Tariff, Wages and Compensation: A General Oligopolistic Equilibrium Analysis

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Abstract

The current paper analyses the impact of strategic trade policy on wages and welfare in a two-country general oligopolistic equilibrium model. Firms face resource constraints and wages are simultaneously determined. Relative to free trade, imposition of tariff leads to a reduction in the wages of the partner country. The welfare of the tariff-imposing country is unambiguously penalized. The revenue generated from tariff and the subsidy required to compensate the affected workers are compared. When trade in only final goods take place, the results indicate that tariff revenue can compensate the workers beyond a specific level of tariff rate. This specific level of tariff is directly related to foreign tariff rate. A high value of foreign tariff implies a lower ability of the domestic government to subsidize the workers. However, when trade in both final and intermediate goods take place, we get the opposite results, where tariff revenue can compensate the workers up to a certain level of tariff rate. The results are of crucial policy relevance, especially given the increasing participation of developing countries in Global Value Chains. Rationalization of these effects suggests a political-economy view on tariff formation in general equilibrium.

Keywords: Cournot Competition, Compensation, General oligopolistic equilibrium, Welfare

JEL Codes: D43, J33, L13, I31

1. Introduction

The most accepted hypothesis regarding trade liberalization is that it creates winners and losers (Eliot et al., 1994; Davidson and Matusz, 2006; Dixon and Rimmer, 2022). Although theory assures that the gains by winners from trade are more than enough to neutralize the losses, such that the economy as a whole benefit, empirical studies have proven otherwise (Jacobson et al.,1993; Kletzer, 2001; Davidson and Matusz, 2004). Sometimes the costs are so high that the gains from trade are realised only partially or get redistributed asymmetrically (Porto and Hoekman, 2010). 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. Compensation measures for the workers who are adversely impacted as a consequence of trade liberalization are provided only in few developed nations (such as the trade adjustment assistance (TAA) and the European Globalization Adjustment Fund (EGAF) schemes that are practiced in the United States and European Union (EU) respectively) and have been explored in the existing literature (Feenstra and Lewis, 1994; Davidson and Matusz, 2006; Cosar, 2013; Lechthaler and Mileva, 2021). The developing nations do not exercise 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 losers of trade, especially in developing nations is the lack of monetary funds (OECD, 2020). Theory states that 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 benefits (Carroll and Hur, 2020). Therefore, one avenue of taxing the gainers can be through the imposition of consumption tax. However, identifying the exact people who gain from trade is a difficult task (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 stopped operating due to trade. Similarly, it is easy to recognize the people who have been fired from those businesses. However, it is hard for the consumers to determine how much the goods purchased by them have become cheaper following trade. Levying consumption taxes arbitrarily on consumers may lead to public retaliation.

Another potential avenue of compensating the losers from trade, is through lumpsum transfers (Dixit and Norman, 1980, 1986; Kemp and Wan, 1986; Egger and Kreickemeier, 2009). According to Brecher and Choudhri (1994), in the presence of many consumers and the absence of any distortions, Pareto gains can be obtained with the aid of lump-sum transfers. However, provision of these transfers requires prior information on the tastes and endowments of the households. Such information is not easy to obtain because every household will have the incentive to misinform their characteristics, so that they receive larger transfer. Dixit and Norman (1980, 1986) have suggested the use of commodity tax, which does not require prior household information, to compensate those who suffer from trade. However, since their model is based on full-employment, the issue of compensating those who lose their jobs following reforms is not addressed. Studies by Brecher and Choudhri (1994) and Feenstra and Lewis (1994) have found that commodity taxes will not lead to Pareto gains in presence of unemployment and imperfect factor mobility respectively.

Moreover, given the government's objective to reduce the adjustment costs, it cannot impose any tax on the trading sector. 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 its utilization. Therefore, tariff revenue can be considered as a potential channel through which the government can finance its compensation policies.

