The disruptive effect caused by imposed tariffs becomes smaller than $t \cdot q^{cu}$, leading to $\Delta TVA > 0$, indicating that trade friction brings about incentive effects. Furthermore, according to the theory of comparative advantage, a country's export quantity is influenced by its factor endowments and labor productivity.

Based on the above analysis, we put forward H0: The impact of US-China trade frictions on the trade gains of Chinese manufacturing industries is a nonlinear effect.

3. Empirical Analysis

3.1. Empirical models and data sources

We employ a dynamic semi-parametric panel model to quantify the nonlinear effect of US-China trade frictions on the trade gains in the Chinese manufacturing industries. This approach is chosen because a simple linear model fails to capture the specific trend changes in the trade gains. Meanwhile, a nonparametric model may encounter dimensionality issues. Therefore, a semiparametric model is deemed appropriate. Additionally, to account for the inertia in the economy, we incorporate a dynamic component into our model.

We use total domestic value-added in gross exports (referred to as TVA) as a proxy variable to measure the trade gains in the Chinese manufacturing industries. The model we have developed is represented by Eq. (20).

$$lnTVA_{it} = f(duty_{it}) + \beta_1 lnTVA_{i,t-1} + \beta_2 lnPRD_{it} + \beta_3 lnSCA_{it} + \beta_4 VSS_{it} + c_i + u_{it} \tag{20}$$

In Eq. (20), the dependent variable is TVA, which represents total domestic value-added in gross exports. For our analysis, we utilize the WIOD2016 dataset, provided by the World Bank. However, the data in its raw form requires decomposition under the WWZ framework. To achieve this, we utilize the specific indicators data from the UIBE GVC Indicators Database.

The core explanatory variable in our analysis is duty, which represents the average anti-dumping and anti-subsidy duties imposed by the United States on China. We utilize this variable as a proxy for US-China trade frictions. The data for tradeduty is sourced from the Temporary Trade Barrier Database (TTBD) provided by the World Bank.

In addition to the main variables, we include several control variables based on traditional international trade theory. These variables are labor productivity (PRD), economies of scale (SCA), and vertical specialization (VSS). We measure PRD as the ratio of industries added value to the industries's average number of employees. The data for PRD is obtained from the social and economic statistical account table in WIOD2016. The ratio of the aggregate assets of industrial enterprises above a certain size threshold to the total number of enterprises within each manufacturing sector represents SCA. The data sources for SCA are the "China Statistical

Yearbook" and the "China Industrial Statistical Yearbook". The ratio of vertical specialization in total exports captures VSS. The data source for VSS is the same as that for TVA.

What's more, we take the logarithms of the three variables TVA, SCA and PRD. The manufacturing industries we select for analysis are shown in Table 2.

Table 2. Industries selected for analysis according to ISIC

Industry code	Industry name
C10-C12	Manufacturing of food, beverage and tobacco products
C13-C15	Textile, clothing and leather goods manufacturing
C16	Manufacture of wood and wood and cork products (other than furniture); Articles made of straw and knitting materials
C17	Manufacturing of paper and paper products
C18	Printing and reproduction of recording media
C19	Manufacturing of coke and refined petroleum products
C20	Chemical industry and chemical product manufacturing
C21	Production of basic drugs and preparations
C22	Manufacturing of rubber and plastic products
C23	Manufacturing other non-metallic mineral products
C24	Base metal manufacturing
C25	Metal products industry, except machinery and equipment
C26	Manufacturing of computer, electronic and optical products
C27	Electrical equipment manufacturing
C28	Machinery and equipment manufacturing
C29	Manufacturing of automobiles, trailers and semi trailers
C30	Other transportation equipment manufacturing
C31_C32	Furniture manufacturing; Other manufacturing industries

3.2. Model estimation process

The explanatory variables in Eq. (20) include the explained variables lagging one period. Therefore, directly using the series method proposed by Baltagi and Li (2002) to estimate the Eq. (20) will lead to biased and inconsistent estimation results. To correct for the bias, we follow Baglan and Yoldas (2014) and use the iterative bootstrap procedure proposed by Everaert and Pozzi (2007) for correction.

