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Trade Wars and Trade Talks Revisited: An extension of the Grossman-Helpman Model (1995)

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Abstract

This paper extends the Grossman and Helpman (1995) model to include environmental regulations, assuming perfectly competitive markets. The politically motivated government uses trade and environmental policies to regulate trade flows (either non-cooperatively through trade wars or through cooperative bargaining as in case of trade talks) and the use of the sector specific environmental resource in the production of the traded good, respectively. Results show that trade wars can be more pronounced when the polluting good traded is subject to environmental regulations in the country of origin. Despite being politically inclined, policy makers may also face a trade-off from trade policies chosen that have several implications on welfare gains/losses from environmental taxes vis-á-vis the improvement/deterioration in environmental quality. The net gain/loss from environmental regulations would thus be an additional factor influencing the trade policy adopted by a nation besides gains/losses from voting support, deadweight loss from price distortion and terms of trade gains/losses.

Furthermore, there arises an additional layer of distortion in trade policy when political action groups cannot directly observe the true type of the regulator, i.e., whether he/she is highly corrupt or not. Incomplete knowledge about the degree of benevolence of the regulator causes an upward distortion in trade policy compared to the former case, except for a scenario where the regulator is purely benevolent.

JEL Classification: C7, D82, F18, P16.

Keywords: Special Interest Groups, Trade Wars, Trade Talks, Environmental Regulations, Incomplete Information.

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1 Introduction

The recent episodes of tariff wars between countries like the United States (US), China and India predicate the role of global political economy in shaping up international trade policies. Trade policies, hitherto chosen through negotiations at international fora like the World Trade Organisation (WTO), seem to be driven by a wave of anti-globalisation, non-cooperation and retaliation. Although there has been a vast array of disputes relating to the violation of clauses of the WTO, the present scenario is unprecedented in terms of its severity and overtness. For instance, in early 2018, the US imposed import tariffs of 25 per cent on steel and 10 per cent on aluminium. This was followed by the US pursuing India at the WTO for unfair trade practices in the form of export subsidies in sectors like steel, pharmaceuticals, information technology, chemicals and textiles. Such actions triggered retaliation by China and India in due course of time. India announced a hike in tariffs on 29 US items including almonds, apples and phosphoric acid in June 2018. Around the same time, China slapped additional duties on 659 American products including agricultural products, vehicles, aquatic products, chemicals, medical equipment and energy products (CWS, 2018).

What drives the paradox is that these nations are, apparently, members of the WTO that emphasises free and fair trade. Consequently, the objectives of trade negotiations directed at gradual movement towards free flow of goods and services across borders become increasingly difficult to attain. In defence of such protectionist policies lies the argument of safeguarding global competitiveness of domestic industries. However, alternate speculations suggest that such tariff wars are driven by threats to the gradual shift in economic order from the west to the Asian nations like China, India, Vietnam, Indonesia and Singapore. What is more worrisome is that such threat is triggered by the scepticism associated with global warming and climate change in the west, especially in the US. Many are of the view that the narrative of human activities impinging on climate change is unfounded and misleading. With the US taking the lead, there are misgivings that environmentalists and climate scientists have twisted facts and science to support and promote hysteria about climate change in order to protect their research funding and ideology. For example, the US did not ratify the Kyoto Protocol (1997) and has withdrawn from the Paris Agreement (2016). On the whole, radical environmentalism has been regarded as anti-industry and affects competitiveness of the manufacturing sector adversely. Such protectionist policies may invite counter action of retaliation from trading partners, thus leading to a tariff war of sorts. Else, there could be more relaxed environmental regulation in Home that counters the impact of higher import tariffs in Foreign. Consequently, protectionist trade policies compounded with environmental regulations influence domestic economic activity coupled with resonating effects in the foreign market in a globalised world. Hence, these policies cannot be studied in isolation.

Accordingly, when national governments interact through trade and environment policies in order to augment their competitive edge in the international market, any rewards or losses from such policies get tied to the welfare of economic agents at the micro level, viz. consumers, producers, environmentalists via the general equilibrium effects. Any change in policies at the sectoral level set by the government would alter domestic as well as world prices (in case of a large open economy) of the associated output. While producers would benefit from higher domestic prices, consumers would lose their surplus to the producers. Environmentalists, on the other hand, are advocates of improved environmental quality. Their motive lies in control or reduction of pollution activities related to production or consumption. Environmental compliance costs or pollution charges escalate production costs and producers shift the burden to consumers, who now face higher prices. This would, however, depend on the elasticities of demand and supply curves. Hence, each group may have 'special interests' attached to trade or environmental policies or both. The social welfare effects, however, remain ambiguous in general.

