



# 2022 ISDSA Presentation

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May 31, 2022

# Overview



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# Topic & Background

# Topic: Modeling U.S.-China Trade Relations: A Time Series Machine Learning Approach Using Stock data

- ▶ Multinational corporations (MNCs) allocate resources and organizing production activity worldwide since 1980s (Cui & Liu, 2019: p. xvii).
- ▶ Global value chains (GVCs) account for almost 50% of global trade today.
- ▶ Anti-dumping duty and other non-tariff barrier(NTBs)
- ▶ The 2018 U.S.-China trade war(January 1, 2018 – till date): tit-for-tat tariff list announcements and implementations

# Research Question & Hypotheses

# Research Question & Measurements



What are the effects of the U.S.-China trade war and U.S. trade policy changes on MNCs?

- ▶ Measuring U.S.-China trade war:
  1. U.S.-China trade tariffs
  2. Sentiment scores of press releases and tweets posted by United States Trade Representative (USTR)
  
- ▶ Measuring MNCs' revenues and health status:
  1. Nasdaq Composite index return rate and its volatility
  2. S&P 500 Composite index return rate and its volatility

# Hypotheses



## Hypothesis 1

**Theory:** The imposed tariffs impede the normal GVCs circulation, increase cost, reduce the profit margins of U.S. MNCs. Anti-U.S. sentiment in China → boycotts (Kapadia, 2021).

**H1:** *U.S. and China tariff rate changes are positively correlated to the volatility of stock return rate.*

## Hypothesis 2

**Theory:** Investors concern about trade policy and government attitudes' changes (Bandopadhyaya & Jones, 2006). Negative announcements affect customers' confidence in the stock market and lead to more variance in stock price changes.

**H2:** *U.S. trade policy and government attitude changes are more likely to negatively affect the volatility of stock return rate.*

# Research Design

# Dependent Variables

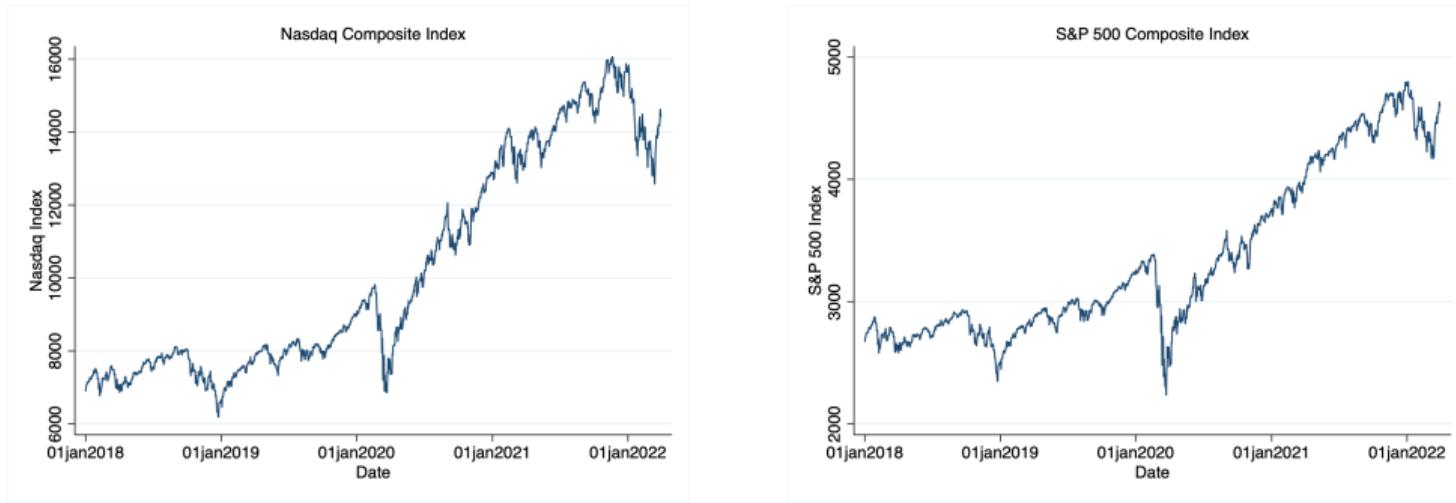


Figure 1 Nasdaq and S&P 500 Composite Index

Data source: Nasdaq and SP 500 Composite Index. Retrieved with R code, from  
<https://finance.yahoo.com/quote/%5EGSPC/> on April 18, 2022.

