Online Appendix to "The Effect of U.S.-China Trade War on U.S. Investment" (Not for Publication)

Mary Amiti
Federal Reserve Bank of New York

Sang Hoon Kong
Columbia University

David E. Weinstein
Columbia University and NBER

April 13, 2020

Table of Contents

A.1 Introduction

This online appendix contains supplementary theoretical and empirical results. Section A.2 presents the method we use to decompose returns into those attributable to U.S. and Chinese events. Section A.3 the derivation of equation (7), and Section A.4 presents sample statistics. Section A.5 presents additional results obtained by varying our assumptions and estimation procedures. In Section A.5.1, we present the results of using a 3-day window in our event studies and varying the number of factors. Section A.5.2 presents estimates of ψ^{-1} and λ based on alternative event windows and numbers of factors. It also presents a reduced-form estimate of the impact of stock prices on investment. Finally, Section A.5.3 presents the data underlying Figure 4.

A.2 Accounting for Aggregate Stock-Market Impacts of U.S. and Chinese Events

If we want to split the events into U.S. and Chinese tariff events, we can do a decomposition that is similar to that in equation (6). We split r_{ft}^{D} (given in equation 4) into two components:

$$r_{ft}^{U} \equiv \sum_{j \in \Omega^{U}} \sum_{i=1}^{N} \gamma_{ij} Z_{if} D_{jt}^{w} \text{ and } r_{ft}^{Chn} \equiv \sum_{j \in \Omega^{C}} \sum_{i=1}^{N} \gamma_{ij} Z_{if} D_{jt}^{w}, \tag{A.1}$$

where Ω^{U} and Ω^{C} are the set of U.S. and Chinese tariff event dates and $r_{ft}^{D} = r_{ft}^{U} + r_{ft}^{Chn}$. Similarly, we define

$$R_{t}^{U} \equiv \sum_{f} S_{f,t-1} r_{ft}^{U} \text{ and } R_{t}^{Chn} \equiv \sum_{f} S_{f,t-1} r_{ft}^{Chn}, \tag{A.2}$$

where we have $R_{t}^{D} = R_{t}^{U} + R_{t}^{C}$. One issue with this further decomposition is that for sufficiently large values of w, event windows can overlap. However, we can handle this problem by defining the market return during U.S. events (R_{t}^{UE}) and the market return during Chinese events (R_{t}^{CE}) as

$$R_{t}^{UE} \equiv R_{t}^{U} + \frac{R_{t}^{\alpha} + R_{t}^{C} + R_{t}^{I}}{\sum_{j} D_{jt}^{w}}, \quad \text{and} \quad R_{t}^{CE} \equiv R_{t}^{Chn} + \frac{R_{t}^{\alpha} + R_{t}^{C} + R_{t}^{I}}{\sum_{j} D_{jt}^{w}}. \tag{A.3}$$

These definitions attribute the market return on an overlapping day to 1/2 of the movements to the common effect plus the differential effect due to the event. Note that $R_{t} = R_{t}^{CE} + R_{t}^{UE}$. Similarly, whenever we split the common effect by country, we can decompose the common effect as follows:

$$R_{t}^{CC} = R_{t}^{UC} \equiv \frac{R_{t}^{C}}{\sum_{j} D_{jt}^{w}}. \tag{A.4}$$

so that $R_{t}^{C} \equiv R_{t}^{UG} + R_{t}^{CG}$. It will also be the case that we can rewrite equation (5) for the case where we split the events into those due to U.S. and China announcements as follows:

$$R_{t} \equiv R_{t}^{\alpha} + R_{t}^{CC} + R_{t}^{UC} + R_{t}^{C} + R_{t}^{U} + R_{t}^{I}. \tag{A.5}$$

We can compute the market return, differential effect and common effect so that these terms are defined consistently across tables. To do this, we define

$$R_{j}^{X}(w) \equiv \sum_{\ell=-1}^{w} R_{j+\ell}^{X} \text{ for } X \in \{U, UE, UC, C, CE, CC\}. \tag{A.6}$$