Feenstra and Bhagwati (1982) have proposed the use of revenue from tariff to compensate the workers affected due to trade. According to their analysis, any protectionist policy is the consequence of lobbying. With the help of a Hecksher-Ohlin model of trade, they showed that lobbying is generated due to a 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. However, given the level of real reward and protection in such an equilibrium, Feenstra and Bhagwati suggests that tariff revenue should be used by the government as part of its compensation budget. Shifting the revenue generated from imposing tariff to the factor, for instance labour, that has lobbied to receive protection, enables the government to maintain their real returns at the level attained via exertion of its political capabilities to affect policy, but with a decreased tariff, and therefore increasing the real rewards of the second factor, capital through the Stolper Samuelson effect (Hillman, 1988). This causes the welfare in the economy to rise.

Therefore, tariff revenue can be utilized to compensate the workers facing loses without exhausting the benefits of free trade. Most of the existing studies on compensation focus on trade in final goods. 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 goods and the intermediate goods. The results indicating that the sources may be different, are of crucial policy relevance, especially given the increasing participation of developing countries in global value chains (GVCs).

2. Strategic Trade Policy (STP) and General Equilibrium

The general contention regarding any policy discission and its associated impact is that it is macroeconomic in nature. However, within the domain of any industry and trade-related policy, the common practice is to analyse them within micro frameworks, thereby neglecting the link to macro that arise due to any general equilibrium repercussions. While micro-based foundation provides significant insights, they suffer from the serious drawback of being build-up on incomplete information. A fully informed policymaker will acknowledge that apart from exerting impact on the production process, any trade or industry related policy will have general equilibrium consequences through the changes in the factor prices as well as the national income. Therefore, neglecting these general equilibrium effects will render the analysis on the impact of any strategic trade policy insufficient. According to Krugman (1987),

> 'to pursue a strategic trade policy successfully, a government must not only understand the effects of its policy on the targeted industry, which is difficult enough, but must also understand all the industries in the economy well enough that it can judge that an advantage gained here is worth advantage lost elsewhere.'

Analysis of STP in the partial equilibrium framework will provide an incomplete understanding regarding its impact on the economy. This is because, these models assume that the policy impacts only the sector under study, taking the factor income and national income as given, thereby neglecting the interaction between the factor and the product market. To get a better comprehension on this phenomenon, consider an economy with an inelastic supply of a single factor. Suppose the government's implementation of STP in favour of a particular sector, leads to an expansion of its production capacity. Partial equilibrium analysis will only take this particular sector into account and conclude that the STP has led to an increase in the firm's profit following

an increase in production. However, it fails to consider the interaction of this sector with the factor market via which there will be a rise in the income of the factor due to an increase in its demand. This will offset some of the increased profits of the final goods sector. Additionally, an augmented factor reward will also affect the profitability of all the other sectors in the economy. Hence, in general equilibrium framework, strategic trade policy can impact factor income and other economic variables of interest. Therefore, the current study will employ a framework in which both the factor market as well as the income effect can be endogenized. This framework is developed by Neary (2003a; 2009) and is known as the General Oligopolistic Equilibrium (GOLE) model.

3. Modelling Oligopoly

Traditional theories of trade since its initiation in the work by Ricardo (1817), have been dominated by models on perfect competition. The firms in these models lack any kind of market power and do not behave strategically with the other firms. The 'new trade theory' developed during the late 1970s has aided in broadening the understanding of international markets by incorporating models based on imperfect competition. But this theory comprises of two different branches of literature which do not have much in common (Neary, 2016). On one hand, there is monopolistic competition embedded in a general equilibrium framework with its application on mostly answering the positive questions relating to trade and location (Krugman, 1991). On the other hand, the application of oligopoly in the partial equilibrium context has been used to answer the normative questions on STP (Brander, 1981; Spencer and Brander, 1983)[1].

While both these streams of studies have provided numerous and interesting results, they suffer from certain limitations. For instance, the models on monopolistic competition accounts for product differentiation and increasing returns to scale. However, it assumes that the firms are infinitesimally small and do not involve in any form of strategic behaviour, such that it deviates little from models of perfect competition (Neary, 2016). Moreover, it does not fit with the recent findings by Bernard et al. (2007), Mayer and Ottaviano (2008) and Freund and Pierola (2015), that a small proportion of large firms account for majority of international trade, especially in case of advanced countries. The recent evidence also suggests that adjustments to shocks in the short run generally occurs within the firms (i.e., at intensive margin) rather than at entry and exit (i.e., at extensive margin) (Bernard et al. 2009; Bricongne et al., 2012). These findings go against the assumption of immediate free entry and exit as stated by these models. On the other hand, models on oligopoly consider large firms as the centre of focus and introduces several strategic behaviours between them.

