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Tariff, Wages and Compensation: A General Oligopolistic Equilibrium Analysis

Abstract

A major section of the existing literature on strategic trade policy, following a partial equilibrium framework, observed that imposition of tariff by the domestic country leads to a rise in their wage level. Analysis on the impact of strategic trade policy intervention (tariff) on wages and welfare in a two-country general oligopolistic equilibrium (GOLE) model framework in the current paper leads to a number of interesting results. First, imposition of tariff does not affect the wages in domestic country. In addition, the welfare of the tariff-imposing country unambiguously comes down. Second, a comparison of the revenue generated from tariff and the subsidy required to compensate the affected workers reveals that when only trade in final goods is allowed, such compensation is possible beyond a specific level of tariff rate, which is directly related to foreign tariff rate. In effect, a high value of foreign tariff implies a lower ability of the domestic government to subsidize the workers. Third, however, when trade in both final and intermediate goods take place, the opposite results emerge, where tariff revenue can compensate the workers up to a certain level of tariff rate. The underlying logic is that imposition of tariff may lead to a fall in the overall demand for workers in the domestic country. The results are of crucial policy relevance, especially given the increasing participation of developing countries in Global Value Chains (GVCs) and re-emergence of tariff protectionism in several countries.

JEL-Codes: D430, J330, L130, I310.

Keywords: Cournot Competition, tariff, wage, compensation, general oligopolistic equilibrium (GOLE), welfare.

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1. Introduction

The universally accepted proposition regarding a trade liberalization policy is that it creates winners and losers (Eliot et al., 1994; Davidson and Matusz, 2006; Dixon and Rimmer, 2022). On one hand, the workers engaged in the expanding export-oriented sectors experience a rise in their real wages and unambiguously gain. On the other hand, workers involved in the contracting import-competing sectors witness a decline in their real earnings (Davidson and Matusz, 2006; Beladi and Kar, 2011). Although the theoretical analyses underline that the gains by winners from trade are more than adequate to neutralize the losses, so as to secure net welfare augmentation for the economy as a whole, a branch of empirical studies have proven otherwise (Jacobson et al., 1993; Kletzer, 2001; Davidson and Matusz, 2004). According to Hammond and Sempere (1995), trade will lead to actual Pareto improvement if some kind of compensation exists, following the enactment of trade reform policies. In light of the existing literature, the first objective of the current paper is to analyse the potential response pattern of wages to trade policy reforms (proxied by changes in tariff rate). Given the increasing participation of countries across the income spectrum in Global Value Chains (GVCs), the study intends to explore the movement of wages in response to tariff dynamics, both for final and intermediate goods in an imperfectly competitive world, within a general equilibrium framework. The second objective is to examine the implications of tariff on the economy's ability to compensate the workers, who suffer due to the enactment of these liberalization policies.

A major branch of the rich literature on strategic trade policy (STP), since its inception, has adopted the partial equilibrium model framework (Brander and Spencer, 1981, 1984, 1985; Brander and Krugman, 1983; De Stefano and Rysman, 2010; Fanti and Buccella, 2020). However, analysis of STP in the partial equilibrium framework provides an incomplete understanding regarding its impact on the economy (Colacicco, 2013). The underlying logic is these models assume that the policy changes influence only the sector under study, taking the factor income and national income as given, thereby neglecting the consequent interactions between the factor and the product market. Therefore, the current study employs a framework in which both the factor market as well as the income effect can be endogenized. This framework has been developed by Neary (2003a; 2009) and is known in the existing literature as the General Oligopolistic Equilibrium (GOLE) model.

The key dimension in any oligopoly model is that firms are large enough to exercise market power and they utilize the same to influence the market outcomes through their strategic behaviour (Neary, 2003b). However, if the interventions of such large firms influence other macroeconomic factors in the economy, then it can lead to generation of several problems. For instance, if they can influence the factor market, then it can be expected that they will behave strategically with their monopsony power. Moreover, the ramification of their actions on the national income will generate badly behaved reaction functions from the resulting income effects, such that the existence of equilibrium cannot be ensured (Roberts and Sonnenschein, 1977). In this context, the main novelty in the GOLE framework is that there exists a continuum of sectors and in each sector the operating firms are large enough to exercise power and behave strategically to influence the prices of the goods in their respective sectors. However, they are considerably small in the economy as a whole, such that they cannot affect the factor market and the national income. The marginal utility of national income is considered as the numeraire good, which is logical as firms are unable to cause any impact on the factor prices and, in turn, the national income.

A section of the literature has analysed the impact of STP on wages and profit-making ability of the firms by adopting the GOLE framework (Colacicco, 2013; Rudsinske, 2023). Colacicco (2013) observed that the aggregate profits of the home country increases when tariff is imposed by the government, although the aggregate welfare level in the nation falls. However, the study considers a passive foreign government, such that only the demand-side aspect of the domestic country, in the absence of any foreign retaliation to domestic government's trade policy, is modelled. Adopting GOLE framework for asymmetric trade partners in the presence of segmented market structure, Rudsinske (2023) concluded that unilateral imposition of tariff raises the nation's profit and welfare while lowering the demand for workers. The case of symmetric market structure has been ignored in the analysis. In light of the existing literature, the current study attempts to fill in these gaps by developing a cross-country demand channel, by assuming a two symmetric country scenario. in which governments of both the countries are active players.

Compensation measures for the workers, who are adversely impacted as a consequence of trade liberalization, are provided only in few developed nations (e.g., the trade adjustment assistance (TAA) in United States and the European Globalization Adjustment Fund (EGAF) in the European Union), and their effectiveness have been explored in the existing literature (Feenstra and Lewis, 1994; Davidson and Matusz, 2006; Cosar, 2013; Lechthaler and Mileva, 2021). On the contrary, the developing nations do not offer such schemes. Furthermore, most of the developing economies do not functionally provide any aid or other social security protection to the unemployed workers (Beladi and Kar, 2011).

One of the major hindrances towards providing compensation to the section of population adversely affected by trade reforms, especially in the developing nations, is the lack of monetary funds (OECD, 2020). The insights from theory requires that such compensation should be provided by taxing the gainers (Hammond and Sempere, 1995). Other than the workers who witness a rise in their real wage, trade also leads to a reduction in the prices of the commodities following greater import competition. Consequently, the consumers who witness an increase in their consumer surplus, benefit (Carroll and Hur, 2020). Therefore, one avenue of taxing the gainers can be through the imposition of consumption tax. However, exactly identifying the set of people who gain from trade openness is a difficult task, potentially associated with substantial costs (Wolla and Esenther, 2017). This is because benefits are less discernible than costs. For instance, it is comparatively easy to recognize the industries or businesses that have either stopped operating due to trade or continuing with excess capacity. Similarly, it is easy to recognize the people who have been laid off from those businesses and are in search of jobs. However, it is difficult for the consumers to determine how much the goods purchased by them have become cheaper, as a result of trade flows. Hence, a policy of levying consumption taxes arbitrarily on consumers may lead to public retaliation in different forms (e.g., protests on streets, change of government in next election).

Arguably, given the government's objective to reduce the adjustment costs, imposition of any taxes on the sectors engaged in trade may lead to unintended consequences (Rodrik, 1992). In contrast, tariff revenue constitutes one of those components of the government's budget in which it has relative flexibility in handling, since the public does not show much concern about utilization of these duties (Anderson and Neary, 2016). Therefore, tariff revenue can be considered as a potential channel through which the government can finance its compensation

policies.

Treating any protectionist policy as a consequence of lobbying, Feenstra and Bhagwati (1982) proposed using the revenue generated from import tariff for compensating the workers affected due to trade. The analysis, in a Hecksher-Ohlin framework, explained lobbying as a result of change in terms of trade that reduces a factor's real rewards. The government attempts to counter this negative impact by providing protection through tariff, which, given the level of real reward and protection in such an equilibrium, should be used as part of the compensation budget. Shifting the revenue generated from imposing tariff to the factor (e.g., labour), that has lobbied to receive protection, enables the government to maintain their real returns (Hillman, 1988). Such an intervention causes the aggregate welfare in the economy to rise.

