Trade Liberalization and Defence in Developing Economies – Theory, Empirics and Application of Artificial Intelligence

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Abstract

The unending debate of the economic effects of defence expenses on the economy continues to grow with no consensus and gained currency especially in the era of globalization. Developing and emerging nations, in the presence of liberalized world, are looking to strengthen their defence sector by their own strength. Producing defence-related goods in their own nations has been becoming quite popular among these nations. In this study, by the help of Granger causality test for panel data of these nations over the period of 1995-2020, we have seen that different trade policy measures have impact on the way o functioning of defence sector in these nations. Ss the empirical study was not enough to get the vivid idea about the alternative policies on defence sector as well as on the other sectors of the economy, we have followed theoretical study as well. In the present paper, for performing the theoretical study, we have divided the economy in two broad categories, each categories having two sectors--- The Consumers' World (TCW) having two sectors: consumer goods producing export sector and consumer goods producing import competing sector and The Defence World (TDW) having two sectors: defence service producing sector which buys equipments and arms from its equipment and arms producing sector. With the help of four-sector general equilibrium trade theoretic framework, we have made an attempt to see the effects of an increase in defence-related capital on rest of the sectors of the economy along with the effects of a reduction in the tariff on the import competing sector. From such set up we have found that an increase in the defence-related capital and a fall in the tariff, due to liberalization, have same effects. Both measures increase the output of defence service producing sector, its equipment-supplying sector, consumer goods producing sector but reduces that of import competing sector.

Key Words: *Defence Sector, Panel Data analysis, Liberalization, International Trade Policy, General Equilibrium.*

1. Introduction

The impact of defence expenses on an economy has been an area of controversy, debate and extensive research for a long time. On one hand, we have seen several lines of thoughts that have viewed increased defence expenses cause negative impact on the economic growth of a nation, again, another line of thoughts has viewed this impact positively. Each perspective has led to different conclusions and thus the net impact is ambiguous. Underdeveloped defence

sector could contribute in the form of oppression, poverty, conflict within developing nations and insecurity, tensions in rest of the world. So, many nations have increased their expenses on defence based on tensions in their national boundaries, or to be in the safe-zone against its powerful rival neighbours, or even for announcing itself as one of the best military powers in the world. There are developing nations which are, right now, important regional players or on the verge of transubstantiate from being a regional player to the one with a global importance. So, the geo-political and economic ambitions of such nations make it even more important to have a strong defence base. But we have seen debates in favour and against of such expenditures for defence, no matter whether there has been an increase in it or reduction. If we look at the theoretical ground, we would see that there is again no common viewpoint amongst economists regarding defence expenditure and economic growth. On one hand we see thatincrease in expenditure on defence could posebarriers in front of growth paths of other sectors of an economy (Eshag, 1983; Fontanel, 1995; Giray, 2004). However, we should not deny that a nation needs to invest in military security and its improvement for being on the safe side from domestic and external threats (Chatterjee and Chatterjee, 2020). The classicists thought that higher military spending would be harmful for economic growth, as it would raise the interest rate and, thus, would be able to crowd out private investment, which, in turn, would result in low levels of domestic savings, aggregate demand and consumption. The neo-classical theories, however, have looked at this concept as a "State-affair". In their views, defence expenditure is a public good and state should play the role of balancing the opportunity cost between defence expenditure and other sectors and take actions accordingly, whereas, Keynesian theories have viewed defence expenditure from a positive angle. In their views, in the presence of lack of aggregate demand, defence expenditure should increase output through the multiplier effects. Endogenous growth theory provides a foundation for the relationship between the share of military expenditure and long run economic growth, predicting an inverse hump-shaped link (Pieroni, 2009). Although there was a fall in the defence expenses in the Post–Cold-War era in certain parts of the world, there are also multiple evidences of increase in defence expenditure and wars during this period. Of late, defence expenditure has again gained an upsurge, especially, on parts of the developing nations. In 2017, global military spending has witnessed a growth rate of 1.1 per cent (Stockholm International Peace Research Institute), which is the highest ($1.739 billion) since the end of cold war. In 2021, we have witnessed four developing nations, namely, China (ranked 2nd), India (ranked 3rd) Saudi Arabia (ranked 6th) and South Korea (ranked 10th) ranked amongst the top 10 nations in defence spending (World Economic Forum). Post the successful attempt of Goldman Sachs in drawing the attention of financial analysts and investors towards a new set of emerging market way back in 2001, the relevance of Developing countries (Brazil, Russia, India, China and South Africa) as a group of nations that can dominate the socio-economic-political scenarios in the whole world started to gain currency and became key points of discussion and policy making very fast. Developing countries nations together not only spread a ray of hope and optimism around the world for being a new economic alternative and that too based on developing economies. We know that the cumulative GDP of developing countries nations in 2019 was over 50 million dollars which was almost 40% of the world's GDP and by 2030 these nations will take over G8 nations which will further establish their economic influence and dominance. The stupendous economic growth rates of these nations have certainly smoothened the process of being "emerging economic powers" to becoming "future economic powers" in the world. The geo-political position of these nations along with their economic upsurge have further put importance to the fact of strengthening their defence sectors. It can easily be followed from the economic and budgetary policies from these nations that they have been placing high priorities in their defence sectors. India has been continuously increasing its spending on defence along with other four nations. Once these five nations were opened up, inflow of FDI started taking