First, in order to remove the fixed effects c_i, the Eq. (20) is transformed through first differencing. The differencing process is illustrated in Eq. (21).

$$lnTVA_{it} - lnTVA_{i,t-1} = f(duty_{it}) - f(duty_{i,t-1}) + \beta_1(lnTVA_{i,t-1} - lnTVA_{i,t-2}) + \beta_2(lnPRD_{it} - lnPRD_{i,t-1}) + \beta_3(lnSCA_{it} - lnSCA_{i,t-1}) + \beta_4(VSS_{it} - VSS_{i,t-1}) + (u_{it} - u_{i,t-1}) \quad (21)$$

Let $T = lnTVA_{it} - lnTVA_{i,t-1}$, $F = f(duty_{it}) - f(duty_{i,t-1})$, $U = u_{it} - u_{i,t-1}$, β is the coefficient vector. Then Eq. (21) can be denoted as Eq. (22).

$$T = F + X\beta + U \quad (22)$$

Then we utilize the series method proposed by Baltagi and Li (2002) to estimate Eq. (22). The method requires the establishment of k basis functions, denoted as $p^k(duty) =$

$(p_1(duty), \dots \dots p_k(duty))$. We approximate F by using the function of p^k . Let ${p^k}_{it} = p^k(duty_{it}, duty_{i,t-1})$. Then we derive the P matrix as shown in Eq. (23).

$$P = (p_{11}^k, p_{12}^k, \dots, p_{1T}^k, \dots p_{N1}^k, \dots p_{NT}^k)' \quad (23)$$

Next, we define a projection matrix $M = P(P'P)^{-1}P'$. The M matrix is multiplied on the left side of Eq. (24).

$$MT = MF + MX\beta + MU \quad (24)$$

Let $\tilde{T} = MT$, $\tilde{F} = MF$, $\tilde{X} = MX$, $\tilde{U} = MU$. By subtracting Eq. (24) from Eq. (22), we obtain:

$$T - \tilde{T} = (F - \tilde{F}) + (X - \tilde{X})\beta + (U - \tilde{U}) \quad (25)$$

The estimated value of β is $\hat{\beta}$.

$$\hat{\beta} = \left[(X - \tilde{X})'(X - \tilde{X})\right]^{-1} (X - \tilde{X})'(T - \tilde{T}) \quad (26)$$

The estimate of the function f(duty) is as follows:

$$\hat{f} = p^k(duty)'\hat{\delta} \quad (27)$$

In Eq. (27), $\hat{\delta} = (P'P)^{-1}P'(T - X\hat{\beta})$.

However, due to the presence of the first-order lagged dependent variable in model (20), the estimator of β obtained in Eq. (27) is biased and inconsistent. To address this issue, we employ the iterative bootstrap method proposed by Everaert and Pozzi (2007) to correct for the deviation in the results. The method involves repeatedly sampling the estimation results of the original model to obtain the Q partial estimation sequences of β: $\hat{\beta}_1^*(\beta)$、$\hat{\beta}_2^*(\beta)$……$\hat{\beta}_Q^*(\beta)$. Then, the expectation of $\hat{\beta}$ can be expressed as:

$$E(\hat{\beta}) = \lim_{Q\to\infty} \frac{1}{Q} \sum_{q=1}^{Q} \hat{\beta}_q^*(\beta) \quad (28)$$

According to Eq. (28), when $\bar{\beta}$ satisfies formula (30), then $\bar{\beta}$ can be considered an unbiased estimator of β.

$$\hat{\beta} = \lim_{Q\to\infty} \frac{1}{Q} \sum_{q=1}^{Q} \hat{\beta}_q^*(\bar{\beta}) \quad (29)$$

When using the iterative bootstrap method, we first determine the sample size B for the bootstrap. In each bootstrap sample q (q=1,2···B), we obtain the estimator $\tilde{\beta}_q^b$. Then, we calculate the mean $\tilde{\beta}^b$ of $\tilde{\beta}_q^b$ in each bootstrap sample.

$$\tilde{\beta}^b = \frac{1}{B} \sum_{q=1}^{B} \tilde{\beta}_q^b(\tilde{\beta}) \quad (30)$$

The mean $\tilde{\beta}^b$ of the bootstrap distribution is used to assess whether the estimator $\tilde{\beta}$ of β is an unbiased estimator $\bar{\beta}$ of β. According to Eq. (29), if $\tilde{\beta}$ is an unbiased estimator $\bar{\beta}$ of β, the mean value $\tilde{\beta}^b$ of the bootstrap distribution of $\tilde{\beta}$ must be equal to the original estimator $\hat{\beta}$, resulting in $\omega = \hat{\beta} - \tilde{\beta}^b = 0$. To find the parameter vector $\tilde{\beta}$ that satisfies this condition, we need to iterate the steps mentioned above. Let's suppose the number of iterations is d. At each iteration, we evaluate whether $\tilde{\beta}_{(d)}$ (with$\tilde{\beta}_{(1)} = \hat{\beta}$) satisfies the condition by computing $\omega_{(d)} = \hat{\beta} - \tilde{\beta}_{(d)}^b$.