Nasdaq and S&P 500 composite index adjusted prices are **non-stationary**.

# Dependent Variables (continued)



To get stationary data, Nasdaq and S&P 500 index return rates are generated using equation:

$$R_t = (P_t - P_{t-1})/P_{t-1}$$

where  $R_t$  denotes  $t$  day's rate of return,  $P_t$  denotes today's adjusted price, and  $P_{t-1}$  denotes yesterday's adjusted price.

**Results of Dickey-Fuller test:** Nasdaq and S&P 500 index return rates are stationary data.

The **dependent variables** include *Nasdaq index return rate* and *S&P500 index return rate*.

# Independent Variables



- ▶ First-difference of U.S. tariff rate toward Chinese exports
- ▶ First-difference of Chinese tariff rate towards U.S. exports

Data source: Bown's U.S.-China tariff data, built based on data from U.N. Comtrade, Trade Map and Market Access Map, and the announcements of China's Ministry of Finance and USTR (Bown, 2021).

# Independent Variables (Continued)



- ▶ AFINN sentiment scores of USTR press releases
- ▶ AFINN sentiment scores of USTR tweets

**Sentiment analysis:** AFINN lexicon: 3300+ words; with sentiment score from -5 to 5.

**Examples:**

*Tweet 1: @POTUS announcement today on China follows USTR's Section 301 investigation finding forced technology transfer, discriminatory licensing processes and other unfair trade practices by China. (-5.0)*

*Tweet 2: @USTradeRep extends best wishes for a happy and prosperous Lunar New Year. May the YearOfTheOx bring you health, happiness, and good fortune. (19.0)*

Data source: USTR Tweets from Twitter Accounts (@USTradeRep, @USTradeRep45). Retrieved with R code on April 18, 2022.

# Control Variables



- ▶ Nasdaq volume
- ▶ S&P 500 volume
- ▶ Federal Funds Effective Rate (DFF)
- ▶ U.S. Dollar and Chinese Yuan Exchange Rate
- ▶ Trade war (dummy)
- ▶ Chinese exports subject to U.S. tariff
- ▶ U.S. exports subject to Chinese tariff
- ▶ U.S. tariff toward the rest of world (ROW)
- ▶ Chinese tariff toward the rest of world (ROW)
- ▶ Press released (dummy)
- ▶ COVID-19 (dummy)

# Methods



The generalized Autoregressive Conditional Heteroscedastic (GARCH) model

Two conditions to run ARCH-GARCH models:

- ▶ Clustering volatility in the residual of dependent variables
- ▶ The volatility follows an ARCH process

The residuals plots (as shown in Figure 2) and Lagrange multiplier (LM) test results (p-values are 0) indicate that there are ARCH effect existed.