place and it has only increased by leaps and bounds and eventually spread over all economic activities. One cannot deny the fact that FDI has been playing a major part in the growth of these nations. The opening up of defence sectors of these nations to the FDI along with increase in their own budgetary allocations for defence sector have aggravated the research interest about the relationship between defence sector and FDI, especially in the context of these economies. FDI in defence sector is an important aspect now for almost every developing nation. This has twin - positive impacts on the developing nations - first, it gets foreign investment or precious foreign currency and secondly, it gets upgraded foreign technology to strengthen its defence base. FDI also plays an important role in R&D of defence sector for having better technology than the developing nations, even when the developing nation is good enough in producing its defence equipments itself (Chatterjee & Chatterjee, 2021a). So, the twin effects of FDI and globalisation either on production of defence equipments or on its further improvements cannot be denied as far as development of defence sector in developing nations is concerned.[1] A number of studies have emerged on Brazil, South Korea and Taiwan, Israel, India, to name a few examples only, being mainly connected to the work of the Stockholm International Peace Research Institute (SIPRI). Partly in response to these writings, a set of "justifications" emerged that suggested not only the existence of good political reasons to establish an indigenous arms industry, but the existence of good economic reasons as well (Brauer, 1998). So, there is growing global consensus about developing indigenous defence manufacturing sectors, across developing nations, by allowing FDI in defence as high as 100%. This helps in several ways- reduces imports, develops import substituting industries, generates employment within the domestic economy at the same time maintains the quality and improvement of defence equipments through FDI, as it contains the improved foreign technology.[2] In the field of literature, we can see there is long existence about this important issue of defence expenditure and its economic importance. The classicists thought that higher military spending would be harmful for economic growth, as it would raise the interest rate and, thus, would be able to crowd out private investment, which, in turn, would result in low levels of domestic savings, aggregate demand and consumption. The neo-classical theories, however, have looked at this concept as a “State-affair”. In their views, defence expenditure is a public good and state should play the role of balancing the opportunity cost between defence expenditure and other sectors and take actions accordingly, whereas, Keynesian theories have viewed defence expenditure from a positive angle. In their views, in the presence of lack of aggregate demand, defence expenditure should increase output through the multiplier effects. Endogenous growth theory provides a foundation for the relationship between the share of military expenditure and long run economic growth, predicting an inverse hump-shaped link (Pieroni, 2009). There were, broadly, two groups of empirical research in the defense literature. The first group consists of those studies which uses single regression equations in order to test the impact of military expenditure on growth via Neoclassical or Keynesian approaches. Whereas the Neoclassical models have focused on the supply-side (modernization, positive externalities from infrastructure, technological spin-offs), the Keynesian models have focused on the demand-side (crowding-out of investment, exports, education, defence). The supply-side model of growth and defense is based on the work of Feder (1982), Ram (1986) and Biswas and Ram (1986), which is referred to as the Feder–Ram model. The Keynesian or demand-side models are based on the initial work of Smith (1980). There is good number of empirical literatures on defence expenses and macroeconomic variables. Since higher defence

[1] There are developing nations which are allowing FDI in defence in varying proportions (up to75% and even more in few cases) supports our view regarding impact of FDI in defence sector.

[2] India’s recent decision regarding reducing defence imports by 35%-40% through reforms such as “Make in India” programme and allowing FDI in defence up to 100% is only a reflection of this view.

expenditure should incorporate higher opportunity cost to the social factors, hence it could create economic barriers in front of economic growth. So, it describes a trade-off between defence expenditure and economic growth (Collier &Hoeffler, 2004; Değer&Şen, 1995; Eshag, 1983; Giray, 2004; Chatterjee & Chatterjee, 2021a). There are studies which uses simultaneous equation models by incorporating both the demand and supply sides to measure the impact of the military expenditure on growth forms the second group of empirical studies. These models are based on the work of Deger and Smith (1983) and Deger (1986) and are known as the Deger type model. However, demand-side arguments may encourage high expenditure on defence and may state positive effect of defence expenditure on economic growth (Brumm, 1997; Guo, Liu &Jin, 2015). Again, positive effects of security on economic factors and supply-side spill overs can also generate positive impact on growth (Benoit, 1978; Hacioglu, Dincer, & Celik, 2013). However, from the empirical studies it appears that there is no clear-cut agreement among the researchers about the nature and extent of the growth effects of military expenditure. Chowdhury (1991) did not find any causality between defence spending and growth for most of a group of 55 LDCs. Dunne and Vougas (1998) found that military burden has a negative impact on the economic growth in South Africa.More emphasis on research and development in defence may enhance the opportunity to serve better outcome from both technical and cost-benefit aspects (Poole & Bernard, 1992; Pradhan et al., 2013). The motivation behind the present paper comes from the fact that very few authors have made an effort to capture the relationship between defence expenditure and economic growth, involving international trade, by considering both empirics and theory. We know, that developing and emerging nations play one of the pivotal roles in the growth of world economy, today, as well as controlling economic policies across the globe and this dominance is only going to increase in the days to come. So, their importance cannot be overlooked. Again, international trade plays an important role in economic growth and in order to maintain stability within nation and across borders, the importance of investment in defence sector cannot be underestimated in the era of globalisation. This area, largely untouched, has to be taken care of. In this study, we have made an attempt to fill up this lacuna. The rest of the study is organized as follows - section 2 of the paper discusses about the empirical findings and focuses on econometric analysis. Section 3 considers the basic model in the backdrop of general equilibrium framework. Section 4 distributes the arguments in favour of trade liberalization in terms of both capital inflows and tariff cut and its impact on defence. Finally, section 5 concludes.