The GOLE framework overcomes these limitations by incorporating the oligopoly model within a general equilibrium set-up. The key factor in any oligopoly model is that firms are large enough to exercise market power and they utilize it to influence the market outcomes through their strategic behaviour (Neary, 2003b). However, if these large firms influence other macroeconomic factors in the economy, then it can lead to the generation of several problems. For instance, if they influence the factor market, then it can be expected that they will behave strategically with their monopsony power. Moreover, their influence 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). The main novelty in the GOLE framework is that there exists a continuum of sectors and in each sector the firms are large enough to exercise power and behave strategically to influence the prices of the goods in their respective sectors. However,

[1] See Helpman and Krugman (1985; 1989) for details regarding these two strands of literature.

they are 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.

The objective of the current study is to analyse the impact of Strategic Trade Policy (STP) (for instance, import tariff) within a general equilibrium framework and analyse its impact on the economy's ability to compensate the workers who suffer due to the imposition of these policies. The vast literature on STP since its inception has primarily adopted the partial equilibrium model (Brander and Spencer, 1981, 1984a,1985; Brander and Krugman, 1983; De Stefano and Rysman, 2010; Fanti and Buccella, 2020)[2]. Studies in literature that have analysed the impact of STP on wages and profit-making ability of the firms by adopting the GOLE framework include that by Colacicco (2013) and Rudsinske (2023). Colacicco (2013) found that the aggregate profits of the home country increases when tariff is imposed by the government, although the welfare level in the nation falls. However, his 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. Rudsinske (2023) concluded that unilateral imposition of tariff raises the nation's profit and welfare while lowering the demand for workers. His work has adopted the GOLE model in case of asymmetric countries in the presence of segmented market structure. The case of symmetric market structure in his study has been ignored. 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 the government of both the countries are active. The main purpose of this analysis however, is not to find the optimal STP for the country. Since tariffs tends to be welfare reducing, the main purpose of this study is to investigate the impact of these trade policies on the wages and welfare of the workers and explore the sources through which the affected workers may be optimally compensated.

The analysis is organized as follows. A survey of literature is presented briefly in the following section. Section 5 sets up the basic GOLE model and analyses the impact of STP on wages and welfare of the workers when trade in final goods take place. This is followed by an investigation of whether tariff revenue can be utilized to compensate all the loss incurred by the workers due to imposition of trade policy. Section 6 carries out similar exercise by modelling trade in final and intermediate goods. Finally, based on the theoretical results, some policy conclusions are drawn.

4. Literature Survey

The studies on strategic trade policy have shown that the optimal trade policy will depend on whether the competition is regarding price or quantity. In the former case, the optimal policy will be an export subsidy and in the latter case the optimal STP will be an export tax (Eaton and Grossman, 1986). 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. In their analysis, 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.

[2] Brander and Spencer (1984b) argued that their model can implement STP in the general equilibrium context. They did so by introducing a composite 'outside' good as the numeraire, produced by an additional perfectly competitive sector. However, according to Leah and Neary (2011) since the good plays a more significant role in the factor market as compared to its role in the oligopoly market, it cannot be considered a general equilibrium framework. This is because the factor earnings are considered to be constant (since the oligopoly market cannot affect them).

The current study also relates to the literature on optimal tariffs. The works by Kaldor (1940) and later on by 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) has studied the case of optimal tariffs in case of two countries characterized by different and exogenously given marginal utility of income. However, their study 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 model 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) model[3]. However, most of these studies considered trade in final commodities. 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. Their analysis showed that subsidies should be given to reduce the distortionary effect of markup on differentiated inputs in addition to imposing tariffs.