The literature based on the interaction between governments and interest groups revolves around the inter-linkages between politics and economics. Incumbent governments, with the motive of being elected to power, announce an extensive array of policies in order to sway voters. In other words, opposing candidates engage in electoral competition in order to maximise the probability of getting elected. Apart from electoral competition, incumbent governments may also act semi-benevolent with an objective to maximise political support. Special interest groups offer campaign contributions to the incumbent government which is contingent upon policies set. The incumbent government, then, maximises the political support function which is a weighted sum of pure social welfare and campaign contributions. Resultantly, policies chosen by the incumbent would not be at the first-best level. The political equilibrium reflects optimal policies which are necessary to sway voters (especially the lobby groups) in favour of the incumbent. In the words of Dixit et al. (1997), this phenomenon is described as common agency where a set of principals (political action groups) overcome the free-rider problem and simultaneously and non-cooperatively offer contributions to the agent (a legislator) to influence political processes that determine economic policies. While only a subset of the population succeeds in overcoming the free rider problem, and lobby for policies in their favour, the legislator cares about the welfare of every individual irrespective of him/her being a part of any political action group or not. Apart from welfare of individuals in general, the legislator also cares for campaign contributions. Equilibrium policies are chosen by maximising a weighted welfare function[1] and revenues generated thereof are redistributed to the public in the form of undistorted lump sum transfers.

One of the seminal works attributed to special interest politics and endogenous trade policy is by Grossman and Helpman (1994). In a multi-sector model with homogeneous labour input and sector specific inputs, it emphasises on the role of organised lobby groups in the determination of trade policy. Owners of sector specific inputs whose incomes are tied to the domestic price of the output of the corresponding sector, have a direct stake in trade policies affecting the domestic price of the sector specific output. If this fraction of the population consumes only non-traded goods, then there is a greater likelihood of pushing for trade policies which raise domestic prices of traded goods. Accordingly, results suggest that only organised lobby groups enjoy protection in terms of tariff while unorganised ones lose protection. Such incongruity in protection levels is attributed to the contributions made by organised lobbies. Incumbent governments peddle their policy stance for campaign contributions and this serves the interests of lobbies with the aim of increasing the chances of being re-elected. For an organised sector, protection level rises with a rise in the level of output per unit of imports. This is due to higher stakes of the owners of the sector specific input. The social cost of protection, reflected by import demand or export supply elasticities, has a negative impact on the level of protection.

Following Grossman and Helpman (1994), Maggi and Rodriguez-Clare (1998) went a step further by introducing the element of time in their model. The assumption that sectors producing traded goods use sector specific inputs would hold only in the short run. In the long run, inputs tend to be mobile across sectors. Therefore, governments may not always choose protection over commitment to free trade. Mobility of inputs across sectors would generate conflict of interests, thereby, precluding the likelihood for lobby formation and hence campaign funding. In that case, the incumbent has no incentive to adopt protectionist policies. The dynamic aspect of trade policy making has also been studied by Celik et al. (2013) by incorporating non-cooperative congressional bargaining. Other related studies on legislative bargaining include Grossman and Helpman (2005) and Willmann (2008). Unlike interactions between the

[1] A weighted welfare function for a policy maker is a weighted sum of aggregate social welfare and campaign contributions by special interest groups, where the weights are exogenous.

incumbent and special interest groups, Celik et al. (2013) model interactions between legislative assemblies. Legislators from each constituency are only concerned with the welfare of their own constituency. As a result, equilibrium outcomes show that a legislator demands import tariff (or export subsidy) for a good that is produced in his/her constituency and an import subsidy (or export tax) on goods produced in the other constituency. The sequential bargaining game may be welfare-worsening for all participants. Moreover, identical industries are subject to different tariff levels. Models on legislative bargaining do not incorporate the political support function approach as in case of Grossman and Helpman (1994).

