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Impact of US-China trade war on Asian economies: neural network multilayer perceptron approach

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Abstract

Purpose – This study aims to find the impact of the trade war between the USA and China on Asian economies. Apart from macroeconomic variables associated with trade, this study explicitly creates a trade war scenario and trade war participant dummies. Using the neural network multilayer perceptron, this study checks for the causal linkages between the predictors and target output for the panel of Asian economies and the USA.

Design/methodology/approach – A conceptual model of the after effects of trade war in a quadrant is developed. Variables related to trade and tariffs are included in the study for a panel of 19 Asian economies. The feedforward structure of neural network analysis is used to identify strong and weak predictors of trade war.

Findings – The hidden layers of the multilayer perceptron reveal the inconsistency in linkages for the predictors' services exports, tariff measures, anti-dumping measures, trade war scenario dummy with gross domestic product. The findings suggest that to curtail the impact of the trade war on Asian economies, predictors with neural evidence must be paid due weightage in policy determination and trade agreements.

Originality/value – The study applies a novel and little explored AI/ML technique of Neural Network analysis with training of 70% observations. The paper will provide opportunity for other researchers to explore techniques of AI/ML in trade studies.

Keywords Feedforward structure, Tariffs, Anti-dumping measures, Countervailing duties, Merchandise exports, Merchandise imports

Paper type Research paper

1. Introduction

The asymmetries between the Global South and Global North are leading to altered economic and political dynamics. One such dynamic is the issue of trade war emerging between the USA and China. The world economy is currently facing a slowdown due to COVID-19 and its aftereffects. The global economy is hit by the tariff war between the two manufacturing giants of the global economic order, the USA and China. We attempt to build a discussion on the growth dynamics of the trade war between the USA and China. The past few years have witnessed escalating trade tensions between the USA and China, particularly on import duties and trade deficits. Each side is justifying its stand but, at the same time, being using protectionist measures in trade policy.

JEL classification – C45, F10, F14, F18

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Journalists, researchers, governments alike were quick to label it as the emergence of the trade war. Few see this as an east versus west dichotomy. The rise of China as a dragon spreading its wings in the Asian region is a fact, which is a subtle challenge to the USA. The USA has already taken all steps to counter the One Belt One Road (OBOR) initiative of China, considering it a geopolitical game changer (Rahman and Rahman, 2019). The recent Indo-Pacific investment policy of the USA is a testimony that China wants to use OBOR to increase export and move manufacturers towards strategic geographical regions. However, as trade war clouds, manufacturers from mainland China have started moving their operations to Malaysia and Vietnam (Rapoza, 2018). The euphoria of full employment and internalization of control is becoming a new trend with the trade war emergence.

The USA has raised the duty on around 180 Chinese products imported by the USA. Raising the duties escalated the issue, and in return, China initiated the non-tariff barriers to curtail the US imports in China. However, there have been recent shifts in the policy from both sides. Both the USA and China held talks with tariff cuts as the outcome, and it was expected to get implemented with a full-fledged agreement before March 2019, but things became uncertain due to COVID-19. The Trump administration had clarified that the Chinese CEO's arrest was not in their information while they were in the G-20. This issue can be seen in the bigger picture of putting pressure on China to get down negotiating on specified terms. The US secretary has already indicated that reducing the trade deficit with China will remain its objective as a long-term strategy (ST, 2018). The USA has put up tariffs on Chinese products worth $250bn, while China has responded with $110bn tariff hike (Schoen and Pramuk, 2018). There is no doubt that Trump is using America First to create a euphoria of the neo-protectionist approach. Trump has used the rhetoric of trade barriers to give a signal indicating more such protectionist policies. There is ample evidence that Trump's policies can be labelled as protectionist and has a substantial impact on the supply chain. Trump's new tariffs in 2018 cover roughly 12% of all US imports (Bown, 2018). Thus, it is clear that the first benefit is political and not economical, given the upcoming presidential elections.

Regarding the US economy, experts have raised concerns that Trump's conservative move may negatively affect the US economy amid few right punches. Reuter had surveyed 104 economists, which revealed that the trade war would hurt the American economy (Reuters, 2018). At the same time, others believe that the trade war will not affect the USA. While there is a general agreement of the negative impact on the US economy, it is believed that some sectors in other nations potentially stand to gain; however, these gains are expected to be highly specific and limited to few sectors. Different opinions on the issue of trade war indicate one commonality: it will hinder the world economic growth and may hamper the speed of economic recovery.