The GOLE framework has been widely used in recent literature covering multiple fields[4]. 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. They found that in the company of publicly owned firm, the Nash Equilibrium locations are socially optimal irrespective of the degree of privatization. Beladi et al. (2015) have shown 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 related industries in the GOLE framework, Beladi et al. (2018) found that a merger between a firm with high-cost and a firm with low-cost, will raise efficiency by removing the firms with high costs, 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 the gains from trade, the distribution of income and the overall trade pattern. In a two-country model, in the presence of small number of firms and zero trade cost, he finds that there will be no gains from trade if the sectors between two symmetric countries have identical costs. There will be gains from trade if the sectors are heterogenous due to the competition effect. Other studies involving the GOLE structure include that by Bastos and Kreickemeier (2009) and its extension by Kreickemeier and Meland (2013). Both these studies show that in the presence of labour union, the welfare in the country will improve when it moves from autarky to free trade. In the general oligopolistic equilibrium model with 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. Fujiwara (2017) analysed the impact of trade and FDI liberalization on the economy's welfare level. The study reveals that welfare in the country will rise if the productivity difference

[3] Felbelmayr et al. (2013) considered Constant Elasticity of Scale (CES) preferences and Demidova (2017) allowed the mark-ups to change.

[4] See for instance: Neary (2003a; 2009) for models on 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. The work by Colacicco (2015) has covered a detailed survey on the literature involving the GOLE framework.

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 non-increasing returns to scale and increasing market concentration, there will 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, will lead to a reduction in wages.

The literature investigating the impact of trade cost on welfare under oligopoly is rich. Markusen (1981) derived the impact of trade costs on the economy's welfare under Cournot duopoly in the presence of integrated markets. It is shown that the output levels of both the firms are positively related to multilateral trade due to procompetitive effect and there are gains from trade. The world real income will rise following trade, if the countries vary in terms of their market size. The large country will witness a welfare loss whereas, the small country will 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. He found that welfare in the home country will 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, he concluded that entry of a foreign firm will decrease the welfare of the domestic country unless the cost of the foreign firm is significantly lower than the domestic firm. 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 positively correlated and that gains from trade increase with an increase in the varieties of the product and the pro-competitive effect.

5. The Model with Trade in Final Goods

As already discussed, earlier works on examining impact of STP in GOLE framework has been covered by Colacicco (2013) and Rudsinske (2023). The current analysis is based on their two-country GOLE framework model. 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 work 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 (this ensures the population size and hence the supply of labour in each country is same). Both the countries are thus assumed to be symmetric in nature. 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. According to their analysis, in the presence of uniform technology, trade in such a production structure will generate results that are similar to the partial equilibrium oligopoly analysis by Brander and Krugman (1983). The main findings of Brander and Krugman (1983) is that there exists a U-shaped relation between welfare and trade costs. However, the current analysis observes a negative relation 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 linear. The current analysis considers the case of duopoly, such that in each sector one domestic firm competes with one foreign firm in Cournot fashion. There is no product differentiation and firms produce only homogenous commodities. The technology is 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, whose market is competitive in both countries.

Since the countries are symmetric, the productivity of any firm 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 undertaken by the government, which otherwise becomes complicated to analyse in the presence of features (in the form of comparative advantage leading to specialization).

5.1 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 $x \in (0,1)$.

$$U[y(x)] = \int_0^1 u[\, y(x)]dx \tag{1}$$

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

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

where $a, b > 0$ and given the assumption of symmetry, a and b are assumed to be identical in both the countries.

Assume that, $u'[.] > 0$ and $u"[.] < 0$.

Quadratic preferences imply that they are quasi-homothetic in nature. Hence, the preferences can be added across people who earn different income, if they have identical demand parameter b, generating parallel and linear Engel curves (Neary 2003b). This feature provides a rationale for using a representative consumer for the country. Moreover, the demand parameter a is assumed to remain unchanged both between as well as within each sector. This ensures that the quality of the products is uniform, that is, there is no vertical differentiation.

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.

$$y(x) = y_h(x) + y_h{}^*(x) \tag{3}$$

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 given as follows,

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

Total supply to Home is given by the following equation,

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

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 sectors[5]. 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:

$$I = wL + \pi + TR \quad (6)$$

The budget constraint of the consumer is:

$$\int_0^1 p(x)y(x)dx \leq I \quad (7)$$

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 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 of the consumer is given as follows[6],

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

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

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

[6] 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.