The Grossman and Helpman (1994) framework has been used in several studies focusing on trade-environment linkages. Damania et al. (2003) suggest that trade liberalisation leads to increase in pollution tax in the protected sector if the level of corruption is high. Although trade policy is assumed to be exogenous, they show that as trade liberalisation reduces output of the polluting good, the bribe offer from the lobby declines and pollution tax rises. In addition to this, the decline in the domestic production of the polluting good also reduces the policy maker's incentive to address the distortion that originates from the negative externality in production. This results in a reduction in pollution tax. When the level of corruption is high, the bribery effect dominates the latter effect and causes pollution tax to rise. Apart from industry lobbies, environmental lobbies too influence policies. With exogenous trade policy, a reduction in protection would result in lower pollution taxes if the lobbying effort by the environmental lobby group declines faster than the lobbying effort by the industry lobby group (Fredriksson, 1999). The endogeneity of both the policies may also result in the policy maker facing a trade-off between lower protection and less stringent environmental regulation versus higher tariffs and higher environmental regulations (Mehra, 2010). A common characteristic shared by these studies is the assumption that trading nations are too small to influence international prices. It is Grossman and Helpman (1995) and Conconi (2003) who attempt to examine policy interactions for large open economies. The former only discusses the implications of domestic politics in determination of trade policies under cooperation as well as non-cooperation by large open economies, in the absence of environmental regulations. An extension of the analysis in Grossman and Helpman (1994), it provides an exposition of the motives for trade protection in large open economies. Apart from the gains from political support, trade protection in the context of large open economies is also driven by terms of trade gains. For a sector producing importables (export goods), protection is inversely related to the elasticity of foreign export supply (foreign import demand). Potential social gains from trade protection rise as the elasticity of foreign export supply (foreign import demand) falls, which reflects the standard Ramsey pricing rule. Employing a similar approach, Conconi (2003) examines the role of green lobbies in shaping environmental policies in the presence of emissions leakage to other countries. Furthermore, this study also incorporates trade policies and concludes that the impact of green lobbying on environmental policy is contingent upon the existing trade policy regime. When trading nations are not constrained by international trade rules, green lobbies have a bias in favour of higher pollution taxes. Under a free trade regime, emissions leakage alters the preference of green lobbies towards lower pollution taxes. Since the focal point of this study revolves around environmental policy, instances of trade-environment linkages have not been addressed in an explicit manner but some pointers are provided. An interesting result of the study that green lobbies favour pollution taxes lower than the optimal level in the presence of transboundary pollution, is based on the premise of a free trade regime. In a similar but more comprehensive study by Schleich and Orden (2000), the trade-environment linkage has been explored in order to compare the impact of each of these policies (trade policy and domestic policy) on environmental quality.

Unlike the aforementioned studies, the present analysis makes an attempt to compare optimal trade policies in the presence of environmental regulations with those obtained by Grossman and Helpman

(1995), hereafter referred to as the G-H model, where environmental regulations are absent. To be more precise, we characterise the trade wars and trade talks equilibrium where production of the traded good generates local pollution and is subject to environmental regulations. Finally, we compare the equilibrium outcomes with those obtained in the G-H model and derive implications thereof. Most of this analysis is done assuming complete information.

As an extension to this analysis, we relax the assumption of complete information and compare the non-cooperative/trade war equilibrium in a single principal-agent framework with incomplete information. Against the backdrop of the common agency framework, most of the existing studies assume that the legislator's (the agent) preferences over social welfare are common knowledge. However, we cannot rule out instances where the lobby (the principal) that makes monetary transfers to the policy maker in order to swerve economic policies in its favour, has incomplete information about the legislator's preference over social welfare. Such a situation typically arises when the policy maker is newly elected and the political pressure groups are unfamiliar with its agent's preferences. The policy maker has an incentive to hide its true preference in order to extract informational rents. As a result, unlike the case of complete information, campaign contributions by political action groups serve more that one purpose: (a) to meet the political objectives of interest groups; (b) to induce the agent to reveal its true type.

In the specific context of asymmetric information, Montanari (2008) develops an explicit principal-agent model where an interest group has incomplete information about the degree of benevolence of the neo-elected government. Results suggest that incomplete information aggravates the level of policy distortion as compared to the benchmark scenario of complete information. Utilising this approach in our model, we introduce the role of information asymmetries on equilibrium trade policies in the presence of environmental regulations and compare the results with the case where the policy maker's preference over social welfare is common knowledge.