More or less, there will be a negative impact on the US economy due to trade war. There have been reports and discussions arguing for the possibility of recession due to trade war (Layne, 2018). The study is important both academically and as a policy issue due to the significant impact of the trade war on regional and global economies. As it is clear that due to the trade war, China's economy will suffer, as 50% of China's exports to the USA have been targeted under tariffs. China may lose in items such as auto parts, engineering goods, electrical goods and chemicals, which can become an edge for other countries producing/manufacturing the same. For instance, the Ministry of Commerce, India, has identified several critical items for exporting to the USA, where now India can have an edge due to the US–China trade war (Business Today, 2018). The world economy may also feel the burn of a trade war if not tackled earnestly. Already eurozone survey has demonstrated weaker business activity due to the trade war. This also motivates the researchers to undertake studies on US–China trade war. The epicentre of the future systematic slowdown in the world economy can be the US–China trade

war. The latest World Economic Outlook report project global growth at 3.7%, which is 0.2 percentage point lower for both years. One of the reasons for downward revision, as stated by IMF, is trade measures (IMF, 2018). IHS Markit's Flash Commodity Purchasing Manager's Index fell to 52.4, its lowest since late 2014, from a final October 2018 reading of 53.1, indicating an overall slowdown (Cable, 2018). The BRICS countries are also facing the concern of economic slowdown and therefore have recently pledged for unity (Agency Fransee Pressee, 2018). The Trade War has benefitted several countries and will change the dynamics of trade in commodities. There seems an opportunity for a few Latin American countries. Sources claim that American exports are facing a significant tariff of 25% from China on soya beans. The matter is severe because China is the world's largest importer of soya bean, while the USA is the second-largest soya bean supplier. The tariff war will severely impact American soya bean farmers on one hand and Chinese pork producers on the other hand. The reason is that China has increased tariffs on US soya beans, which is input food for the pigs in China. An increase in the price of soya beans will increase the cost of pork, making the exports expensive. China has already shunned the US soya beans and is now turning towards Brazil. This shift away from the US beans by China, which comprises 60% of the commodity world trade, will further tumble the benchmark Chicago Board of Trade prices.

The whole event of the US–China trade war is a tragic one for the world economy which was already struggling to get out of the repercussions of the Global Financial Crisis, 2008, and currently facing COVID-19. The issue cannot be seen in economics' isolation, but certain political instincts need to be considered. Since the past couple of decades, the realization has set in that China has emerged as a strategic power coupled with its economic rise, which seems to be a threat to the US-led world order. China's aggressive economic ambitions such as silk route, strategic ports in the Indian ocean, etc., are a severe challenge to the USA's domination. China's accession to World Trade Organization (WTO) was in the USA's interest, but now the USA feels China has betrayed it. The USA claims that the colossal trade deficit with China is due to protectionist measures used by China. Ultimately, the Asian economies engaged in intermediary trading between China and the USA feel the brunt of the trade war. The emerging uncertainty in the export–import market owes to the US–China conflict. The economic costs of the Trade War are grave. To torture a dying person is to make him die, an excellent example of the world economy's condition. The trade war will harm the world economy and will lead to lose–lose outcomes. The trade war will also allow the developing and under-developed countries to come together and give them the confidence to enter the world market with much-coordinated effort.

In this context, the paper seeks to analyse the impact of US–China trade war on Asian economies. The research gap which the study attempts to pertains to the panel of 19 Asian economies. No study has made a comprehensive effort to understand and examine the linkages between tariff measures (TMs) and trade war. There remains disparate evidence when it comes to non-tariff measures (NTMs) that have largely been ignored in the trade war studies. However, the importance of NTMs cannot be undermined. The study contributes the evidence on TMs and NTMs in relation to US–China trade war. The core research question is:

RQ1. How the tariff and non-tariff measures in the presence of the dummy of trade war linked to GDP of the Asian economies?

The research objective is to identify the impact of trade indicators, TMs, NTMs and the trade war on gross domestic product (GDP) of Asian economies. The rest of the paper is organized as follows. Section 2 reviews the existing sparse literature on the topic and introduces the novel technique of neural network approach. Section 3 conceptualizes the trade war scenario. Section 4 analyses the impact of US–China trade war on Asian economies. Section 5 provides policy recommendations and concludes. The findings of the

study suggest strong causal linkages of merchandise exports, merchandise imports, services imports, countervailing duties (NTM) and trade war participant dummy on GDP of the Asian economies, while inconsistent linkages for the predictors services exports, TMs, anti-dumping measures and trade war scenario dummy.

2. Review of literature

The USA has continued with the escalated tariffs on Chinese imports despite the expiry of the four-year period the tariffs were implemented for and the signing of the phase one agreement to de-escalate trade tariffs. Regardless of the change in US administration and the ambivalent attitude towards China, the tariffs remain the same. This has affected global trade as well as bilateral trade. After carefully scrutinizing the definitions, timings and scale of the products that were under tariffs during the trade war between 20 January 2017 and 20 January 2021, it was identified that new tariffs and counter-tariffs reached to 50% of the bilateral trade (Bown, 2021).

