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Hedging Along the Global Value Chain: Trade War and Firm Value

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Abstract

We study the asset pricing implications of firms' participation in the global supply chain. A firm's global sourcing strategy serves as an option to hedge its value against trade shocks. Higher output tariffs increase firm value through reduced import competition, whereas higher input tariffs decrease firm value through higher input costs. The negative effects of input tariffs are more substantial for firms more reliant on foreign suppliers. We test the theoretical predictions in the context of the US-China trade war and quantify the impact of trade protectionism on Chinese firm value. One standard deviation increase of input tariff reduces the daily stock return by 0.12 percent for firms importing inputs, more than offsetting the gains from raising output tariffs by one standard deviation. The negative effect of input tariffs is larger for firms with high import intensity and low import substitutability. The welfare loss of the Chinese retaliatory tariffs was as much as $5.50 billion, 0.81% of the total value added of Chinese listed firms.

Keywords: Trade War, Global Supply Chain, Firm Value
JEL: F13, F14, G12, G14

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1 Introduction

The global supply chain has become a dominant feature of world trade over the past decades, and many firms import inputs from foreign suppliers. How does a firm's position along the global supply chain affect its market value? During trade liberalization, a firm's global sourcing strategy maintains an option to hedge its value against the negative impact of intensified import competition. Lower output tariffs decrease firm value through intensified import competition, whereas lower input tariffs increase firm value because it becomes cheaper to import inputs. With the rise of trade protectionism, however, the positive trade protection effect triggered by higher output tariffs was partly offset by the increase of input tariffs, and the reliance on foreign suppliers becomes a negative asset. Faced with higher input tariffs, importing firms have to spend more on input expenditure. If firms switch suppliers, it is also costly as they need to pay fixed costs to find new suppliers and establish new business relationships. This is especially the case if firms cannot easily find alternative supplies, such as suppliers of semiconductor chips and lithography equipment.

We propose that supplier switch friction leads to an input-induced form of operating leverage, which is an important determinant of the cross-section of equity returns. In this paper, we refer to the input-induced operating leverage as core input leverage. Like financial leverages and other operating leverages such as labor leverage, core input leverage creates a source of risk for firms. However, core input leverage has been relatively unexplored both empirically and theoretically despite the extensive literature on financial leverage and a growing number of works on labor leverage. We fill this gap and provide theoretical support and empirical validation for core input leverage, measured as the cost share of core foreign inputs. To construct this leverage at the firm level, we utilize novel transnational-level Chinese Customs data and link it to the subsidiary-level data of Chinese listed firms. In the empirical analysis, we present new evidence for the economic significance of core input leverage in explaining cross-sectional differences in expected returns.

In this paper, we study the impact of core input leverage on firm value in times of rising trade protectionism. The US-China trade war provides a perfect setting to study this topic. Between 2018 and 2019, the U.S. government implemented a series of protective tariffs, which provoked a cascade of retaliatory tariffs from trade partners. The US-China trade war inspired, among policy-makers, business practitioners, and academics, extensive discussions of the economic consequences of trade protectionism, one of them being the impact on firm values.

To guide the empirical analysis, we build a model to show how a firm's position along the global supply chain affects its stock return in times of rising trade protectionism. We get three testable hypotheses. First, a higher output tariff is value-enhancing due to less intensified import competition. Second, a higher input tariff is value-destructing because of the higher input cost. Third, the negative impact of input tariffs is more severe for firms more reliant on foreign suppliers, namely firms with higher core input leverage.

Guided by the theoretical framework, we estimate the impact of Chinese retaliatory tariffs on the stock returns of Chinese listed firms under an event study setting. We find that the daily abnormal returns fall (rise) by 0.13% (0.08%) for a one-standard-deviation increase in input (output) tariff on average. Overall, the loss from a rise in input tariffs outweighs the gains from raising output tariffs. These results hold robustly when we control the U.S. (export) tariff and exchange rate fluctuations. The findings are not sensitive to different benchmark asset pricing models and ways of constructing tariffs and trade exposures. To further explore the underlying mechanisms, we plan to study the effect of tariff escalation on firm fundamentals, including operation costs, sales, investments, debt structures, and R&D investments. We expect that the rise in input tariff will push up the operating cost and stimulate domestic innovations, while the rise in output tariff will raise operating revenues.

We find that the negative effect of input tariffs is more substantial for firms with higher foreign input share. In the next step, to capture the impact of core input leverage on equity return, we plan to try three ways to measure firms' reliance on foreign suppliers. First, we define core inputs based on the high-tech product list published by China's National Bureau of Statistics because high-tech products are generally more complex and difficult to substitute. Second, for each product we calculate the share of U.S. exports relative to the world total exports. Higher export share indicates that the U.S. product is less substitutable. Third, for each product we calculate the ratio of China's imports from the U.S. to China's imports from the world, which measures China's dependency on the U.S. We expect that firms with higher core input leverage will respond more negatively to input tariff escalations.

Apart from the above treatment effect, we find that trade shocks also indirectly induce co-movements of the stock returns, which we refer to as the macro effect. The negative macro effect reveals that trade war generates policy uncertainty and causes panic in the market, exerting downward pressure on all firms' stock prices regardless of their US import exposure. The macro effect is comparable in magnitude to the above treatment effect. The dynamic effect shows that the treatment effect is short-lived while the macro effect is long-lasting. Combining these two effects, the welfare loss we estimated is $ 45.6 billion, 1.8% of the total market value or 6.7% of the total value added of the listed firms in 2018.

This paper contributes to the literature on the impact of operating leverage on equity returns. We propose a novel source of operating leverage, namely core input leverage, and show that it is an important determinant of the cross-sectional equity returns. Like labor leverage which induces a greater profit to economic conditions sensitivity due to sticky wage (Favilukis and Lin 2016;

Bouvard and De Motta 2021; Donangelo et al. 2019), core input leverage induces high sensitivity of marginal cost to trade protectionism policies for firms reliant on incumbent foreign suppliers. Beyond the scope of trade protectionism, our framework can be applied to other scenarios related to the disruption of supply chain, such as the Covid-19 pandemic and the current energy crisis in Europe.

This paper adds to the burgeoning literature on international trade and stock markets. Breinlich (2014), Moser and Rose (2014), and Greenland et al. (2020) analyze the impact of trade liberalization on stock returns. Recently, there is a growing literature examining the impact of the US-China trade war on US listed firms, where trade exposure is measured as whether the US listed firms sell to or buy from China (Amiti, Kong, et al. 2021; Huang et al. 2022). In this paper, we collect the punitive tariff data and quantifies trade exposure by constructing output tariffs and input tariffs. We focus on exploring firm heterogeneity and investigate the impact of core input leverage. Our work builds on and extends the literature on input tariff and productivity, which find that firms can obtain substantial gains in productivity from trade through access to cheaper and new imported inputs (Amiti and Konings 2007; Goldberg et al. 2010; Halpern et al. 2015).

This paper is also related to the literature on trade protectionism. There have been a growing number of empirical studies on the US-China trade war, including the tariff pass-through (Amiti, Redding, et al. 2019; Amiti, Redding, et al. 2020; Fajgelbaum et al. 2020), trade policy uncertainty (Benguria et al. 2022), determinants of punitive tariff settings (Bown 2021), election and politics (Blanchard et al. 2019; Flaaen and Pierce 2019; Fetzer and Schwarz 2021), employment (Autor et al. 2022), and stock return (Amiti, Kong, et al. 2021; Huang et al. 2022). Most of these papers focus on the US economy, and less is known about what has happened in China. Among the few exceptions (Chor and Li 2021; Ma et al. 2021; Benguria et al. 2022; Feng et al. 2022), none of them is about the stock returns. We contribute to this strand of literature by evaluating the impact of trade protectionism on stock returns of Chinese firms.

The remainder of this paper proceeds as follows. Section 2 establishes model linking tariffs and stock returns. Section 3 introduces the background of China's retaliatory tariffs during the U.S.-China trade war. Section 4 describes the data and event-study methodology. Section 5 presents the main findings and robustness checks. Section 6 concludes.

2 Theoretical Framework

We build up a theoretical framework to connect stock return to input tariff and output tariff and formulate testable implications. Our framework consists of two main components, namely strategic complementarity (Atkeson and Burstein 2008) and the decision of importing intermediate inputs

(Amiti and Konings 2007). Under oligopolistic competition, lower output tariffs reduce firm value through tougher import competition. Lower input tariffs, however, enhance firm value through lower input costs. The two offsetting effects imply that a firm can use its global sourcing decision as an option to hedge its value against the negative impact of lower output tariffs during trade liberalizations. In times of rising trade protectionism, however, the reliance on foreign suppliers weakens the positive effect of trade protection on firm value. In the model, we make several simplifying assumptions to focus the analysis on the relationship between tariffs and returns. We assume all firms are single-product, set each firm's import choice bundle as given, abstract the entry and exit decisions of firms.

2.1 Production and Imported Inputs Decisions

The firm's cost structure and import decision of intermediate inputs are established on the models in Halpern et al. (2015) and Amiti, Itskhoki, et al. (2014). A firm's production function is given as:

$$Y_i = \Omega_i X_i^{\phi} L_i^{1-\phi} \tag{1}$$

where X_i and L_i denote intermediate inputs and labor used in production, and Ω_i is total factor productivity. The share of intermediate inputs in the total expenditure, characterized by the parameter $\phi \in [0, 1]$, is sector specific but the same for all firms in the sector.

Intermediate inputs are composed of a continuum of intermediate products indexed by $j \in [0, 1]$:

$$X_i = exp\left\{\int_0^1 \gamma_j log X_{i,j} dj\right\} \tag{2}$$

where the Cobb-Douglas weight γ_j, which satisfy $\int_0^1 \gamma_j dj = 1$, characterizes the importance of intermediate inputs j for production. Each intermediate product j can be purchased from domestic or foreign suppliers. Different varieties are imperfect substitutes:

$$X_{i,j} = \left[Z_{i,j}^{\frac{\zeta}{1+\zeta}} + \sum_{c=1}^{C} a_{j,c}^{\frac{1}{1+\zeta}} M_{i,j,c}^{\frac{\zeta}{1+\zeta}}\right]^{\frac{1+\zeta}{\zeta}} \tag{3}$$

where $Z_{i,j}$ is the quantity of domestic intermediate inputs j for production, and $M_{i,j,c}$ is the quantity of foreign intermediate inputs j imported from country c. $a_{j,c}$ captures the productivity advantage of the foreign intermediate inputs due to high quality (when $a_{j,c} > 1$). The elasticity of substitution between intermediate products is $(1 + \zeta)$.

Given the output Y_i, firm i minimizes its total cost subject to the constraints in equations (1)-(3)

by choosing inputs:

$$TC\left(Y_i\right) \equiv min\left\{WL_i + \int_0^1 V_j Z_{i,j} d_j + \int_0^1 \left(\sum_{c=1}^{C} \tau_i^I U_{j,c} M_{i,j,c}\right) dj\right\} \tag{4}$$

where W is the wage rate, which measures the cost of labor. The prices of domestic and foreign intermediates are V_j and $U_{j,c}$. τ_i^I is the iceberg cost, measured as tariff rates of intermediate inputs plus 1. τ_i^I is referred as a generic tariff of imported intermediates, which is the import-weighted input tariff faced by firms.

In the equilibrium, a firm's import decision, i.e. the ratio between the cost expenditure on imported intermediate goods and domestic intermediate goods, depends on tariffs and the relative quality of foreign intermediates, and it is higher with lower tariff or higher quality:

$$\frac{M_{i,j,c}}{Z_{i,j}} = a_{j,c}\left(\frac{\tau_i^I U_{j,c}}{V_j}\right)^{-(1+\zeta)} \tag{5}$$

The Lagrange multiplier for constraints (1), (2) and (3) are denoted by λ_i^V, λ_i^M and λ_i^P respectively. And then we can also derive the following cost structures from the first-order conditions of cost minimization:

$$TVC\left(Y_i\right) = \lambda_i^V Y_i \tag{6}$$

$$TMC\left(X_i\right) = \lambda_i^M X_i \tag{7}$$

where TVC and TMC refer to the total variable costs (equivalent to the total cost in our setting without fixed cost) and total material costs. The average variable cost, λ_i^V, and the average material cost, λ_i^M, satisfy the following relationship:

$$\lambda_i^V = \frac{1}{\Omega_i}\left(\frac{W}{1-\phi}\right)^{1-\phi}\left(\frac{\lambda_i^M}{\phi}\right)^{\phi} \tag{8}$$

Specifically, the average material cost is equal to the material cost index for a non-importer C^N divided by the cost-reduction factor B_i:

$$\lambda_i^M = \frac{C^N}{B_i} \tag{9}$$

where $C^N = exp\left\{\int_0^1 \gamma_j log\frac{V_j}{\gamma_j} dj\right\}$ is only related to domestic prices but not to tariffs. And $B_i = exp\left\{\int_0^1 \gamma_j log b_j dj\right\}$ is a combination of the cost-saving effects (b_j) of the foreign intermediate inputs. b_j incorporates two important cost-saving elements induced by the quality channel and the imperfect substitutability of foreign intermediates, which coincides with the quality and variety gains from importing stressed in the previous studies. b_j is higher when $a_{j,c}$ is higher or ζ is lower and correlated with the tariff negatively:

$$b_j = \left[1 + \sum_{c=1}^{C} a_{j,c} \left(\frac{\tau_i^I U_{j,c}}{V_j}\right)^{-\zeta}\right]^{\frac{1}{\zeta}} \tag{10}$$

The fraction of material costs spent on foreign intermediate inputs j from country c is

$$\varphi_{i,j,c} = \frac{\tau_i^I U_{j,c} M_{i,j,c}}{\lambda_i^M X_i} = \gamma_j b_j^{-\zeta} a_{j,c} \left(\frac{\tau_i^I U_{j,c}}{V_j}\right)^{-\zeta} \tag{11}$$

where we denote $\varphi_{i,j,c}$ as the import intensity of the firm i on intermediate inputs j from country c.