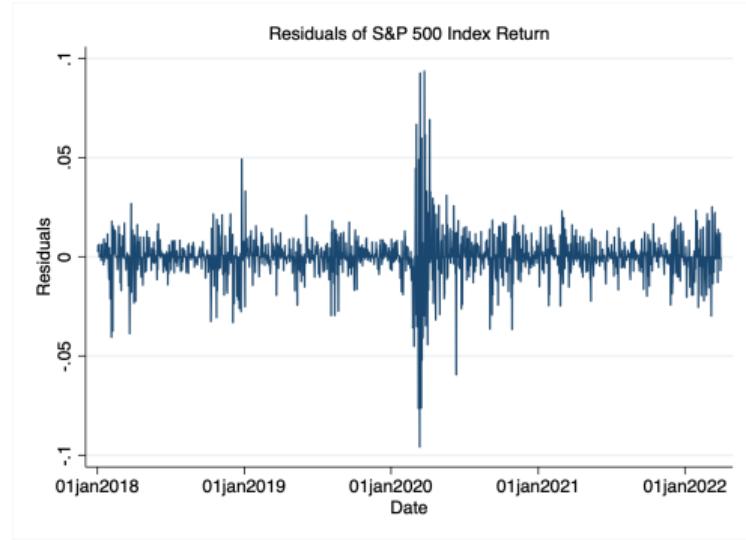
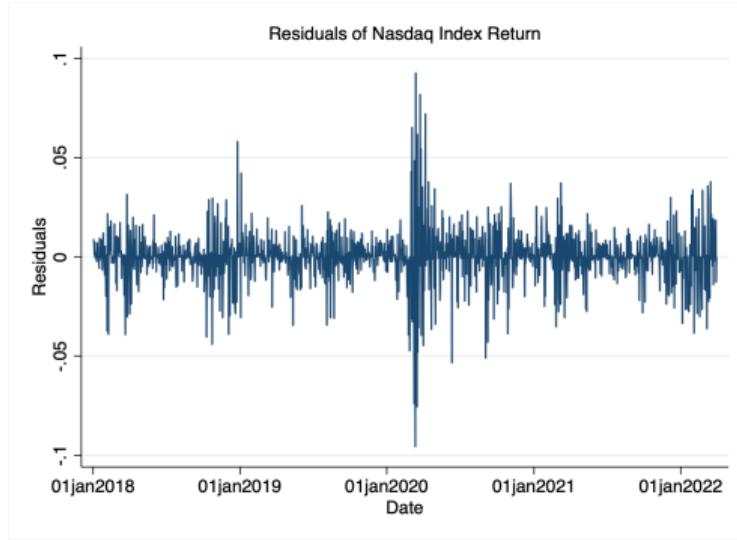


Figure 2 Residuals of Nasdaq and S&P 500 Index Return Rates

Data source: Nasdaq and SP 500 Composite Index. Retrieved with R code, from  
<https://finance.yahoo.com/quote/%5EGSPC/> on April 18, 2022.

The GARCH model contains three equations:

$$R_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 UTC_t + \beta_3 CTU_t + \beta_4 ATweets_t + \beta_5 APress_t + \beta_6 Controls_t + \varepsilon_t \quad (1)$$

where *UTC* represents *U.S. tariff rate toward Chinese exports*, *CTU* stands for *Chinese tariff rate towards U.S. exports*, *ATweets* stands for *AFINN sentiment scores of USTR tweets*, *APress* represents *AFINN sentiment scores of USTR press releases*, and *Controls* include all control variables.

$$\varepsilon_t = \eta_t \sigma_t \quad (2)$$

where  $\eta_t$  is a white noise with zero mean and variance of one, and  $\eta_t$  may or may not follow normal distribution.

$$\sigma_t^2 = \gamma \varepsilon_{t-1}^2 + \theta \sigma_{t-1}^2 + \alpha_1 UTC_t + \alpha_2 CTU_t + \alpha_3 ATweets_t + \alpha_4 APress_t + \alpha_0 \quad (3)$$

where  $\gamma$  is the ARCH parameter,  $\theta$  is the GARCH parameter, and  $\alpha_i$  is the parameter for conditional variables and constant.