The discussion so far suggests that tariff revenue can be utilized to compensate the workers from the import-competing sectors facing loses, without exhausting the benefits of free trade. Most of the existing studies on compensation focus on trade in final goods and a comparable analysis on trade in intermediate sectors is relatively scarce. The current study attempts to bridge this gap in literature by investigating the optimal sources of compensation in case of trade in both the final as well as intermediate goods. The obtained results, indicating that the sources in the two cases may be different, are of crucial policy relevance.

The current analysis is organized as follows. A survey of literature is presented briefly in the following section. Section 3 discusses the primary motivation behind the theoretical model. Section 4 sets up the basic GOLE model and analyses the impact of STP on wages and welfare of the workers, when trade in final goods takes place. This is followed by an investigation on whether the consequent tariff revenue can be utilized to compensate all the losses incurred by the workers, due to imposition of trade policy. Section 5 carries out a similar exercise by modelling trade involving both final and intermediate goods. Finally, based on the obtained theoretical results, some policy conclusions are drawn.

2. Literature Survey

The two seminal works to model STP include the segmented-market framework by Brander (1981) and the third-country framework by Spencer and Brander (1983), in which the importing country acts passively on the imports. Under this framework, the abstraction from domestic and foreign consumption prevents any change in the consumer surplus in the exporting countries and enables them to focus on profit shifting policies.

With the primary focus on compensation policies, the current study relates to the literature on optimal tariffs as well. The early works by Kaldor (1940) and De Scitovszky (1942) have found that it is optimal for the domestic economy to impose import duties as long as the foreign economy remains passive. Fleming (1956) subsequently studied the case of optimal tariffs in case of two countries characterized by different and exogenously given marginal utility of income. However, this line of literature did not analyse the endogenous effects that the imposition of tariffs can have on the marginal utilities of income. The current study builds up the framework in such a way that the marginal utility of income is determined endogenously within the system. Horwell and Pearce (1970) and Bond (1990) extended the argument on optimal tariffs in a large country setting from a two-good case to a multi-goods case. Their analysis showed that import tariff is the optimal trade policy and at the optimum there should exist at least one commodity whose trade is taxed. Gros (1987) found that tariffs are the optimal trade policy even in the case of a small economy, in the presence of monopolistically competitive market with product differentiation. The non-negativity of optimal tariffs in general equilibrium has also been confirmed by Felbelmayr et al. (2013) and Demidova (2017), in asymmetric Melitz (2003) framework¹. However, most of these studies considered trade in final commodities only. In a relatively recent branch of literature, Caliendo et al. (2023) derived a new formula for finding the optimal tariff in a small country with Melitz (2003) type production structure, in the presence of trade in intermediate inputs. The analysis showed that subsidies should be given to reduce the distortionary effect of markup on differentiated inputs, in addition to imposing tariff barriers.

The GOLE framework has been widely used in recent literature, covering a wide range of perspectives². Using the GOLE framework, Beladi et al. (2014) investigated how privatization influenced the firm's decision to locate in an industry, where firms do not manufacture all the varieties of a good demanded. The analysis noted that in publicly owned firms, the Nash Equilibrium locations are socially optimal, irrespective of the degree of privatization. Beladi et al. (2015) observed that in the GOLE framework, an increase in the degree of product differentiation can suppress the extensive margins of firms and reduce the gains from cross border mergers. Extending their work by incorporating vertically integrated industries in the GOLE framework, Beladi et al. (2018) found that a merger between high-cost and low-cost firms would raise efficiency by removing the high-cost firms, and increase price by augmenting concentration. As a result, the extensive margin of trade gets suppressed in the presence of vertical integration. Neary (2016) incorporated the GOLE framework to study its impact on gains from trade, distribution of income and overall trade pattern. In a two-country model, in the presence of small number of firms and zero trade cost, the results indicated no gains from trade, if the sectors between two symmetric countries have identical costs. The gains from trade however can be realized, if the sectors are heterogenous due to the competition effect.

Another branch of literature in the GOLE framework noted that in the presence of labour union, the welfare in a country will improve when it moves from autarky to free trade (Bastos and Kreickemeier, 2009; Kreickemeier and Meland, 2013). In the presence of product differentiation, Bastos and Straume (2012) concluded that the welfare effects of free trade are ambiguous, if certain portions of the country are protected from competition. Analysing the impact of trade and FDI liberalization, Fujiwara (2017) concluded that welfare in the country will rise if the productivity difference between FDI and export-competing industries is very small. In a single sector GOLE model, Azar and Vives (2021) found that in the presence of nonincreasing returns to scale and increasing market concentration, there would be a fall in real wages, employment and labour share. In the presence of labour rigidity, Maiti (2024) concluded that specialization effect for movement of labour from high to low labour-intensive sector, occurring due to the heterogenous productivity distribution of firms, would lead to a reduction in wages.

The literature investigating the impact of trade cost on welfare under oligopoly is quite extensive. Markusen (1981) derived the impact of trade costs on the economy's welfare under Cournot duopoly in the presence of integrated markets. The analysis concluded that the output

¹ Felbelmayr et al. (2013) considered Constant Elasticity of Scale (CES) preferences, while Demidova (2017) allowed the mark-ups to change.

² See for instance, Neary (2003a; 2009) for models in a Ricardian trade structure; Brakman et al. (2005), Neary (2007), Beladi et al. (2013) in case of cross-border mergers; Basile and De Benedictis (2008), Neary and Tharakan (2012) in case of unions and unemployment; Eckel and Neary (2010), Egger and Koch (2012) in case of multiproduct firms. A detailed survey on the literature involving the GOLE framework can be obtained from Colacicco (2015).

levels of both the firms would be positively related to multilateral trade due to procompetitive effect, in the presence of gains from trade. The world real income would rise following trade, if the countries vary in terms of their market size. The large country would witness a welfare loss, while the small country would gain. Cordelia (1993) studied the welfare consequences of free trade in a Cournot setting, in the presence of linear demand, zero marginal costs and many firms. The analysis observed that welfare in the home country would increase after the entry of foreign firms, if the domestic firms are more concentrated vis-a-vis their foreign counterparts. Collie (1996) analysed the impact of unilateral free trade on the welfare of an economy under Cournot duopoly. In the presence of linear demand structure and homogeneous goods, the analysis concluded that entry of a foreign firm will decrease the welfare of the domestic country, unless the corresponding cost incurred by the foreign firm is significantly lower. Bernhofen (2001) extended the work by Cordelia (1993) by incorporating product differentiation, a Bowley demand structure and zero transportation cost. The level of product differentiation and amount of IIT are found to be positively correlated, while gains from trade increase with an increase in the varieties of the product and the pro-competitive effect.

3. Motivation

The ramifications of the tariff policy on wages is a key research question in trade theory, owing to its protectionist nature in case of import-competing sectors, particularly in case of developing countries. The current study is motivated by the stylized evidence of asymmetry in relation between wages and tariff barriers imposed on final goods as opposed to intermediate products, in case of trade between two developing countries. The following Figure 1 highlights the observed relationship between weighted average tariff imposed on final goods (WAT(F)) and weighted average tariff imposed on intermediate goods (WAT(INT)) with wages in a few leading developing countries. Data on effectively applied weighted average tariff for the intermediate (UNCTAD SoP-2) and final products (UNCTAD Sop-3) between 1990 to 2023 is obtained from World Integrated Trade Solutions (WITS) (World Bank, undated). Data on average monthly wages of workers (at 2021 PPP \$) during the corresponding period has been collected from ILOSTAT (ILO, undated).

The obtained results indicate that tariff on final and intermediate goods affect the wages differently. One possible explanation behind this result may be extended to the fact that the final products (intermediate good) contain the intermediate goods (final goods) embedded in them. Since this is a simple scatter plot, all the other factors affecting the relationship between these variables cannot be simultaneously changed. The theoretical framework developed in the subsequent section contributes to providing a deeper understanding on the mechanism behind such relations, when both the product market and the factor market interacts with each other.