The partial elasticity of the marginal material cost to the (input) tariff is:

$$\frac{\partial log \lambda_i^M}{\partial log \tau_i^I} = \int_0^1 \sum_{c=1}^{C} \gamma_j b_j^{-\zeta} a_{j,c} \left(\frac{\tau_i^I U_{j,c}}{V_j}\right)^{-\zeta} dj = \int_0^1 \sum_{c=1}^{C} \varphi_{i,j,c} dj = \varphi_i \tag{12}$$

where φ_i is the import intensity of the firm i, measuring the share of total imported material cost in total material cost. In the empirical analysis, we measure it using the Chinese Customs data. The above equation underlines the role of import intensity in determining a firm's sensitivity to trade shocks. The marginal cost of a firm with higher import intensity increases more given the same unit of tariff increase.

2.2 The Oligopolistic Competition

We assume that firm i produces a differentiated final good in sector s and engages in oligopolistic competition with foreign firm $c = 1, 2, 3...C$ in domestic market. For simplicity, we abstract the export of domestic firms to exclude the interference of export tariffs and we assume that each country has only one representative firm in each sector. The elasticity of substitution across sectors η is less than the elasticity of substitution within sectors ρ (i.g., $1 < \eta < \rho$). And the firm faces a nested CES demand over the varieties of products. Hence, the demand function for the product of firm i in sector s is:

$$Y_{i,s} = \xi_{i,s} P_{i,s}^{-\rho} P_s^{\rho-\eta} D_s \tag{13}$$

where $Y_{i,s}$ is the quantity of product demand, $\xi_{i,s}$ measures the relative preference of consumers, $P_{i,s}$ denotes the price of firm i, P_s is the sectoral price, and D_s is demand shifter for the sector s, which is exogenous for firms.

The sectoral price index can be computed as follows:

$$P_s = \left(\xi_{i,s} P_{i,s}^{1-\rho} + \sum_{c=1}^{C} \xi_{c,s} \left(\tau_i^O P_{c,s} \right)^{1-\rho} \right)^{\frac{1}{1-\rho}} \tag{14}$$

where τ_i^O is the average output tariff in sector s (the sector the firm i belongs to) weighted by imported values at the country level (the superscript O stands for output tariff, hereinafter the same). The generalization of the model to heterogeneous output tariffs across countries (i.e., heterogeneous impacts of tariff shocks on the market share of foreign producers) is straightforward.

2.3 Stock Returns and Tariffs

To link stock returns and tariffs, we introduce a 2-period (date 0 and 1) stochastic general equilibrium model. The economy is made up of a representative household and domestic and foreign firms engaged in oligopolistic competition. The setup of the household side is standard. The household maximizes the expected utility, $U(C_0) + \rho E_0[U(C_1]$, by consumption, where C_0 and C_1 represents consumption at dates 0 and 1 respectively, and ρ represents time preference. The household's stochastic discount factor, $M_1 = \rho U'(C_1)/U'(C_0)$, is taken as given.

On the production side (we omit the sector subscript s), firm i utilizes its initial endowment, Π_0, to purchase labor and intermediates for production. The free cash flow, $D_{i,0} = \Pi_0 - \lambda_{i,0}^V Y_{i,0}$, is distributed back to households as dividends, where $\lambda_{i,0}^V$ is the marginal variable cost as well as the marginal cost because our model does not involve fixed costs. The products are sold at the price $P_{i,1}$ on date 1 (domestic firms sell all their output domestically). The revenue $P_{i,1} Y_{i,0}$ is fully distributed as dividends $D_{i,1}$ because firms do not produce at date 1. The ex-dividend equity price $P_{i,0}^s$ at date 0 is $E_0[M_1(P_{i,1}^s + D_{i,1})]$ while the ex-dividend equity price $P_{i,1}^s$ at date 1 is zero. Firm i chooses the optimal production $Y_{i,0}$ to maximize the present value at date 0:

$$D_{i,0} + P_{i,0}^s = \max_{Y_0} \{ \Pi_{i,0} - \lambda_{i,0}^V Y_{i,0} + E_0[M_1 P_{i,1} Y_{i,0}] \} \tag{15}$$

Taking the first order condition, we obtain:

$$E_0[\frac{M_1 P_{i,1}}{\mu_i}] = \lambda_{i,0}^V \tag{16}$$

where $\mu_i = \frac{\sigma_i}{\sigma_i - 1}$ is the firm's markup over its costs, and $\sigma_i = -\frac{\partial log Y_{i,1}^D}{\partial log P_{i,1}}$ is the demand elasticity for the firm. Product market clearing ensures that product supply and product demand are equal, i.g. $Y_{i,0} = Y_{i,1}^D$. In our setup, the markup or the demand elasticity is assumed to be constant [1]. Note that the stock return is $R_{i,1} = (P_{i,1}^s + D_{i,1})/P_{i,0}^s = P_{i,1}Y_{i,0}/E_0[M_1P_{i,1}Y_{i,0}] = P_{i,1}/E_0[M_1P_{i,1}]$. Hence, we can rewrite the above equation as:

$$\frac{E_0[P_{i,1}]}{E_0[R_{i,1}]} = \mu_i \lambda_{i,0}^V \tag{17}$$

Intuitively, the present value of the expected optimal price (equivalently, the expected marginal revenue) with the stock returns set as the discount rate equals the product between markup and the marginal cost. All else being equal, a rise in marginal cost reduces stock return, while a rise in expected marginal revenue increases stock return.

The firm's marginal cost is only positively correlated with the firm's input tariff ($\frac{\partial log\lambda_{i,0}^V}{\partial log\tau_{i,0}^I} = \phi\varphi_i$) and the expected optimal price is only positively with the output tariff ($\frac{\partial log E_0[P_{i,1}]}{\partial log\tau_{i,1}^O} = 1$)[2] Intuitively, the percentage increase in prices for domestic firms is aligned with the percentage increase in output tariffs to maintain a relatively stable market share for firms. Therefore, the elasticity of the stock return to the import-weighted input tariff is as follows:

$$\frac{\partial log R_{i,1}}{\partial log\tau_{i,0}^I} = -\frac{\partial log\lambda_{i,0}^V}{\partial log\tau_{i,0}^I} = -\phi\varphi_{i,s} < 0 \tag{18}$$

It can be seen that the stock return is negatively related to the firm's input tariff and this relationship works mainly through the positive term $\frac{\partial log\lambda_{i,0}^V}{\partial log\tau_{i,0}^I}$. In other words, all else being equal, a rise in input tariffs pushes up the firm's marginal cost, leading to a return drop. Another noteworthy point is that the absolute value of the elasticity of returns on input tariff is positively correlated with the import intensity of firm i. The greater the import intensity, the more sharply an input tariff shock will cause the firm's marginal costs to rise, resulting in a more pronounced fall in returns. We summarize this analysis in Proposition 1.

Proposition 1: *The elasticity of the stock return to the input tariff is negative and this negative elasticity is more pronounced for stocks with high import intensity.*

[1] This assumption may hold when there are many firms involved in oligopolistic competition because each firm's market share tends to be small at this time and the elasticity of markup to market share is positively correlated with market share.

[2] Since the price elasticity of demand is constant, we can obtain $\frac{\partial S_i}{\partial \tau_{i,1}^O} = 0$, where $S_i = \frac{P_{i,1}Y_{i,0}}{P_{i,1}Y_{i,0}+\sum_{c=1}^{C}(\tau_{i,1}^O P_{c,1})Y_{c,1}} = (\frac{P_{i,1}}{P_1})^{1-\rho}$ is the market share of firm i. Simplifying this equation, we can get $\frac{\partial log E_0[P_{i,1}]}{\partial log\tau_{i,1}^O} = 1$ when the foreign firms' prices are given.

The elasticity of the stock return to the output tariff is strictly positive:

$$\frac{\partial log R_{i,1}}{\partial log \tau^O_{i,1}} = \frac{\partial log E_0[P_{i,1}]}{\partial log \tau^O_{i,1}} = 1 > 0 \tag{19}$$

The rise in output tariff creates competitive protection for domestic firms so that their market shares do not lose even if they raise their prices. And all else being equal, the increase in price enhances the expected marginal revenue (when demand elasticity does not change), leading to higher returns. This discussion gives us another key theoretical prediction:

Proposition 2: *The elasticity of the stock return to the output tariff is positive due to the competition protection.*

In our theoretical framework, we show that the elasticity of the stock return to the input tariff and the output tariff deliver the opposite signs. Two effects offset each other when the tariff covers both inputs and outputs of the firm, making the overall impact of the tariff shock on stock return ambiguous.

3 The US-China Trade War

In 2018, the Trump administration enacted tariff increases on massive U.S. imports from China to seek trade protection. This protection is unprecedented in the post-war era due to the extent of tariff increase and breadth of the variety of products targeted. In response to this, China took tit-for-tat actions by levying several waves of retaliatory tariffs on U.S exports. We compile these retaliatory tariffs from the Ministry of Finance of China and summarize the relevant information in Table 1. We only focus on events during 2018 to avoid the contamination of investors' anticipation effect. Although there are also 2 striking tariff hikes in 2019 (China impose tariffs on $60 billion and $75 billion U.S. exports on 1 June 2019 and 1 September 2019 respectively), by this time more than a year has passed since the start of the trade war. Investors have developed expectations and advanced perceptions of new tariff events, and thus the stock price reactions around these events may be full of noise.

Table 1 identifies the corresponding execution dates for each new tariff event. As can be seen from the table, the value and range of U.S. exports subject to retaliatory tariffs imposed by China have expanded dramatically as the trade war has progressed. In 2018, China placed retaliatory tariffs on $3 billion worth of U.S. goods in April, followed by tariffs on $34 billion of U.S. goods in July, on $16 billion of U.S. goods in August, and on U.S. goods worth $60 billion in September. The number of products subject to retaliatory tariffs also expanded from the initial 128 products to an eventual total of nearly 5,200 products.

Table 1: Timeline for China's Imposition of Retaliatory Tariffs

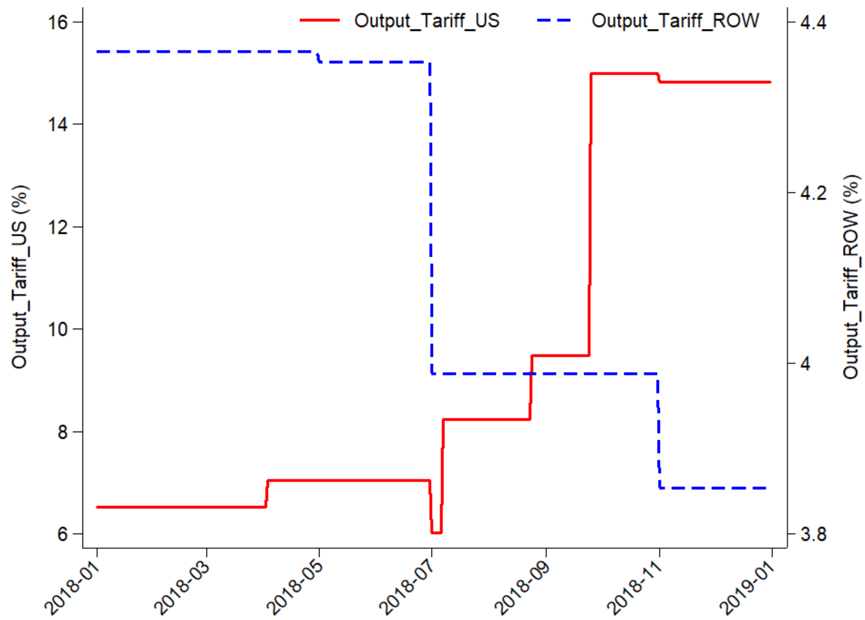
Event date	Description
02Apr18	China imposed retaliatory tariffs of 15% and 25% on imports of 120 items of fruit products and 8 items of pork products originating in the U.S., respectively. The value of target imports was worth $3 billion.
06Jul18	China imposed retaliatory tariffs of 25% on 545 U.S. exports worth $34 billion including agricultural products, automobiles, and aquatic products.
23Aug18	China imposed retaliatory tariffs of 25% on 114 U.S. goods worth $16 billion including chemicals, medical equipment, and energy products.
24Sep18	China imposed retaliatory tariffs on $60 billion worth of U.S. goods, including 10% tariffs on 3571 products and 5% tariffs on 1636 products.