# Results & Discussion

**Table 1 Descriptive Statistics for Numerical Variables**

	Mean	Variance	Std.Dev.	Min	Max	Obs
Nasdaq Index Return	0.00	0.00	0.01	-0.12	0.09	1,550
S&P 500 Index Return	0.00	0.00	0.01	-0.12	0.09	1,550
AFINN Tweets Scores	1.83	5.94	2.44	-4.00	11.00	1,551
AFINN Press Scores	11.99	368.72	19.20	-16.00	100.00	1,551
Chinese Tariffs on US Exports(FD)	0.01	0.04	0.21	-1.70	4.30	1,550
US Tariffs on Chinese Exports(FD)	0.01	0.05	0.21	-1.70	5.60	1,550
Chinese Exports s.t. US Tariffs (FD)	0.04	1.16	1.08	0.00	37.10	1,550
US Exports s.t. Chinese Tariffs (FD)	0.04	1.14	1.07	-9.20	34.40	1,550
Chinese Tari. on ROW Exports (FD)	-0.00	0.00	0.03	-1.10	0.00	1,550
US Tari. on ROW Exports (FD)	0.00	0.00	0.01	-0.10	0.40	1,550
Nasdaq Volume (Logged)	21.87	0.21	0.45	18.82	23.13	1,551
S&P500 Volume (Logged)	22.07	0.07	0.27	20.98	23.01	1,551
US Dollar to Chinese Yuan XR	4.57	9.77	3.13	0.00	7.18	1,551
Federal Funds Effective Rate (FD)	-0.00	0.00	0.03	-0.85	0.25	1,550

# Descriptive Statistics

Table 1 shows the descriptive statistics for numerical variables:

- ▶ The average Nasdaq and S&P 500 index return rate through the whole period is 0, the variance is 0, and the standard deviation is also 0, showing that the stock return data is stationary.
- ▶ The U.S. tariff rates toward China and the Chinese tariff rate toward the U.S. throughout the period are increasing while the tariffs toward the rest of the world by the two sides are consistent.
- ▶ The percentages of U.S. and Chinese exports subject to tariffs imposed by the other side also hold an increasing tendency.
- ▶ The means of AFINN sentiment scores for tweets and press releases by USTR are positive, with high variance and standard deviation.

Overall, we could say that the tariff rates and sentiment scores are distinguishable.

Table 2 GARCH(1,1) Model Results for Stock Return Rates

	<i>Model 1</i>		<i>Model 2</i>	
	<i>Nasdaq Index Return</i>	<i>S&amp;P 500 Index Return</i>		
	Coefficient	Std. Err.	Coefficient	Std. Err.
<b>Mean Equation</b>				
AFINN Tweets Scores	-0.000140496*	(0.0001)	-4.87750e-05	(0.0001)
AFINN Press Scores	-2.40433e-06	(0.0000)	-1.03267e-05	(0.0000)
CN Tari. on US Exp.(FD)	-0.00229939	(0.0103)	-0.00209588	(0.0115)
US Tariffs on CN Exp.(FD)	0.00189226	(0.0073)	0.00223792	(0.0082)
CN Tari. on ROW Exp.(FD)	-0.000295342	(0.0259)	0.00114781	(0.0265)
US Tariffs on ROW Exp.(FD)	0.0118521	(0.0102)	0.00304805	(0.0122)
CN Exp. S.T. US Tari.(FD)	-0.000538780	(0.0012)	-0.000440814	(0.0014)
US Exp. S.T. CN Tari.(FD)	0.000684634	(0.0015)	0.000356453	(0.0015)
Nasdaq Volume(Logged)	-0.00127260*	(0.0008)		
Federal Funds Rates(FD)	0.0166953**	(0.0079)	0.00580704	(0.0062)
US Dollar to CN Yuan XR	0.000164685	(0.0002)	0.000162866	(0.0002)
Trade War	-5.92363e-05	(0.0007)	-6.36219e-05	(0.0006)
COVID-19	0.000573782	(0.0009)	9.79872e-05	(0.0006)
S&P 500 Volume(Logged)			-0.00282559***	(0.0008)
Constant	0.0278902*	(0.0168)	0.0622742***	(0.0171)
<b>ARMA</b>				
L.ar	-0.0215595	(0.3123)	-0.969723***	(0.0224)
L.ma	-0.0756301	(0.3122)	0.981661***	(0.0161)
<b>Variance Equation</b>				
AFINN Tweets Scores	-0.188714***	(0.0649)	-0.0132377	(0.0386)
AFINN Press Scores	-0.00234630	(0.0035)	-0.000159220	(0.0039)
CN Tari. on US Exp.(FD)	0.340731	(34.2269)	0.594717	(23.8309)
US Tariffs on CN Exp.(FD)	-2.910205	(10.0815)	-3.300012	(7.0187)
Constant	-12.52393***	(0.1765)	-12.94136***	(0.1566)
<b>ARCH</b>				
L.arch	0.106162***	(0.0113)	0.127031***	(0.0119)
L.garch	0.878597***	(0.0110)	0.849860***	(0.0125)
Observations	1550		1550	