If $\omega_{(d)}$ is equal to 0 or below an acceptable level, $\tilde{\beta}_{(d)}$ can be considered an unbiased estimator $\bar{\beta}$ of β. However, if $\omega_{(d)}$ is not equal to 0 or exceeds an acceptable level, we need to update $\tilde{\beta}_{(d+1)} = \tilde{\beta}_{(d)} + \omega_{(d)}$ and continue with $d + 1$ iterations until $\omega_{(d)}$ equal to 0 or falls below an acceptable level. This iterative process allows us to fine-tune the estimator $\tilde{\beta}$. With these iterations, we complete the calibration process.

3.3. Model estimation results

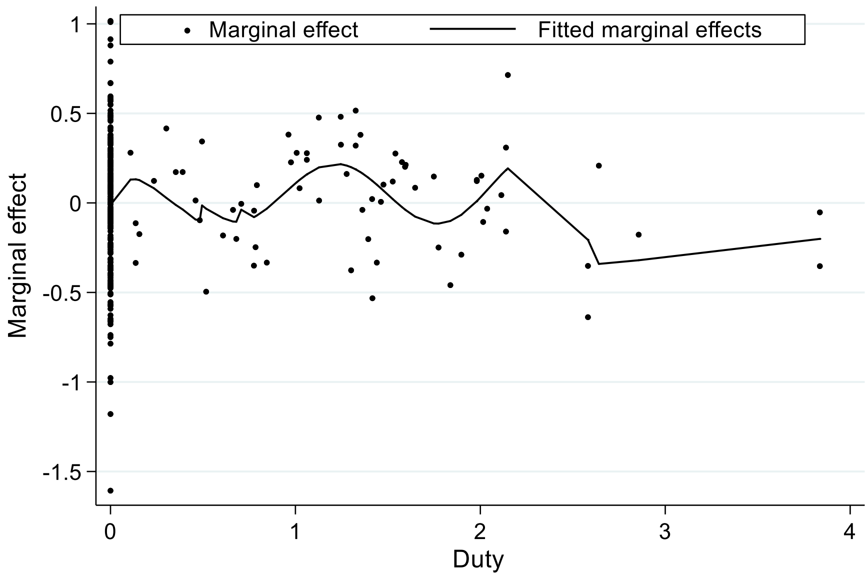
We estimate Eq. (20) using the aforementioned estimation process. The estimated results are presented in Table 3.

Table 3. The estimate results of model (20)

Variable	Estimate results
Ln TVA	0.652 [0.552, 0.752]
Duty	See Figure 1
Ln PRD	0.275 [0.115, 0.434]
Ln SCA	0.063 [-0.072, 0.197]
VSS	4.176 [0.552, 0.752]

Note: Inside [ ] is the 95% confidence interval for the corresponding variable bootstrap process.

Figure 1. Marginal effect of trade frictions on TVA



According to the estimated results of Eq. (20) in Table 3, the coefficient of the first-order lagged dependent variable indicates that a 1% increase in the trade gains of export products in the previous period is associated with a 0.652 percentage point increase in current trade income.

As shown in Figure 1, it is observed that US-China trade frictions exhibit a nonlinear effect on the trade gains of the Chinese manufacturing industries. The null hypothesis (H0) is verified. Specifically, when the average anti-dumping and anti-subsidy duties imposed by the United

States on China fall within the ranges of 0.4-0.9, 1.6-1.9, and greater than 2.4, the fitted marginal curve shows negative values. This suggests that during these periods, the negative impact of US-China trade frictions on the Chinese manufacturing industries surpasses any positive incentives, leading to a decline in the trade gains for the Chinese manufacturing industries. The primary reason for the stronger disruptive effect is that, during these stages, the United States imposes tariffs on Chinese products. This directly reduces the demand for Chinese products among American consumers, thereby hindering the export of Chinese products to the United States. As a result, Chinese products are compelled to shift towards either domestic sales or third-party markets. When Chinese products are redirected towards the domestic market, the increased supply of consumer goods leads to a decrease in domestic market prices. This, in turn, reduces the trade gains for manufacturers. When Chinese products enter third-party consumer markets, Chinese manufacturers encounter trade-related costs associated with accessing these markets. Similarly, these costs erode their trade gains.