Notes: The table reflects the dates of events when China implemented retaliatory tariffs during the trade war in 2018. And it also provides a brief description of the value and range of U.S. exports subject to retaliatory tariffs imposed by China.

In the course of the trade war, Chinese tariffs on U.S. exports and exports from the rest of the world deliver an opposite pattern, as shown in Figure 1. Import-weighted tariffs on exports from the rest of the world (denoted as $Output\_Tariff\_ROW$) have shown significant reductions from 4.37% at the beginning of 2018 to 3.85% at the end of 2018 as China has cut MFN tariffs on various products including pharmaceuticals, broken rice, information technology products, autos, consumer goods, etc. In contrast, import-weighted tariffs on U.S. exports (denoted as $Output\_Tariff\_US$) rose sharply from 6.53% at the beginning of 2018 to 14.84% at the end of 2018, driven by trade frictions.

Considering that China imposed retaliatory tariffs on a wide range of products, basically covering both inputs and outputs of Chinese firms, we further analyze the changes in average input tariffs and output tariffs of Chinese listed firms. As shown in Figure 2, although tariffs on exports from the rest of the world declined, the overall average output tariff still increased significantly throughout 2018, from 4.53% to 5.00%, due to China's huge imports from the U.S. Likewise, import tariffs also faced a surge from 0.21% to 0.29% throughout 2018.

We explore the average change in input and output tariffs for each stock in each event over a three-day window (the day before, the day of, and the day after the event). Table 2 reports the distribution of the tariff changes. All tariff changes deliver a right-skewed pattern. On average, China's imposition of retaliatory tariffs raised input tariffs and output tariffs of listed firms by 0.03% and 0.31% respectively. Chinese listed firms faced an average 0.17% increase in export tariffs following the imposition of U.S. tariffs on Chinese exports. The abnormal returns based on the Fama-French five factors model over the three-day event window are -0.06% on average

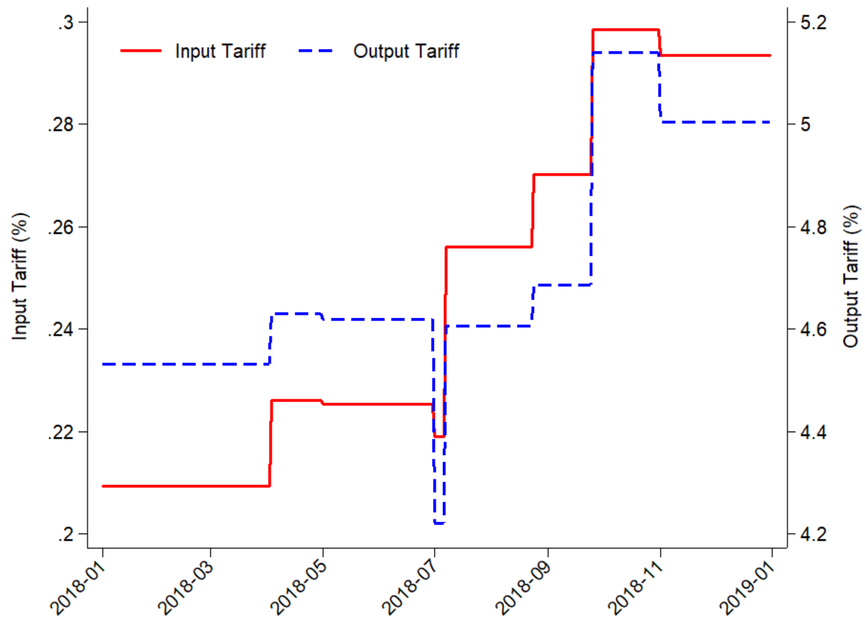


Notes: This figure plots the simple average of import-weighted output tariff on the U.S. exports (the solid red line) and the exports from the rest of the world (the dashed blue line) in 149 I/O sectors throughout 2018.

Figure 1: Average Output Tariff on the U.S. and the Rest of the World

with a standard deviation of 2.02%, indicating that China's levying retaliatory tariffs overall put downward pressure on the stock prices of listed firms.

We are also very concerned about the industry distribution of tariff changes during the trade war. As can be seen in Table 3, the top ten industries in terms of output tariff changes are concentrated in agricultural products and automobiles, with an increase in output tariff caused by levying retaliatory tariffs in the agricultural products industry of 7.18% (= 1.7939%*4) during 2018, and in the automotive industry of 4.74% (= 1.1855%*4). This corresponds to the scope of China's first two waves of retaliatory tariffs in Table 1. The industries that experience significant increases in input tariffs are plastics, automobiles, and processed agricultural products or food. The common feature of these industries is that they may have many upstream industries or their upstream industries are exposed to large retaliatory tariffs. For example, the agricultural product industry, the key target of China's countermeasures in this trade war, has brought about a serious input tariff increase in the downstream processed agricultural products or food industry.



Notes: This figure plots the simple average of the input (the solid red line) and output tariff (the dashed blue line) in 149 I/O sectors throughout 2018. The input tariff for a given sector is a weighted average of the output tariffs of all upstream sectors, weighted by the proportion of imported intermediates purchased by the sector from the upstream sector.

Figure 2: Average Input and Output Tariff

Table 2: Summary Statistics

Variables	P10 (%)	P25 (%)	P50 (%)	P75 (%)	P90 (%)	Mean (%)	Std (%)
Abnormal Returns ($AR_{i,l,t}$)	-2.02	-1.06	-0.17	0.74	1.96	-0.06	2.02
Change of Input tariff ($\Delta\tau^{I}_{i,l}$)	0.00	0.00	0.01	0.04	0.08	0.03	0.04
Change of Output tariff ($\Delta\tau^{O}_{i,l}$)	0.00	0.00	0.00	0.26	0.98	0.31	0.76
Change of Export tariff ($\Delta\tau^{US}_{i,l'}$)	0.00	0.00	0.00	0.08	0.47	0.17	0.48

Notes: This table depicts the quantile, mean, and standard deviation of the abnormal returns and tariff changes for all stocks within a 3-day window (the day before, the day of, and the day after the event) for all events. Abnormal returns, input tariffs, and output tariff changes are calculated based on the event date when China levied retaliatory tariffs on U.S. exports (see Table 1 for details), while export tariffs are computed based on the execution date when the U.S. imposed tariffs on Chinese exports (March 23, 2018, August 24, 2018, and September 24, 2018, respectively). Abnormal returns are calculated based on the Fama-French five-factor model.

Table 3: Top 10 and bottom 10 industries for input and output tariff changes in 2018

Industries	$\Delta\tau(\%)$	Industries	$\Delta\tau(\%)$
Panel A: Output tariff			
Bottom 10		Top 10	
Coal mining and washing products	0.0002	Agricultural products	1.7939
Sugar and sugar products	0.0003	Agricultural service products	1.5727
Woolen textiles and dyeing and finishing products	0.0069	Slaughtered and processed meat products	1.3229
Iron and ferroalloy products	0.0092	Alcohol and wine	1.3110
Oil and gas extraction products	0.0112	Processed products from waste resources recovery	1.3104
Hemp and silk textiles and processed products	0.0137	Complete automobiles	1.1855
Non-ferrous metals and alloys	0.0143	Automotive parts and accessories	0.8508
Processed coal products	0.0149	Other transport equipment	0.8024
Knitting or crochet and products thereof	0.0168	Processed aquatic products	0.7148
Steel	0.0170	Speciality chemical products and explosives products	0.6339
Panel B: Input tariff			
Bottom 10		Top 10	
Coal Mining and washing products	0.0004	Processed products from waste resources recovery	0.2218
Processed coal products	0.0014	Milled grain products	0.1090
Non-metallic mined products	0.0015	Sugar and sugar products	0.0900
Fishery products	0.0016	Processed vegetable oil products	0.0778
Refractory products	0.0018	Processed feedstuffs	0.0719
Cement, lime and gypsum	0.0018	Processed agri-food products	0.0712
Other services	0.0020	Refined teas	0.0711
Ceramic products	0.0020	Complete automobiles	0.0599
Graphite and other non-metallic minerals products	0.0022	Paper and paper products	0.0554
Livestock products	0.0028	Plastic products	0.0551

Notes: This table shows the top ten and bottom ten industries for input and output tariff changes during the trade war in 2018. We calculate the tariff changes within a 3-day window (the day before, the day of, and the day after the event) for each event. Then we select the top and bottom ten industries by ranking industries based on a simple average of the tariff changes for all events. $\Delta\tau$ indicates the average tariff change per event window for the industry.

4 Data, Variable Construction, and Econometric Specification

4.1 Data

Tariff. We manually collect and collate China's retaliatory tariffs imposed on US goods at the HS-8 level from official documents released by the Chinese Ministry of Finance. We obtain monthly MFN tariffs at the HS-8 level based on the annual benchmark tariff schedules issued by the General Administration of Customs of China in January each year, combined with adjustments for tariff exemptions, MFN tariff schedules, and Free Trade Agreement (FTA) preferential rates.–

Trade.–Trade data is sourced from China's Customs Bureau, which provides details of import and export activity in terms of value and quantity by HS 8-digit products and countries. The only recent available data before the trade war is for 2016. We assume that the firm's trade structure was stable until the trade war, thus using trade data from 2016 as a proxy for trade in 2018. To get the trade data of listed firms, we match the firms in the customs database with the listed firms. Specifically, in 2016, there are 437,909 customs firms, 3,148 non-financial listed firms, and 95,246 subsidiaries of non-financial listed firms. We first match the names of customs firms and listed firms and their subsidiaries with the full name. In the remaining unmatched samples, we simplify the firms name by removing "company", "limited", "shares", "group" and " Liability" and use the simplified name to perform fuzzy matching. Finally, 2316 listed companies are matched, accounting for 73.57% of non-financial listed companies. Using the above-matched information, we obtained a total of 734,186 import and export data of listed firms in 2016.

Input-Output table.–We utilize the Input-Output table issued by China's National Bureau of Statics for 2017 to compute the input tariffs for each sector. The tables come in two forms, a competitive Input-Output table (149 sectors) and a non-competitive Input-Output table (41 sectors). The former has a more refined division of sectors while the latter makes a distinction between domestic purchases and imports of intermediate inputs. We combine the information from these two tables to calculate the relevant indicators (discussed below).

Listed firm data.–Our analysis includes listed firms for the Chinese A-share market. Consistent with the extant studies, we perform the following sample screenings: first, we restrict our sample to the non-financial firms whose financial reporting structure differs from that of financial firms; second, we remove the firms with special treatment from the sample because they are financially distressed and have different price limits than normal firms; third, we exclude transaction data within one month of listing to avoid excessive price volatility at the beginning of the listing. We obtain the daily stock returns from the China Stock Market and Accounting Research Database (CSMAR). Annual financial statement data including balance sheet, income statement, and cash flow statement are collected from the Resset database.

Macro variables and economic forecasts.–From the Wind database, we collect time series data on 71 macro variables which encompass main price indexes, consumptions, investments, policy uncertainty, and other macroeconomic variables used to form economic forecasts. Analyst forecasts exist for 16 of these 71 variables. For the remaining variables, we adopt their moving average as the proxy for their forecasts. Specifically, the length of the moving average window for quarterly, monthly, and daily variables are one year, one quarter, and one month, respectively.

4.2 Variable Construction

4.2.1 Industry Tariff

Tariff measures are defined in terms of HS product codes. And the tariff data for 2018 that we utilize are based on 2017 HS codes. We first convert 2017 HS 6-digit-product codes to the 2018 GBT 3-digit-sector codes and then further transform them into I/O 5-digit-sector codes. In our conversion table, there are a total of 97 I/O sectors (tradable sectors) and 5391 HS 6-digit codes.

We first calculate the output tariff of each I/O sector s on the country c on the day t as

$$\tau^O_{s,c,t} = \sum_{p \in s} \frac{X_{p,s,c,2016}}{\sum_{p \in s} X_{p,s,c,2016}} ln(1 + \tau_{p,s,c,t}) \tag{20}$$

where $\tau_{p,s,c,t}$ is the tariff imposed on country c's HS 8-digit product p which belongs to sector s on day t. $X_{p,s,c,2016}$ is China's import of product p from country c in 2016. And the output tariff change for sector s within the event window, $\Delta\tau^O_s$, is an import-weighted average of the tariff change on the output of sector s in the country c.

$$\Delta\tau^O_s = \sum_{c} \frac{X_{s,c,2016}}{\sum_c X_{s,c,2016}} \left(\tau^O_{s,c,t_1} - \tau^O_{s,c,t_0}\right) \tag{21}$$

where $X_{s,c,2016}$ is China's import of sector s's output from country c in 2016, t_0 and t_1 refer to the beginning and end of the event window respectively. We use the change of tariff to eliminate the interference of other potential factors which do not vary over time for each sector.