To sum up, the present model is a novel attempt to address the following research gaps: *one,* it extends the G-H common agency model by including environmental regulations faced by industries; *two,* it addresses the trade-environment linkage when nations do not necessarily engage in free trade; *three,* it extends the framework by introducing information asymmetry between the interest group and the policy maker with regard to the weight attached to social welfare by the policy maker, i.e., how corruptible is the policy maker? Furthermore, it compares the trade war equilibrium under asymmetric information with that of full information.

We introduce environmental regulations in our model through the following channel. The production function includes an additional input apart from labour and sector specific capital. This is a natural resource or an environmental resource.[2] For simplicity, the supply of this resource is assumed to be perfectly elastic which implies that the equilibrium quantity of resource used would depend on the demand only. In order to regulate the use of this resource, the government charges a resource tax, which is assumed to be exogenous.

Results suggest that the equilibrium trade policies in each country can be expressed as a sum of three components, namely the political support, the terms of trade motive and net pollution tax revenue gains (losses) from trade intervention. The result is at variance with the G-H model in terms of the third component. However, the pollution tax revenue gains (losses) disappear in case the exogenous rate of pollution tax is set equal to the marginal damage, i.e., a Pigouvian tax and the standard G-H model result holds. The analysis becomes interesting when pollution taxes do not reflect true marginal damage. It is observed that trade wars become more (less) pronounced in terms of equilibrium outcomes (an import

[2]For instance, coal used in the production of iron and steel, cement and electricity.

tax/subsidy or an export tax/subsidy based on the pattern of trade) when environmental regulations exceed (fall short of) the marginal damage from pollution. When the revenue generated from pollution tax exceeds the total environmental damage from production of the traded good, there is a net gain from imposing environmental regulations. Therefore, the optimal trade policy would exceed the level associated with the G-H trade war equilibrium. Without loss of generality, if the home country is an importer of the traded good, an import tariff raises domestic production due to a rise in the domestic price of the importable. This causes the demand for the environmental resource, used as an input to production, to rise. For a given level of pollution tax, total tax revenue from pollution increases. In contrast, the marginal environmental damage, being lower than the pollution tax, the total value of environmental quality degradation is less than the revenue generated from pollution tax. Based on individual country's environmental priorities, several configurations can be studied: (a) Pollution tax rate exceeds marginal damage from pollution, i.e., environmental regulations are relatively stringent both at home and foreign; (b) Pollution tax rate exceeds marginal damage at home and it is equal to marginal damage in the foreign country (c) Pollution tax rate exceeds marginal damage at home and it is lower than the marginal damage in the foreign country (d) Pollution tax rate is lower than the marginal damage in both countries, i.e., environmental regulations are laxer (e) Pollution tax rate falls short of marginal damage at home while it is equal to the marginal damage in the foreign country (f) Pollution tax rate is less than marginal damage at home and it is higher than the marginal damage at foreign. Similar sub-cases can be studied with respect to the foreign country as well.

When pollution tax exceeds marginal damage, an organised import competing sector is characterised by a protective tariff which is higher than the tariff in the G-H model. This wedge is driven by the net marginal gains from pollution tax revenue, which rise due to increased production of the importable in the home country. An interesting result may emerge in case of an unorganised export industry at home. Unlike in case of the G-H model, this industry may not always suffer from an export tax. For instance, the net marginal gains from a higher pollution tax revenue associated with an export subsidy[3] can outweigh the marginal gains from driving up the world price with an export tax and increased consumer surplus from reduction in domestic price of the exportable. This would result in an export subsidy in the exportable sector. However, in cases of organised export industry and unorganised import industry, ambiguity in terms of export subsidy/tax and import subsidy/tax respectively, remains. For instance, for an organised export industry, prospects for securing an export subsidy are better the greater the industry output, the smaller the price sensitivities of domestic supply and demand and lower the weight attached by the politicians to average welfare. Ceteris paribus, the home government would be more inclined to choose an export tax and raise the world price when the foreign import elasticity of demand would be less elastic. Finally, the home government's proclivity for an export subsidy is increasing in the price sensitivity of demand for the environmental resource. A rise in domestic price of the exportable would lead to an increase in demand for the environmental resource, which is an input to production and hence raise the net pollution tax revenue accruing to the home government. Hence, the trade policy adopted would depend on the relative strengths of each of these effects.