2. Empirical Analysis

2.1 Data and Methodology

In this section, our foucs will be about finding out association defence and international trade in 10 selected emerging economies across the world. We have chosen emerging nations for three reasons. Firstly, these nations are emerging from economic aspects as well as they are able to achieve sustainable GDP growth rates in the past few decades which have further widened their trade environment with the rest of the world. Secondly, the geo-political position of these nations are such that whenever there are wars with their neighbour enemies or even instability within their own nations, foreign investors lose interest in investing in these nations or there is a tendency of outflow of foreign capital from these nations. This makes the necessiy to invest more in defence sector not only for the sake of peaceful internal economic growth and good relation with its neighbours but also to ensure smooth inflow of foreign capital. (Guo et. al., 2015). Thirdly, studies on group of nations using panel data analysis may provide a better framework in explaining the overall relationship between the concerned variables. variables

under concern.variables (Dawson, 2010). To serve the said purposes, here we consider a panel data set of 25 years from 1995 to 2020 for ten developing nations. The main source of our data is the World Development indicators (hereafter, WDI). As our main focus here is to describe the association between defence expenditure and trade policies, and also how variables of growth domain are associated or affected by such relationship, we have used Military Expenditure or Defence Expenditure (DE), Arms Imports (AI), Net Foreign Direct Investment (NFDI), Openness index of trade (OPN), Per capita Gross Capital Formation (PCGCF) and Per Capita Gross Domestic Product (PCGDP) as our major variables. Since we want to explore the existing association between DE, AI, NFDI, OPN, PCGCF and PCGDP, here, we have employed panel causality test to justify our objective. In order to check whether we can consider an endogenous variable as exogenous, that is, for testing the causality, we have applied the Pairwise Granger causality test. If we follow the extensive literature on panel data, we would see that causality is generally checked by three methods. First, Generalised method of moments. Second, Konya's method (2006)[3] and third, Hurlin's method (2008).[4] Here, we have employed a vanilla model in which the bivariate regressions, in a panel data context, take the following form:

$$y_{i,t} = \alpha_{0,i} + \alpha_{1,i} y_{i,t-1} + ... + \alpha_{1,i} y_{i,t-1} + ... + \beta_{1,i} x_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

$$x_{i,t} = \alpha_{0,i} + \alpha_{1,i} x_{i,t-1} + ... + \alpha_{1,i} x_{i,t-1} + ... + \beta_{1,i} y_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

Here, t stands for time period element of the panel, and i stands for cross-sectional aspect. To check the robustness of the above-stated causality test, we have applied Dumitrescu and Hurlin (2012) panel causality test. We know that Dumitrescu and Hurlin (2012) panel causality test is an advanced form of Panel Granger causality test and can be specified as -

$$y_{i,t} = \alpha_i + \sum_{K=1}^{K} \beta_i^k y_{i,t-k} + \sum_{K=1}^{K} \gamma_i^k y_{i,t-k} + \varepsilon_{i,t} \quad (3)$$

In equation (3), the causality relationship between y and x is analyzed. Note, that K represents optimum lag interval.

2.2 Results and Analysis

In this study, we have performed four panel unit root tests. The first one is LLC test or Levin – Lin – Chu test following Levin et al (2002) which verifies the null hypothesis regarding the presence of unit-root in the panel, assuming the common unit root process across the cross-sectional units. We have also applied both the Philips Perron--Fisher chi-square test and the Augmented Dicky Fuller test. Both these tests check individual unit-root processes. All of these tests have not rejected the null hypothesis of the unit root in any of the variables across the panels. Further, we have applied the panel unit root tests with a constant and linear time trend in the same specification, and we have got robust outcomes. We have also carried out IPS panel unit root tests for verification of the cross-section correlation properties of the raw data (Pesaran, 2007). This test has also confirmed that all the variables of our concerned follow unit root processes. Table 1 illustrates the results of panel unit root tests at first difference for overall panel of the developing nations.

[3]Konya's method assumes the characteristics of cross-sectional dependency and slope heterogeneity among countries simultaneously (Kar et al., 2011).

[4]Hurlin's method states that all co-efficient are different across cross-sections. Hence, it needs application of Granger Causality regression for each individual cross section in order to test the causality.

Table 1: Panel unit root tests for Overall Panel of developing countries

	At level				At First Difference			
Variables	**LLC test**	**IPS test**	**ADF test**	**PP test**	**LLC test**	**IPS test**	**ADF test**	**PP test**
DE	1.23 (0.87)	1.52 (0.91)	4.11 (0.78)	11.04 (0.82)	-4.82 (0.00)	-7.28 (0.00)	24.21 (0.00)	29.01 (0.00)
AI	0.87 (0.54)	2.04 (0.48)	3.24 (0.74)	9.25 (0.43)	-3.47 (0.00)	-5.81 (0.00)	27.21 (0.00)	37.21 (0.00)
PCGDP	0.11 (0.88)	3.21 (0.79)	3.44 (0.80)	3.68 (0.98)	-8.18 (0.00)	-8.38 (0.00)	65.78 (0.00)	88.21 (0.00)
NFDI	-2.75 (0.28)	-0.48 (0.84)	10.25 (0.48)	18.24 (0.98)	-9.24 (0.00)	-17.24 (0.00)	87.24 (0.00)	86.26 (0.00)
OPN	-2.26 (0.25)	-0.89 (0.56)	18.25 (0.42)	17.21 (0.62)	-8.26 (0.00)	-8.85 (0.00)	54.58 (0.00)	60.88 (0.00)
PCGCF	-1.01 (0.67)	0.94 (0.58)	4.28 (0.84)	9.21 (0.35)	-3.44 (0.00)	-8.20 (0.00)	28.20 (0.00)	58.80 (0.00)