Troubled trade has been the case for 62 economies of the world, as noted by Guo *et al.* (2018). The effect on exports, imports, output and real wages differs in the three scenarios envisioned, although the impact is irrevocable. In case of a further increase in tariff by the USA, exports will decline by 90%. This drop is observed throughout 9 of the 18 tradable sectors in China. In a tit-for-tat scenario, there will be a widespread decline in output and real wages across sectors in the USA as well as China. However, in the first scenario, the USA appears to lose out more in terms of social welfare, while China's effect is severe in the second scenario, where even China press a 45% tariff on US exports. In a general equilibrium analysis of trade war, the economic fallout is detrimental for both China and the USA (Li *et al.*, 2018). Trade war has also been seen linked to gold and oil prices, wherein a series of evidence is available (Ulyah *et al.*, 2021; Rahmayanti *et al.*, 2021; Andreas *et al.*, 2021). In the event of a unilateral tariff hike by the USA, China will bear the whole brunt. If China chooses to retaliate full-fledged in response to the US hike in tariff, the fallout will be as disastrous for the USA as has been for China in the scenario of a unilateral tariff.

The associated impacts of the trade war on output, productivity, GDP and foreign direct investment are acute, percolating through the global value chains (GVCs). There could be an anticipated GDP decline of 1.41 and 1.35% for both China and the USA (Itakura, 2020). The impact on output is substantial for both countries with a cascading effect on imports and exports across sectors. Given the vast integration in the GVCs, the fall in GDP, export and import is much worse. Albeit, the USA has not adjusted its GVCs as yet (Hanson, 2020). Hanson (2020) finds that with every 1% increase in tariff rate, there follows a 2% decline in imports from China. Without making any alterations in their GVCs, the USA's impact can only be called one of the short run. The adjustment in GVCs could aggravate effect on imports. The disturbances in the GVCs due to trade war can drastically displace global trade (Iqbal *et al.*, 2019a, 2019b). The dip is also expected in exports of both China and the USA. Trade disruption is supported by panel data analysis by Doifode and Narayanan (2020). With every 1% increase in tariff rate, exports from the USA to China will diminish by 1.6 times more. Nevertheless, the negative impact of tariff increases enabled by the trade war is tumultuous for both China (0.058%) and US (0.094%) bilateral exports. In terms of welfare, the impact on the USA is more egregious than on China (Sengupta and Rastogi, 2018). However, following the signing of phase one trade deal in January 2020, decrease in welfare in China (1.7%) is more pronounced than in the USA (0.2%). Both China's exports to and imports from USA decline by 52.3% and 49.3%, respectively (Li *et al.*, 2020). Notwithstanding the decline in bilateral trade between the USA and China due to tariff escalation, global trade increased by 3%, as more trade opportunities were created when third countries re-shuffled exports to the USA and

shifted away from China (Fajgelbaum *et al.*, 2021). Individually, countries like Indonesia are expected to receive negative blow from US–China trade war, with a decline in exports (Purwono *et al.*, 2022). The impact of US–China trade war has not been limited to Asian region, but the European Union has also been affected by it (Goulard, 2020). The announcement of tariffs in 2018 and 2019 lowered the investment growth rate of listed US companies by 1.9 percentage points (Amiti *et al.*, 2020). More recently, the studies have been conducted to identify the impacts of trade war on specific economies or the global economy. Trade war provides a learning opportunity to the economist to understand tariff glitch and asymmetric information (Fajgelbaum and Khandelwal, 2022). A protectionist approach has also emerged in the developed countries towards the rising developing countries, as it is clear from steel sector in the USA, where national security is a major concern with the entry of foreign players, particularly, that are politically not allied with the USA (Bown and Kolb, 2022). From a politico-economic prism, the view of American regarding trade war has also been studied, and the findings reveal that Americans are divided over US–China trade war though 76% of the surveyed adults supported trade with China (Jin *et al.*, 2022). In addition, by applying difference in difference technique, it was found that trade war has a negative impact for US firms with high outsourcing (Fan *et al.*, 2022). Recent findings on the decrease in China's exports to the USA are not surprising, and the specific fall in the exports has been reported to be 16.47% associated with quantity fall while price remain unchanged, relatively (Jiang *et al.*, 2023).

In recent years, neural network analysis has entered in the domain of economics and finance as inference drawing technique. The use of neural networks is in the early phase as it is not yet popularized. Neural network has been used in areas such as bankruptcy (Hosaka, 2019), financial system modelling (Duan, 2019), financial capabilities (Kadhim and Erzaij, 2020), training models for financial markets (Karlov *et al.*, 2019), financial market digitalization (Aleshin *et al.*, 2020), etc. Few studies have attempted to use neural network in trade issues such as competitive strategy of trade enterprises (Shalimov *et al.*, 2020), economic growth and trade parameters (Sokolov-Mladenović *et al.*, 2016) and water allocation trade prices (Nguyen-Ky *et al.*, 2018).