Figure 1: Movement of Wages with WAT(INT) and WAT(F) for Select Developing Country pairs











Source: Constructed by Authors

4. The Model with Trade in Final Goods

As discussed in the literature survey section, earlier works on examining impact of STP in GOLE framework has ignored the symmetric market structure (Rudsinske, 2023). The current analysis is based on the two-country GOLE framework model developed in the existing literature. In the current context, there are two countries – the domestic or the Home country (H) and the Foreign country (F), who engage in trade in homogenous products. Contrary to the

analysis by Rudsinske (2023) and Quint and Rudsinske (2024), a simple general equilibrium model is build-up by removing any kind of asymmetry between the two countries.³ This assumption also implies that the marginal utility of income between the two countries are same. Quint and Rudsinske (2024) have extended the GOLE framework to asymmetric countries, where trade, in the presence of uniform technology, generated results that are similar to the partial equilibrium oligopoly analysis by Brander and Krugman (1983). The main findings of Brander and Krugman (1983) noted that there exists a U-shaped relation between welfare and trade costs. However, the current analysis observes a negative relationship between social welfare and tariffs.

On the demand side of the economy, a representative consumer is considered who has preferences over two goods, which are of homogeneous variety. The economy is characterized by the presence of continuum of sectors or goods, $x \in (0,1)$ and the demand structure is assumed to be linear. The current analysis considers the case of duopoly, such that in each sector one domestic firm competes with one foreign firm in a Cournot framework. There is no product differentiation and firms produce only homogenous commodities. The technology is assumed to be linear with constant marginal costs, which is common to both the domestic and foreign firms, as long as they operate in the same sector. The model considers only an inelastically supplied factor of production, labour, which is traded in a competitive market in both countries.

Since the countries are symmetric, the productivity of any firm operating in the Home country is equal to that of the Foreign country. In the presence of fixed amount of input (labour), this implies that the marginal cost of production between the two countries are same. When the sectors have similar costs in two similar countries (termed as 'featureless economy' by Neary (2003a)), there will be no gains from trade. This kind of framework aids in an easy comprehension on the impact of tariffs and the optimal decisions that need to be imposed by the government, which otherwise becomes complicated to analyse in the presence of discernible features (e.g., in the form of comparative advantage leading to specialization).

4.1 Demand Side

It is assumed that each country is occupied by one representative consumer who furnishes L units of labour. The preferences of the consumer in the domestic country are illustrated by an additively separable utility function over a continuum of goods of unit mass, indexed by $x \in (0,1)$.

$$U[y(x)] = \int_0^1 u[y(x)]dx$$
(1)

The sub-utility functions are quadratic in nature, and it includes two homogeneous varieties of each good. The sub-utility functions are given by:

$$u[y(x)] = ay(x) - \frac{1}{2}by(x)^2$$
⁽²⁾

³ This assumption ensures that the population size, and hence the supply of labour, in each country is same. While in real world, there can a difference in the population level of the countries, the current analysis assumes that the trading partners are symmetric in nature.

where a, b > 0 and given the assumption of symmetry, a and b are assumed to be identical in both the countries. It is further assumed that, u'[.] > 0 and u''[.] < 0.

In the current analysis, y(x) is the amount of the homogeneous good consumed in sector x. The good can be produced either domestically or imported and the consumer is indifferent between the two.

$$y(x) = y_h(x) + y_h^*(x)$$
 (3)

 y_h is the amount of goods produced in Home country for itself and y_f is the export supply.

 y_h^* is the amount of goods produced in Foreign country for Home and y_f^* is produced in Foreign country for Foreign firms.

Total production by Home is therefore given as follows:

$$\bar{y}(x) = y_h(x) + y_f(x) \tag{4}$$

Moreover, total supply to Home is given by the following equation:

$$y(x) = y_h(x) + y_h^*(x)$$
 (5)

The national wage rate is w and the country is endowed with L units of labour. Therefore, total wage income is denoted by wL. As in the case of most of the oligopoly markets, it is assumed that some kind of unspecified barrier prevents free entry (Ervik and Seogaard, 2014). It is also assumed that the goods produced in each sector within a country cannot be substituted with the goods produced in the other sectors⁴. Therefore, each firm earns substantial profits despite the existence of continuum of sectors. The wage income (wL), aggregate profits (π) and tariff revenue (TR) are costlessly disbursed to the representative consumer, who utilizes it for consumption purpose. So national income (I) can be expressed as:

$$I = wL + \pi + TR \tag{6}$$

The budget constraint of the consumer is:

$$\int_0^1 p(x)y(x)dx \le I \tag{7}$$

In the present study, p(x) denotes the price per unit of the commodity produced in sector x. Since the commodities manufactured in each sector are homogenous, the demand or the price

⁴ The preferences in this case will generate a demand function that is linear in its own price and quantities. For details, see Colacicco (2013).

of any variety in the Home country will be equal to that in the Foreign country, that is, $p(x) = p^*(x)$ for all $x \in (0,1)$. This implies that there will be no price heterogeneity that can impact the utility of the consumer (Neary, 2016).

Therefore, the optimization problem for the consumer is given as follows⁵:

$$Max_{y(x)} L = \int_0^1 [ay(x) - \frac{1}{2}by(x)^2] dx + \lambda [I - \int_0^1 p(x)y(x) dx]$$
(8)

The first order condition yields:

$$0 = a - by(x) - \lambda p(x)$$

Therefore,
$$p(x) = \frac{[a-by(x)]}{\lambda}$$
 (9)

where λ stands for the Lagrangian multiplier of the budget constraint which can be interpreted as the marginal utility of national income. Equation (9) provides the linear inverse demand function for the optimal consumption of y(x). The salient feature of this equation is that other than the marginal utility of income, the demand price of commodity x is determined solely from variables related to sector x. In the current set-up, λ acts as the 'sufficient statistic' for the country in each of the sectors (Neary, 2003b). Following Colacicco (2013), the current analysis assumes that both p(x) and λ are positive, such that the demand for each good is always greater than zero. Therefore, at any positive price, all the commodities are essential. This will ensure the existence of interior solutions.

4.2 Supply Side

Given the demand, the objective of the producer is to maximise their profits. Following Neary (2016), the current analysis assumes that firms possess market power only in their corresponding sector, but they are considerably small in comparison to the market size in the country as a whole. Therefore, they do not exert any impact on overall economic factors like wage rate (w) and the marginal utility of income (λ). The presence of continuum of sectors ensures that the market power and these variables are collectively determined endogenously at the national level.

In the current framework, labour is the only factor of production. The supply of labour is inelastic, and its market is competitive⁶. The labourers can costlessly move across the various sectors in the economy, but they cannot move across the national borders. Hence, w is obtained endogenously at the country level by equating the aggregate labour demand with the fixed

⁵ The concavity of the sub-utility function ensures that both the necessary and the sufficient conditions for utility maximization are fulfilled by the first-order conditions.

⁶ The assumption of perfectly competitive labour market is reasonable if a continuum of sectors competes over a single factor of production, labour.

labour supply. Furthermore, there is no fixed \cos^7 and no transportation cost such that the prices charged by the firms in both the countries are the same. Constant returns to scale and common technology prevails in the production process in each sector x. The cost of production, c(x) in sector x will be linear in the level of output it produces. The sector-specific common unit-labour requirement is $\beta(x)$.

The unit-cost function for sector x is then given by:

$$c(x) = w\beta(x) \tag{10}$$

The analysis assumes that the technology across the various sectors as well as between the two countries are identical such that $\beta(x) = 1 \forall x$. So, unlike Neary (2003b; 2016) and Colacicco (2013), the model, when considering trade in final goods, does not apprehend a Ricardian style technological comparative advantage. This kind of framework only allows intraindustry trade to occur that arises due to strategic interactions between the firms (Rudsinske, 2023).

4.3 Cournot Equilibrium for the Final Goods

Firms in each sector engage in Cournot competition attempting to maximize their own outputs (which is used for domestic consumption, y_h and export, y_f). They also have complete information and assume that the wage rates in both countries, the government's trade policy and their foreign rival's output are given. Since the goods in each sector are not substitutes of each other and the firms take λ to be given, they do not include the prices of other goods and the national income (I) in their profit-maximization problem. In the first stage, the equilibrium outputs that both the firms will produce in absence of any trade policy is observed. The game is deciphered by backward induction.