Source: Author's calculation.
Notes: The values in the parenthesis are p-values

Overall panel results for the Granger-Causality tests are reported in the following table - Table 2. We have started our analysis by taking a maximum of eight lags of the endogenous variables and maximum of four lags of the exogenous variables and then we have permuted their order of lags. We have found bidirectional causality between PCGDP and DE and between AI and DE. We have also obtained unidirectional causality running from OPN to DE; NFDI to DE and PCGCF to DE. The significant outcomes are shown in bold.

Table 2. Panel Granger Causality Test Results for Overall Panel of developing nations

Null Hypothesis	Lags	F statistic	Prob. Values
PCGDP does not Granger cause DE	**8**	**3.2110**	**0.0504**
DE does not Granger cause PCGDP	**8**	**0.5870**	**0.0030**
OPN does not Granger cause DE	**4**	**0.8938**	**0.0267**
DE does not Granger cause OPN	4	2.2216	0.8524
NFDI does not Granger cause DE	**7**	**1.7211**	**0.0021**
DE does not Granger cause NFDI	3	2.2488	0.3230
AI does not Granger cause DE	**8**	**1.0258**	**0.0075**
DE does not Granger cause AI	**3**	**2.0853**	**0.0054**
PCGCF does not Granger cause DE	**8**	**0.8219**	**0.0821**
DE does not Granger cause PCGCF	8	1.8071	0.9809

Source: Author's calculation.

For checking the robustness of our causality analysis, we have used Dumitrescu and Hurlin (2012) panel causality test and its results are reported in Table 3, which shows our results as a robust one. Here also, the significant ones are reported in bold.

Table 3. Dumitrescu-Hurlin Panel Causality Tests for Overall Panel

Null Hypothesis	Prob. Values
PCGDP does not cause DE	**0.0335**
DE does not cause PCGDP	**0.0539**
OPN does not cause DE	**0.0105**
DE does not cause OPN	0.3739
NFDI does not cause DE	**0.0311**
DE does not cause NFDI	0.3351
AI does not cause DE	**0.0081**

DE does not cause AI	**0.0028**
PCGCF does not cause DE	**0.0308**
DE does not cause PCGCF	0.8528

Source: Author's calculation.

2.3 Theory-Empirics Linkages

The findings of the above tables based on different causality tests help us to find the ways of looking at the defence sector from the perspective of trade policies in these nations. Our empirical findings help us in leading to a few significant concords and these are as follows: i) defence sector of developing countries are dependent upon various international trade policies. To be more specific, Openness, Net FDI inflow and Per capita Gross capital formation affect defence sector in the developing economies nations. ii) there exists both way causal relationship between Defence Expenditure and per-capita GDP and between Defence Expenditure and Import of Arms in these nations. But these consensuses also pose few questions before the policy-setters. First of all, we have found that openness index, Net FDI and PCGCF affect DE but the results are non-responsive over the sign of such impact and even about the level of efficiency of such impact. Secondly, what impact does higher Defence Expenditure have on PCGDP and on other sectors of the economy? Is there any Inter-industry trade off owing to high spending for defense?[5] There is almost no proper economic theoretical background on this issue. Third, what form of liberalization has what type of impact on the defence industries alongside rest of the economy?[6] Finally, one may also ask whether import substitution in defence sector is a feasible policy in developing nations? So, we can see that there are few perspectives that need further research on theoretical ground. One can see that these aspects can be more precisely understood and can be dealt with more instructionally if we adopt a proper theoretical technique. Interestingly, these questions can be answered more informatively using right. We need to follow an appropriate theoretical framework of trade policies that would give us a vivid conception about the impact of different trade policy regimes on defence sector. For this purpose, we have employed general equilibrium (GE) framework which helps us to deal with the following areas efficiently- i) in General Equilibrium framework, we can see the effects of changes in the different production units of an economy along with the defence unit; ii) General Equilibrium framework would help us to understand the meaning of bidirectional causality between DE and PCGDP (what we have already found in empirical analysis) and the impact of such a relationship on other different exporting-importing sectors of the economy. More importantly, what would be the impact on the different consumer goods industries? These aspects have been effectively dealt with by the help of General Equilibrium Model in the following section.

3. The Basic Model

3.1 Product market

In this section we consider an economy which is supposed to be divided broadly on two aspects: first one, category of economic activities engaged with consumers' preference-supply world

[5]Inter-industry trade off implies the trade-off that exists between defence industry and other industries of the economy due to high level of investment in defence.