3. Conceptualizing trade war scenario

The starting point for conceptualizing trade war is to develop a trade relations quadrant. Existing theories of trade argue for the motive of trade between countries focusing on trade-offs. This is captured in absolute cost advantage theory propounded by Adam Smith (Schumacher, 2012), comparative cost advantage theory by David Ricardo (Ruffin, 2002), factor endowment theory based on Heckscher–Ohlin model (Baskaran *et al.*, 2011), new trade theory (Krugman *et al.*, 1989), etc. However, the hindrance to trade is not much prevalent in theorizing, though anomalies in trade relations have been explained (e.g. Leontief paradox). The importance of trade agreements, membership of the WTO, participation in dispute settlement, to name a few, are considered to impact the trade relations between countries. Apart from economic relations, the social, political and geopolitical constraints may determine trade relations. The concept of natural partners in trade cannot be ignored, and several studies on the gravity between nations found distance to be a factor for trade relations. The emergence of regional blocks and agreements such as BRICS (Iqbal and Rahman, 2016), RCEP, CPEC, TPP, ASEAN, BRI, and BIMSTEC are also the cause of better trade for member countries.

We conceptualize a trade relations scenario assuming the two most crucial constraints relevant to the times of trade war and membership of the WTO, that is, TMs and NTMs. The sample countries (see Appendix 2) in our study are all members of WTO. We represent the trade relations quadrant in Figure 1.

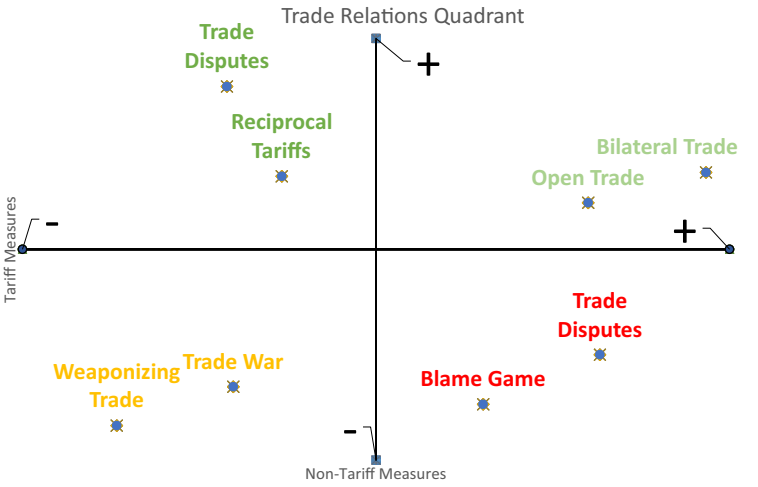

Figure 1.
Conceptualized trade relations quadrant

Source: Developed by the Researchers

Figure 1 has four quadrants with two variables, that is, TMs (horizontal axis: + and −) and NTMs (vertical Axis: + and −). The interface and interaction of these two results in trade relations, from cooperation to dispute and eventually to war. A lot depends on how the countries use tariff (TM) and NTM. Quadrant one is the positive–positive area (+, +), indicating the positive use of tariff and NTMs. When the two countries having bilateral trade are using TM and NTM in the ordinary course of operations with cooperation and collaboration, it leads to open trade and bilateral trade. The next quadrant is the positive–negative area (+, −), indicating the positive use of NTM but a contentious use of TM by one or both the countries. The detrimental use of TM may lead to trade disputes and reciprocal tariffs between the two countries. The third quadrant is the negative–negative (−, −) area, indicating the detrimental use of both TM and NTM. The negative–negative area symbolizes the generation of a trade war situation between countries due to non-cooperative and rival use of TM and NTM. Continuous harmful use of TMs and NTMs eventually leads to a trade war situation and opens up the gate for weaponizing trade in the bilateral relations. In the present political and geopolitical scenario of the world, it cannot be denied that the future can witness the use of trade as a weapon. The fourth quadrant captures the negative–positive area (−, +), indicating the detrimental use of NTM and TM's positive use. The cynical use of NTMs leads to trade disputes. However, the proper use of the dispute settlement mechanism may solve the issue. Re-emergence and status quo of disputes may further start a blame game between countries and may hamper the bilateral trade. However, this never leads to a trade war scenario as TMs are within the acceptable limits and cooperative for the two countries.

4. Impact of US–China trade war on Asian economies: neural network multilayer perceptron approach

We are interested in determining the impact of the US–China trade war on the Asian economies. The default techniques for a researcher, in general, are techniques based on regression or the computational equilibrium models. Recent literature on the impact of the

trade war has applied these techniques. However, we would argue that other computational techniques may give us new perspectives by modelling in a non-conventional manner. One of the significant criticisms of general techniques remains linearity; however, modelling in a non-linear fashion is more realistic in a dynamic world. Therefore, we approach the issue with the neural network multilayer perceptron approach.