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.

5.2 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 small in comparison to 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 competitive[7]. 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 labour supply. Furthermore, there is no fixed cost[8] 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 intra-industry trade to occur that arises due to strategic interactions between the firms (Rudsinske, 2023).

5.3 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 wages rates in both countries, the government's trade policy and

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

[8] 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 (see Colacicco (2013) for details). So, to simplify the model, fixed costs are assumed to be zero.

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 can be written as,

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

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

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,

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

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

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

$$y_h = \frac{a - by_h^* - \lambda w}{2b} \quad (15)$$

$$y_f = \frac{a - by_f^* - \lambda^* w}{2b} \quad (16)$$

The output produced in the Home country show 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 can be written as:

$$\pi^* = (p^* - w^*)y_f^* + (p - w^*)y_h^* \quad (17)$$

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

Solving the first order conditions yields,

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

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

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

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

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

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:

$$y_h = \frac{a + \lambda w^* - 2\lambda w}{3b} \quad (23)$$

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

The supplied quantities in Foreign are as follows:

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

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

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).

5.4 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:

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

The total supply to Home market is computed as:

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

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

$$L = y_h + y_f \text{ and } L^* = y_h{}^* + y_f{}^* \quad (29)$$

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.

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

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

Where $\tilde{\lambda} = \lambda + \lambda^*$.

From equations (30) and (31), it is clear that for $L = L^*$, wages across both the countries will be equal[9]. 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.

5.5.1 Impact of Output Tariff

The analysis will consider 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 ($t^*(x) \geq 0$) 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,

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

$$= (p - w)y_h + (p^* - w - t^*)y_f \tag{33}$$

For simplicity it will be assumed that the tariff imposed is uniform across all sectors[10].

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

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

[9] 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).
[10] 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 the large number 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.

$$w^*_t = \frac{2a - b(L + 2L^*)}{\tilde{\lambda}} \quad (35)$$

The results obtained above can be summarized in terms of Proposition1 given below:

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 (that is 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.

So the profit function of Foreign firms changes to:

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

The new supply quantities are:

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

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

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

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

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

$$L = y_h + y_f$$

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

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

$$w = \frac{a + \lambda^* w^* + \lambda w^* + \lambda t - 2\lambda^* t^* - 3bL}{2\tilde{\lambda}} \quad (42)$$

$$\frac{dw}{dt} = \frac{\lambda}{2\tilde{\lambda}} \; (>0) \quad (43)$$

From equation (42) it is clear that the wages in the domestic country are positively related with 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:

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

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

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 impact of t falls and 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 which does not consider the impact of t on w^*.

Since the domestic wages eventually become independent of government trade policy, one may then wonder what is the rationale behind implementation of such trade policies. As stated earlier, the objective of the current analysis is to find suitable sources for financing the compensation policies, which is the most challenging part for the government of any developing nation. Imposition of tariffs enables the government to generate tariff revenue which can be utilized as a potential source of finance for subsidizing the workers whose wages have declined due to imposition of tariff.

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 (see Colacicco (2013) for details).

5.5.2 Social Welfare

In the literature of STP, the optimal tariff is usually determined with the help of the welfare criterion. The social welfare in the partial equilibrium 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 of 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 of 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) = $\int_0^1 t(x)\, y_h{}^*(x)\, dx$

$$V = CS + PS + TR$$

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

$$+ \int_0^1 t(x)\, y_h{}^*(x)\, dx \qquad (46)$$

Equation (46) gives the social welfare function which the policymaker in the partial equilibrium scenario will maximize, that is, a policymaker who only takes into account the impact of tariff on the industry, assuming the aggregate macroeconomic variables to be exogenous will consider. 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:

$$\left(ty_h{}^* - t^* y_f\right) + \left(p^* y_f - py_h{}^*\right) = 0 \qquad (47)$$

The left term in the parentheses representing the difference between the Home tariff revenue and the Foreign tariff revenue is the capital balance. The right term in the parentheses 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) in the expression for welfare in (46) collapses to equation (48) (details given in Appendix 1).[11]

$$V = \int_0^1 U[y(x)] - wL\ dx \qquad (48)$$

The aggregate marginal utility of income is normalized to unity. So $\bar{\lambda} = 1$. 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 the above equation (48), the following equation (49) is obtained (details given in Appendix 2).