In case pollution tax is less than marginal pollution damage, an unorganised export industry at home suffers an export tax. The interesting case arises for an organised import industry. An organised import industry may suffer an import subsidy if the reduction in loss of pollution tax revenue from an import

[3]An export subsidy would typically raise the domestic price and hence domestic production of the exportable. This would increase demand for the environmental resource used as an input to production. Consequently, the total revenue from pollution tax accruing to the government would exceed the total value of environmental damage. Following the net gain in pollution tax revenue, there is an over-adjustment in the distortion emanating from the negative production externality.

subsidy outweighs the gains from political support and improvement in the terms of trade owing to an import tariffs.

The trade talks equilibrium shows that any gain or loss from trade agreements between the participating nations depend on the relative differences in political pressures and environmental regulations. Without loss of generality, if the home country is an importer of the good produced by a particular sector and this sector is organised in both countries, a trade agreement benefits the group that has higher stakes (in terms of output) in protection. An additional source of divergence in trade policies is brought about by relative differences in environmental priorities of nations. An importing country gains from a trade negotiation if stringent environmental norms are in place. The protective tariff in the organised import competing sector drives up the domestic price and increases demand for the environmental resource input. As a result, the marginal revenue from pollution tax rises. The converse is true when environmental regulations are less stringent. This completes the full information model.

Lastly, the benchmark model for a common-agency framework under incomplete information suggests that the equilibrium trade policy is higher than that of complete information. In case the policy maker is least corrupt (i.e., a purely benevolent policy maker), the equilibrium outcome coincides with that of the trade war equilibrium under complete information. Ideally, the lobby has to contribute more to the policy maker as the level of information asymmetry rises. With a rise in the level of corruption, there is an upward distortion in the equilibrium outcome in terms of an import tax/subsidy or an export tax/subsidy. In order to ensure that this outcome is well-behaved, the assumption that the conditional probability of coming across an incumbent who is less corrupt than any given level of its preference over aggregate social welfare is declining in the preference parameter. Except for the scenario where the policy maker is purely benevolent, there is positive information rent accruing to the policy maker irrespective of their preference over aggregate social welfare. The lobby gives up positive information rent to the policy maker in order to induce truth-telling and thereby preclude the likelihood of mimicking of a more corrupt policy maker by a less corrupt policy maker. Therefore, incomplete information over the policy maker's preferences generates another layer of distortion in the model.

The sequence of the paper is as follows. Section 2 develops the analytical model followed by the key conclusions in Section 3.

The following section develops the formal analysis.

2 Model structure

The world comprises two large open economies, namely, home and foreign. The political and economic structures are assumed to be identical across the nations. However, tastes and preferences, factor endowments and political scenarios may differ. In what follows is an exposition of the structure of the home country. An '*' is appended to each of the notations in the formal model for denoting the foreign counterparts.

2.1 Consumers

Consumers in the home country face identical and additively separable preferences which are assumed to be quasi-linear. Each resident maximises a utility function given as

$$U = c_Z + \Sigma_{i=1}^{n} u_i(c_{X_i}) - \Sigma_{i=1}^{n} \theta_i X_i; \tag{1}$$

where c_Z denotes consumption of numeraire good Z whose price is unity in the domestic as well as the foreign market and c_{X_i} is consumption of non-numeraire good X_i $(i = 1, 2, ..., n)$. The function $u_i(.)$ is differentiable, increasing and concave in each of its arguments. θ_i denotes marginal damage from production of X_i and is independent of the level of output. The last term on the right hand side of the equation implies that consumers suffer disutility from aggregate production of pollution associated with the entire range of non-numeraire goods.

While the domestic price of good X_i is p_i, ω_i denotes the offshore/world price of the good. Given these prices and income I, a consumer maximises his/her utility subject to the budget constraint

$$c_Z + \mathbf{p}\mathbf{c_X} = I; \tag{2}$$

where $\mathbf{p} = (p_1\ p_2\ p_3.....p_n)$ and $\mathbf{c_X} = (c_{X_1}\ c_{X_2}\ c_{X_3}......c_{X_n})$ denote the vector of home prices and home consumption respectively.