[6] By form of liberalization, we mean the strictness or looseness of export-import policies by means of imposing high or low tax rates on imports.

and we call it The Consumers' World (TCW) and second one describes the statehood of defence and security aspect of the said economy and we refer it as The Defence World (TDW). Without creating any confusion, here, we describe each TCW and TDW one by one. TCW consists with two sectors, namely, consumer goods producing export sector (X) and consumer goods producing import sector (Y). Here, sector X producing output by using labour (L) and capital (K) and claiming the following product market equilibrium scenario;

$$\bar{W}a_{LX} + ra_{KX} = P_X = P_X^* = 1 \quad (1)$$

Here, return to the labour engaged in sector X is assumed to be fixed owing to unionization at $\bar{W}$ and the rate of return to capital is r, which shall be determined from the domestic market clearing condition. Second sector under TCW produces the import competing product by employing the same the inputs used by the export sector and the corresponding price-average cost equality gives us

$$Wa_{LY} + ra_{KY} = P_Y = P_Y^*(1+t) \quad (2)$$

Where, import competing sector is protected by tariff (t) and hiring labour at the competitive wage rate (W). Now we have considered TDW, and it also comprises with two defence and security related segments. In general, defence and security of any nation are coming by combining two simultaneous works; first the defence service producing unit (D) buying equipments and arms from its equipment and arms producing wing (V) and, the first unit serving security to the nation. Here, Sector D producing output by using labour (L), defence capital (K_D) and output of equipment and arms producing wing (V) as an intermediate input, and ensuring the following price equation for the defence service sector:

$$\bar{W}a_{LD} + Ra_{K_DD} + P_V a_{VD} = P_D \quad (3)$$

Here, again the wage rate is assumed to be fixed institutionally ($\bar{W}$) and the rate of return to defence capital (R) is assumed to be determined from the competitive equilibrium. Second sector under TDW produces the intermediate product for the defence service sector by employing labour (L) and defence capital (K_D) and the corresponding zero profit condition.

$$Wa_{LV} + Ra_{K_DV} = P_V \quad (4)$$

3.2 Factor Market

To complete general equilibrium, here, we illustrate the full employment conditions for all the inputs of our interest. The relationship between the defence-equipment producing intermediate sector and defence sector is given as:

$$a_{VD}D = V \quad (5)$$

Mobility of traditional capital between sectors X and sector Y is given as

$$a_{KX}X + a_{KY}Y = K \quad (6)$$

Full employment condition of the labour market is given by

$$a_{LX}X + a_{LY}Y + a_{LD}D + a_{LV}V = L \quad (7)$$

The mobility of defence capital between sector D and sector V is given by

$$a_{K_DD}D + a_{K_DV}V = K_D \quad (8)$$

The working of the model is simple. From equation (1) we can solve for r. Using the value of r in equation (2) we can get w. From equation (4) we can express R in terms of P_V .As R can be expressed in terms of P_V , by using this relation, from equation (3) we can get the value of P_V , using which again in equation (4) one can get the value of R. From equation (5) we can express V in terms of D, by using this relationship in equation (8), one can get the value of Z and again by using the value of D in equation (5) we can get the value of V. Thus, both D and V becomes known. Now we are left with two equations, that is, equation (6) and equation (7), and two unknowns – X and Y. So, we can solve for the values of X and Y from these two equations.

4. Liberalization, Input Movements and Size of the Defence Sector

Here we would like to examine the impact of an increase in the defence capital also a decrease in the tariff on per unit of output of sector y. First, we would like to examine the impact of an increase in defence capital K_D. When we examine the change in K_D, then the system or the model becomes decomposable as the input-output co-efficients can be determined independent of the output system. From equation (5) we can see that V can be expressed in terms of D. So, equation (8) can be expressed in terms of D only. In equation (8), as K_D rises, to maintain the equilibrium, it implies that D should also increase. As $\hat{D} = \hat{V}$, it also implies that V should rise. This is shown by the following two equations that express change in D and V with respect to change in K_D.

$$\frac{\hat{D}}{\hat{K}_D} = \frac{\varepsilon}{(\lambda_{K_DD} + \lambda_{K_DV})} \quad (9)$$

and

$$\frac{\hat{V}}{\hat{K}_D} = \frac{\varepsilon}{(\lambda_{K_DD} + \lambda_{K_DV})} \quad (10)$$

Both the two equations above show a direct relationship between K_D and output of sector D and sector V because ε is positive (greater than zero) in sign. So as K_D rises, the output levels of both sectors V and sector D increase, it implies that the availability of effective labour decreases in rest of the two sectors, that is, in sector x and sector y. This creates a *Rybczynski effect* for which output of the capital-intensive sector or sector X rises and that of the labour-intensive sector or sector Y falls. Mathematical expressions of these results are shown below.

$$\frac{\hat{Y}}{\hat{K}_D} = \{ - \frac{(\lambda_{K_DD} + \lambda_{K_DV})\lambda_{KX}}{(\lambda_{LX}\lambda_{KX} - \lambda_{KY} + \lambda_{LY}\lambda_{KX})} \frac{\varepsilon}{(\lambda_{K_DD} + \lambda_{K_DV})} \} \quad (11)$$

and

$$\frac{\hat{X}}{\hat{K}_D} = \lambda_{KY} \{ \frac{\varepsilon}{(\lambda_{LX}\lambda_{KX} - \lambda_{KY} + \lambda_{LY}\lambda_{KX})(\lambda_{KD} + \lambda_{KV})} \} \quad (12)$$

Again, as ε is positive in nature, the above two equations express an inverse relation between Y and K_D and a direct relation between X and K_D, respectively. These findings can be expressed with the help of following proposition.