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

[11] 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 present 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.

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 $x \in (0,1)$ so;

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

$$\frac{dV}{dt} = -\frac{1}{18}\left(\theta + \frac{1}{4}t\right) \quad (50)$$

$$\frac{d^2V}{dt^2} = -\frac{1}{72} \ (< 0) \quad (51)$$

It is immediate from equation (50) that social welfare falls as t rises. The following proposition regarding welfare can be written.

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

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

Equation (52) gives the 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 negative[12]. The intuition behind the outcome is as follows. 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 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. 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 obtained results above, the following is proposed.

[12] 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.

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.

5.5.3 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,

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

Total subsidy required

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

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:

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

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

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

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

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

And at $t = 0$, $\frac{dTR}{dt} > 0$ iff $A > 0$. (58)

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

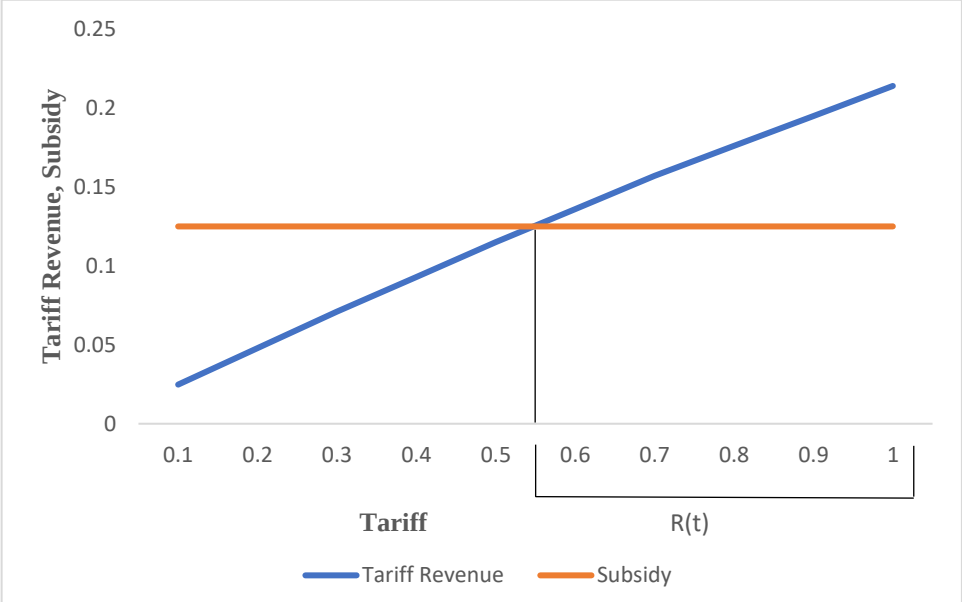
Putting the value of w and w^* from equations (44) and (45), equation (54) can be written in the following form.

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

From the above expression, a graph of tariff revenue can be generated for different values of the variables.

The following figure shows the graph of TR and S by setting $b = 10, L = 10, t^* =$ 2.5 percent and t varying between 0 to 100 percent.

Figure 1: Tariff Revenue and Subsidy Schedule in Presence of Trade in Final Goods



Source: Constructed by authors

From Figure 1 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 (it is 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.*

6. The Model with Trade in Final and Intermediate Goods

The discussions so far have explored the ability of the government to compensate the losers 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), global sourcing and outsourcing. Moreover, Assche and Gangnes (2019) in their work have found that

presence of inputs in international trade 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 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 analysis extends the above model by incorporating trade in inputs. This will give 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 good 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 ${y_f}^* = 0$. Different from the earlier model, the Home country now exports only the input to the Foreign country. In other words, its export of final goods is zero, $y_f = 0$.