A neural network is a computational family of models with ample parameter space, independent of hypothesis, flexible structure and developed resembling brain functioning. Neural network analysis has an advantage over traditional regression models. Regression models are based on ordinary least squares (along with finite sample properties, Rahman, 2018) and store judgemental knowledge in the regression coefficients. Regression analysis is just one type of neural network, but neural network analysis is far more than ordinary least squares. Another superiority of a neural network is that it is dynamic rather than static (regression). We use the multilayer perceptron method for a model with one dependent variable (target output) and several predictive variables. The variable description is presented in Appendix 1, and the data description with justification is presented in Appendix 2.

4.1 The algorithm behind feedforward structure

We use the feedforward structure with the input layer (predictors), hidden layers (unobservable nodes) and output layer (responses). The underlying algorithm for a multilayer perceptron with a hidden layer is captured in a stepwise manner.

Step 1: Initializing network weights and threshold with random values in the range $\frac{-2.4}{F_i}$ $\frac{2.4}{F_i}$, where F_i is the total number of inputs of the neuron i.

Step 2: Training of the data set initializing gradients of the weights and error with 0 ($\Delta w_{ij} = 0$ and $E = 0$).

Step 3: Forward propagation by applying the training set. The hidden layer is used to calculate the outputs of the neurons with $y_{j(P)} = f\left[\sum_{i=1}^{n} x_i(p).w_{ij} - \theta_j\right]$, where n is inputs for neurons j (hidden layer), and sigmoid activation function is denoted by f. The equation $y_k(p) = f\left[\sum_{i=1}^{m} x_{jk}(p).w_{jk}(p) - \theta_k\right]$ is used to calculate real outputs (m = inputs; k = output neuron) with the error epoch as $E = E + \frac{(e_k(p))2}{2}$.

Step 4: The weights are adjusted for the backward propagation. Gradients of the errors are determined with $\delta_k(p) = f'.e_k(p)$ and updated (between hidden and output layer) with $\Delta w_{jk}(p) = \Delta w_{jk}(p) + y_j(p).\delta_k(p)$.

Step 5: The iteration stage where the hit and trial happen. If an epoch is completed, it is tested with the condition that $E < E_{\max}$ to terminate the function (Figure 2).

We run the neural network analysis with multilayer perceptron for the complete data set in one go. The objective to run in one go is to reduce the training time and understand all Asian economies' scenario. The impact of the trade war is to be determined by using the trade war scenario and trade war participant. All predictors are fed as covariates due to close linkages between exports, imports, trade war, TMs, and NTMs. Table 1 shows the case processing summary for the multilayer perceptron.

The total cases in Table 1 are 180, while the total number of observations in the data set is 1,798. Cases here means the corresponding year figure as the dataset is a panel. A total of two cases are excluded, and rest are used for training and testing. For training purposes (Step 2 of the figure), 67.4% cases are used (1,212 observations), and for testing purposes (Step 3–5 of the figure), 32.6% cases are used (586 observations). The algorithm decides this

Figure 2.
Steps in the algorithm propagation of the neural network

Source: Developed by the researchers

Sample division		*N*	%
Sample	Training	120	67.4
	Testing	58	32.6
Valid		178	100.0
Excluded		2	
Total		180	

Table 1.
Case processing summary

Source: Output generated through neural network by the researchers

division to bolster the predictive power of the model. With respect to reliability and validity of the model, the conceptual understanding of a neural network suggests that the train and test approach incorporates the reliability and validity. For a simulated model such as neural network, relative error is considered to be a comprehensive indicator for validity. The percentage of the relative error is 1.9 which is less than 5% and thus the model is accepted to be valid (Kat and Els, 2012). The network, with its internal dynamics, is presented in Table 2.

Nine input layers denote the predictors (covariates) and one hidden layer with a hyperbolic tangent for GDP (target output). We use the standardized method for covariates and scale dependents. The network structure is selected to make the model robust and parsimonious. Appendix 3 shows the network nodes and the outcome of the analysis. The blue lines in the hidden layer activation function suggest a causal relationship, while the dull lines indicate a weak relationship (meaning thereby insignificant relationship). The significant variables

Input layer	Covariates	1	MEXP
		2	MIMP
		3	SEXP
		4	SIMP
		5	TRFF
		6	ADP
		7	CVD
		8	TWSC
		9	TWPT
	Number of units[a]		9
	Rescaling method for covariates		Standardized
Hidden layer(s)	Number of hidden layers		1
	Number of units in hidden layer 1[a]		3
	Activation function		Hyperbolic tangent
Output layer	Dependent variables	1	GDP
	Number of units		1
	Rescaling method for scale dependents		Standardized
	Activation function		Identity
	Error function		Sum of squares

Note: [a]Excluding the bias unit
Source: Output generated through neural network by the researchers