The first-order condition for utility maximisation yields

$$p_i = \frac{\partial u_i}{\partial c_{X_i}}; \tag{3}$$

which gives the demand function $d_i(p_i)$ as the inverse of $\frac{\partial u_i}{\partial c_{X_i}}$.

Net consumer surplus from consumption of non-numeraire goods is given by

$$S(\mathbf{p}) = \mathbf{ju} - \mathbf{pd}; \tag{4}$$

where $\mathbf{j} = (1\ 1\ 1....1)$, $\mathbf{u} = (u_1\ u_2\ u_3......u_n)'$; and $\mathbf{d} = (d_1(p_1)\ d_2(p_2)\ d_3(p_3).....d_n(p_n))'$. Here, $\mathbf{u}$ denotes the vector of gross consumer surplus and $\mathbf{d}$ is the vector home demand respectively. Since, a consumer spends the remaining income on consumption of the numeraire good, indirect utility function is given as

$$V(\mathbf{p}, I) = I - \mathbf{pd} + \mathbf{ju} = I + S(\mathbf{p}). \tag{5}$$

2.2 Producers

The production technology associated with the numeraire good Z exhibits constant returns to scale (CRS). By choice of units appropriately, the labour-output coefficient is assumed to be unity, i.e., one unit of labour produces one unit of output. Under the assumption of perfect competition, wage rate equals unity in the sector producing the numeraire good. The aggregate supply of labour l is sufficiently large to maintain a positive level of output of good Z in equilibrium. Each of the other n sectors, characterised by perfect competition, uses CRS technology to produce X_i using labour, sector specific capital and sector specific pollution causing natural/environmental resource. While the supply of sector specific capital is inelastic, the sector specific resource is perfectly elastic in supply. Further, labour is assumed to be mobile across sectors and there is no inter-sectoral mobility of sector specific inputs. The equilibrium level of resource use depends solely on its demand. Given this Ricardo-Viner framework, the owners of the sector specific input derive residual rents from this production sector. For each sector producing the non-numeraire good, Hotelling's lemma ensures that the slope of the profit function with respect to home prices would give the supply function, i.e.,

$$X_i(p_i) = \frac{\partial \Pi_i}{\partial p_i}. \tag{6}$$

2.3 Government

The government has a set of policies that it can implement, namely, trade policies and environment policies, both of which act as potential tools for redistribution of income. Trade flows of the non-numeraire goods are regulated through trade taxes or subsidies. Similarly, production of these goods which requires use of pollution causing natural/environmental resource, is also subject to some constant charge, say, pollution tax per unit of resource use, which is assumed to be exogenous. Hence, price based instruments are employed for regulation of both trade flows and use of natural/environmental resource. Revenues generated from such policies are distributed to the public in a lump sum fashion.

Tariffs and subsidies on imports or exports drives a wedge between domestic prices and world prices. Suppose, sector i is subject to an advalorem tariff or subsidy t_i. Consequently, domestic price can be expressed as

$$p_i = (1 + t_i)\omega_i = T_i\omega_i; \tag{7}$$

where $T_i(= 1 + t_i)$ is greater than one in case of an import tariff or an export subsidy and less than one for an import subsidy or an export tax.

Per capita government revenue generated from trade policy is given as

$$r(\mathbf{T}, \boldsymbol{\omega}) = \Sigma_{i=1}^{n}(T_i - 1)\omega_i\Big(d_i(p_i) - X_i(T_i\omega_i)\Big); \tag{8}$$

where $\mathbf{T} = (T_1\ T_2\ T_3......T_n)$ and $\mathbf{w} = (w_1\ w_2\ w_3......w_n)$ denote trade policy vector and world price vector respectively. Total population has been normalised to unity, and this does not impact our results qualitatively.

Similarly, per capita revenue from pollution tax net of environmental damage is given as

$$e(\mathbf{T}, \boldsymbol{\omega}) = \Sigma_{i=1}^{n}(\tau_i - \theta_i)N_i(T_i\omega_i); \tag{9}$$

where τ_i is the exogenous pollution tax imposed on the use of the environmental resource in sector i.