A.3 Derivation of Equation (7)

We assume that at the start of any period (which in our empirical work will correspond to a *quarter*) s, managers in firm f produce based on the firm's existing capital stock, K_{fs}. This production yields a flow of revenues equal to $A_{fs}g\left(K_{fs}, L_{fs}\right)$, where A_{fs} captures the firm's productivity (and output price), and L_{fs} is labor.[1] Firms then choose an amount to be invested, I_{fs}, and pay the remainder to shareholders in the form of dividends. Thus, the amount of dividends to be paid out at the start of the period is given by

$$\pi_{fs} = A_{fs}g\left(K_{fs}, L_{fs}\right) - w_s L_{fs} - p_s I_{fs} - c\left(I_{fs}, K_{fs}\right), \tag{A.7}$$

where w_s is the wage; p_s is the cost of the investment good; and $c\left(I_{fs}, K_{fs}\right)$ is the adjustment cost associated with increasing or decreasing the firm's capital stock.

In this formulation, it costs p_s to purchase investment goods (i.e., investment that procures capital to replace the depreciated amount), but there is an additional "adjustment" cost to produce output with more or less capital than in the previous period. We assume that the adjustment cost function is given by

$$c\left(I_{fs}, K_{fs}\right) = \frac{\psi}{2}\left(\frac{I_{fs}}{K_{fs}} - \rho_f\right)^2 K_{fs}, \tag{A.8}$$

where ψ is some positive parameter that represents how costly it is for firms to adjust their capital stock from the one in the previous period. If $\psi = 0$, we are in a frictionless world in which capital stocks adjust instantly to the optimal level, so the shadow value of capital equals the cost of investment of goods (i.e., $q_{fs} = p_s$). In contrast, if ψ is infinite, firms are unable to adjust their capital stocks (as in the specific-factors model), and movements in the returns to capital will not affect investment. In general, we expect that $0 < \psi < \infty$. The firm's capital stock (K_{fs}) in period s evolves according to the following equation:

$$K_{f,s+1} = \left(1 - \rho_f\right) K_{fs} + I_{fs}, \tag{A.9}$$

where ρ_f is the rate of depreciation, which we allow to vary by firm.

Firms maximize the present discounted value of profits. The owners of the firm at the beginning of the period receive a dividend equal to whatever revenues are not reinvested as well as the present value of the future stream of dividend (profits):

$$V_{fs} = \sum_{\ell=s}^{\infty}\left(\frac{1}{1+r}\right)^{\ell-s}\pi_{f\ell} = \pi_{fs} + \frac{V_{fs+1}}{1+r}, \tag{A.10}$$

where V_{fs} equals the stock market value of a firm. The firm's problem is to choose investment so as to maximize the present discounted value of profits (V_{fs}) subject to the law of

[1] Adding more factors of production would add notational clutter but would not change the derivation.

motion governing the capital stock (equation A.9). We can write this problem formally as the firm's managers maximizing the following Lagrangian equation:

$$L_s = \sum_{\ell=s}^{\infty} \left(\frac{1}{1+r}\right)^{\ell-s} \{A_{fs} g\left(K_{fs}, L_{fs}\right) - w_s L_{fs} - p_s I_{fs} - c\left(I_{fs}, K_{fs}\right) \\ - q_{fs}\left[K_{f,s+1} - \left(1-\rho_f\right) K_{fs} - I_{fs}\right]\} \tag{A.11}$$

where we have replaced π_ℓ in equation (A.10) with the elements given in equation (A.7). Here, q_{fs} is the Lagrange multiplier, which equals the shadow value of an additional unit of capital, i.e., $q_{fs} = \frac{\partial V_{fs}}{\partial K_{fs}}$.