Table 2.
Network information

affecting the GDP for the panel of Asian economies are merchandise imports (MIMP) via hidden layer 1:2 and 1:3; services imports (SIMP) via hidden layer 1:1, 1:2 and 1:3; merchandise exports (MEXP) via hidden layer 1:1 and 1:2; countervailing duties (CVD) via hidden layer 1:2 and 1:3; and trade war participant (TWPT) via hidden layer 1:1 and 1:3. The hidden layers H (1:2) and H(1:3) have a stronger relationship with the GDP of the Asian economies. The network suggests that variables having an association with H(1:2) and H(1:3) are having a significant relationship with the GDP of Asian economies, indicating MIMP, SIMP, MEXP, CVD and TWPT. An important finding for us is that trade war participant countries, along with merchandise trade (exports and imports), services imports and NTMs, have a significant relationship with the GDP of the Asian economies. The parameter estimates of the neural model (see Appendix 4 for the model summary) are presented in Table 3.

The parameter estimates suggest that bias (omitted variables) does play an essential role in impacting the Asian economies' GDP, which is natural. However, it also suggests that the trade war is affecting the GDP of the Asian economies. Economic intuition and common sense indicate that trade war negatively affects the Asian economies GDP (not only Asian). The relative importance of the predictors is shown in Figure 3 (for statistics, see Appendix 5).

The normalized importance of the predictors in the neural network multilayer perceptron suggests NTMs, merchandise imports and services imports to be of paramount importance. To revive the Asian economies' GDP in the trade war scenario, strong policy consideration is required for NTMs, merchandise imports and services imports. Our study has found that the trade war scenario in the Asian region is not having a strong relationship with GDP, while trade war participant countries (the USA and China) affect the economic scenario of the Asian region. Table 4 captures the summarized results of neural network multilayer perceptron analysis for the Asian economies.

5. Policy recommendations and conclusion

The US–China trade war gave a setback to the global trade environment, especially for the Asian economies. Significant factors associated with the trade war have shattered the

		Predicted			
		Hidden layer 1			Output layer
Predictor		H(1:1)	H(1:2)	H(1:3)	GDP
Input layer	(Bias)	−0.182	0.553	−0.234	
	MEXP	−0.327	−0.207	0.003	
	MIMP	0.348	−0.587	−0.129	
	SEXP	0.207	0.225	0.380	
	SIMP	−0.104	−0.345	−0.282	
	TRFF	0.135	−0.046	0.094	
	ADP	0.175	0.098	0.093	
	CVD	0.292	−0.569	−0.640	
	TWSC	0.510	0.088	0.470	
	TWPT	−0.056	0.280	−0.297	
Hidden layer 1	(Bias)				0.539
	H(1:1)				0.875
	H(1:2)				−0.950
	H(1:3)				−0.912

Table 3.
Parameter estimates

Source: Output generated through neural network by the researchers

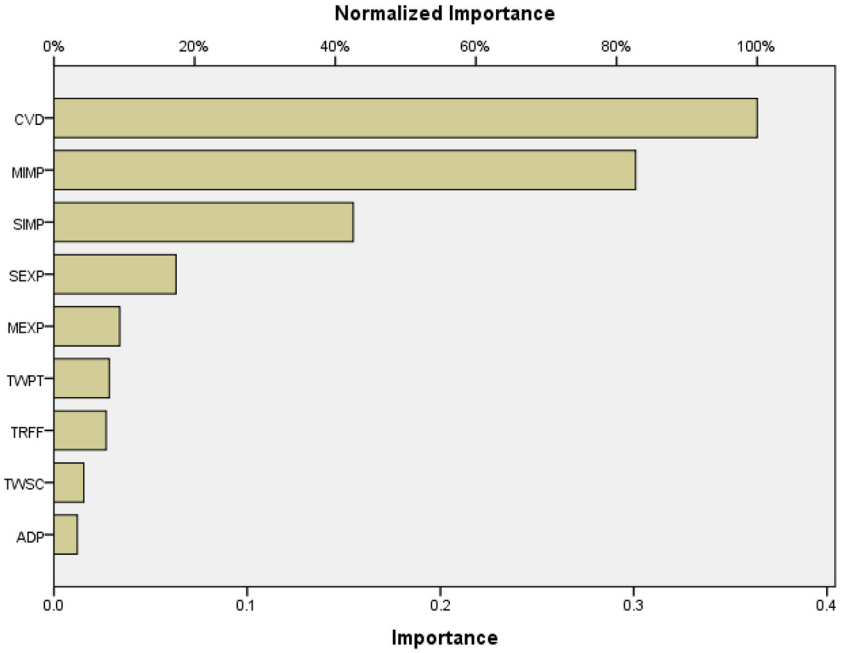

Figure 3.
Normalized importance of predictors based on multilayer perceptron

Source: Developed by the researchers

growth prospects of the Asian economies. The complexity of the issue may lead the Asian economies to new challenges for maintaining bilateral relations. We conceptualize the trade relations scenario with the quadrant axis of TMs and NTMs. We found that the third quadrant with the negative–negative area, indicating detrimental use of TMs and NTMs,