The profit maximization problem of the Home firm (H) can be written as:

$$max_{y_h, y_f} \Pi = (p - w)y_h + (p^* - w)y_f$$
(11)

$$= \left[\frac{a - b(y_h + y_h)}{\lambda}\right] y_h - wy_h + \left[\frac{a - b(y_f + y_f)}{\lambda^*}\right] y_f - wy_f$$
(12)
where $p = \lambda^{-1} [a - by(x)] = \frac{a - b(y_h + y_h)}{\lambda}$ $p^* = \lambda^{*-1} [a - by^*(x)] = \frac{a - b(y_f + y_f)}{\lambda^*}$

Solving the first order conditions yields:

⁷ Significantly high fixed costs may be present, inducing oligopolistic market structure in any sector. However, in the presence of exogenously given number of firms, these fixed costs will not have any prominent role to play as long as the firms are earning positive profits (Colacicco, 2013). So, to simplify the model, fixed costs are assumed to be zero.

$$\frac{a-2by_h-by_h^*}{\lambda} - w = 0 \tag{13}$$

$$\frac{a-2by_f-by_f^*}{\lambda^*}-w=0$$
(14)

Equation (13) and Equation (14) can be transformed into the following reaction functions:

$$y_h = \frac{a - b y_h^* - \lambda w}{2b} \tag{15}$$

$$y_f = \frac{a - b y_f^* - \lambda^* w}{2b} \tag{16}$$

The output produced in the Home country illustrates the expected negative relation with the domestic wage rate. An increase in w will lead to an increase in the firm's cost of production, causing the domestic producers to decrease the level of output produced by them.

Similarly, the profit function for the Foreign firm (F) can be written as:

$$\pi^* = (p^* - w^*) y_f^* + (p - w^*) y_h^* \tag{17}$$

$$=\left[\frac{a-b(y_f+y_f^*)}{\lambda^*}\right]y_f^* - w^*y_f^* + \left[\frac{a-b(y_h+y_h^*)}{\lambda}\right]y_h^* - w^*y_h^*$$
(18)

Solving the first order conditions yields:

$$\frac{a - by_f - 2by_f^*}{\lambda^*} - w^* = 0$$
(19)

$$\frac{a - by_h - 2by_h^*}{\lambda} - w^* = 0$$
(20)

Equations (19) and (20) can be transformed into the following reaction functions:

$$y_f^* = \frac{a - by_f - \lambda^* w^*}{2b} \tag{21}$$

$$y_h^* = \frac{a - by_h - \lambda w^*}{2b} \tag{22}$$

Combining the system of reaction functions in equations (15), (16), (21) and (22), the Cournot-Nash (CN) Equilibrium supply of the firms in both the countries, Home and Foreign is obtained. The equilibrium supply of Home firms is:

$$y_h = \frac{a + \lambda w^* - 2\lambda w}{3h} \tag{23}$$

$$y_h^* = \frac{a + \lambda w - 2\lambda w^*}{3b}$$
(24)

Similarly, the supplied quantities in the Foreign country are as follows:

$$y_f = \frac{a + \lambda^* w^* - 2\lambda^* w}{3b} \tag{25}$$

$$y_f^* = \frac{a + \lambda^* w - 2\lambda^* w^*}{3b} \tag{26}$$

Since both the cost functions and demand functions are linear in output, the stability and hence the uniqueness of the CN Equilibrium in pure strategies is assured with no incentive on the part of either of the firms to deviate from their equilibrium (Colacicco, 2013).

4.4 General Equilibrium for the Final Goods

Let *L* and *L*^{*} be the inelastic supply of workers in Home and Foreign countries respectively. The total demand for labour (LD) in the country will be determined by the total production (\bar{y}) and it is expressed as LD = \bar{y} . For the market to clear, total labour demand must be equal to total labour supply. Therefore, the labour market equilibrium in Home country entails that, L = \bar{y} . The labour market equilibrium condition for the Foreign firms can be similarly obtained.

The total production (\bar{y}) by Home firms is computed as follows:

$$\overline{y} = y_h + y_f = \frac{2a + \lambda w^* + \lambda^* w^* - 2\lambda w - 2\lambda^* w}{3b}$$
(27)

The total supply to Home market is computed as:

$$y = y_h + y_h^* = \frac{a - \lambda w^* - \lambda w}{3b}$$
(28)

Putting the labour market equilibrium condition for the Home and Foreign firms, the following expressions are obtained:

$$L = y_h + y_f$$
 and $L^* = y_h^* + y_f^*$ (29)

Putting the equilibrium values of y_h , y_f , y_h^* and y_f^* from equations (23)-(26) and solving the above equation (29), the corresponding wages in both countries are derived as follows:

$$w_0 = \frac{2a - b(2L + L^*)}{\tilde{\lambda}} \tag{30}$$

$$w_0^* = \frac{2a - b(L + 2L^*)}{\tilde{\lambda}}$$
(31)
Where $\tilde{\lambda} = \lambda + \lambda^*$.

From equations (30) and (31), it is clear that for $L = L^*$, wages across both the countries will be equal⁸. Following (Rudsinske, 2023), the study assumes $\tilde{\lambda} = 1$. In other words, the aggregate value of the marginal utility of income is taken as the numeraire in the model.

4.5.1 Impact of Output Tariff

The analysis next considers a situation where the Foreign country government first implements a trade policy. The domestic government observes the outcome of this trade policy on the economy, more specifically on the wages of the workers and then decides on its own trade policy. Suppose Foreign country imposes a specific tariff ($t^*(x) \ge 0$) on each unit of the good produced in sector x in Home country, that are exported to the Foreign country. Since the tariff is being imposed on the final goods produced by the country, the analysis will use the term output tariff to define it.

So, the profit maximisation problem of Home firms can be written as:

$$max_{y_h, y_f} \Pi = (p - c)y_h + (p^* - c - t^*)y_f$$
(32)

$$= (p - w)y_h + (p^* - w - t^*)y_f$$
(33)

For simplicity it is assumed that the tariff imposed is uniform across all sectors⁹.

Thus, the new Cournot-Nash Equilibrium supply and wages for Home and Foreign firms are obtained. The new wages are derived as:

$$w_t = \frac{2a - b(2L + L^*) - \lambda^* t^*}{\tilde{\lambda}}$$
(34)

$$w_{t}^{*} = \frac{2a - b(L + 2L^{*})}{\tilde{\lambda}}$$
(35)

⁸ Other works in literature which have found equal wages across symmetric countries in the GOLE framework include that by Bastos and Kreickemeier (2009) and Kreickemeier and Meland (2013).

⁹ Theoretically, the government has the ability to internalize the impact of tariffs on variables like marginal utility of income and wages. Therefore, it can impose sector-specific tariffs. However, in reality it is very difficult for the government to obtain all the required information on a wide range of sectors in the economy and impose different tariffs on different sectors (Dixit and Grossman, 1986). Hence the assumption of uniform tariff across sectors is fairly reasonable.

The results obtained in the preceding section can be summarized in terms of Proposition 1 noted in the following:

Proposition 1: The wages in Home country falls when the Foreign country imposes tariff on its own imported goods.

Proof: Follows from (34).

The imposition of tariff reduces the demand for the imported good (i.e., Home's exported good) in the Foreign country, leading to a fall in the demand for labour in the domestic market. Now suppose, the domestic government decides to retaliate by imposing a specific tariff of t on all its imported goods.