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

# Empirical Results



- ▶ Models 1 could provide partial evidence to *Hypothesis 1* that the sentiment shown in Tweets posted by USTR is negatively correlated to the volatility of stock return rate.
- ▶ While there is evidence for *Hypothesis 2*, I find the positive relationship between federal funds rates and stock return rate and the negative correlation between trading volume and stock return rate.
- ▶ The ARCH and GARCH effects indicate that the previous day's volatility of stock return rate could affect today's stock return rate and its volatility.

Table 3 GARCH(1,1) Model Results for Stock Return Rates(Lag 1)

	Model 3		Model 4	
	Nasdaq Index Return	S&P 500 Index Return		
<b>Mean Equation</b>				
AFINN Tweets Scores(LD)	-3.57002e-05	(0.0001)	1.42853e-05	(0.0001)
AFINN Press Scores(LD)	-2.45628e-06	(0.0000)	-5.65415e-06	(0.0000)
CN Tari. on US Exp.(LD)	0.00256418	(0.0371)	0.00187671	(0.0255)
US Tariffs on CN Exp.(LD)	-0.00227428	(0.0282)	-0.00129668	(0.0173)
CN Tari. on ROW Exp.(LD)	-0.00766646	(0.0479)	-0.00321363	(0.0455)
US Tariffs on ROW Exp.(LD)	-0.000752210	(0.1190)	0.00164062	(0.1352)
CN Exp. S.T. US Tari.(LD)	8.73265e-05	(0.0040)	-2.48161e-05	(0.0022)
US Exp. S.T. CN Tari.(LD)	-9.80616e-05	(0.0055)	-0.000106385	(0.0029)
Nasdaq Volume(Logged,LD)	1.63150e-05	(0.0008)		
Federal Funds Rates(LD)	-0.0102674*	(0.0062)	-0.0106790**	(0.0050)
US Dollar to CN Yuan XR(LD)	5.12475e-05	(0.0001)		
US Dollar to CN Yuan XR(LD)			0.000150887	(0.0002)
Trade War(LD)	-0.000139490	(0.0007)	-3.03191e-05	(0.0006)
COVID-19(LD)	-0.000446051	(0.0008)	-0.000191909	(0.0006)
S&P 500 Volume(Logged,LD)			0.000277057	(0.0007)
Constant	0.000654063	(0.0166)	-0.00595632	(0.0160)
<b>ARMA</b>				
L.ar	0.0358294	(0.3024)	-0.386935	(0.3245)
L.ma	-0.132392	(0.3002)	0.312444	(0.3310)
<b>Variance Equation</b>				
AFINN Tweets Scores(LD)	-0.165667***	(0.0630)	-0.0599027	(0.0379)
AFINN Press Scores(LD)	0.000273322	(0.0034)	0.000151717	(0.0039)
CN Tari. on US Exp.(LD)	0.165845	(39.5934)	0.353280	(27.0179)
US Tariffs on CN Exp.(LD)	-2.980048	(11.6436)	-3.260412	(7.9502)
Constant	-12.59260***	(0.1879)	-12.88083***	(0.1567)
<b>ARCH</b>				
L.arch	0.106986***	(0.0110)	0.129283***	(0.0119)
L.garch	0.878017***	(0.0109)	0.849649***	(0.0127)
Observations	1549		1549	