Variable	Relationship	Hidden layers	Impact on GDP through H (1:2) and H (1:3)
MEXP	Strong	H (1:2)	Significant
MIMP	Strong	H (1:2); H (1:3)	Significant
SEXP	Weak	None	Insignificant
SIMP	Strong	H (1:2); H (1:3)	Significant
TRFF	Weak	None	Insignificant
CVD	Strong	H (1:2); H (1:3)	Significant
ADP	Weak	None	Insignificant
TWSC	Weak	None	Insignificant
TWPT	Strong	H (1:3)	Significant

Source: Output generated through neural network by the researchers

Table 4. Neural network multilayer perceptron summary

has all the aspects of the trade war and may further lead to weaponizing of the trade relations. Our neural network analysis using hidden layers multilayer perceptron approach suggests critical causal linkages between trade variables and GDP of Asian economies. The dummy variables of trade war scenario and trade war participant have also been modelled into the network. The neural analysis with hidden layers suggests strong causal linkages of merchandise exports, merchandise imports, services imports, countervailing duties (NTM), trade war participant dummy on GDP of the Asian economies. The hidden layers of the multilayer perceptron reveal the inconsistency in linkages for the predictors services exports, TMs, anti-dumping measures and trade war scenario dummy with GDP. Recognizing the significant and strong impact of trade war participating countries, i.e. the USA and China on Asian economies, it is important for the Asian countries to negotiate an elimination of tariff barriers and transparency in NTMs. The Asian economies must take the road towards globalization and strike new deals and bilateral agreements within and outside the region to bring down TMs and NTMs.

6. Limitations of the study and future research direction

The study has used data for the sample period 2010–2019 without checking for the breakpoint due to the time frame being close to trade war. As the time period increases with trade war year (2018) as the reference point, analysis with more data can give better and precise results. The future researchers must check for structural breaks as well. The present study does not use structural breaks. The study has focused on the secondary data, though trade war is also a matter of perception. Considering the fact, primary research should be conducted with exporters/importers/economist, etc., to delve on the trade war perception.

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Appendix 1

Type	Variable	Measure (source)	Symbol
Target output	Gross domestic product (Annual)	US$millions (UNCTAD, IMF Outlook Report 2019)	GDP
Predictor	Merchandise exports (Partner: World)	US$millions (WTO Data)	MEXP
Predictor	Merchandise imports (Partner: World)	US$millions (WTO Data)	MIMP
Predictor	Services exports (Partner: World)	US$millions (WTO Data)	SEXP
Predictor	Services imports (Partner: World)	US$millions (WTO Data)	SIMP
Predictor	Tariffs	MFN – Trade weighted average duty (per cent) (WTO Data)	TRFF
Predictor	Non-tariff measures-countervailing duties	CVD final measures in force (cumulated) (Number) (WTO Data)	CVD
Predictor	Non-tariff measures-anti-dumping	ADP final measures in force (cumulated) (number) (WTO Data)	ADP
Predictor (dummy)	Trade war scenario	Different values assigned (0 = years with no trade war, 1 = years with trade war) (assigned by authors)	TWSC
Predictor (dummy)	Trade war participant	Different values assigned (0 = countries not participating in trade war, 1 = countries participating in trade war) (assigned by authors)	TWPT