Hence, the profit function of Foreign firms changes to:

$$max_{y_f^*,y_h^*}\pi^* = (p^* - w^*)y_f^* + (p - w^* - t)y_h^*$$
(36)

The new supply quantities are:

$$y_h = \frac{a + \lambda(w^* + t) - 2\lambda w}{3b} \tag{37}$$

$$y_h^* = \frac{a + \lambda w - 2\lambda(w^* + t)}{3b}$$
(38)

$$y_f = \frac{a + \lambda^* w^* - 2\lambda^* (w + t^*)}{3b} \tag{39}$$

$$y_f^* = \frac{a + \lambda^* (w + t^*) - 2\lambda^* w^*}{3b}$$
(40)

Solving the labour market equilibrium conditions, the following equations are generated:

$$L = y_h + y_f$$

$$L = \frac{2a + \lambda^* w^* - 2\lambda w + \lambda (w^* + t) - 2\lambda^* (w + t^*)}{3b}$$
(41)

Rearranging the above equation (41), the following expression is obtained:

$$w = \frac{a + \lambda^* w^* + \lambda w^* + \lambda t - 2\lambda^* t^* - 3bL}{2\tilde{\lambda}}$$
$$\frac{dw}{dt} = \frac{\lambda}{2\tilde{\lambda}} (>0)$$
(43)

(42)

From equation (42), it is clear that the wages in the domestic country are positively related to the domestic government's trade policy. However, since this is a general equilibrium analysis, the value of w^* is not considered to be exogenously given but rather determined from within the system. Solving the system of labour market equilibrium conditions for the wages, the following expressions are obtained.

The new wages are computed as follows:

$$w_T = \frac{2a - b(2L + L^*) - \lambda^* t^*}{\tilde{\lambda}}$$
(44)

$$w_T^* = \frac{2a - b(L + 2L^*) - \lambda t}{\widetilde{\lambda}}$$
(45)

Clearly, from equation (44), it can be observed that the domestic wage rate becomes independent of the domestic government's trade policy. This is due to the general equilibrium feedback that it receives from the Foreign country. When the domestic government imposes tariff (t), the demand for goods in the Foreign country falls. This leads to a fall in their demand for labour and consequently w^* falls. This relationship can also be observed from equation (45) where w^* and t are negatively related. The fall in Foreign wage makes their goods more competitive in the international market. So, the positive impact of tariff on domestic wage falls. Eventually, the rise in w due to rise in domestic country demand on imposition of t, is offset by a fall in its demand due to foreign goods becoming more competitive. This outcome is different from the standard partial equilibrium analysis on STP, which does not consider the impact of ton w^* .

Since the domestic wages eventually become independent of government trade policy, one may then wonder what the rationale is behind implementing them in the first place. As stated earlier, the objective of the current analysis is to find suitable sources for financing the compensation policies, which is the most challenging proposition for the government of any developing nation. Imposition of tariffs enables the policymakers to generate a revenue, which can be utilized as a potential source of finance for subsidizing the workers, whose wages have come down owing to trade reforms.

The current study only considers the case of specific tariff and not ad valorem tariffs. This is because in the GOLE framework, imposition of ad valorem tariffs will make the output levels independent of the government's trade policy and hence any strategic interaction between firms due to policy intervention cannot be analysed.¹⁰

¹⁰ For detailed discussion on this aspect, see Colacicco (2013).

4.5.2 Social Welfare

In the literature on STP, the optimal tariff is usually determined with the help of the welfare criterion. The social welfare in partial equilibrium framework is computed based on the following objective function:

V = Total consumer surplus in the Home market + Total Profits of the Home Firm + Tariff Revenue for the Home

The consumer surplus is the aggregate of the surplus realized by each $x \in (0,1)$.

Consumer Surplus (CS) = $\int_0^1 U[y(x)] - p(x)y(x)dx$

The producer surplus is the aggregate profit realized by each $x \in (0,1)$ of the Home country.

Producer Surplus (PS) = $\int_0^1 (p(x) - w) y_h(x) + (p^* - w) y_f(x) dx$

Tariff revenue is the aggregate revenue collected from imposing t on each x.

Tariff Revenue (TR) = $\int_0^1 t(x) y_h^*(x) dx$

$$V = CS + PS + TR$$

= $\int_0^1 U[y(x)] - p(x)y(x)dx + \int_0^1 (p(x) - w)y_h(x) + (p^* - w)y_f(x)dx$
+ $\int_0^1 t(x)y_h^*(x)dx$ (46)

Equation (46) represents the social welfare function, which the policymaker in the partial equilibrium scenario will maximize.¹¹ However, in the general equilibrium context, a policymaker should also take into account the impact of tariffs on the macroeconomic variables. This is done by introducing the balance of payments condition (which implicitly aids in the determination of marginal utility of income) in the welfare function (Ervik and Seogaard, 2014).

The balance of payments (BoP) condition is given by the following equation:

$$(ty_{h}^{*} - t^{*}y_{f}) + (p^{*}y_{f} - py_{h}^{*}) = 0$$
(47)

¹¹ In other words, here a policymaker only takes into account the impact of tariff on the industry, assuming the aggregate macroeconomic variables to be exogenous.

The left term in the expression representing the difference between the Home tariff revenue and the Foreign tariff revenue is the capital balance. The right term in the expression is the trade balance which is equal to Home export value minus the Home import value.

Using the full employment condition in equation (29) and the BoP equation in (47), the expression for welfare in (46) collapses to equation (48):¹²

$$V = \int_{0}^{1} U[y(x)] - wL \ dx$$
(48)

The aggregate marginal utility of income is normalized to unity. So $\overline{\lambda} = 1$. Since, both the countries are symmetric in nature, their marginal utilities of income will be equal. Therefore, $\lambda = \lambda^* = \frac{1}{2}$. Putting the values of y_h and y_h^* from equation (37) and (38) in equation (48), the following equation (49) is obtained:¹³

$$V = -\frac{1}{9} \int_0^1 [\theta + \frac{1}{4} t(x)]^2 - wL$$
(49)

where $\theta = a + 4a\lambda - 3bL\lambda - 3bL^*\lambda - t^*\lambda^*\lambda$

Since t is assumed to be uniform across all the sectors in the country, that is t(x) = t for each $x \in (0,1)$, then;

$$V = -\frac{1}{9} \left(\theta + \frac{1}{4}t\right)^2 - wL$$

$$\frac{dV}{dt} = -\frac{1}{18} \left(\theta + \frac{1}{4}t\right)$$

$$(50)$$

$$\frac{d^2V}{dt} = -\frac{1}{18} \left(\epsilon 0\right)$$

$$(51)$$

$$\frac{dv}{dt^2} = -\frac{1}{72} \ (<0) \tag{31}$$

It is imperative from equation (50) that social welfare falls as t rises. The following proposition regarding welfare, after imposition of tariff policy, can be written.

Proposition 2: The social welfare in the country unambiguously declines due to the imposition of tariff by the government.

¹² The expression obtained by Neary (2016) for social welfare is similar to equation (48) with an additional labour income component. This is because *PS* in Neary (2016) model comprise of profits and wage income. In the current analysis, $PS = Revenue(R) - wL = \pi + wL - wL = \pi$. Therefore, an additional wage income component is present in the social welfare expression in the current study. It, however, does not change any of the conclusions drawn from the analysis. This is because the purpose of computing social welfare is to analyse the impact of trade policy on it and the term *wL* is independent of the policy instrument. The detailed account of the steps undertaken is given in Appendix 1.

¹³ The detailed account of the steps undertaken is given in Appendix 2.

Proof: It follows from equation (50).

To find welfare maximising optimum tariff, put $\frac{dV}{dt} = 0$

So, $t = -4\theta$ $t = -4\left(a + \frac{4a}{2} - \frac{3bL}{2} - \frac{3bL^*}{2} - \frac{t^*}{4}\right)$

The welfare maximising optimum tariff is computed as:

 $t_{optimal} = -12a + 6b(L + L^*) + t^*$ (52)

Equation (52) gives the final expression for welfare maximizing optimal tariff. Two interesting conclusions emerge from equation (52). First, it shows that the optimal tariff of the Home country is positively related to t^* .

Second, it can be observed that for low value of t^* , the optimal tariff may be negative¹⁴. The intuition behind the outcome is the following. Suppose t^* is very low such that Foreign country purchases more of Home country goods. So, the demand for labour in the Home will rise and consequently the wages will experience an increment. Therefore, an extra t cannot increase the producer surplus effectively. So, when t^* is very low, it is better for Home to subsidize its imports. Conversely, when t^* starts to rise, it becomes more lucrative to increase t and hence a positive relation is established between these two variables.

From the results obtained above, the following is proposed.

Proposition 3: If the tariff imposed by the Foreign country is very low, then the optimal trade policy for the domestic government is subsidy.