We can use the first-order conditions to understand how firms adjust labor and capital in response to changes in firm value. The first-order condition with respect to labor (or any freely-adjustable factor) is

$$A_{fs} g_L\left(K_{fs}, L_{fs}\right) = w_s, \tag{A.12}$$

which means that each period, firms equate the marginal product of labor with the wage.[2] This result does not obtain for capital. The first-order condition with respect to investment is given by

$$q_{fs} = p_s + \psi\left(\frac{I_{fs}}{K_{fs}} - \rho_f\right). \tag{A.13}$$

This equation intuitively tells us that in the absence of adjustment costs ($\psi = 0$), the marginal benefit of additional capital (q_{fs}) will equal its marginal cost, p_s. When adjustment costs are positive, however, this condition need not hold. Rearranging terms in this expression gives us equation (7) in the paper.

[2]This result is the same as that in a specific-factors model

A.4 Sample Statistics

Table A.1: Descriptive Statistics

	N	Mean	Standard Deviation	25th Percentile	Median	75th Percentile
$\hat{\epsilon}_{ft}$	137,472	0.01	2.93	-0.88	-0.01	0.84
China Importer Dummy	137,472	0.27	0.44	0.00	0.00	1.00
China Exporter Dummy	137,472	0.04	0.20	0.00	0.00	0.00
China Revenue Share	137,472	0.02	0.06	0.00	0.00	0.02
Non-China Revenue Share	137,472	0.16	0.23	0.00	0.01	0.29
Large Company Dummy	121,392	0.62	0.49	0.00	1.00	1.00
Industry Protected Dummy	137,472	0.01	0.12	0.00	0.00	0.00
$I_{fs}/K_{f,s-4}$	36,016	0.06	0.09	0.02	0.04	0.08
$\text{Cashflow}_{fs}/K_{f,s-4}$	36,075	0.69	6.25	0.07	0.21	0.53
$\text{MTB}_{f,s-4}$	36,365	1.82	1.67	1.05	1.37	2.04
I_{fs}	40,270	119.68	499.85	1.59	9.93	48.81

Note: Factor model using stock returns RET from CRSP, ϵ_{ft} is estimated from equation 1. Section 5.1 (daily) summary stats are in the first part of the table and section 5.2 (quarterly) in the lower part for the period 2016Q1 to 2019Q4. China Importer Dummy and China Exporter Dummy equal one for firms that import or export to China as recorded in Datamyne. China Revenue Share and Non-China Revenue Share are the shares of a firm's revenues that come from China and foreign countries other than China, respectively. The Large Company Dummy is one when a firm has at least 1,000 employees, sourced from FactSet. Industry Protected Dummy is defined when a firm's 6-digit NAICS code is affected by US tariff events.The respective variables in CCM are as follows: I_{fs} is quarterly capital expenditures (CAPXQ) in millions of dollars, K_{fs} capital stocks are measured by PPENTQ (Property Plant and Equipment), Cashflow_{fs} is OIBDPQ (Operating Income Before Depreciation). MTB_{fs} defined as (ATQ+PRCCQ*CSHOQ-SEQQ-TXDITCQ)/(ATQ), where ATQ is total assets, PRCCQ is the closing stock price in the quarter, CSHOQ is common shares outstanding, SEQQ is total shareholder's equity, and TXDITCQ is deferred taxes and investment tax credit. We used TXDBQ (deferred taxes) if TXDITCQ was missing.

A.5 Additional Results

In this section, we replicate all of our main results using alternative event windows, numbers of factors, and specifications.