However, when the average anti-dumping and anti-subsidy duties imposed by the United States on China fall within the ranges of 0-0.4, 0.9-1.6, and 1.9-2.4, the fitted marginal values are greater than 0. This indicates that during these intervals, the incentive effect of US-China trade frictions on the Chinese manufacturing industries outweighs the disruptive effect, resulting in an increase in the trade gains of the Chinese manufacturing industries. The main reason for this stronger incentive effect is that, in these stages, companies change their production structure through adjustments in technological investments, leading to improvements in trade structure. On one hand, when the United States imposes tariffs on China, the obstruction of Chinese export investment products can positively stimulate domestic investment demand, increasing overall investment (Yan *et al*., 2023). In the context of trade friction, companies adjust their investments in domestic technology when making investments, enhancing their technological capabilities through research and development. On the other hand, companies can also enhance their domestic production lines by importing intermediate technology products (Chen *et al*., 2019). Therefore, Chinese manufacturing production and trade structure undergo improvements, resulting in an increase in their trade gains.

The conclusions of this study align with previous research findings. On one hand, it is consistent with the research conducted by Chandra and Long (2013), Chandra (2017), and Shen *et al.* (2021), which have identified a disruptive effect of the US-China trade frictions on the Chinese economy. On the other hand, it agrees with the findings of Xu *et al.* (2022), which suggest a stimulating effect of the US-China trade frictions on the Chinese economy. It also supports the viewpoint put forth by Chen *et al*., (2019), which suggests a positive impact of trade friction on the economy of a country facing trade sanctions.

However, unlike their research outcomes, this study discovers that the impact of US-China trade frictions on the Chinese economy is not a singular positive or negative effect but rather a complex combination of both disruptive and incentive effects. These two effects play a stronger role in alternating phases, ultimately leading to either positive or negative consequences for the overall trade earnings of the Chinese manufacturing industry. When the disruptive effect is stronger, US-China trade frictions reduce the trade gains of the Chinese manufacturing industries. Conversely, when the incentive effect is stronger, US-China trade frictions increase the trade gains of the Chinese manufacturing industries.

In general, the effect of trade frictions between the US and China on the trade gains in the Chinese manufacturing industries exhibits a non-linear pattern. The trade gains of Chinese manufacturing industries can either increase, decrease or remain constant with average anti-dumping and anti-subsidy duties imposed by the United States on China.

4. The impact of US-China trade frictions on the further decomposition of the gain from trade

In order to further investigate the specific impact of US-China trade frictions on the trade gains of Chinese manufacturing industries, we employ the WWZ accounting framework to decompose TVA. As a result, we obtain several components: domestic value added absorbed abroad (DVA), domestic value added absorbed abroad in final goods exports (DVA_FIN), intermediates exports absorbed by direct importers (DVA_INT), and intermediates re-exported to third countries (DVA_INTREX). In this section, we utilize dynamic semi-parametric panel models to analyze the nonlinear effects of US-China trade frictions on DVA, DVA_FIN, DVA_INT, and DVA_INTREX. These models are represented by Eq. (31) to Eq. (34).

$$lnDVA_{it} = f(duty_{it}) + \beta_1 lnDVA_{i,t-1} + \beta_2 PRD_{it} + \beta_3 lnSCA_{it} + \beta_4 VSS_{it} + c_i + u_{it} \quad (31)$$

$$lnDVA\_FIN_{it} = f(duty_{it}) + \beta_1 lnDVA\_FIN_{i,t-1} + \beta_2 PRD_{it} + \beta_3 lnSCA_{it} + \beta_4 VSS_{it} + c_i + u_{it} \quad (32)$$

$$lnDVA\_INT_{it} = f(duty_{it}) + \beta_1 lnDVA\_INT_{i,t-1} + \beta_2 PRD_{it} + \beta_3 lnSCA_{it} + \beta_4 VSS_{it} + c_i + u_{it} \quad (33)$$

$$lnDVA_{INTREX\,it} = f(duty_{it}) + \beta_1 lnDVA_{INTREX\,i,t-1} + \beta_2 PRD_{it} + \beta_3 lnSCA_{it} + \beta_4 VSS_{it} + c_i + u_{it} \quad (34)$$

The data sources for DVA, DVA_FIN, DVA_INT, and DVA_INTREX are the same as TVA. The estimated results of models (31), (32), (33), and (34) are presented in Table 4.