Proposition 1: *An increase in the defence-capital increases the production of defence-serving producing sector and output of defence equipments supplying sector. It increases output of the consumer goods producing exporting sector and reduces output of the consumer goods producing importing sector.*

Now, we would like to see the effect of change in tariff (t) on the output of all the sectors as well as on the input prices.[7]

From equation (13) we find that the relation between price of the intermediate sector (sector V) and price of the price of the importing sector (sector Y) is given as:

$$\frac{\hat{P}_V}{\hat{t}} = \frac{\theta_{K_D D}}{\theta_{LY}(\theta_{K_D D} + \theta_{VD}\theta_{K_D V})} \quad (13)^{8}$$

The above expression is positive, so, the relation between $\hat{P}_V$ and $\hat{t}$ is direct, that is, as $\hat{t}$ falls, $\hat{P}_V$ falls. The economic interpretation is simple. A decrease in the tariff rate on the output of the importing sector reduces effective price of the product of the importing sector, t, as r is already determined from equation (1), a fall in, t causes a fall in w, as we find from equation (2). For given P_V, a fall in w causes a rise in R from equation (4). However, P_V is not given as sector v is the non-traded sector. This is evident from equation (3) where we find, for given P_D, a rise in R implies a fall in P_V. So, we conclude a fall in t causes a fall in P_V. As R increases, it implies that a_{KD} and a_{KV} also falls, as a result of which D increases and consequently V also increases, (as $\hat{D} = \hat{V}$) it is shown by the following equation.

$$\frac{\hat{D}}{\hat{t}} = \{ - \frac{(\lambda_{K_D D} A_2 + \lambda_{K_D V} A_1)}{(\lambda_{K_D D} + \lambda_{K_D V})} \} = \frac{\hat{V}}{\hat{t}} \quad (14)$$

As w falls (for given r), w/r falls or we can say that r/w increases. It also results in a fall in a_{KX} and a_{KY} for given X and Y. So, there is excess supply of capital. From equation (7) we see that a fall in w results in an increase in a_{LY} and a_{LV}. It results in a reduction in the availability of labour for sector x and sector y as {L-($a_{LD} + a_{LV} a_{VD}$) D} falls. This is known as *Rybczynski-type effect.* This will result in an increase in the output of sector X and a fall in that of sector Y, given that X is the capital-intensive sector than sector Y. We thus have:

[7]Here, we have assumed that $\hat{P}_Y$ and $\hat{t}$ are synonymous as per economic interpretation.

[8]Equation (13) and equation (4.1) (in the appendix) are same, only for the sake of the simplicity, it is numbered differently, first, here and later in the appendix.

$$\frac{\hat{X}}{\hat{t}} = \frac{A_5\lambda_{KY} - \lambda_{LY}A_6}{\lambda_{LX}\lambda_{KY} - \lambda_{KX}\lambda_{LY}} \qquad (15)$$

and

$$\frac{\hat{Y}}{\hat{t}} = \frac{\lambda_{LX}A_6 - \lambda_{KX}A_5}{\lambda_{LX}\lambda_{KY} - \lambda_{KX}\lambda_{LY}} \quad (16)$$

These results are presented by the following proposition.

Proposition 2: *A decrease in the tariff rate on the output of the importing sector increases the output of defence- equipments producing intermediate sector as well as the output of defence sector, it also increases the output of export goods producing capital-intensive sector but decreases the output of the labour-intensive importing sector.*

5. Neural Network Methods

Nonlinear Autoregressive models with exogenous input (NARX) neural network is a variant of Recurrent Network (Lin et al. 1996, Gao and Meng, 2005) that has been successfully utilized in time series prediction problems. Contrary to the conventional econometric methods, NARX on the contrary can efficiently be used for modelling non stationary and nonlinear time series for forecasting (Chatterjee & Chatterjee, 2021b) . Mathematically input output representation of nonlinear discrete time series in NARX network is specified as

$$Defence(n+1) = f[Defence(n); Trade(n)] \qquad (17)$$

Where, Defence(n) and RRDGDP(n) are the sample value of the time series at time n. In order to use the full computational abilities of the NARX network for nonlinear time series prediction, we use following mechanism (Xie, Tang & Liao, 2009);

$$Trade(n) = x_1(n) = [Trade(n), Trade(n-\tau), \ldots, Trade(n-(d_E-1)\tau)] \qquad (18)$$

Where, τ is theembedding delay, d_E is the embedding dimension and we set $d_{Trade} = d_E$.

It is to be noted that there are two modes which have a concern in training NARX network. The first one is called parallel (P) mode and the other one is called series-parallel (SP) mode. Output signal corresponding to each mode can be expressed as

$$Defence_{sp}(n) = [Trade(n), \ldots\ldots, Trade(n-(d_E-1)] \qquad (19)$$

$$Defence_{p}(n) = [Trade(n), \ldots\ldots, Trade(n-(d_E-1)] \qquad (20)$$

Therefore, the NARX networks implement following predictive mappings:

$$\widehat{Defence}(n+1) = \hat{f}[Defence_{sp}(n), Trade(n)] = \hat{f}[Defence_{sp}(n), x_1(n)] \qquad (21)$$

$$\widehat{Defence}(n+1) = \hat{f}[Defence_{p}(n), Trade(n)] = \hat{f}[Defence_{p}(n), x_1(n)] \qquad (22)$$

Where, the nonlinear function $\hat{f}(.)$ is readily implemented through a multilayer perceptron trained with usual NN backpropagation algorithm.