A.5.1 Event Study Results with 3-Day Windows

Table A.2: Impact of US Tariff Announcements (3-Day Windows)

Dep. Var.: $\hat{\epsilon}_{ft}$	Average	01Mar18 Steel and Aluminum Announcement	22Mar18 China Target Announcement	17Sep18 $200 Billion Announcement	10May19 10-25% Tariff Increase Announcement
China Importer	-0.076**	-0.275***	-0.114**	0.218***	-0.135*
	(0.034)	(0.073)	(0.058)	(0.058)	(0.079)
China Exporter	-0.080	-0.325***	-0.148*	0.224	-0.071
	(0.056)	(0.113)	(0.088)	(0.139)	(0.103)
China Revenue Share	-1.097***	-0.477	-1.223***	0.059	-2.746***
	(0.207)	(0.444)	(0.319)	(0.321)	(0.535)
Decomposition of Market Return in Percent					
Market Return	-8.63	-1.58	-4.66	-0.03	-2.37
Differential Effect	-1.31	-0.66	-0.43	0.46	-0.68
Common Effect	-5.58	0.04	-2.81	-0.55	-2.26
Total Event Effect	-6.89	-0.62	-3.24	-0.09	-2.94

Note: This table presents the results from estimating equation (2). The dependent variable ($\hat{\epsilon}_{ft}$) is the abnormal return obtained from estimating the factor model (equation 1). China Importer is a dummy that equals one if the firm or any of its subsidiaries or suppliers imports from China. China Exporter is a dummy that equals one if the firm or its subsidiaries export to China. China Revenue Share is the share of the firm's revenue that comes from sales in China. The average is the the average of the coefficients on each of the event days. Standard errors are in parentheses. In the lower panel of the table, we report the cumulative market decline as well as the differential and common effects as defined in equation (6). In this lower panel, the first column is the total (not the average) for all the events.

Table A.3: Impact of Chinese Tariff Announcements (3-Day Windows)

Dep. Var.: $\hat{\epsilon}_{ft}$	Average	02Apr18 China $128 Bln Announcement	15Jun18 China $50 Bln Announcement	23Aug19 China Soy/Auto Announcement
China Importer	0.008	0.066	-0.024	-0.018
	(0.038)	(0.064)	(0.065)	(0.067)
China Exporter	-0.074	0.183**	-0.205**	-0.200**
	(0.050)	(0.083)	(0.088)	(0.091)
China Revenue Share	-0.868***	0.112	-1.489***	-1.228***
	(0.246)	(0.539)	(0.361)	(0.355)
Decomposition of Market Return in Percent				
Market Return	-1.11	0.37	0.11	-1.59
Differential Effect	-0.44	0.20	-0.35	-0.29
Common Effect	-0.99	-0.21	0.70	-1.47
Total Event Effect	-1.43	-0.02	0.35	-1.76

Note: This table presents the results from estimating equation (2). The dependent variable ($\hat{\epsilon}_{ft}$) is the abnormal return obtained from estimating the factor model (equation 1). China Importer is a dummy that equals one if the firm or any of its subsidiaries or suppliers imports from China. China Exporter is a dummy that equals one if the firm or its subsidiaries export to China. China Revenue Share is the share of the firm's revenue that comes from sales in China. The average is the the average of the coefficients on each of the event days. Standard errors are in parentheses. In the lower panel of the table, we report the cumulative market decline as well as the differential and common effects as defined in equation (6). In this lower panel, the first column is the total (not the average) for all the events.

Table A.4: Impact of U.S.-China Trade-War Announcements (3-Day Windows)

	Average of Coefficients			
	(1)	(2)	(3)	(4)
China Importer	-0.112***	-0.020	-0.005	0.031
	(0.033)	(0.038)	(0.033)	(0.028)
China Exporter	-0.086	-0.079	-0.004	-0.009
	(0.056)	(0.050)	(0.058)	(0.040)
China Revenue Share			-0.021	0.797***
			(0.272)	(0.177)
N	60,144	60,144	34,368	42,960
w	1	1	1	1
Events	U.S.	China	Other	5 Largest Declines 2017
Decomposition of Market Return in Percent				
Market Return	-8.63	-1.11	-1.71	-3.24
Differential Effect	-0.88	-0.19	-0.06	0.81
Common Effect	-5.77	-1.10	-2.90	-4.59
Total Event Effect	-6.65	-1.28	-2.95	-3.78

Note: This table presents the results from estimating equation (2). The dependent variable ($\hat{\epsilon}_{ft}$) is the abnormal return obtained from estimating the factor model (equation 1). China Importer is a dummy that equals one if the firm or any of its subsidiaries or suppliers imports from China. China Exporter is a dummy that equals one if the firm or its subsidiaries export to China. China Revenue Share is the share of the firm's revenue that comes from sales in China. Standard errors are in parentheses. In the lower panel of the table, we report the cumulative market decline as well as the differential and common effects as defined in equation (6). In this lower panel, the first column is the total (not the average) for all the events.