Table 4. The estimate results of model (31) - (34)

Variable	DVA	DVA_FIN	DVA_INT	DVA_INTREX
L.lnDVA	0.652 [0.552, 0.752]			
L.ln DVA_FIN		0.910 [0.843, 0.978]		
L.ln DVA_INT			0.757 [0.645, 0.870]	
L.ln DVA_INTREX				0.729 [0.633, 0.824]
Duty	See Figure 2	See Figure 3	See Figure 4	See Figure 5
lnPRD	0.274 [0.115, 0.433]	0.228 [0.067, 0.390]	0.207 [-0.006, 0.420]	0.268 [0.041, 0.495]
lnSCA	0.062 [-0.072, 0.196]	0.083 [-0.052, 0.218]	0.018 [-0.211, 0.246]	0.092 [-0.101, 0.284]
VSS	4.170 [2.218, 6.122]	2.568 [1.009, 4.128]	3.300 [0.677, 5.923]	5.947 [3.368, 8.524]

Note: Inside [ ] is the 95% confidence interval for the corresponding variable bootstrap process.

Figure 2. Marginal effect of trade frictions on DVA

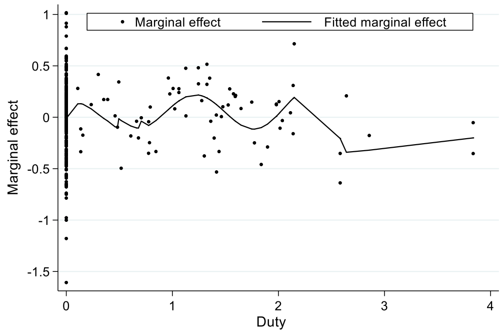


Figure 3. Marginal effect of trade frictions on DVA_FIN

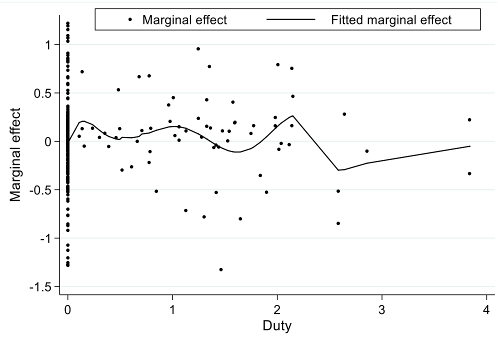


Figure 4. Marginal effect of trade frictions on DVA_INT

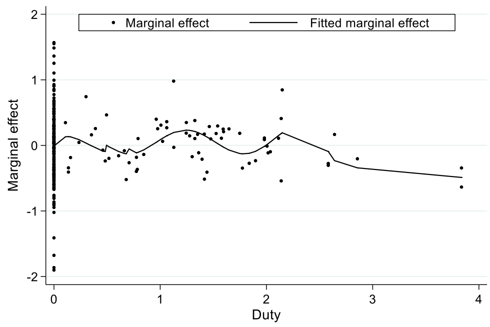
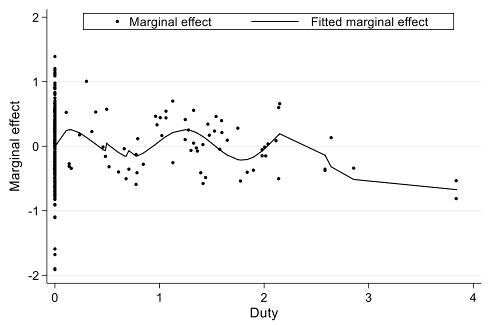


Figure 5. Marginal effect of trade frictions on DVA_INTREX



According to the estimated results of Eq. (31) to Eq. (34) in Table 4, the coefficients of the first-order lagged dependent variables indicate that the variables in the previous period have an impact on the variables in the current period. This finding further confirms the appropriateness of our identification of the four models.

Upon comparing Figure 2 with Figure 1, it can be observed that US-China trade frictions have a similar impact on both DVA and TVA.