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 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 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,

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

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

6.1 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 relation 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 some of the fall in the marginal revenue of the domestic firms. Therefore, there is trade-off between producing more output and producing more input.

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

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

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

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,

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

The profit of the foreign firm is given as follows:

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

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,

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

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

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

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

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

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

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

6.2 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.

$$L_y{}^d + L_m{}^d = L^S \tag{69}$$

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

Putting the values of y_h and $y_h{}^*$ in equation (69) and solving for w generates the following results,

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

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 $\alpha < \beta$, that is, 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 in the Foreign country's final good, which in turn leads to a fall in the demand for Home country's intermediate input. 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 input 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 $\alpha > \beta$.
Following proposition summarizes the 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.

6.3 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,

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

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

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

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,

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

Differentiating equation (73) with respect to τ the following is obtained,

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

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

Unlike the case with trade in final goods, the wages in case of trade in final good and intermediate input is dependent on 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,

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

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

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

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

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

$$\frac{dTR}{dt} > 0 \text{ iff } \frac{1}{2}\left[a-(\alpha w^*+p_m)-\frac{0.5(\beta-\alpha)}{(2\alpha+\beta)}\right] > \tau \tag{80}$$

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

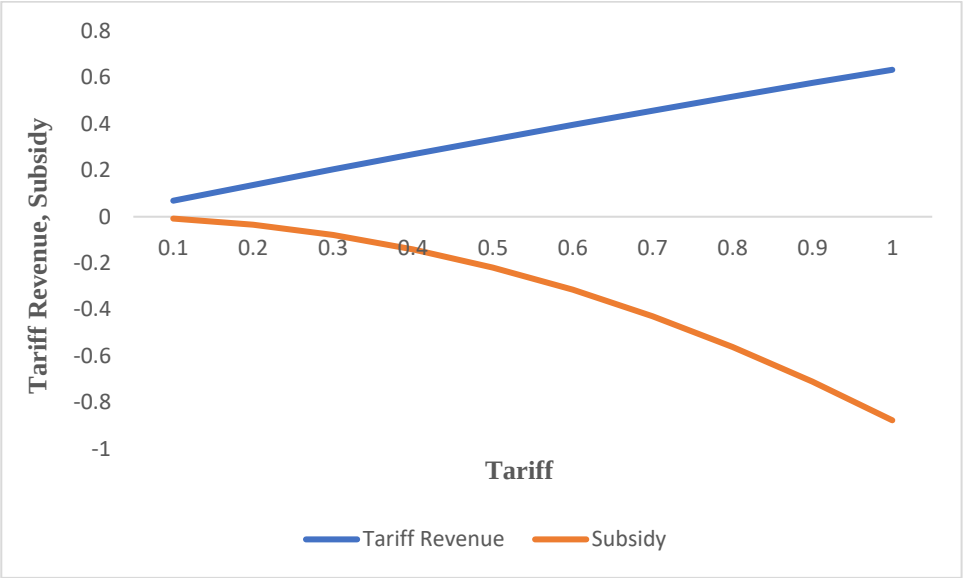
Case I: Wages rise with the rise in tariff.

This is the case when the amount of labour required for producing the final good is greater than that of the intermediate good, $\alpha > \beta$. Then it is clear from equation (72), 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 $a - \frac{0.5(\beta-\alpha)}{(2\alpha+\beta)} > (\alpha w^* + p_m)$.

The following figure 2 shows the 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 2: Tariff Revenue and Subsidy Schedule in Presence of Trade in Final Goods and Intermediate Inputs with $\alpha > \beta$



Source: Constructed by authors

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 takes place.

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 ability 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 > rise in subsidy iff,

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

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 country. The expression of τ_N is given by the following equation.