Table A.5: Impact of Chinese Tariff Announcements (3-Day Windows)

	Average of Coefficients						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
China Importer	-0.060*	-0.049	-0.024	-0.068*	-0.004	-0.024	-0.009
	(0.035)	(0.035)	(0.036)	(0.036)	(0.039)	(0.033)	(0.037)
China Exporter	-0.072	-0.055	-0.093*	-0.074	-0.083	-0.074	-0.082
	(0.057)	(0.057)	(0.050)	(0.057)	(0.050)	(0.055)	(0.050)
China Revenue Share	-0.967***	-1.134***	-0.956***	-1.009***	-1.000***	-1.008***	-0.896***
	(0.214)	(0.211)	(0.251)	(0.219)	(0.276)	(0.206)	(0.245)
Industry Protected	0.100						
	(0.125)						
Large Company		-0.103*	-0.138*				
		(0.054)	(0.072)				
Non-China Revenue Share				-0.068	0.101		
				(0.080)	(0.094)		
N	60,144	53,109	53,109	60,144	60,144	60,144	60,144
Events	U.S.	U.S.	China	U.S.	China	U.S.	China
Number of Factors	2	2	2	2	2	5	5
Decomposition of Market Return in Percent							
Market Return	-8.38	-6.58	-1.70	-8.63	-1.11	-8.63	-1.11
Differential Effect	-1.11	-1.12	-0.67	-1.43	-0.31	-0.90	-0.55
Common Effect	-5.46	-4.15	-1.16	-5.50	-1.08	-6.10	-0.84
Total Event Effect	-6.56	-5.27	-1.83	-6.93	-1.39	-7.00	-1.39

Note: This table presents the results from estimating equation (2). The dependent variable ($\hat{\epsilon}_{ft}$) is the abnormal return obtained from estimating the factor model (equation 1). China Importer is a dummy that equals one if the firm or any of its subsidiaries or suppliers imports from China. China Exporter is a dummy that equals one if the firm or its subsidiaries export to China. China Revenue Share is the share of the firm's revenue that comes from sales in China. Large Company is a dummy that equals 1 if the firm has 1000 or more employees. Non-China Revenue Share is the share of the firm's revenues that comes from foreign companies other than China. Standard errors are in parentheses. In the lower panel of the table, we report the cumulative market decline as well as the differential and common effects as defined in equation (6). In this lower panel, the first column is the total (not the average) for all the events.

A.5.2 Additional IK Regressions

In Table A.6, we consider a number of robustness exercises to see how sensitive our investment results are to alternative specifications. In the first two columns, we switch the length of the event window to three days, re-estimate the event study and instruments, and then redo the investment regression. We obtain an almost identical estimate of $\widehat{\psi^{-1}}$ (0.009). Our estimate of the sensitivity of MTB values to the common effect ($\hat{\lambda}_C$) does not move much, but the sensitivity to the differential effect ($\hat{\lambda}_D$) rises from 3.2 to 5.0. As we see in Table A.7, we obtain slightly larger estimates of the overall effect of the trade war than those reported in the paper. In columns 3 and 4, we report estimates of ψ^{-1} obtained using abnormal returns based on a five-factor model using different window lengths. These results are also similar to those earlier reported.