Proof: Follows from equation (52) and the above discussions.

4.5.3 Compensation under GOLE for Trade in Final Goods

The current analysis computes and compares the tariff revenue gained, and the amount of subsidy required to cover all the losses. Loss to the domestic workers due to the imposition of tariff can be computed as the difference between the wages pre and post imposition of tariff. Loss of each worker or the subsidy required per worker is given as:

¹⁴ For the marginal utility of consumption to attain a positive value, it requires that a > by in equilibrium. Following Rudsinske (2023) the study considers the most extreme scenario where y = 1. This implies that a > b. Therefore, equation (52) will generate a negative value of optimal tariff unless t^* is high enough to counter the negative effect.

 $Loss = w_0 - w_t = \frac{t^*}{2}$

Total subsidy required is given by:

$$S = \frac{t^*}{2}L$$
(53)

Equation (53) gives the total loss and hence the total amount of subsidy that the government needs to provide to the workers.

The total tariff revenue (TR) generated can be computed as:

$$TR = t \left[\frac{a + 0.5w - w^*(t) - t}{3b} \right]$$
(54)

$$\frac{dTR}{dt} = \frac{A + tA'(t) - 2t}{3b}$$
(55)

Where, $A = a + 0.5w - w^{*}(t)$

$$= \frac{3bL^*}{2} - \frac{1}{4}t^* - \frac{1}{2}t$$
⁽⁵⁶⁾

(58)

$$\frac{dTR}{dt} > 0 \text{ iff } \frac{1}{3} \left(\frac{3bL}{2} - \frac{t^*}{4} \right) > t \tag{57}$$

And at t = 0, $\frac{dTR}{dt} > 0$ iff A > 0.

The derivation of equation (57) and (58) is given in Appendix 3.

Putting the value of w and w^* from equations (44) and (45), equation (54) can be written in the following form:

$$TR = t \left[\frac{0.75b - 0.25t^* - 0.5t}{3b} \right]$$

From the above expression, a graphical representation of tariff revenue can be generated for different values of the variables. Figure 2 illustrates one of the iterations of the projected trajectories of TR and S by setting b = 10, L = 10, $t^* = 2.5$ percent and t varying between 0 to 100 percent.





Source: Constructed by authors

From Figure 2 it can be observed that tariff revenue will be sufficient to cover the subsidy required for all values of tariff beyond a certain critical level (lying between 50 to 60 percent in the current diagram). Let the critical value of tariff beyond which revenue exceeds the subsidy be denoted as t^s . From equation (57) it can be observed that a higher value of t^* will imply a flatter tariff revenue schedule. This implies that the level of tariff (t^s) that the government needs to set up to fully subsidize the loss of the workers will be higher. Let R(t) be the range of tariff rates for which the revenue generated from the policy instrument is greater than the amount of subsidy required. This range will be smaller if value of t^* is very high and vice-versa. Therefore, it can be concluded that it is possible to use tariff revenue to compensate the workers facing loses as long as the foreign rival is not too aggressive in setting-up its trade policy.

The above obtained result can be summarized as follows.

Proposition 4: In case of trade in final goods, if the foreign government imposes lower t^* , it is easier for the domestic government to maintain the balanced budget to finance the subsidy.

5. The Model with Trade in Final and Intermediate Goods

The discussions so far have explored the ability of the government to compensate the workers losing out from trade by imposing tariffs on its final good. However, bulk of trade globally has always been dominated by exchange of intermediate products (Sanyal and Jones, 1982; Amendolagine et al., 2019). According to Kleinert (2003), the primary factors contributing to the surge in trade in intermediate products include growing relevance of multinational enterprises (MNEs), changes in global sourcing patterns owing to trade dost dynamics and outsourcing decisions. Moreover, Assche and Gangnes (2019) observed that

presence of intermediate inputs in international trade flows changes the types of workers who win or lose due to trade liberalization. According to their analysis, the managers of firms that predominantly trade in inputs (more specifically GVC-oriented firms), prefer trade openness since they can substitute the local unskilled workers with their corresponding foreign counterparts. This in turn jeopardizes the position of the workers whose earnings and jobs are threatened due to greater competition. Given the growing importance of intermediate goods in international trade, the current analysis extends the model specified earlier by incorporating trade in inputs. This extension provides a more realistic and comprehensive understanding on the government's ability to compensate the workers with the help of tariff revenue.

Both the Home and Foreign country are assumed to use labour and the intermediate good (m) as inputs for producing their final products. For simplicity, it is also assumed that the intermediate input is produced only in the Home country using labour. The input market is competitive, supplying any amount of the good that will be jointly demanded by both the countries. The wage rate of labour is same for producing both the final and intermediate products and is denoted by w. The Foreign country imports this input to produce the final good for the Home country only. It does not use the final good for its own consumption, that is $y_h^* > 0$ and $y_f^* = 0$. The difference from the earlier model is that the Home country now exports only the input to the Foreign country. In other words, its export of final goods is zero, i.e., $y_f = 0$.

Let α be the units of labour required for producing one unit of the final good in both the countries and β be the units of labour required for producing one unit of the intermediate good in the Home country. For simplicity, only the domestic market of the Home country will be considered for the analysis of trade in final and intermediate goods.

The total profit in the Home country will now comprise of two components. The first component is the profits earned by the producer by selling the final good in the domestic market. The second component is the profits earned by the Home country by selling the input to both its domestic market and the Foreign country. The demand for the input will depend on the final goods production in both the countries.

The profit function of the Home country is given as follows:

$$Max \pi = [p - (\alpha + \beta)w]y_h + (p_m - \beta w)(y_h^*)$$
(59)

Here p_m is the price per unit of the intermediate input and it is determine competitively based on total demand.

5.1 Impact of Input Tariff

Suppose Foreign country imposes τ^* on its import of the intermediate input (also called input tariff). There will be a two-way impact of this tariff on the domestic country's profit. The reaction functions (15), (16), (21), (22), show that there exists an inverse relationship between Home and Foreign country output production. In other words, an increase in output production by the Foreign firm leads to a decline in the output production by the Home firm. This implies a fall in marginal revenue of the domestic firms. This is the standard result under Cournot competition when firms compete over outputs. However, in the current exercise, an increase in

foreign output will also imply an increase in demand and consequently an increase in the domestic production of the intermediate input. This counters a proportion of the fall in the marginal revenue of the domestic firms. Therefore, there exists a trade-off between producing more output and producing more input in the Home market.

The new profit function of the Home producers, after imposition of τ^* , is given by:

$$Max \pi = [p - (\alpha + \beta)w]y_h + (p_m - \beta w - \tau^*)(y_h^*)$$
(60)

$$= \left[\frac{a - b(y_h + y_h^*)}{\lambda} - (\alpha + \beta)w\right]y_h + (p_m - \beta w - \tau^*)(y_h^*)$$
(61)

As stated earlier, only the situation in the Home market will be estimated in the current analysis. The first order condition for the final goods in Home market is given by:

$$\frac{d\pi}{dy_h} = \frac{a - 2by_h - by_{h^*}}{\lambda} - (\alpha + \beta)w = 0$$
(62)

The profit of the foreign firm is given as follows:

$$Max \pi^* = [p - (\alpha w^* + p_m)] y_h^*$$
(63)

Following the steps in the previous analysis involving trade in the final goods, the domestic government will retaliate by imposing tariff (τ) on its import of final goods from Foreign country.