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

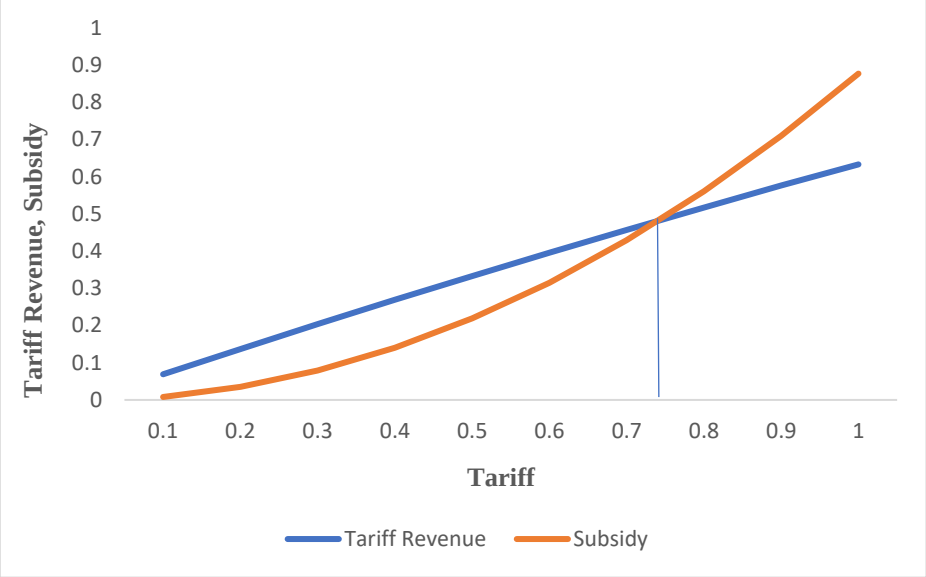
Putting $\frac{dTR}{dt} = 0$ from equation (74), the expression for tariff revenue maximising tariff is obtained as follows,

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

Equation (83) gives the tariff rate at which the total tariff revenue is maximized.
Clearly, $\tau_N < \tau_{max}$
At $\tau = 0$, $\frac{dTR}{d\tau} > 0$ iff $a > (\alpha+\beta p_m)w^* + \frac{0.5(\beta-\alpha)}{(2\alpha+\beta)}$

Figure 3 shows the graph of TR and S 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.

Figure 3: Tariff Revenue and Subsidy Schedule in Presence of Trade in Final Goods and Intermediate Inputs with $\alpha < \beta$



Source: Constructed by authors

If tariff rate is less than τ_N, the tariff revenue generated can optimally subsidize workers. In Figure 3, the value of τ_N lies between 70 to 80 percent. Beyond, τ_N, the loss to the workers will exceed the revenue generated.

7. 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 market. 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 disregard the general equilibrium feedbacks. 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 attempted 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 literature on this front 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 in the GOLE framework.

Imposition of tariff by the Home country on its final goods raises the domestic wage rate as well as aids in the 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 certain level. However, in case of intermediate goods when $\alpha < \beta$, tariff revenue (generated beyond τ_N) is not sufficient to fully compensate the workers. This happens because raising tariff, implies that foreign output and consequently the demand for Home's intermediate input decreases. If the labour required for producing intermediate good is greater than that of final good, then this implies an overall fall in labour demand in the domestic country, leading to a fall in the worker's wages.

The obtained results have crucial policy implications, especially given the current scenario of increasing participation of countries in GVCs. As such, the case as observed with respect to intermediate good 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 can potentially 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. Moreover, modification of the framework to incorporate the impact of ad-valorem tariff will also bear crucial policy implications for developing countries. In case of trade in final and intermediate goods, the current analysis assumes foreign consumption of the final good to be zero. Extending the model to include positive consumption of the good by the foreign country can generate interesting results. Lastly, an imperfect labour market can be introduced to analyse its consequence on the wages and welfare of the country.

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Appendix A

Appendix 1: Derivation of Social Welfare Function

V = CS + PS + TR

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

$$\int_0^1 t(x)\, y_h{}^*(x)\, dx$$

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

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

Rearranging the above expression yield the following,

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

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

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

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

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

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

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

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

$$V = -\frac{1}{9}\int_0^1 \left[\theta + \frac{1}{4}t(x)\right]^2 - wL\ dx \qquad \text{(A.3)}$$

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

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

$$\frac{dTR}{dt} = \frac{A+tA'(t)-2t}{3b} \qquad \text{(A.4)}$$

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,

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

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

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 $A > 0$.