The calculation of the input tariff proceeds in two steps. First, we calculate the import value of sector s from upstream sector s' and country c as

$$I^X_{s,s',c} = I_{s,s'} \frac{I^X_{S,S'}}{I^X_{S,S'} + I^D_{S,S'}} \frac{X_{s',c}}{\sum_c X_{s',c}} \tag{22}$$

where $s = 1, 2, ..., 149$ and $S = 1, 2, ..., 41$ denotes the sector of the competitive and non-competitive Input-Output table respectively. And s is the sub-sector of S. $I_{s,s'}$ is sub-sector s's intermediate inputs purchase from sub-sector s', $I^X_{S,S'}$ and $I^D_{S,S'}$ are sector S's foreign and domestic intermediate input purchases from sector S', respectively. Second, we compute the imported average change in input tariff in sector s by combining the output tariff change in all 149 upstream sectors within the event window with the corresponding importing share. The resulting value is

$$\Delta\tau^{I,149}_s = \sum_c \sum_{s' \in [1,149]} \frac{I^X_{s,s',c}}{\sum_{s' \in [1,149]} I_{s,s'}} \left(\tau^O_{s,c,t_1} - \tau^O_{s,c,t_0}\right) \tag{23}$$

where $I_{s,s'}$ is the total intermediate input value of sector s purchased from upstream sector s'.

We assign the tariff of the I/O sectors (output and input tariff) to which the firm belongs as the firm's tariff (i.e.,$\Delta\tau^O_i$ and $\Delta\tau^I_i$ equal $\Delta\tau^O_s$ and $\Delta\tau^{I,149}_s$ respectively when firm i belongs to sector s). To this end, we match the Shen Wan Hong Yuan 2014 industry classification standard with the I/O sectors classification standard so that we can determine which I/O sectors each listed firm belongs to.

4.2.2 Import Intensity

Inspired by the model, import intensity is an important firm characteristic that affects the elasticity of stock returns to input tariffs. We measure the firm's import intensity, φ_i, as the share of imported intermediate inputs to total intermediate inputs.

$$\varphi_i = \frac{I^X_i}{I^T_i} = \frac{I^X_i}{OC_i - W_i - DP_i} \tag{24}$$

where I^X_i is the imported intermediate inputs of firm i, which equals the total imported value of firm i calculated based on the trade data of listed firms. I^T_i is the total intermediate inputs of firm i, which is not directly observable. We indirectly measure total intermediate inputs as the firm's operating costs(OC_i) minus total wage bill (W_i) minus depreciation (DP_i).

4.3 Econometric Specification

4.3.1 Event Study

We use the event study method to analyze the impact of tariff shocks on stock returns. Inspired by Amiti, Kong, et al. (2021), we focus not only on the direct impact of events on abnormal stock returns through firm characteristics as analyzed by the traditional event study approach but also on the indirect impact through the movement of pricing factors in the benchmark model. According to the framework in Amiti, Kong, et al. (2021), the stock returns on day t ($r_{i,t}$) are assumed to be additively log divided into macro and treatment effects:

$$r_{i,t} = r^M(\delta(\Phi_t, \tau_t), \beta_i) + r^T(Z_i, \tau_t) + \nu_{i,t} \tag{25}$$

where the superscripts M and T refer to macro effects and treatment effects respectively. $\delta(\Phi_t, \tau_t)$ is a set of pricing factors (policy uncertainty, market returns, etc.) that may be impacted by event shocks (tariff shocks in our setting, τ_t) on day t and a set of macro variables unrelated to the event shocks (ϕ_t); β_i is a vector of factor loadings on these pricing factors, which measures how to matter the pricing factors influence firms; Z_i is a vector of firm characteristics that are closely related to the events. Differences in these firm characteristics may lead to heterogeneous responses of stock returns to the event. And $\nu_{i,t}$ is a mean-zero error term that captures firm's idiosyncratic shocks. Hence, impacts of events on stock returns within the event window can originate from two components: one is that stock returns are directly influenced by firm characteristics related to the events(Z_i), which is the so-called event's treatment effect ($E[r_i^T|\tau_t]$), and the other is that event-induced changes in pricing factors (δ) lead to indirect stock price reactions, namely, event's macro effect ($E[r_i^M|\tau_t]$).

To empirically measure the treatment and macro effect of the event, we focus on the following formal framework:

$$r_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{k,i}\delta_{k,t} + \epsilon_{i,t} \tag{26}$$

$$\epsilon_{i,t} = \sum_{l}\sum_{n} \gamma_{n,l} Z_{i,n,l} D_{l,t} + \sum_{l} \theta_l D_{l,t} + \varepsilon_{i,t} \tag{27}$$

$$\nu_{i,t} = \sum_{l} \theta_l D_{l,t} + \varepsilon_{i,t} \tag{28}$$

where $\alpha_i + \sum_{k=1}^{K} \beta_{k,i}\delta_{k,t}$ describes the movements in stock returns due to pricing factors ($r^M(\delta(\Phi_t, \tau_t), \beta_i)$). And $\sum_{k=1}^{K} \beta_{k,i}\delta_{k,t}$ nests many common models in the asset pricing literature, such as the capital asset pricing model (CAPM), the Fama-French five-factor model (FF5) and q-factor model. $\epsilon_{i,t}$

is stocks' adjusted returns by the benchmark factor model, also known as the abnormal returns in the event studies. $D_{l,t}$ is a dummy variable that equal 1 when day t is included in the event window of event l, and 0 otherwise. $\sum_l \theta_l D_{l,t}$ is an event fixed effect that controls the other shocks experienced jointly by all firms during the event window. $\sum_l \sum_n \gamma_{n,l} Z_{i,n,l} D_{l,t}$ captures the stock price reactions owing to firm characteristics that is closely related to events $(r^T (Z_i, \tau_t))$.

To measure the event's macro effect, we should isolate the impact of the events that we are interested in. Specifically, we assume that changes in pricing factors $(\delta (\Phi_t, \tau_t))$ can be separable into changes owing to economic surprise variables unrelated to the events $(ES_{e,t})$ and changes caused by the events $(\delta_k (\tau_t))$:

$$\delta_{k,t} = \alpha_k^{'} + \sum_{e=1}^{E} \phi_{e,k} ES_{e,t} + \delta_k (\tau_t) \tag{29}$$

where $\alpha_k^{'}$ and $\phi_{e,k}$ are parameters to be estimated. We conduct time-series regression of pricing factors $\delta_{k,t}$ on the economic surprise variables and identify $\delta_k (\tau_t)$ as the error term. Then the expected cumulative macro effect caused by a set of l events τ (where we drop the subscript t when calculating the cumulative effect of all events) is:

$$E[r_i^M | \tau] = \sum_k \sum_l \sum_t \beta_{k,i} \delta_k (\tau_t) D_{l,t} \tag{30}$$

For the treatment effect, we first obtain the key parameter $\gamma_{n,l}$ from the regression model of Equation (27), and then we can compute the expected cumulative treatment effect as:

$$E[r_i^T | \tau] = \sum_t \sum_l \sum_{n=1}^{N} \gamma_{n,l} Z_{i,n,l} D_{l,t} \tag{31}$$

Hence, we obtain the expected impact of the events on stock returns:

$$E[r_i | \tau] = E[r_i^M | \tau] + E[r_i^T | \tau] \tag{32}$$

4.3.2 Macro Effect

The key parameters in computing macro effect is $\delta_k (\tau_t)$ and $\beta_{k,i}$. According to the regression specification shown in Equation (29), we conduct time-series regressions in the whole sample of each pricing factor on 71 economic surprise variables to derive the residual. The reason why we use such many economic surprise variables is to eliminate the noise of residuals as much as possible and to ensure that the residuals contain only information about the tariff shocks. Our benchmark model for macro factors is the Fama-French five-factor model. That is, $\delta_{k,t}$ (k=1,2,...,5) is MKT_t, SMB_t, HML_t, RMW_t, CMA_t respectively (see the construction details in Fama and French (2015)).

The factor loadings, $\beta_{k,i}$, are obtained from the daily time-series regression coefficients of individual stock returns on the pricing factors during the estimation window. We set the estimation window to be the past 750 trading days of the first event in the event set, and the regression coefficients are adopted as factor loadings for each event window. Three main benefits of this set-up are: first, the three-year estimation window is long enough to ensure that the factor loadings estimates are stable; second, the same estimates across events allow the macro or treatment effects calculated for different events windows to be comparable; third, focusing on the first event can avoid to a greater extent the endogenous effect of previous events on the factor loadings estimates. After deriving the key parameters, we compute the macro effect of tariff shocks on stock returns based on Equation (30).

4.3.3 Treatment Effect

Motivated by our theoretical framework, we adopt input tariff and output tariff as the firm characteristics ($Z_{i,n,l}$) in the context of a trade war where China's retaliatory tariff against the US is the shock we are concerned about. Under this circumstance, we make a more detailed regression setting for the Equation (27):

$$AR_{i,l,t} = \sum_l \gamma_{1,l}\Delta\tau_{i,l}^I D_{l,t} + \sum_l \gamma_{2,l}\Delta\tau_{i,l}^O D_{l,t} + \sum_l \theta_l D_{l,t} + \varepsilon_{i,l,t} \tag{33}$$

where $AR_{i,l,t}$ is firm i's tth day abnormal return for event l, where t ranges from t_0 to t_1 (t_0 and t_1 refer to the beginning and ending of the event window, e.g. t_0 and t_1 equal -1 and 1 respectively in the three-day window). The abnormal returns are calculated as the difference between the realized returns and normal returns, the sum of products between macro factors during the event window, and corresponding factor loadings obtained from the estimation window. $\Delta\tau_{i,l}^I$ and $\Delta\tau_{i,l}^O$ are the change in input tariff and output tariff of firm i for event l, and the construction details can be seen in Section 4.2.1. Hence, the treatment effect of input tariff shocks and output tariff shocks on stock returns are:

$$E[r_i^{T,I}|\tau] = \sum_t \sum_l \gamma_{1,l}\Delta\tau_{i,l}^I D_{l,t} \tag{34}$$

$$E[r_i^{T,O}|\tau] = \sum_t \sum_l \gamma_{2,l}\Delta\tau_{i,l}^O D_{l,t} \tag{35}$$

The regression specification in Equation (33) is aimed to analyze the treatment effect of each event

($\gamma_{n,l}$) when the effects of other events in the event set are controlled. To explore the average treatment effect of these multiple events, we pool all tariff changes across event windows and then conduct the regression of abnormal returns on tariff changes and event-fixed effects as follows:

$$AR_{i,l,t} = \gamma_1 \Delta\tau_{i,l}^I + \gamma_2 \Delta\tau_{i,l}^O + \sum_l \theta_l D_{l,t} + \varepsilon_{i,l,t} \tag{36}$$

where γ_1 and γ_2 measure the average treatment effect of input tariff and output tariff respectively.

4.3.4 Heterogeneous Responses

According to our theoretical framework, the absolute value of the elasticity of stock returns to input tariffs is positively correlated with the firm's import intensity. To test this conjecture empirically, we adopt the following estimation specification:

$$AR_{i,l,t} = \gamma_1 \Delta\tau_{i,l}^I + \gamma_2 \Delta\tau_{i,l}^O + \gamma_3 \varphi_i + \gamma_4 \varphi_i * \Delta\tau_{i,l}^I + \sum_l \theta_l D_{l,t} + \varepsilon_{i,l,t} \tag{37}$$

where φ_i is the import intensity of firm i, the share of imported intermediate inputs in total intermediate inputs. The coefficient on the interaction term, γ_4, captures the heterogeneous effects of input tariff shocks on stock returns for firms with different import intensities. We expect γ_4 to be significantly negative, meaning that firms with high import intensity suffer higher production costs and more severe profit declines for the same input tariff shock.

5 Empirical Findings

In this section, we first examine the short-run effect of tariff shocks on stock returns in terms of treatment effect and macro effect within a three-day window. Then we check how persistent the stock price movement triggered by the tariff shocks is in a dynamic analysis where the event window extends to 120 trading days after the event date. At last, we estimate the effect of these trade events on welfare.

5.1 Short-run Effects

All analyses in this section are established on a three-day event window, [-1,1]. For the event window [-a,b], the nearest trading day to the event day that is not earlier than the event day is set to 0 and the start date of the window is the ath trading day before the event day and the end date is the bth trading day after the event day.

5.1.1 Tariffs and Abnormal Returns

We identify the treatment effect by regressing firms' trade exposure, input and output tariff changes, on the stocks' abnormal returns. The abnormal returns are the difference between realized returns and normal returns in the event window. We conduct the time-series regression of individual stock returns on the Fama-French five factors to obtain the factor loadings in the estimation window, which is set to be the past 750 trading days of the first event in the event set. And the normal returns are the intercept plus the product between estimated factor loadings and the pricing factors in the event window.