Therefore, the profit function of the Foreign country becomes:

$$Max \pi^* = [p - (\alpha w^* + p_m) - \tau] y_h^*$$
(64)

$$= \left[\frac{a - b(y_h + y_h^*)}{\lambda} - (\alpha w^* + p_m) - \tau\right] y_h^*$$
(65)

The first order condition for the Foreign country is given by the following equation:

$$\frac{d\pi^*}{dy_h^*} = \frac{a - by_h - 2by_h^*}{\lambda} - (\alpha w^* + p_m) - \tau = 0$$
(66)

Solving equation (62) and equation (66), the value of the output levels y_h and y_h^* are obtained as follows:

$$y_h = \frac{a + (\alpha w^* + p_m)\lambda + \tau \lambda - 2(\alpha + \beta)\lambda w}{3b}$$
(67)

$$y_h^* = \frac{a - 2(\alpha w^* + p_m)\lambda + (\alpha + \beta)\lambda w - 2\tau\lambda}{3b}$$
(68)

5.2 Labour Market Equilibrium

Equilibrium in the labour market will be generated at the point where total labour demand will be equal to the total labour supply:

$$L_y^{\ d} + L_m^{\ d} = L^S$$

$$\alpha y_h^{\ h} + \beta (y_h^{\ h} + y_h^{\ *}) = L^S$$
(69)

Putting the values of y_h and y_h^* in equation (69) and solving for w generates the following result:

$$w = \frac{(\alpha + 2\beta)a + (\alpha - \beta)[(\alpha w^* + p_m)\lambda + \tau\lambda] - 3bL}{0.5(\alpha + \beta)(2\alpha + \beta)}$$
(70)

From equation (70) it can be observed that the relation between τ and w will depend on the term $(\alpha - \beta)$. The wages will be negatively related to τ when $\alpha < \beta$, i.e., when the unit labour requirement for producing intermediate good exceeds that of the final good. The rise in τ imposed by the Home country will reduce the demand for foreign goods. This will lead a fall in production of final goods in the Foreign country, which in turn leads to a fall in the demand for Home country's intermediate inputs. Consequently, the demand for labour and hence the wages in domestic country falls, offsetting some of the positive impact of τ on w. The net impact on w will depend on the magnitude of the two opposing effects. If β is very high, then the fall in foreign demand for the intermediate inputs will have greater impact on the labour market as compared to the rise in domestic demand, such that the overall demand for workers in the domestic country will fall. This will exert an overall negative effect on the wages. Conversely, w will rise with the rise in the τ when $\alpha > \beta$.

The following proposition summarizes the obtained result.

Proposition 5: The wages in the domestic country will fall with the imposition of tariff by the domestic government if $\alpha < \beta$.

Proof: Follows from equation (70) and the above discussion.

5.3 Tariff Revenue and Worker's Wage Loss

The total loss to the workers due to imposition of tariff is obtained through the difference between their initial wages and the final wages.

In order to fully compensate the workers, the subsidy provided to each worker should be equal to the loss they incurred. Total subsidy required (S) is given as follows:

$$S = \frac{(\beta - \alpha)\tau L}{(\alpha + \beta)(2\alpha + \beta)}$$
(71)

The total change in subsidy when the tariff rate changes by one unit, is given as follows:

$$\frac{dS}{d\tau} = \frac{(\beta - \alpha)L}{(\alpha + \beta)(2\alpha + \beta)}$$
(72)

Therefore, when τ rises by one unit, subsidy needs to rise by $\frac{(\beta-\alpha)}{(\alpha+\beta)(2\alpha+\beta)}$ units.

Tariff revenue (TR) is computed as:

$$TR = \tau y_h^*$$
$$= \tau \left[\frac{a - (\alpha w^* + p_m) + 0.5(\alpha + \beta)w - \tau}{3b} \right]$$
(73)

Differentiating equation (73) with respect to τ , the following conditions are obtained:

$$\frac{dTR}{d\tau} = \frac{a - (\alpha w^* + p_m) + 0.5(\alpha + \beta)w - 2\tau}{3b}$$
(74)

And,
$$\frac{d^2 TR}{d\tau^2} = -\frac{2}{3b} \ (<0)$$
 (75)

Unlike the case with trade in final goods, the wages in case of trade in final goods as well as intermediate inputs is dependent of tariff. Therefore, the change in tariff revenue is computed when both the tariff rate and the wages change simultaneously. To do so, equation (70) is differentiated with respect to τ to obtain:

$$\frac{dw}{d\tau} = \frac{-(\beta - \alpha)\lambda}{0.5(\alpha + \beta)(2\alpha + \beta)}$$
(76)

Differentiating equation (73) with respect to τ and putting the value of equation (76), the following expression is obtained:

$$\frac{dTR}{d\tau} = \frac{a - (\alpha w^* + p_m) + 0.5(\alpha + \beta)\frac{dw}{dt} - 2\tau}{3b}$$
(77)

$$= \frac{a - (\alpha w^* + p_m) - 2\tau}{3b} - \frac{\lambda(\beta - \alpha)}{3b(2\alpha + \beta)}$$
(78)

$$= \frac{a - (\alpha w^* + p_m) - 2\tau}{3b} - \frac{0.5(\beta - \alpha)}{3b(2\alpha + \beta)}$$
(79)

$$\frac{dTR}{dt} > 0 \text{ iff } \frac{1}{2} \left[a - (\alpha w^* + p_m) - \frac{0.5(\beta - \alpha)}{(2\alpha + \beta)} \right] > \tau$$

$$\tag{80}$$

In case of trade in intermediate goods, given the two-way effect of tariff on wages, there will be two different scenarios, which are discussed below:

Case I: Wages rise with the rise in tariff

This is the case when the amount of labour required for producing the final good is greater than that of the intermediate good, i.e., $\alpha > \beta$. Then it is clear from equation (72) that, the subsidy required falls with an increase in tariff. This is because w is positively correlated with τ , such that with every unit rise in tariff, the loss of the workers declines, thereby reducing the amount of subsidy required.

At
$$\tau = 0$$
, $\frac{dTR}{d\tau} > 0$ iff $a - \frac{0.5(\beta - \alpha)}{(2\alpha + \beta)} > (\alpha w^* + p_m)$.

Figure 3 shows one of the iterations of the projected graph of TR and S by setting $a = 40, b = 10, L = 10, \alpha = 0.7, \beta = 0.5, w = $160, w^* = $150, p_m = $10 and t varying between 0 to 100 percent.$

Figure 3: Tariff Revenue and Subsidy Schedule in presence of Trade in Final Goods and



Intermediate Inputs (when $\alpha > \beta$)

In this case, the tariff revenue generated is always sufficient to fully compensate the loss to the workers. The obtained result is different from the earlier scenario, where only trade in final goods was considered.

Case II: Wages fall with the rise in tariff

This is the case when the amount of labour required for producing the final good is less than that of the intermediate good, $\alpha < \beta$. In this case, there are two opposing forces that are operating. First, an increase in tariff will imply an increase in revenue generated, such that the

Source: Constructed by authors

ability of the Home country to compensate the workers rises. On the other hand, since wages fall with the rise in tariff, an increase in τ will also imply an increase in the amount of subsidy required. This is also evident from the positive value of $\frac{ds}{d\tau}$ in equation (72).

From equation (72) and equation (79), it follows that the rise in tariff revenue would be greater than the rise in subsidy, iff:

$$\frac{a - (\alpha + \beta p_m)w^* - 2\tau}{3b} - \frac{0.5(\beta - \alpha)}{3b(2\alpha + \beta)} > \frac{(\beta - \alpha)L}{(\alpha + \beta)(2\alpha + \beta)}$$
(81)

Solving equation (81), the maximum value of tariff rate (τ_N) is obtained, at which the revenue generated will exceed the total loss to the workers. In other words, beyond τ_N , the fall in wages will be so high that the revenue generated will be insufficient to subsidize all the workers in the Home country. The expression of τ_N is given by the following equation:

$$\tau_N = \frac{a - (\alpha + \beta p_m)w^* - 0.5(\beta - \alpha)}{2} - \frac{3b(\beta - \alpha)L}{2(\alpha + \beta)(2\alpha + \beta)}$$
(82)

Putting $\frac{dTR}{dt} = 0$ from equation (74), the expression for revenue maximising tariff is obtained in equation (83) as follows:

$$\tau_{max} = \frac{a - (\alpha + \beta p_m)w^* + 0.5(\alpha + \beta)w}{2}$$
(83)

Clearly, $\tau_N < \tau_{max}$

At
$$\tau = 0$$
, $\frac{dTR}{d\tau} > 0$ iff $a > (\alpha + \beta p_m)w^* + \frac{0.5(\beta - \alpha)}{(2\alpha + \beta)}$

To see the result in perspective, the projected graph of TR and S of one of the iterations is shown with the help of Figure 4, when $a = 40, b = 10, L = 10, \alpha = 0.5, \beta = 0.7, w =$ \$160, $w^* =$ \$150, $p_m =$ \$10 and t varying between 0 to 100 percent.