2.4 Complete Information

2.4.1 The political structure

The aspect of politics in the model of trade policy determination is driven by the production process in each sector. Immobility and indivisibility of certain sector specific inputs ensure that their owners have direct claims in the rent accruing to that sector. Returns to the factors of production in sector i are directly linked to the price of X_i prevailing at home. Since, advalorem trade taxes or subsidies would have a direct impact on domestic prices of goods, and the associated rents emerging there, stakes of the owners of specific inputs get tied to trade policies. The owners of specific inputs, also being consumers, have their welfare attached to all policies that affect domestic prices.

Trade policies which drive up domestic prices have a favourable impact on the welfare of owners of the specific input. Consequently, a subset of such groups may jointly pursue their common interest to the incumbent government. The inherent assumption made here is that members of such groups overcome the free rider problem. Further, the set of organised industries is assumed to be exogenously given. These groups, referred to as lobbies, finance campaign funding for the incumbent government in exchange of policies (trade and environmental ones) set in their favour. The incumbent, on the other hand, aims to maximise the probability of getting re-elected. Higher welfare generated by policies set by the incumbent would increase the chance of being re-elected. However, there are general voters including consumers, workers and unorganised specific factor owners who fail to make campaign contributions, can by no means influence the incumbent. As a result, the incumbent government weighs both campaign contributions and pure social welfare while choosing policies.

The lobby in industry i offers a contribution schedule $C(\mathbf{T},\ \bullet)$ that maximises its joint welfare given as

$$v_i = W_i(\mathbf{T}, \boldsymbol{\omega}) - C(\mathbf{T}, \bullet); \tag{10}$$

where

$$W_i(\mathbf{T}, \boldsymbol{\omega}) \equiv l_i + \Pi_i(T_i\omega_i) + \alpha_i\Big[r(\mathbf{T}, \boldsymbol{\omega}) + e(\mathbf{T}, \boldsymbol{\omega}) + S(\mathbf{T}\boldsymbol{\omega})\Big]. \tag{11}$$

Welfare (gross of contributions) of lobby in sector i is a sum of labour income of the factor owners, profits/rents earned, consumer surplus from consumption of non-numeraire goods and transfers from the government. Transfers include revenues generated from trade policy and environmental regulations. α_i refers to the proportion of the population (normalised to unity) that owns the specific input used in sector i.

The incumbent government is politically motivated and, hence, values campaign contributions. However, he/she also cares for the general voter whose voting preference in future would depend on the welfare generated in the present. If the general voter is content with the policies chosen, the probability of the incumbent getting re-elected rises. Resultantly, the incumbent maximises a political support function given as

$$G = \Sigma_{i\in L} C_i(\mathbf{T}, \bullet) + aW(\mathbf{T}, \boldsymbol{\omega}); \quad a \geq 0; \tag{12}$$

where L denotes the set of organised sectors which make campaign contributions to the government and

$$W(\mathbf{T}, \boldsymbol{\omega}) \equiv l + \Sigma_{i=1}^{n}\Pi_i(T_i\omega_i) + r(\mathbf{T}, \boldsymbol{\omega}) + e(\mathbf{T}, \boldsymbol{\omega}) + S(\mathbf{T}\boldsymbol{\omega}). \tag{13}$$

Here, $l = \Sigma_{i=1}^{n} l_i$ denotes total labour income and a is the weight attached to pure social welfare (recall that the wage rate is normalised to unity).

Analogously, similar expressions can be derived for the foreign country. The most interesting aspect of the model is the interdependence in trade policies between the two nations. Since both trading partners are large open economies, any change in domestic prices of traded goods would have a significant impact on the world prices. Thus, our model internalises these terms of trade effects. Optimal policies can be set in a non-cooperative fashion and may result is policy competition of trade wars or through negotiations at the international level, i.e., through trade talks. We focus on the non-cooperative equilibria first and then move to the case of a negotiated equilibrium of trade talks.