The regression coefficients on tariff changes are reported in Table 4. The first column shows the average effect of tariff changes on abnormal returns across all the trade events according to the regression specification of Equation 36. And columns 2-5 are estimated jointly based on Equation 33 to explore the individual impact of each event. The coefficients in the first column corresponding to the $\hat{\lambda}_n$ in Equation 36 and the coefficients in columns 2-5 correspond to the $\hat{\lambda}_{n,l}$ in Equation 33, respectively. These regression coefficients can be interpreted as the degree of change in abnormal stock returns caused by a unit change in firms' trade exposures within the event window. For instance, the coefficient of -2.94 in column 3 indicates that a one-standard-deviation increase in input tariff reduces daily abnormal returns by 0.12% when controlling for output tariff during the event window around July 6, 2018. Similarly, the coefficient on the output tariff change of 0.06 in this column implies that a one-standard-deviation increase in output tariff boosts daily abnormal returns by 0.05% when controlling for input tariff. In the first column, the coefficient on input (output) tariff changes is -3.17 (0.11), revealing that the daily abnormal returns fall (rise) by 0.13% (0.08%) for a one-standard-deviation increase in input (output) tariff on average. Overall, in the case of unit standard deviation increases, the negative effect of input tariffs on returns outweighs the positive effect of output tariffs on returns.

Table 4 shows that input (output) tariffs always have a negative (positive) effect on abnormal returns within each event window with the vast majority of these coefficients significant at the 95% confidence level. And the average impact of input (output) tariffs on abnormal returns across all events is even significant at the 99% confidence level. These results are quite consistent with our theoretical predictions: All else being equal, increases in input tariffs push up the firm's marginal cost and thus lead to a fall in stock returns while increases in output tariffs enhance the expected optimal output price (marginal revenue), leading to a rise in stock returns.

Table 4: The Impact of Tariffs on Stock Returns

	(1)	(2)	(3)	(4)	(5)
	Average	**Sub-events**			
		02Apr18	06Jul18	23Aug18	24Sep18
$\Delta\tau_{i,l}^{I}$	-3.17***	-3.99***	-2.94***	-2.77	-8.66***
	(-6.18)	(-2.98)	(-4.37)	(-1.41)	(-6.03)
$\Delta\tau_{i,l}^{O}$	0.11***	0.13	0.06**	0.35***	0.19***
	(4.02)	(0.89)	(2.06)	(2.60)	(2.88)
Observations	16,959	16,959			

Notes: The table shows the short-term impact of tariffs on stock returns in terms of the average impact of the entire event set ("Average") and the individual impact of each event ("Sub_events"). These estimated coefficients are obtained from Equation 36, and 33 respectively. The dependent variables are the stock's abnormal returns based on the Fama-French five-factor model within a three-day window around each event date ([-1,1]). The independent variables involve the change of input tariffs ($\Delta\tau_{i,l}^{I}$) and output tariffs ($\Delta\tau_{i,l}^{O}$) within a four-day window around each event date ([-2,1]). Event-fixed effects are not reported. T statistics are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.1.2 Confounding Factors

Although we control for event-fixed effects in the previous analysis, the estimated coefficients may still be contaminated by other potential shocks within the event window. More rigorously, we take changes in U.S. tariffs and the exchange rates within the event window into account and analyze whether our baseline results hold after controlling for these potential shocks.

U.S. tariffs. In our baseline settings, we only concentrate on the impact of China's retaliatory tariffs on the returns of Chinese firms, neglecting to explore the impact of tariffs imposed by the U.S. The tariffs levied by the U.S., which served as export tariffs for Chinese firms, should be expected to have an impact on the export revenue and foreign market share of Chinese firms. Therefore, this part examines whether our findings still hold when controlling for the tariffs placed by the U.S.

We obtain data on the tariffs imposed by the U.S. during the trade war from Amiti, Redding, et al. (2019) and compute export-weighted tariffs for 149 I/O sectors. Similarly, we assign the export tariffs of the I/O sectors to which the firm belongs as the firm's export tariff. The execution date when the U.S. imposed tariffs on Chinese exports in 2018 involved March 23, 2018, August 24, 2018, and September 24, 2018, respectively. And we calculate the export tariff changes ($\Delta\tau_{i,l'}^{US}$) for each stock over a four-day window around these event dates ([-2,1]). We regress the abnormal returns on the firm's input, output, and export tariff changes and event-fixed effects based on a regression specification similar to Equation 36. Note that the execution dates of the imposition of tariffs by the U.S. and China are different. The event dates when China levies tariffs are the main subject of our study. Specifically, if the day t within the event window for Chinese retaliatory tariffs also falls within the event window when the U.S. imposes tariffs then we need to control for export tariff changes in the corresponding U.S. event window, otherwise, the export tariff changes are treated as 0. The short-term impacts of tariffs on abnormal returns are shown in the first column in Table 5.

In Table 5, the short-term impact of input (output) tariff changes on abnormal returns is significantly negative (positive) when export tariff changes are controlled. The coefficient on input and output tariff changes are -3.17 and 0.11 respectively, both of which are significant at the 99% confidence level. The result that export tariffs have no significant effect on abnormal returns even in the short run (coefficient is 0.01 with a t value of 0.15) is not surprising, as the abnormal returns based on the China events are too far apart in time from the changes in export tariffs based on the U.S. events.

Firm-level Exchange Rates. The fluctuations in the exchange rate play an important role in international trade, both in terms of the costs of import and export prices. In this part, we attempt to offer evidence confirming our baseline results by controlling the firm-level exchange rate.

We collect daily exchange rate data from the Wind database for 203 countries or regions (there are 233 countries or regions in the Customs database) in 2018 and convert them into an indirect quotation method based on the RMB (i.e. a larger exchange rate indicates an appreciation of the RMB and a depreciation of the foreign currency). We calculate the firm's exchange rates weighted by the value of exports and imports for each country, respectively, as e_i^{EX} and e_i^{IM}. $\Delta e_{i,l}^{IM}$ and $\Delta e_{i,l}^{EX}$ are the change in import- and export-weighted exchange rate for firm i during the three-day event window [-1,1] around the event l. The coefficients of the regression of abnormal returns on tariffs and exchange rate changes and event-fixed effects are shown in the last three columns in Table 5.

Columns 2 and 3 report the results of controlling for import- and export-weighted exchange rates respectively and these two exchange rates are both considered in column 4. Our baseline results still hold when exchange rates are considered. For example, in column 4, the firm with lower (higher) input (output) tariff change experiences larger gains in stock returns. The corresponding t value is -4.98 (2.84), significant at the 99% confident level.

Table 5: The Impact of Tariffs on Stock Returns When Controlling for Other Shocks

	(1)	(2)	(3)	(4)
$\Delta\tau^{I}_{i,l}$	-3.17***	-3.15***	-3.27***	-3.19***
	(-6.18)	(-5.34)	(-5.48)	(-4.98)
$\Delta\tau^{O}_{i,l}$	0.11***	0.11***	0.11***	0.10***
	(3.99)	(3.60)	(3.25)	(2.84)
$\Delta\tau^{US}_{i,l'}$	0.01			
	(0.15)			
$\Delta e^{IM}_{i,l}$		-0.09**		-0.11***
		(-2.33)		(-2.63)
$\Delta e^{EX}_{i,l}$			-0.05	-0.03
			(-1.12)	(-0.69)
Observations	16,959	12,843	13,167	11,721

Notes: This table reports the impact of China's retaliatory tariffs on the abnormal returns when other shocks during the event window are controlled. In the first column, we control for tariffs imposed by the U.S., which served as export tariffs for Chinese firms. We calculate the export tariff changes ($\Delta\tau^{US}_{i,l'}$) for each stock over a four-day window around the event dates ([-2,1]). And the execution date when the U.S. imposed tariffs on Chinese exports in 2018 involved March 23, 2018, August 24, 2018, and September 24, 2018. We control the exchange rates in the last three columns. Daily exchange rate data is collected from the Wind database for 203 countries or regions in 2018 and is converted into an indirect quotation method based on the RMB (i.e. a larger exchange rate indicates an appreciation of the RMB and a depreciation of the foreign currency). We calculate the firm's exchange rates weighted by the value of exports and imports for each country, respectively, as e^{EX}_{i} and e^{IM}_{i}. $\Delta e^{IM}_{i,l}$ and $\Delta e^{EX}_{i,l}$ are the change in import- and export-weighted exchange rate for firm i during the three-day event window [-1,1] around the event l. We regress the abnormal returns on the firm's input, output tariff changes, control variables, and event-fixed effects based on a regression specification similar to Equation 36. The event-fixed effects are not reported. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.1.3 Heterogeneous Responses

In this subsection, we seek to explore the firms' heterogeneous returns response to tariff changes. That is, we are concerned about whether the firms' losses in the trade war vary from the firms' characteristics. We consider two important characteristics in international trade: import intensity and import substitutability.

Import Intensity. According to our theoretical prediction that firms with different import intensities exhibit heterogeneous stock price responses to the same input tariff shock, we implement the regression specification in Equation 37 by including import intensity interaction with input tariff changes.

According to Section 4.2.2, we measure import intensity as the ratio of imported intermediates to total intermediate inputs, which equals operating costs minus total wage bill minus depreciation. We adopt wage bill payable or wage bill paid to be the proxies for the total wage bill. The former can be computed as the change in the "Employee Compensation Payable" item in the 2016 balance sheet plus the "Cash Paid to and on Behalf of Employees" item in the 2016 statement of cash flows (denoted as "BS_CF") while the latter can be measured as the "Cash Paid to and on Behalf of Employees" item in the 2016 statement of cash flows (denoted as "CF"). The regression coefficients, corresponding to the $\hat{\lambda}_n$ in Equation 37, are reported in the first two columns in Table 6.

Our focus is the coefficient of the interaction. These two columns in Table 6 deliver a similar pattern: the coefficients on the input tariff changes and interaction are both significantly negative. For example, the coefficient on the input tariff changes is -2.94 while the coefficient of the interaction is -6.76 in column 1, both of which are significant at the 99% confident level. These results imply that the negative impact of input tariff changes on abnormal returns is more pronounced in firms with high import intensity, supporting the theoretical prediction. When faced with the same input tariff changes, firms with high import intensity will suffer a greater increase in marginal costs and thus face a sharper decline in abnormal returns than firms with low import intensity.

Import Substitutability. The range of U.S. exports subject to retaliatory tariffs imposed by China expanded dramatically and covered most industries as the trade war progressed. According to Ossa (2015), in certain industries, international productivity differences are so great that substituting efficiently produced imports with inefficiently produced domestic products may incur extreme costs, leading to very low import substitutability in these industries. We expect firms in industries with low import substitutability to suffer higher production costs due to the inability to flexibly convert imports into domestic substitutes when input tariffs rise.

Considering that China's high-tech industries are significantly more dependent on imported intermediate goods from the U.S., such as chips and semiconductors, than other industries are on

Table 6: The Heterogeneous Effect of Tariff Changes on Abnormal Returns

	(1)	(2)	(3)
	BS_CF	CF	Tech
$\Delta\tau^{I}_{i,l}$	-2.94***	-2.88***	-2.68***
	(-4.85)	(-4.74)	(-4.70)
$\Delta\tau^{O}_{i,l}$	0.11***	0.11***	0.08***
	(3.50)	(3.48)	(2.86)
φ_i	0.00***	0.01***	
	(3.76)	(3.36)	
$\Delta\tau^{I}_{i,l} * \varphi_i$	-6.76***	-9.81***	
	(-2.76)	(-2.61)	
D_{Tech}			0.00**
			(2.21)
$\Delta\tau^{I}_{i,l} * D_{Tech}$			-3.65***
			(-2.66)
$\Delta\tau^{O}_{i,l} * D_{Tech}$			0.18**
			(2.36)
Observations	12,576	12,576	16,959

Notes: This table reports the heterogeneous impacts of tariff changes on abnormal returns. The results in the first two columns show the heterogeneous impact of input tariff changes on abnormal returns for firms with different import intensities. These regression coefficients are estimated according to Equation 37. The third column presents the heterogeneous impacts of tariff changes between high-tech and other industries. Whether or not each stock is in the high-tech industry is identified based on the high-tech industry codes issued by the National Bureau of Statistics. The dummy variables, D_{tech}, equal 1 when the stock belongs to the high-tech industry, and 0 otherwise. We regress abnormal returns on the tariff changes, import intensities (or dummy variable), the interaction terms between tariff change and import intensities (or dummy variable), and the event-fixed effects. The event-fixed effects are not reported. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

imported intermediate goods from the U.S., such as agricultural products, we use a dummy variable (D_{tech}), which equal 1 when the stock belongs to the high-tech industry, and 0 otherwise, to proxy for the import substitutability. The larger the dummy variable, the lower the import substitutability. We identify listed firms in the high-tech industry by matching the high-tech industry codes issued by the National Bureau of Statistics with the stock industry codes. We analyze the heterogeneous impact of tariff changes on stock returns between high-tech and non-high-tech industries by including the interaction terms between tariff changes and D_{Tech} ($\Delta\tau_{i,l}^{I} * D_{Tech}$ and $\Delta\tau_{i,l}^{O} * D_{Tech}$) in Equation 33. The regression coefficients are reported in the third column in Table 6.

As shown in Table 6, the impacts of input tariffs are more pronounced in the high-tech industry than in other industries. The regression coefficient on the interaction term between the input tariff and the dummy variable is -3.65, statistically significant at the confidence level of 99%, indicating that high-tech industries will experience a more negative impact of input tariffs on abnormal returns than non-high-tech industries for the same tariff shocks. This finding confirms our conjecture that firms in the high-tech industry suffer more due to the low substitutability of their imported products. This may, to some extent, stimulate China's domestic innovation to break away from dependence on U.S. exports.