6. Defence Forecast and Innovation

Only one hidden layer has been used while number of neurons in hidden layer has been varied at four levels (10, 20, 30 & 40 number of neurons). Delay of 2 units to consider the lagged values of both dependent and independent variables have been considered for model building. Number of neurons in hidden layer is varied at four levels and five learning algorithms have been used. five back-propagation algorithms namely, Levenberg-Marquardt (LM), Scaled Conjugate Gradient (SCG), Conjugate Gradient with Powell-Beale Restarts (CGB), Fletcher-Powell Conjugate Gradient (CGF), Polak-Ribiére Conjugate Gradient (CGP) are used for training.

Figure 1- Best Validation Performance of DE

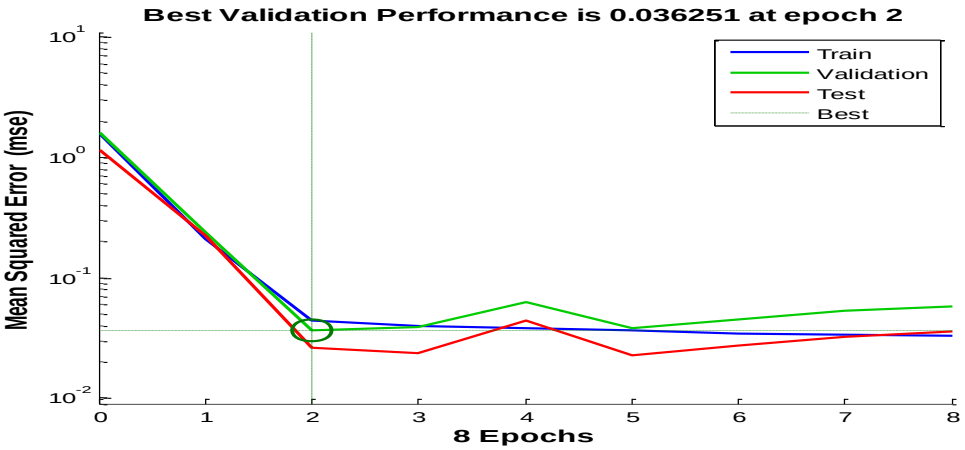


Figure 2- Performance of NARX in case of DE

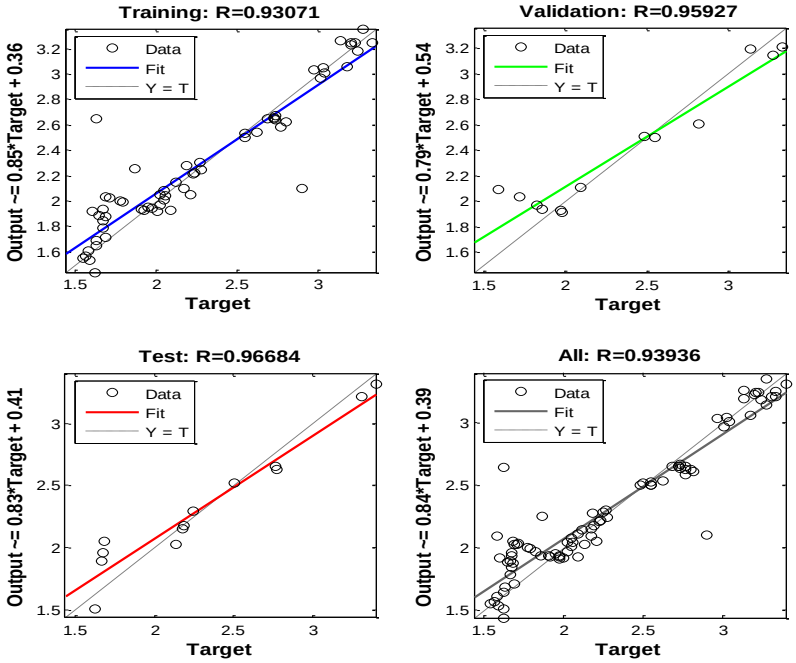


Figure 3- Best Validation Performance of AI

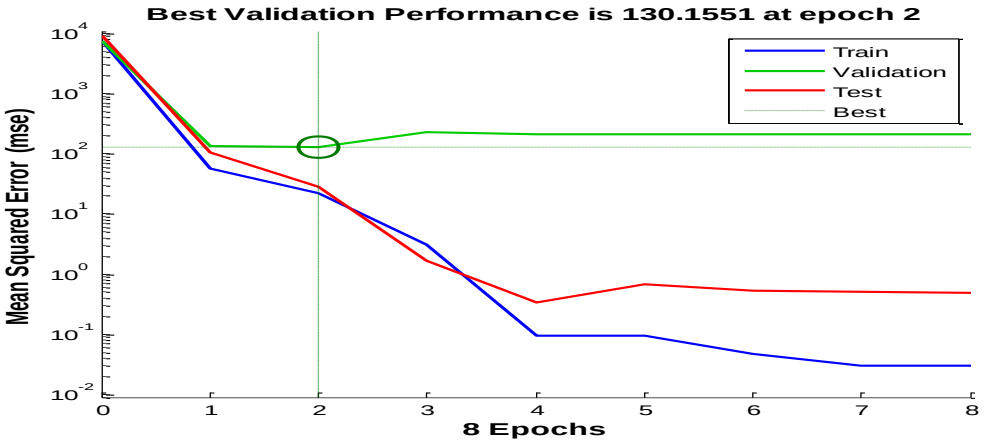
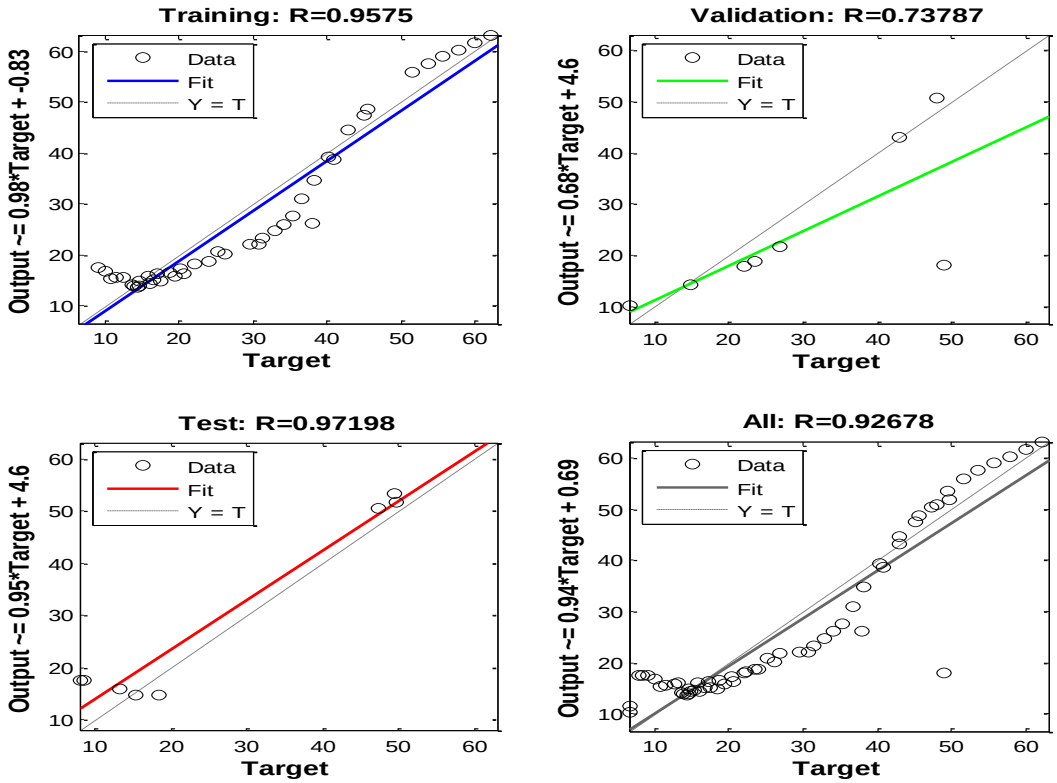


Figure 4- Performance of NARX in case of AI



Figures 1 and 2 (Figures 3 and 4) graphically represents association of the actual and predicted DE (or AI) for all training, test and validation sample. Magnitude of error in terms of MAE, MAPE and MSE are illustrated in Figures 2 and 4. Although graphical representation strongly suggests goodness of fit of NARX network in DE (or AI) in presence of RDGDP, for quantitative justification Table 4 is drawn for training and test dataset. Statistics of MAE,

MAPE and MSE of predictive modelling performance of NARX network on training and test dataset of DE (or AI) owing to trade liberalization for all experimental trials are summarized in Tables 4.

Table-4 Performance on Training Dataset of DE and AI for developing economies

Variable	DOLS			NARX		
	Panel: ***Developing countries***					
	MAE	**MAPE**	**MSE**	**MAE**	**MAPE**	**MSE**
DE	0.2477	0.3035	0.3334	0.1237	0.2409	0.1229
AI	0.0182	0.4879	0.0259	0.0145	0.0159	0.0191

Source: Author's calculation.