According to Figure 3, when the average anti-dumping and anti-subsidy duties are below 1.4 and within the range of 1.8-2.2, the fitted marginal effect curve is positive. It indicates that the incentive effect of US-China trade frictions on DVA_FIN is stronger than the disruptive effect during these stages. However, when the average anti-dumping and anti-subsidy duties fall within the range of 1.4-1.8 and exceed 2.2, the fitted marginal effect curve is negative. It suggests that the disruptive effect of US-China trade frictions outweighs the incentive effect within these ranges.

According to Figure 4, when the mean anti-dumping and anti-subsidy duties are in the intervals of 0-0.4, 0.9-1.6 and 1.9-2.4, the fitted marginal effect curve above 0. Similarly, it demonstrates that at these particular phases, the impact of US-China trade frictions on DVA_INT is primarily driven by the stronger incentive effect rather than the disruptive effect. But when the average levels of anti-dumping and anti-subsidy duties are in the range of 0.4-0.9, 1.6-1.9 and greater than 2.4, the fitted marginal effect curve is below zero. It shows that within these ranges, the disruptive effect exhibits greater strength.

Similarly, according to Figure 5, when the mean anti-dumping and anti-subsidy duties are in the range of 0-0.4, 0.9-1.6, and 2-2.4, the US-China trade frictions exert a more significant incentive effect on DVA_INTREX. In the intervals of 0.4-0.9, 1.6-2 and greater than 2.4, the US-China trade frictions have a more pronounced disruptive effect. When comparing Figure 5 and Figure 6, the effect of US-China trade frictions on DVA_INT and DVA_INTREX shows minimal differences.

Comparing Figure 1 with Figures 3 to 5, with the different average anti-dumping and anti-subsidy duties, the impact of US-China trade frictions on TVA, DVA_FIN, DVA_INT, and DVA_INTREX varies. However, overall, when the average anti-dumping and anti-subsidy duties are below 0.4 or above 2.2, the changing trends in the impact of US-China trade frictions on TVA, DVA_FIN, DVA_INT, and DVA_INTREX are the same. That is, when the average anti-dumping and anti-subsidy duties are below 0.4, the incentive effect becomes more prominent, as evidenced by the positive values of all the fitted marginal curves. When the average anti-dumping and anti-subsidy duties exceed 2.2, all the fitted marginal curves display negative values, signifying a greater dominance of the disruptive effect.

In conclusion, when the average anti-dumping and anti-subsidy tariffs resulting from US-China trade frictions are low, they stimulate the growth of the trade gains in the Chinese manufacturing industries. However, when the mean levels of anti-dumping and anti-subsidy duties are too high (above 2.4 in the sample data of this paper), US-China trade frictions negatively impact the trade gains in the Chinese manufacturing industries. Moreover, the effect of US-China trade frictions on TVA and DVA exhibits a consistent pattern. Similarly, the impact of US-China trade frictions on DVA_INT and DVA_INTREX also displays a high degree of consistency.

Conclusions

This paper shows that the effect of US-China trade frictions on the trade gains in the Chinese manufacturing industries exhibits nonlinearity. From one perspective, the trade costs incurred due to US-China trade frictions directly undermine the trade gains of the Chinese manufacturing industries. From another perspective, trade frictions compel Chinese manufacturing companies to phase out outdated production methods and transform their trade structures. These measures result in long-term improvements, ultimately leading to increased the trade gains in the Chinese manufacturing industries. They can be referred to as the disruptive effect and the incentive effect of trade frictions. We establish a dynamic semi-parametric panel model to measure the nonlinear impact of US-China trade frictions. And using the WWZ trade accounting framework, we assess the trade gains by incorporating trade added value. The main conclusions are as follows:

(1) The trade gains in the Chinese manufacturing industries can either increase, decrease, or remain constant depending on the average anti-dumping and anti-subsidy duties imposed by the United States on China.

(2) In general, when the average anti-dumping and anti-subsidy tariffs arising from US-China trade frictions are at a low level, they foster an increase in the gains derived from trade within the Chinese manufacturing industries. When the average anti-dumping and anti-subsidy duties reach high levels, US-China trade frictions have an adverse effect on the trade gains in the Chinese manufacturing industries.

(3) According to the WWZ trade accounting framework, there is a consistent pattern in the impact of US-China trade frictions on TVA and DVA. Similarly, there is a high degree of consistency in the impact of US-China trade frictions on DVA_INT and DVA_INTREX.

Acknowledgements

This work was supported by Fujian Province Innovation Strategy Research Joint Project (Grant No. 2022R0153).

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