5.1.4 Robustness Checks

In this subsection, we conduct a battery of tests to check the robustness of our baseline results. We examine whether the relationships between tariff changes and abnormal returns still hold when we adopt alternative asset pricing models, alternative tariff constructions, alternative event sets, and alternative estimation methods.

Alternative Asset Pricing Models. In the previous analysis, the abnormal returns are calculated based on the Fama and French five-factor model. In fact, the choice of the optimal pricing model has always been controversial in studies relevant to asset pricing. It is not the objective of this paper to determine the optimal benchmark model, and therefore this part directly adopts several popular pricing models to calculate abnormal returns to ensure the robustness of our findings.

We adopt the four benchmark pricing models: CAPM, Q4 (consisting of the market, size, profitability, and investment factors, which are constructed according to Hou et al. (2015)), CH4 (consisting of the market, size, value, and abnormal turnover rates factors, which are constructed according to Liu et al. (2019)), and PCF4 (A model formed by principal component analysis of 71 macro variables used to calculate economic surprise variables and extracting the first four principal components). The procedure for calculating abnormal returns remains the same as in the previous

Table 7: The Impact of Tariffs on Stock Returns: Alternative Asset Pricing Models

	(1)	(2)	(3)	(4)
	Q4	CAPM	CH4	PCF4
$\Delta\tau^{I}_{i,l}$	-1.69***	-1.99***	-1.84***	-2.38***
	(-3.35)	(-3.89)	(-3.63)	(-3.98)
$\Delta\tau^{O}_{i,l}$	0.07***	0.07***	0.05**	0.07**
	(2.64)	(2.69)	(1.98)	(2.17)
Observations	16,959	16,959	16,959	16,959

Notes: This table reports the average impacts of abnormal returns on tariff changes when the baseline model is switched. We adopt the four alternative benchmark pricing models: CAPM, Q4 (consisting of the market, size, profitability, and investment factors, which are constructed according to Hou et al. (2015)), CH4 (consisting of the market, size, value, and abnormal turnover rates factors, which are constructed according to Liu et al. (2019)), and PCF4 (A model formed by principal component analysis of 71 macro variables used to calculate economic surprise variables and extracting the first four principal components). We regress the abnormal returns on the tariff changes for the short-term ([-1,1]) event windows based on Equation 36. The event-fixed effects are not reported. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

analysis. Based on Equation 36, we regress the abnormal returns on the tariff changes, and the results are presented in Table 7.

In Table 7, our baseline results hold regardless of the choices of benchmark pricing models. That is, the relationship between abnormal returns and input (output) tariffs is significantly negative (positive). For example, when the benchmark model is Q4, the regression coefficient of abnormal returns on input (output) tariff change is -1.69 (0.07), significant at a 99% confidence level. A similar pattern can be found in other pricing model settings.

Alternative Tariff Constructions. We examine whether the baseline results are sensitive to the constructions of the input tariff. The input tariff is calculated by weighting the output tariff with the import share. In this part, we adopt three alternative methods to measure the input tariff.

The first method is to weigh the change in output tariffs of all upstream sectors by the proportion of imported intermediate goods from the corresponding upstream sector to the total imported intermediate goods of the sector. The second method is to weigh the change in output tariffs of all tradable upstream sectors (97 sectors) by the proportion of imported intermediate goods from the corresponding upstream sector to the total intermediate goods of the sector. And the third method is to weigh the change in output tariffs of all tradable upstream sectors (97 sectors) by the proportion of imported intermediate goods from the corresponding upstream sector to the total imported intermediate goods of the sector. The calculation details are shown below:

$$\Delta\tau_s^{I,149} = \sum_c \sum_{s'\in[1,149]} \frac{I_{s,s',c}^X}{\sum_{s'\in[1,149]} \sum_c I_{s,s',c}^X} \left(\tau_{s',c,t_1}^O - \tau_{s',c,t_0}^O\right) \tag{38}$$

$$\Delta\tau_s^{I,97} = \sum_c \sum_{s'\in[1,97]} \frac{I_{s,s',c}^X}{\sum_{s'\in[1,97]} I_{s,s'}} \left(\tau_{s',c,t_1}^O - \tau_{s',c,t_0}^O\right) \tag{39}$$

$$\Delta\tau_s^{I,97} = \sum_c \sum_{s'\in[1,97]} \frac{I_{s,s',c}^X}{\sum_{s'\in[1,97]} \sum_c I_{s,s',c}^X} \left(\tau_{s',c,t_1}^O - \tau_{s',c,t_0}^O\right) \tag{40}$$

where $I_{s,s'}$ is the total intermediate input value of sector s purchased from upstream sector s', $I_{s,s',c}^X$ is the import value of sector s from upstream sector s' and country c.

We use these new indicators to reproduce the previous basic results by regressing abnormal returns on tariff changes based on Equation 36 and the results are shown in Table 8. Regardless of the measure, rising input tariffs put significant downward pressure on stock prices. Output tariffs do not have a significant impact on abnormal returns when the weight is the share of imported intermediate goods from the corresponding upstream sector to the total imported intermediate goods of the sector (Method 1 and 3), but the sign is still consistent with our theoretical prediction (the regression coefficients are both 0.03).

Alternative Event Sets. One may argue that the empirical results rely on the choice of the event set and investors or firms may also react to the announcement date of the event. Therefore, to ensure objectivity and comprehensiveness, we sorted all announcement and execution dates during the trade war period according to the search volume of the Baidu index for the keyword "trade war" on that day and selected four event dates with the highest search volume, namely 23 March 2018, 02 April 2018, 6 July 2018 and 13 May 2019 (two announcement dates, denoted as "ANN", and two execution dates, denoted as "EXE"). Using this new event set, we estimate the impacts of tariff changes on abnormal returns according to Equation 36, and 33. It is important to note that the actual tariff does not change around the announcement date but the expected tariff changes. Therefore, the tariff change in the event window around the announcement date is calculated based on the expected tariff. The expected tariff on date t is the actual tariff on the day before the execution date corresponding to the nearest announcement date after date t. For example, for 20 March 2018, the nearest declaration date after that date is 23 March 2018 and the implementation date corresponding to 23 March 2018 is 2 April 2018, so the actual tariff on 1 April 2018 is assigned to the expected tariff on 20 March 2018. The results are reported in Table 9.

Table 8: The Impact of Tariffs on Stock Returns: Alternative Tariff Constructions

	(1)	(2)	(3)
	Method 1	Method 2	Method 3
$\Delta\tau_{i,l}^{I}$	-0.09**	-1.28***	-0.08**
	(-2.36)	(-3.26)	(-2.48)
$\Delta\tau_{i,l}^{O}$	0.03	0.05*	0.03
	(1.19)	(1.73)	(1.21)
Observations	16,959	16,959	16,959

Notes: This table reports the impact of tariff changes on the abnormal returns using alternative measures for the input tariff. The first method is to weigh the change in output tariffs of all upstream sectors by the proportion of imported intermediate goods from the corresponding upstream sector to the total imported intermediate goods of the sector. The second method is to weigh the change in output tariffs of all tradable upstream sectors (97 sectors) by the proportion of imported intermediate goods from the corresponding upstream sector to the total intermediate goods of the sector. And the third method is to weigh the change in output tariffs of all tradable upstream sectors (97 sectors) by the proportion of imported intermediate goods from the corresponding upstream sector to the total imported intermediate goods of the sector. We regress abnormal returns on tariff changes and event-fixed effects based on Equation 36. The event-fixed effects are not reported. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9: The Impact of Tariffs on Stock Returns Based on Other Event Dates

	(1)	(2)	(3)	(4)	(5)
	Average	**Sub-events**			
		ANN 23Mar18	EXE 02Apr18	EXE 06Jul18	ANN 13May19
$\Delta\tau^{I}_{i,l}$	-2.80***	-4.75***	-3.94**	-3.18***	1.85
	(-4.45)	(-2.82)	(-2.33)	(-3.80)	(1.11)
$\Delta\tau^{O}_{i,l}$	0.08**	0.07	0.12	0.06*	0.13
	(2.39)	(0.36)	(0.69)	(1.65)	(1.40)
Observations	16,959	16,959			

Notes: The table shows the short-term impact of tariffs on stock returns when we use another event set. We sorted all announcement and execution dates during the trade war period according to the search volume of the Baidu index for the keyword "trade war" on that day and selected four event dates with the highest search volume: two announcement dates (denoted as "ANN") and two execution dates (denoted as "EXE"). We explore the average impact of the entire event set ("Average") and the individual impact of each event ("Sub_events"). These estimated coefficients are obtained from Equation 36, and 33 respectively. The dependent variables are the stock's abnormal returns based on the Fama-French five-factor model within a three-day window around each event date ([-1,1]). The independent variables involve the change of input tariffs ($\Delta\tau^{I}_{i,l}$) and output tariffs ($\Delta\tau^{O}_{i,l}$) within a four-day window around each event date ([-2,1]). The tariff change in the event window around the announcement date is calculated based on the expected tariff. The expected tariff on date t is the actual tariff on the day before the execution date corresponding to the nearest announcement date after date t. Event-fixed effects are not reported. T statistics are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In column 1, the average impact across all events of input (output) tariffs on the abnormal returns is significantly negative (positive), consistent with our theoretical predictions that the increase in input (output) tariff pushes up the marginal cost (revenue), leading to the decline (rise) in returns, In the sub-event analysis where the individual impacts of events are explored, we find that the effect of output tariffs on returns is almost insignificant, but the signs are all in line with expectations. The impact of input tariffs on returns is significantly negative for events during 2018. However, in the event of 2019 (Column 5), the impact becomes insignificantly positive. We speculate that this is because 2019 has been a long time away from the start of the trade war, and investors have already formed an expectation effect on the event shock, which interferes with the estimation of the impact of input tariffs on returns.

Alternative Estimation Methods. In the trade war, China imposed retaliatory tariffs on U.S. exports in waves. The major challenge in estimating the impact of tariff changes on stock returns is that the individual events in the event set affect each other, especially in the long-term event window. In addition to the empirical methods used in the previous section, two other methods are used in this part to estimate the impact of tariff changes on returns.

The first method divides the event window, [-1,1+T], into two parts, [-1,1] and [1+T], and calculates the tariff change for each part separately. The former is considered as the tariff change caused by the focus event (denoted as $\Delta\tau_{i,l}^{I}$ and $\Delta\tau_{i,l}^{O}$) and the latter as the tariff change caused by other tariff events within the event window (denoted as $\Delta\tau_{i,l}^{I,C}$ and $\Delta\tau_{i,l}^{O,C}$). We regress the cumulative abnormal returns over the entire event window on these two tariff changes as well as on the event fixed effects. The regression coefficient for the tariff change at [-1,1] then represents the effect of the focus event on the cumulative abnormal returns, controlling for the effects of other tariff events within the event window. The second method regresses the cumulative abnormal returns on the tariff change for the event window [-1,1+T] (denoted as $\Delta\tau_{i,l}^{I,AVG}$ and $\Delta\tau_{i,l}^{O,AVG}$)and event fixed effects, and the regression coefficient then represents the average effect of the tariff change (which may be due to one or more tariff events) on returns. We conduct short- ([-1,2]) and long-term ([-1,121]) analysis and the results are shown in Table 10.

In Panel A where the first method is adopted, cumulative abnormal returns (CAR) fall (rise) significantly when the input (output) tariffs increase, with a regression coefficient of -10.44 (0.22), in the short-term event window. In the long-term window when other events are controlled, the predictive power of tariff changes on CAR becomes insignificant, but the sign remains in line with expectations. The regression coefficient on the input (output) tariff changes for the focus event is -20.91 (0.52). The short-term results in Panel B are identical to those in Panel A. The average impact of the tariff change on the long-term CAR was insignificant but the sign was in accordance with expectations. The coefficient of input tariff changes is -9.05 and that of output tariff changes is 0.46.

5.1.5 Average Treatment and Macro Effects

In this part, we compute the treatment and macro effect of tariffs on stock returns according to the procedure described in Section 4.3. The upper part of Figure 3 shows the simple average of the average treatment and macro effect across all events for individual stocks (equal to the value calculated by Equation 34, 35 and 30 divided by the number of events) while the bottom plot depicts the simple average of the individual treatment and macro effect of each event for individual stocks (equal to the value calculated by Equation 34, 35 and 30 for a given event l).