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 4 GARCH(1,1) Model Results based on Data before COVID-19

	<i>Model 5</i>		<i>Model 6</i>	
	<i>Nasdaq Index Return</i>	<i>S&amp;P 500 Index Return</i>		
<b>Mean Equation</b>				
AFINN Tweets Scores	-1.35719e-05	(0.0001)	9.73894e-06	(0.0001)
AFINN Press Scores	2.84977e-05**	(0.0000)	1.29189e-05	(0.0000)
CN Tari. on US Exp.(FD)	-0.00211801	(0.0082)	-0.00196314	(0.0093)
US Tariffs on CN Exp.(FD)	0.00186886	(0.0067)	0.00204552	(0.0069)
CN Tari. on ROW Exp.(FD)	-0.000403061	(0.0214)	0.000424820	(0.0200)
US Tariffs on ROW Exp.(FD)	0.0160130*	(0.0091)	0.00417944	(0.0131)
CN Exp. S.T. US Tari.(FD)	-0.000551313	(0.0010)	-0.000466319	(0.0009)
US Exp. S.T. CN Tari.(FD)	0.000703956	(0.0012)	0.000394009	(0.0011)
Nasdaq Volume(Logged)	-0.000272386	(0.0010)		
Federal Funds Rates(FD)	0.00868265	(0.0097)	-0.00138199	(0.0066)
US Dollar to CN Yuan XR	0.000235968	(0.0002)	0.000195283	(0.0002)
Trade War	0.000630638	(0.0006)	0.000489018	(0.0006)
S&P 500 Volume(Logged)			-0.00167672	(0.0013)
Constant	0.00494286	(0.0208)	0.0361322	(0.0276)
<b>ARMA</b>				
L.ar	0.0478383	(0.3681)	-0.0811905*	(0.0471)
L.ma	-0.177124	(0.3595)		
<b>Variance Equation</b>				
AFINN Tweets Scores	-0.443786***	(0.1236)	-0.282169***	(0.1077)
AFINN Press Scores	-0.0244568**	(0.0116)	-0.00587122	(0.0080)
CN Tari. on US Exp.(FD)	-1.499003	(2.6367)	-0.565844	(13.8199)
US Tariffs on CN Exp.(FD)	0.426173	(7.8223)	-0.727476	(44.7808)
Constant	-12.09455***	(0.1981)	-12.75342***	(0.2327)
<b>ARCH</b>				
L.arch	0.115118***	(0.0159)	0.133926***	(0.0182)
L.garch	0.859186***	(0.0165)	0.843576***	(0.0199)
Observations	751		751	

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

# Robustness Test



- ▶ The robustness test provides strong evidence to the *Hypothesis 2*.
- ▶ No evidence for *Hypothesis 1*.
- ▶ Models 3 and 4 suggest a negative relationship between federal funds rates and stock return rate, which is consistent with the results of previous research that the effect of a Federal Funds target rate decrease on stocks is positive while the reaction of a Federal Funds target rate increase is negative (E Kanayake, 2008).
- ▶ Model 5 suggest a positive connection between U.S. tariffs toward the rest of the world and the stock return rate.
- ▶ The ARCH and GARCH terms through all four models are significant, providing strong evidence for the effect of previous days' volatility on today's stock return rate and its volatility.

# Conclusion



- ▶ Descriptive statistics: tariff rates are distinguishable and U.S.-China trade war increases the costs for U.S. MNCs in importing manufacturing materials and exporting their products to China.
- ▶ The sentiments of tweets and press releases posted by USTR are negatively related to the volatility of stock return rates.
- ▶ The U.S.-China trade war could affect the stock market's volatility through its announcements and the sentiment reflected.
- ▶ The significant ARCH term shows that the previous day's stock return rate can influence today's stock return rate volatility. And the significant GARCH term illustrates that the previous day's volatility of the stock return rate can influence today's stock return rate.

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