If the tariff rate is less than τ_N , the tariff revenue generated can optimally subsidize workers. In Figure 4, the value of τ_N lies between 70 to 80 percent. Beyond, τ_N , the loss to the workers will exceed the revenue generated.

Figure 4: Tariff Revenue and Subsidy Schedule in presence of Trade in Final Goods and Intermediate Inputs (when $\alpha < \beta$)



Source: Constructed by authors

6. Conclusion

The impact of STP on the wages and welfare of a country is an area of crucial consideration for the policymakers. Since the works by Brander (1981) and Brander and Spencer (1984a), the common contention is that, in the presence of strategic competition, government intervention will be beneficial for the domestic players. According to the existing literature, optimal tariff improves the terms of trade of a country and augment the domestic market's profit. Brander and Spencer (1984a) have provided a comprehensive analysis of the case of optimal tariff under oligopoly. However, their model is based on a partial equilibrium framework and hence it tends to omit the general equilibrium feedback effects. Since STP affects a large number of sectors in the economy, it is imperative that the linkages between the sectors are taken into consideration in the model. The current study attempts to fill in this gap in literature by sketching the effect of STP in a two-country framework within a general oligopolistic equilibrium (GOLE) model developed by Neary (2003a, 2016). The existing research on this branch of literature has so far concentrated on the final goods. The current analysis focuses on the effects of import tariff on both the final and intermediate goods, which is the first attempt at incorporating the latter segment within the GOLE framework.

The model results reveal that imposition of tariff by the Home country on its final goods raises the domestic wage rate in addition to generation of tariff revenue, which can be used to compensate the workers who have faced a decline in their wages, as long as the tariff rate is above a critical level. However, in case of intermediate goods, when $\alpha < \beta$, tariff revenue (generated beyond τ_N) is not sufficient to fully compensate the workers. The underlying logic is that the rise in tariff implies that foreign output, and consequently the demand for Home's intermediate input decreases. If the labour required for producing intermediate goods is greater than that of final goods, then this implies an overall fall in labour demand in the domestic country, leading to a fall in the worker's wages. Given the negative relation obtained between WAT(INT) and wages in Section 3, when trade between different countries take place, the latter case is most likely to occur in reality. A negative relationship between WAT(F) and wage is

observed, which may indicate the dominance of intermediate goods embedded in the final products. At the same time, it also underlines the possibility that the intermediate goods market requires a larger share of unit labour requirement as compared to the final goods segment.

In the recent period, the strategic importance of tariff in several countries are re-emerging with a possibility of retaliation in some cases looming large (White House, 2025). In this backdrop, the obtained results have crucial policy implications, especially given increasing participation of countries in GVCs. Intrinsically, the case as observed with respect to intermediate goods is most likely to occur, where tariff revenue may not provide a sufficient source to compensate the workers. Therefore, there is a need to think of other alternative ways to elevate the wages of the workers, without putting any budgetary pressure on the government. One such way is to bring in more foreign direct investment (FDI) in the country. In the present analysis, FDI will enter the economy through y_h^* . From equation (68), clearly there exists a positive relation between y_h^* and w. Therefore, an inflow of FDI, given the potential of technology transfer, can augment the wages of the workers in the domestic country.

For future work it would be interesting to see the GOLE framework extended to incorporate various other features, such as asymmetries between the countries, when trade in intermediate goods take place. This can generate different result for the optimal tariff in the Home country. This may also have an impact on the country's ability to use tariff revenue as a financial source of compensation.

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Appendix A

Appendix 1: Derivation of Social Welfare Function

$$V = CS + PS + TR$$

= $\int_0^1 U\{y(x)\} - p(x)y(x)dx + \int_0^1 \{p(x) - w\}y_h(x) + (p^* - w - t^*(x))y_f(x)dx +$
 $\int_0^1 t(x) y_h^*(x) dx$
= $\int_0^1 \left[U\{y(x)\} - p(x) \left(y_h(x) + y_h^*(x)\right) + \{p(x) - w\}y_h(x) + (p^* - w - t^*(x))y_f(x) + t(x)y_h^*(x)\right] dx$
= $\int_0^1 \left[U\{y(x)\} - w\{y_h(x) + y_f(x)\} + p^*y_f(x) - p(x)y_h^*(x) + ty_h^*(x) - t^*(x)y_f(x)\right] dx$

Rearranging the above expression yield the following,

$$V = \int_0^1 \left[U\{y(x)\} - wL + p^* y_f(x) - p(x) y_h^*(x) + t y_h^*(x) - t^*(x) y_f(x) \right] dx$$

$$V = \int_0^1 [U\{y(x)\} - wL] dx$$
(A.1)

Appendix 2: Derivation of Social Welfare Function After Imposition of Tariff

$$V = \int_0^1 y(x) \left[a - \frac{1}{2} by(x) \right] - wL \, dx$$

=
$$\int_0^1 \left[\frac{a - \lambda p(x)}{b} \right] \left[a - \frac{1}{2} b \left(\frac{a - \lambda p(x)}{b} \right) \right] - wL \, dx$$

=
$$\int_0^1 \left[\frac{a - \lambda p(x)}{b} \right] \left[\frac{2a - (a - \lambda p(x))}{2} \right] - wL \, dx$$

=
$$\frac{1}{2b} \int_0^1 [a^2 - \lambda^2 p(x)^2] - wL \, dx$$
(A.2)

Ignoring the constant terms, equation (A.2) collapses to the following:

$$V = -\lambda^{2} \int_{0}^{1} p(x)^{2} - wL \, dx$$

Now, $p = \frac{a - b(y_{h} + y_{h}^{*})}{\lambda}$
 $V = -\int_{0}^{1} [a - b(y_{h} + y_{h}^{*})]^{2} - wL \, dx$

$$= -\int_{0}^{1} \left(\frac{a + \lambda w^{*} + \lambda t(x) + \lambda w}{3}\right)^{2} - wL \, dx$$

$$= -\int_{0}^{1} \left(\frac{a + 4a\lambda - 3bL\lambda - 3bL^{*}\lambda - t^{*}\lambda^{*}\lambda + t(x)\lambda(1 - \lambda)}{3}\right)^{2} - wL \, dx$$

$$= -\frac{1}{9} \int_{0}^{1} [\theta + t(x)\lambda(1 - \lambda)]^{2} - wL \, dx$$

Where $\theta = a + 4a\lambda - 3bL\lambda - 3bL^{*}\lambda - t^{*}\lambda^{*}\lambda$
Putting the value of $\lambda = \lambda^{*} = 0.5$, the above expression collapses to
 $V = -\frac{1}{9} \int_{0}^{1} \left[\theta + \frac{1}{4}t(x)\right]^{2} - wL \, dx$
(A.3)

Appendix 3: Derivation of Equation (57) and Equation (58)

$$TR = t \left[\frac{a + 0.5w - w^*(t) - t}{3b} \right]$$
$$\frac{dTR}{dt} = \frac{A + tA'(t) - 2t}{3b}$$
(A.4)

Where,
$$A = a + 0.5w - w^*(t)$$
 (A.5)

From equations (44) and (45) the values of wages obtained are,

$$w = 2a - b(2L + L^*) - 0.5t^*$$
 and
 $w^* = 2a - b(L + 2L^*) - 0.5t^*, \ \tilde{\lambda} = 1$

Putting the value of w and w^* in equation (A.5) yields the following,

$$A = a + 0.5w - w^{*}(t)$$

= $\frac{3bL^{*}}{2} - \frac{1}{4}t^{*} - \frac{1}{2}t$ (A.6)

Putting the value of A in equation (A.6) in equation (A.4), the following is obtained.

$$\frac{dTR}{dt} > 0 \text{ iff } \frac{1}{3} \left(\frac{3bL}{2} - \frac{t^*}{4} \right) > t$$

And at t = 0, $\frac{dTR}{dt} > 0$ iff A > 0.