The treatment effect can be interpreted as the direct impact of events on daily returns through the firms' trade exposure, while the macro effect measures the co-movements of the stock price due to the change in pricing factors triggered by the events. In Figure 3, we find that the average

Table 10: The Impact of Tariffs on Stock Returns: Alternative Estimation Methods

	(1)	(2)
	[-1, 2]	[-1, 121]
Panel A: Controlling Tariffs beyond the Event Window		
$\Delta\tau_{i,l}^{I}$	-10.44***	-20.91
	(-5.93)	(-1.61)
$\Delta\tau_{i,l}^{I,C}$		-3.20
		(-0.28)
$\Delta\tau_{i,l}^{O}$	0.22**	0.52
	(2.43)	(0.76)
$\Delta\tau_{i,l}^{O,C}$		0.20
		(0.40)
Observations	5,646	5,290
Panel B: Using tariffs in the Whole Estimation Window		
$\Delta\tau_{i,l}^{I,AVG}$	-10.44***	-9.05
	(-5.93)	(-1.06)
$\Delta\tau_{i,l}^{O,AVG}$	0.22**	0.46
	(2.43)	(1.17)
Observations	5,646	5,290

Notes: This table reports the regression coefficients when other estimation methods for the impact of the tariff on returns are adopted. We use two other methods. The first method divides the event window, [-1,1+T], into two parts, [-1,1] and [1+T], and calculates the tariff change for each part separately. The former is considered as the tariff change caused by the focus event (denoted as $\Delta\tau_{i,l}^{I}$ and $\Delta\tau_{i,l}^{O}$) and the latter as the tariff change caused by other tariff events within the event window (denoted as $\Delta\tau_{i,l}^{I,C}$ and $\Delta\tau_{i,l}^{O,C}$). We regress the cumulative abnormal returns over the entire event window on these two tariff changes as well as on the event fixed effects. The second method regresses the cumulative abnormal returns on the tariff change for the event window [-1,1+T] (denoted as $\Delta\tau_{i,l}^{I,AVG}$ and $\Delta\tau_{i,l}^{O,AVG}$)and event fixed effects. We conduct short- ([-1,2]) and long-term ([-1,121]) analysis. The event-fixed effects are not reported. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

treatment effect of input (output) tariff is negative (positive) with a value of -0.38% (0.17%) and the average macro effect is negative with a value of -0.32%. A similar pattern can be seen in the individual effects of each event. For instance, for the fourth event on September 24, 2018, the treatment effect of the input (output) tariff is -0.92% (0.26%), and the macro effect is -0.25%.

Consistent with the previous analysis, the absolute value of the treatment effect of input tariff is always larger than that of output tariff, indicating that although input tariff and output tariff offset each other, tariff shocks have a net negative impact on individual stock returns through trade exposures on average. A natural question is whether there are individual firms that ultimately benefit from the trade war, even though on average the losses from input tariffs outweigh the gains from output tariffs. We retain firms with a positive treatment effect and analyze the industry distribution of these firms, as shown in Table 11. We find that very few firms benefit from the trade war, only 84 out of a sample of 1459 firms. These firms are mainly from industries that are upstream in the supply chain and are highly protected from import competition (i.e., high output tariff increase), such as the agricultural products and building materials industries. Therefore, for the majority of Chinese firms (94% of the sample), retaliatory tariffs imposed by China would put severe downward pressure on their operations and stock prices by raising production costs.

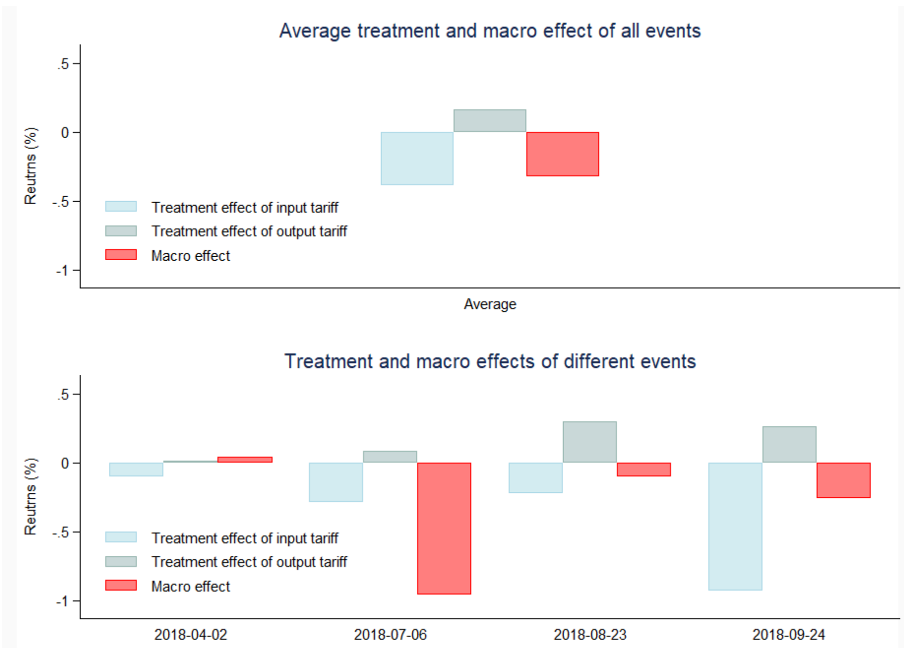
It is also worth noting that the absolute value of the macro effect is comparable in magnitude to the treatment effect in Figure 3. This suggests that the macro effect is non-negligible and that trade wars do generate significant policy uncertainty or trigger panic in the market, thus exerting downward pressure on all individual stock prices, regardless of the individual stock's trade exposure.

5.2 Dynamic Effects

One may argue that the short-term results only reflect investors' overreaction to the shocks, and it is a matter of concern whether the impact of the event is long-lasting or reverses. Hence, we conduct a dynamic analysis by extending the length of the event window. Specifically, we set the event window as [-1,1+T] where the T equals 0,1,2...,120.

Under event windows of different lengths, we still estimate the average impact of tariff changes on abnormal returns based on Equation 36. However, it should be noted that although observations of the dependent variable, $AR_{i,l,t}$ changes with the window length, the independent variables, tariff changes, are always calculated based on the four-day window of [-2,1]. The estimated coefficients for event windows of different lengths are shown in Figure 4. Each point in the figure represents the regression coefficient of the tariff changes on abnormal returns at that event window length.

In Figure 4, we find that the predictive power of tariff changes on abnormal returns decays with



Notes: This figure plots the treatment and macro effect of tariffs on stock returns. The upper part shows the simple average of the average treatment and macro effect across all events for individual stocks (equal to the value calculated by Equation 34, 35 and 30 divided by the number of events) while the bottom part presents the simple average of the individual treatment and macro effect of each event for individual stocks (equal to the value calculated by Equation 34, 35 and 30 for a given event l).

Figure 3: Average Treatment and Macro Effects

Table 11: Industry distribution of firms that benefited from the trade war

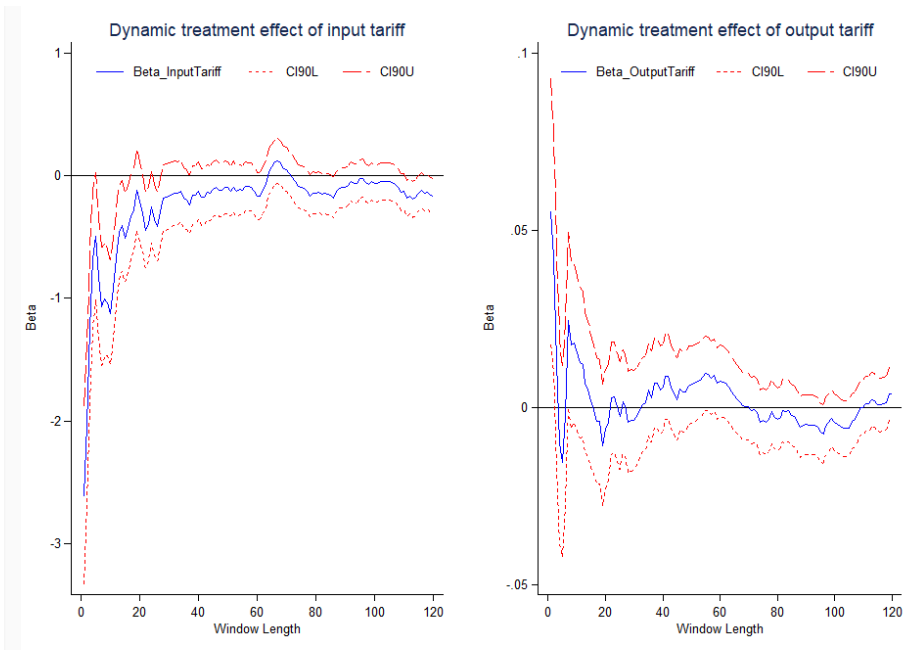
Industries	TE_IT (%)	TE_OT (%)	TE (%)	Share (%)
Agricultural products	-0.18	1.32	1.14	0.15
Livestock products	-0.13	0.75	0.62	0.18
Cement, lime and gypsum	-0.16	0.57	0.41	0.20
Building materials	-0.19	0.56	0.36	0.25
Forest products	-0.18	0.46	0.28	0.02
Refractory products	-0.14	0.32	0.18	0.06
Glass and glass products	-0.28	0.38	0.11	0.07
Pharmaceutical products	-1.38	1.41	0.03	0.05
Metal products	-0.32	0.35	0.03	0.01

Notes: This table reports the industry distribution of firms that benefited from the trade war. We calculate the simple average of the treatment effect across all events for individual stocks during 2018 and retain the stocks with a positive treatment effect. Within these stocks, we calculate the share of stocks in each industry (denoted as Share), the average treatment effect due to input tariff (denoted as TE_IT), output tariff (denoted as TE_OT"), and the total treatment effect (denoted as TE) for each stock within the industry.

increasing window length. Specifically, the negative impact of input tariff on abnormal returns can persist for roughly 18 trading days (0 is not within the 10% confidence interval for the event window where T does not exceed 18). In other words, the event-induced rise in input tariff has little impact on abnormal returns beyond the 18th trading day after the event. The positive effect of output tariff on abnormal returns is also short-lived, lasting only about 5 trading days. Although the effect of output tariff on abnormal returns may be negative sometimes, it is always insignificant and thus does not imply a reversal. Overall, it takes some time for investors to fully incorporate the information from the trade war into the stock price.

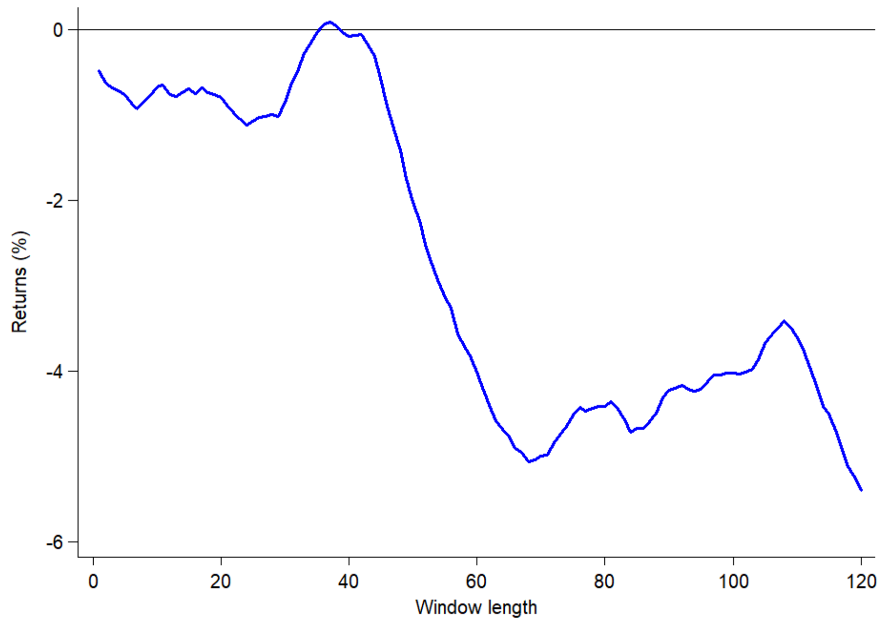
We also examine the individual dynamic treatment effect of each event in Appendix 7.1. Consistent with the all-event average effect, the predictive power of each event's tariff change on abnormal returns exists only in the short run when controlling for the effects of other tariff events. In these four events, the impacts of the first and fourth events are more striking. These differences may be because compared to the second and third events, the first event was able to deliver the strongest unanticipated shock to investors and the fourth event involved the largest tariff levy, leading to more delayed incorporation of information into stock prices by investors.

We also calculate the cumulative macro effect under event windows of different lengths according to Equation 30. In Figure 5, each point represents the cumulative macro effect within an event



Notes: This figure reflects the regression coefficients of tariff changes on abnormal returns based on Equation 36 over the event windows of different lengths. The event window is set as [-1,1+T] where the T equals 0,1,2...,120. The solid blue line represents the regression coefficient, and the dashed red lines represent the upper and lower bounds of the 10% confidence interval.

Figure 4: Dynamic Treatment Effects of Tariffs on Stock Returns



Notes: This figure plots the cumulative macro effect under event windows of different lengths according to Equation 30. The event window is set as [-1,1+T] where the T equals 0,1,2...,120. Each point represents the cumulative macro effect within an event window of that length.

Figure 5: Dynamic Macro Effects

window of that length[3].

The macro effect is almost always negative regardless of the event window length. Moreover, the absolute value of the cumulative macro effect tends to increase with window length. This further highlights that the macro effect is non-trivial. Compared with the short-lived treatment effect, the impact of trade events on stock returns through the macro effect is remarkably more long-lasting.