Table 4 reveals that neural network based NARX technique outperform DOLS for the panel of developing economies. It is to be noted that NARX network with 2 delay units has predicted DE (or AI) as a nonlinear function of defence activities in terms of trade activities.

5. Conclusions with Policy implications

The uniqueness of the study lies in the fact that it has incorporated empirical study and theoretical aspect as a complementary to each other. The empirical approach of panel data analysis shows the dependency sector on various trade policies in these developing economies nations. But, the inconclusiveness of the empirical study to answer all the related possible queries because of lack of availability of confidential data of the defence sector, we have to adopt the path of theoretical study as well for which we have followed General Equilibrium approach. From the theoretical perspective, our study explores the impact of trade in defence, that is, effects of different trade measure, either in terms of capital inflow or tariff cut, on the size of defence sector of a small open economy. To capture such types of issue we have developed a four-sector general equilibrium trade model that mixes both flavours of consumer's world and defence world within same framework. This paper claims that an increase in the defence-capital increases the production of defence-serving producing sector and output of defence equipments supplying sector. It increases output of the consumer goods producing exporting sector and reduces output of the consumer goods producing importing sector. From the same framework we can also predict that A decrease in the tariff rate on the output of the importing sector increases the output of defence- equipments producing intermediate sector as well as the output of defence sector, it also increases the output of export goods producing capital-intensive sector but decreases the output of the labour-intensive importing sector.

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