Table A.6: IK Regression Robustness

Dep. Var.	$\Delta^4\left(\frac{I_{f,s}}{K_{f,s-4}}\right)$ IV (1)	$\Delta^4\left(\frac{I_{f,s}}{K_{f,s-4}}\right)$ IV (2)	$\Delta^4\left(\frac{I_{f,s}}{K_{f,s-4}}\right)$ IV (3)	$\Delta^4\left(\frac{I_{f,s}}{K_{f,s-4}}\right)$ IV (4)
$\Delta^4\text{MTB}_{f,s-4}$	0.008***	0.008***	0.009***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
$\Delta^4\left(\text{Cashflow}_{fs}/K_{f,s-4}\right)$	0.008***	0.008***	0.008***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)
N	14,390	14,390	14,390	14,390
Time FE	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes
Factor	2	2	5	5
w	1	1	5	1
Overid J-testχ^2	2.22		12.20	2.06
[p value]	[0.53]		[0.01]	[0.56]
Weak IV F-test	1,636.5	6,504.7	1,634.3	1,636.3
First Stage	$\Delta^4\text{MTB}_{f,s-4}$	$\Delta^4\text{MTB}_{f,s-4}$	$\Delta^4\text{MTB}_{f,s-4}$	$\Delta^4\text{MTB}_{f,s-4}$
$\tilde{r}^C_{f,s-4}$	0.954*		0.589	0.526
	(0.545)		(0.447)	(0.352)
$\tilde{r}^D_{f,s-4}$	5.011***		3.276***	6.361***
	(0.778)		(0.493)	(1.073)
$\tilde{\nu}_{f,s-4}$	1.064***		1.018***	1.101***
	(0.089)		(0.063)	(0.091)
$\dot{r}_{f,s-4}$	0.969***		0.969***	0.969***
	(0.012)		(0.012)	(0.012)
$\tilde{r}_{f,s-4}$		0.973***		
		(0.012)		
First stage F-test	1,637	6,505	1,634	1,636
[p value]	[0.00]	[0.00]	[0.00]	[0.00]

Notes: $I_{f,s}/K_{f,s-4}$ is the firm's quarterly capital expenditures (investment) relative to its 4-quarter lagged capital stock; $\Delta^4(I_{f,s}/K_{f,s-4})$ is the 4-quarter change in this variable, MTB_{fs} is the firm's market-to-book value, and $\text{Cashflow}_{f,s}/K_{f,s-4}$ is the firms cash flow divided by its lagged capital stock. As defined in equation (16), $\tilde{r}^G_{f,s-4}$ and $\tilde{r}^D_{f,s-4}$ are the lagged 4-quarter movement in returns due to the common and differential effects; $\tilde{\nu}_{f,s-4}$ is the lagged 4-quarter movement in returns due to idiosyncratic shocks; and $\dot{r}_{f,s-4}$ is the lagged 4-quarter movement in returns outside of the event window; and $\tilde{r}_{f,s-4}$ is is the lagged 4-quarter movement in returns. The coefficient on cashflow in first stage is not reported.

A.5.3 Data Underlying Figure 4

Table A.7: Effect on Investment Growth Over Time

Date	Effects using 7-Day Event Window			Effects using 3-Day Event Window		
	Differential	Common	Total Event	Differential	Common	Total Event
2019q1	-0.19	-0.07	-0.26	-0.76	-0.23	-0.99
2019q2	-0.31	-0.07	-0.39	-0.84	-0.29	-1.14
2019q3	-0.28	-0.07	-0.35	-0.48	-0.36	-0.84
2019q4	-0.22	-0.05	-0.27	-0.37	-0.29	-0.66
2020q1	-0.11	-0.04	-0.15	0.33	-0.16	0.18
2020q2	-0.17	-0.95	-1.12	-0.00	-0.46	-0.46
2020q3	-0.10	-1.52	-1.62	-0.67	-0.69	-1.36
2020q4	-0.10	-1.47	-1.57	-0.63	-0.67	-1.30

Note: These are the values underlying Figure 4.