Source: Compiled by researchers

Table A1.
Variables description

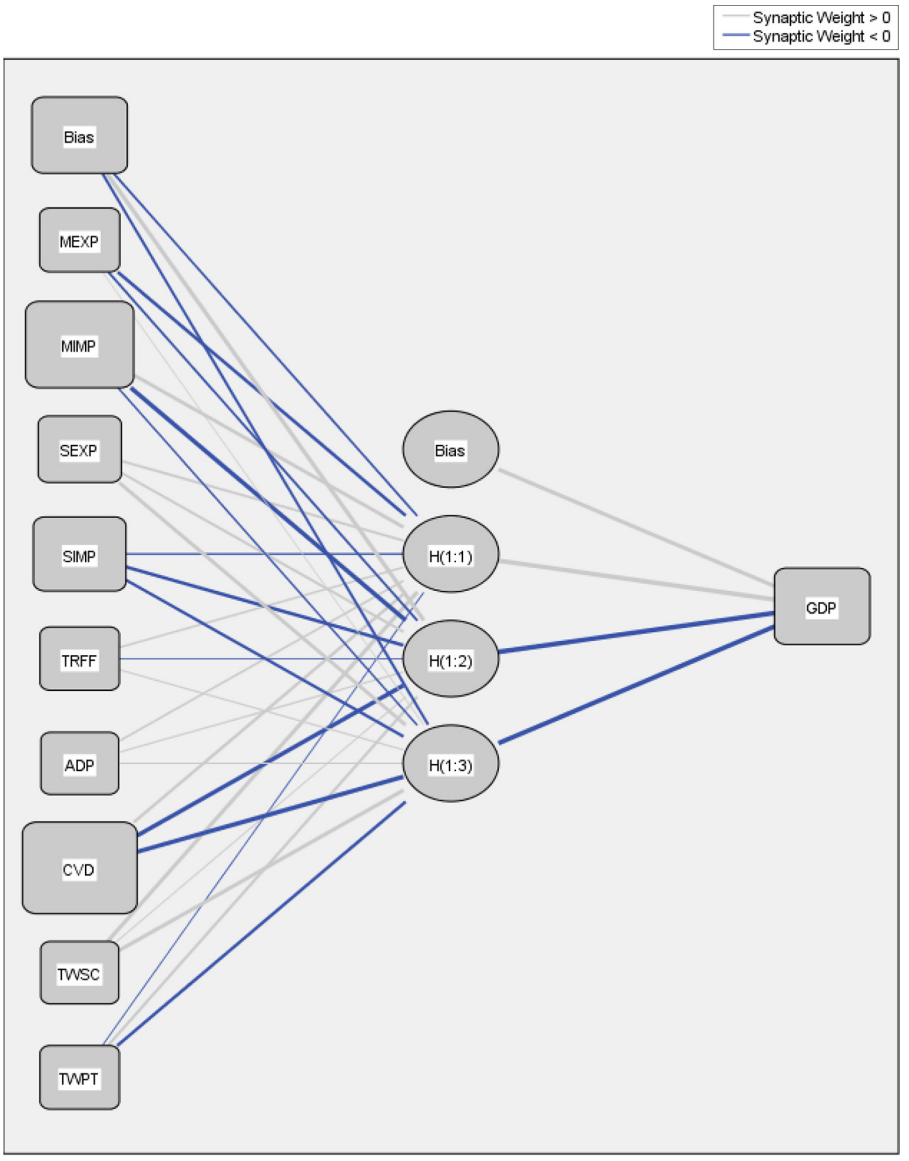
Appendix 2

Table A2.
Data description

Symbol	Sample period	Sample countries	Justification from trade war literature	Expected relationship with the target variable
GDP	2010–2019	Bangladesh, China, India, Indonesia, Indonesia, Japan, Jordan, Kazakhstan, Republic of Korea, Kuwait, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Turkey, United States and Viet Nam	Petri and Plummer (2020); Doifode and Narayanan (2020); Itakura (2020), Li *et al.* (2018); Liu and Woo (2018), Lukin (2019); Rahman (2016)	
MEXP	2010–2019		Guo *et al.* (2018); Hanson (2020); Iqbal *et al.* (2019a)	Strong causal linkages
MIMP	2010–2019		Guo *et al.* (2018), Hanson (2020); Iqbal *et al.* (2019a)	Strong causal linkages
SEXP	2010–2019		Guo *et al.* (2018), Hanson (2020); Iqbal *et al.* (2019a)	Strong causal linkages
SIMP	2010–2019		Guo *et al.* (2018), Hanson (2020); Iqbal *et al.* (2019a)	Strong causal linkages
TRFF	2010–2019		Doifode and Narayanan (2020), Itakura (2020); Li *et al.* (2018), Liu and Woo (2018); Lukin (2019)	Strong causal linkages
CVD	2010–2019		Petri and Plummer (2020)	Strong causal linkages
ADP	2010–2019		Petri and Plummer (2020)	Strong causal linkages
TWSC	2010–2019		Petri and Plummer (2020)	Strong causal linkages
TWPT	2010–2019		Participant countries in trade war are the USA and China for which no specific justification is required	Weak causal linkages

Source: Compiled by researchers

Appendix 3



Source: Output generated through neural network by the researchers

Figure A1.
Neural nodes and network

Appendix 4

Training	Sum of squares error	1.373
	Relative error	0.023
	Stopping rule used	1 consecutive step(s) with no decrease in error[a]
	Training time	0:00:00.03
Testing	Sum of squares error	0.394
	Relative error	0.019

Dependent variable: GDP

Table A3. Model summary

Note: [a]Error computations are based on the testing sample
Source: Output generated through neural network by the researchers

Appendix 5

Independent variable	Importance	Normalized importance (%)
MEXP	0.034	9.4
MIMP	0.301	82.7
SEXP	0.063	17.4
SIMP	0.155	42.6
TRFF	0.027	7.4
ADP	0.012	3.3
CVD	0.364	100.0
TWSC	0.015	4.2
TWPT	0.029	7.9

Table A4. Independent variable importance

Source: Output generated through neural network by the researchers

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