These results reveal that although investors may show a great perception of the firm's trade exposure and thus can incorporate the impact of trade shocks on firm value through firm characteristics into the stock price in a relatively timely manner, they are still unable to have a clear grasp of the future evolution direction of the trade war. Policy uncertainty and panic persist, and the downward pressure on stock prices continues into the long term, regardless of firms' trade exposures.

[3]The measurement of economic surprise variables is key to estimating macro effects. And due to the lack of analyst forecast data, we use short-term historical averages of macro variables as a proxy for analyst forecasts. In Appendix 7.2, we widen the moving window to calculate the historical mean and find that the baseline results hold robustly.

5.3 Welfare

In this subsection, we estimate the welfare change induced by trade events in a three-day event window. The income in the economy is made up of the payments to factors plus tariff revenue. Hence, the change in welfare, $E[\hat{W}|\tau]I$, consists of three parts: the changes in returns to capital ($\sum_i E\left[\hat{r}_i^C|\tau\right] r_i^C C_i$), payments for labor ($E\left[\hat{w}|\tau\right] wL$), and tariff revenues ($\widehat{TR}TR$), as shown in the following equation.

$$E[\hat{W}|\tau]I = \sum_i E\left[\hat{r}_i^C|\tau\right] r_i^C C_i + E\left[\hat{w}|\tau\right] wL + \widehat{TR}TR \tag{41}$$

where W is welfare, I is the income, C_i is the capital of firm i, r_i^C is the total returns to the capital of firm i, L is the total labor of all firms, w is the wage rate, and TR is the tariff revenues. Following Amiti, Kong, et al. (2021), we adopt the change of stock returns induced by tariff to be the proxies for the change of returns to capital induced by tariff:

$$E[\hat{r}_i^C|\tau] = E[r_i|\tau] = E[r_i^T|\tau] + E[r_i^M|\tau] \tag{42}$$

The total returns to the capital, $r_i^C C_i$ can be replaced by earnings before interest, EBI_i. And the full-employment condition requires the aggregate demand for labor to remain constant. In other words, the change in wages ($\hat{w}$) should equal a weighted average of the change in returns to the capital ($\sum_i \frac{L_i}{L}\hat{r}_i^C$). Hence, the change in welfare can be rewritten as:

$$E[\hat{W}|\tau]I = \sum_i EBI_i \left(E\left[r_i^M|\tau\right] + E\left[r_i^T|\tau\right]\right) + \sum_i wL_i \left(E\left[r_i^M|\tau\right] + E\left[r_i^T|\tau\right]\right) + \widehat{TR}TR \tag{43}$$

where wL_i is the payment for labors in firm i, for which we use the "Cash Paid to and on Behalf of Employees" item in the statement of cash flows to be the proxy. The change in tariff revenue is computed as follows:

$$\widehat{TR}TR = \sum_s imports_{s,2018}\Delta\tau_s = \sum_s \left[Imports_{s,2016}(1 - \sigma\Delta\tau_s)\right]\Delta\tau_s \tag{44}$$

where $\sigma = 1.92$ is import demand elasticity, $imports_{s,2018}$ is the implied import levels of sector s caused by tariff in 2018. $\Delta\tau_s$ is the output tariff change for sector s from the beginning of 2017 to the end of 2018.

The welfare loss we estimated owing to the trade war was \$5.50 billion with a labor income loss of \$4.38 billion, capital return loss of \$3.49 billion, and tariff revenue of \$2.38 billion. The decline in welfare was 0.22% of the total market value or 0.81% of the total value added (operating revenue minus material costs) of the listed firms in 2018. Although we calculate the welfare loss ratio based on a sample of listed firms, we still consider it to be a feasible noise proxy for the welfare loss ratio calculated based on all firms in the whole Chinese economy, assuming a stable firm composition between listed and non-listed firms. These results reveal that the trade war does trigger severe adverse forces to depress firm returns and wages in both countries.

6 Conclusion

We study the asset pricing implications of a firm's decision to participate in the global value chain by exploring whether a firm's global sourcing strategy maintains an option to hedge its value against trade policy shocks. In particular, we seek to understand to what extent a firm's reliance on the global supply chain affects its market value. This question has recently gained even more salience as policymakers try to understand the economic consequences of punitive tariffs or import bans across products.

To explore the mechanism, we develop a two-period stochastic general equilibrium model. During trade liberalization, lower output tariffs decrease firm value through intensified import competition, whereas low input tariffs increase firm value through cheaper input costs. With the rise in trade protectionism, however, higher input tariffs are value-destructing. Firms relying more on a certain foreign supplier are more negatively affected.

The US-China trade war provides a perfect setting to examine the impact of trade protectionism and a firm's position along the global supply chain on firm value. Applying this framework to the US-China trade war, we estimate the impact of trade protectionism on firm values.

We estimate the impact of the Chinese retaliatory tariff on the stock return of Chinese-listed firms under the event study setting. We find that the daily abnormal returns fall (rise) by 0.13% (0.08%) for a one-standard-deviation increase in input (output) tariff on average. Overall, the loss generated from a rise in input tariffs outweighs the gains from raising output tariffs. To explore firm heterogeneity, we match the firm-level trade data with the listed firm data. We find that the negative effect of input tariffs is more substantial for firms with high import intensity and low import substitutability. These results hold robustly when we control the U.S. (export) tariff and exchange rate. The findings are not sensitive to different benchmark asset pricing models and different ways of constructing tariffs and estimation methods.

Additionally, we find that trade events can indirectly induce the co-movements of the stock price due to the change in pricing factors triggered by the events, namely, the macro effect. The negative macro effect reveals that trade wars do generate significant policy uncertainty or panic in the market, thus exerting downward pressure on all individual stock prices, regardless of the individual stock's trade exposure. The macro effect is comparable in magnitude to the treatment effect, the direct impact of trade events on returns through the firm's trade exposure. And the dynamic analysis shows that the treatment effect is short-lived while the macro effect is long-lasting. Combining these two effects, the welfare loss we estimated is $ 5.50 billion, 0.22% of the total market value or 0.81% of the total value added of the listed firms in 2018.

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7 Appendix

7.1 Dynamic Treatment Effects: by Four Events

The previous analysis revealed dynamic all-event average treatment effects. We are still concerned about the individual dynamic treatment effect of each event. We seek to analyze whether there are differences in the individual treatment effects across events and which event dominates the average impact. Thus, in this part, we estimate the individual dynamic effects of each event by expanding the event window based on Equation 33. The event window is set to [-1, 1+T], where T=0, 1, 2, ...,120.

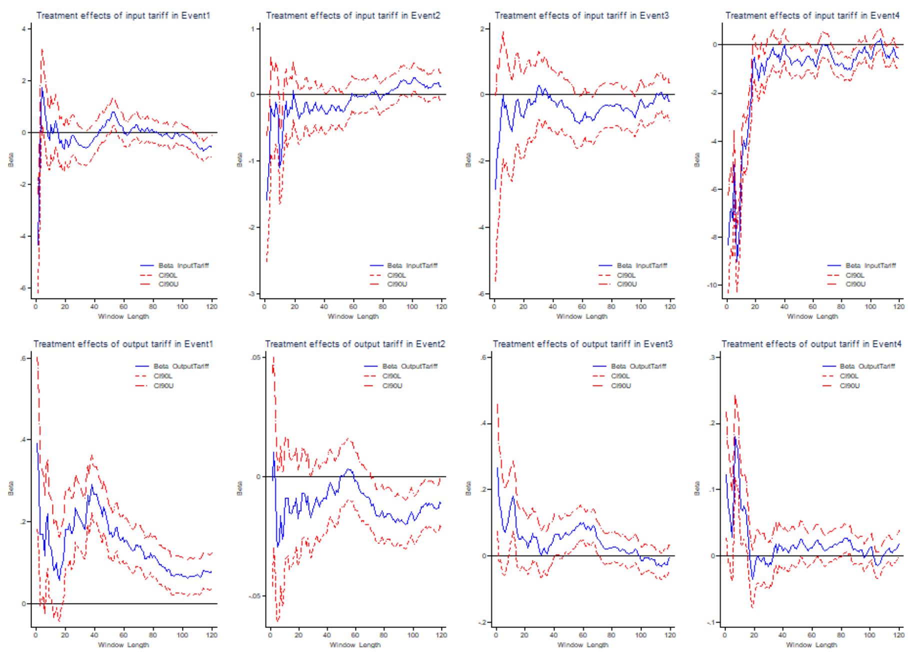
We regress the abnormal returns on the interaction term between tariff changes and event dummies. The regression coefficients in different event windows are plotted in Figure 6 where the first row reports the coefficients of input tariff changes, $\gamma_{1,l}$ and the second row reports the coefficients of output tariff, $\gamma_{2,l}$.

Consistent with the average effect, the predictive power of each event's tariff change on abnormal returns exists only in the short run when controlling for the effects of other tariff events. In these four events, the impacts of the first and fourth events are more striking. For the first event, the significant predictive power of the input tariff persists for roughly 10 trading days, while the output tariff does not lose significant predictive power even for longer-term returns. For the fourth event, the significant impacts of input tariffs and output tariffs on returns can both last until about 20 trading days after the event. In contrast, the significant impact of tariff changes on abnormal returns for events 2 and 3 is fairly short-lived, lasting only 5 trading days after the event. These differences may be because compared to the second and third events, the first event was able to deliver the strongest unanticipated shock to investors and the fourth event involved the largest tariff levy, leading to more delayed incorporation of information into stock prices by investors.

7.2 Alternative Variable Construction: Economic Surprise

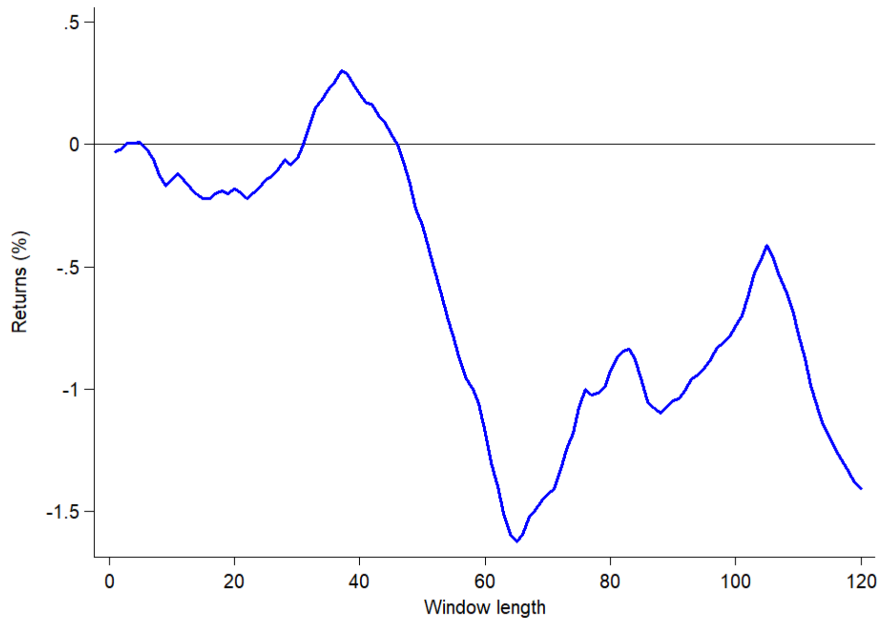
The measurement of economic surprise variables is key to estimating macro effects. And due to the lack of analyst forecast data, we use short-term historical averages of macro variables as a proxy for analyst forecasts. In this part, we widen the moving window to calculate the historical mean and test whether the baseline results hold robustly. Specifically, the lengths of the moving average window for quarterly, monthly, and daily macro variables are two years, half a year, and one quarter, respectively.

We recalculate the cumulative macro effect under event windows of different lengths. In Figure 7, each point reveals the cumulative macro effect in the event window of that length. Consistent



Notes: This figure reports the individual dynamic treatment effect of each event. We regress the abnormal returns on the interaction term between tariff changes and event dummies based on Equation 33 during the event window [-1, 1+T], where T=0, 1, 2, ...,120. The first row reports the coefficients of input tariff changes, $\gamma_{1,l}$ and the second row reports the coefficients of output tariff, $\gamma_{2,l}$.

Figure 6: Dynamic Treatment Effects of Different Events



Notes: This figure plots the cumulative macro effect under event windows of different lengths according to Equation 30 when the economic variables are calculated using a long moving-average window. The lengths of the moving average window for quarterly, monthly, and daily macro variables are two years, half a year, and one quarter, respectively. The event window is set as [-1,1+T] where the T equals 0,1,2...,120. Each point represents the cumulative macro effect within an event window of that length.

Figure 7: Dynamic Macro Effects: Alternative Variable Constructions

with the previous findings, the cumulative macro effect is negative in the short-term window when the length is less than 30 trade days. And the negative effects become more severe with increasing window length. These results indicate that the trade war did generate considerable downward pressure on the stock price, regardless of the firm's trade exposure. The slight reversals in the figure are inferred to be due to the noise in this measure of ES variables for the long moving average window. And the noise may cause the macro effect to include some non-trade event shocks.