The international trade equilibrium is given as

$$M_i(T_i\omega_i) + M_i^*(T_i^*\omega_i) = 0 \quad \forall\ i; \tag{14}$$

where $M_i(p_i) = d_i(p_i) - X_i(p_i)$ and $M_i^*(p_i^*) = d_i^*(p_i^*) - X_i^*(p_i^*)$ denote net imports of good i by the home and foreign country respectively. The world market equilibrium for a particular good is reached when exports by one country equal imports by the other. The market clearing world price of the good is obtained thereof and is denoted by $\omega_i^0 (= \omega_i(T_i, T_i^*))$.

$$M_i(T_i\omega_i) = -M_i^*(T_i^*\omega_i) \quad \forall\ i;$$

$$\Rightarrow \omega_i^0 = \omega(T_i, T_i^*) \quad \forall\ i.$$

At this price, export supply of good i equals import demand.

2.5 Stages of the game

The game takes place in three stages. In the first stage, a non-cooperative menu auction takes place among political action groups or lobbies in each country, i.e., they choose contribution schedules contingent upon an array of policy outcomes which maximise their welfare. Each lobby acts simultaneously and non-cooperatively, taking the contribution schedules of all other lobbies at home and in the foreign country as given. Faced with the contribution schedules of the set of organised industries, the government sets policies in the second stage. Neither the lobbies nor the government renege on their commitments. Observing the set of policies announced, lobbies make contribution to the government. In the final stage, labour and world markets clear and production and consumption take place.

2.6 Trade war equilibrium

Following Grossman and Helpman (1995), Nash equilibrium in case of a trade war between the home and the foreign country can be defined as follows:

Proposition 1: *For any arbitrary policy vector* $\mathbf{T}^*$ *of the foreign country,* $\mathbf{T^0}$ *and* $\{C_i^0\}_{i\in L}$ *are the equilibrium responses in trade policy and contribution schedules contingent upon trade policy if*

(a) $\mathbf{T^0} = \arg\max_{\mathbf{T}} \mathbf{\Sigma_{i\in L} C_i^0(T; T^*) + aW(T, T^*)}$*, and*

(b) there does not exist any feasible contribution function $C_i(\mathbf{T}; \mathbf{T}^*)$ *and a trade policy vector* $\mathbf{T^i}$ *for every organised interest group* $i \in L$ *such that*

(i) $\mathbf{T^i} = \arg\max_{\mathbf{T}} \mathbf{C_i(T; T^*) + \Sigma_{j\neq i, j\in L} C_j^0(T; T^*) + aW(T, T^*)}$*, and*

(ii) $W_i(\mathbf{T^i}, \mathbf{T}^*) - \mathbf{C_i(T^i; T^*) > W_i(T^0, T^*) - C_i(T^0; T^*)}$.

While (a) shows that the policy vector chosen by the government maximises its objective function, (b) states that any lobby group i is unable to raise its welfare by unilaterally deviating and revising its contribution schedule from $C_i^0(\mathbf{T^0}; \mathbf{T}^*)$, given the contribution schedules of all other groups. Taken together, (a) and (b) imply

$$\mathbf{T^0} = \arg\max_{\mathbf{T}} \mathbf{W_i(T, T^*) - C_i^0(T; T^*) + \Sigma_{j\neq i, j\in L} C_j^0(T; T^*) + aW(T, T^*)} \; \forall \, \mathbf{i \in L}. \tag{15}$$

Broadly speaking, an equilibrium response by the home government to any arbitrary policy chosen by the foreign government should maximise the joint welfare of each lobby as well as the objective function of the government, assuming that the contribution schedules of all other lobbies are given. The same holds true for the foreign country.

Assuming that the contribution schedules as well as the pure social welfare functions are differentiable around the point of equilibrium, we have the following first-order conditions

$$\nabla_{\mathbf{T}} W_i(\mathbf{T^0}, \mathbf{T}^*) - \nabla_{\mathbf{T}} \mathbf{C_i^0(T^0; T^*)} + \mathbf{\Sigma_{j\neq i, j\in L}} \nabla_{\mathbf{T}} \mathbf{C_j^0(T^0; T^*)} + \mathbf{a} \nabla_{\mathbf{T}} \mathbf{W(T^0, T^*) = 0} \; \forall \, \mathbf{i \in L}; \tag{16}$$

and

$$\Sigma_{j\neq i, j\in L} \nabla_{\mathbf{T}} C_j^0(\mathbf{T^0}; \mathbf{T}^*) + \mathbf{a} \nabla_{\mathbf{T}} \mathbf{W(T^0, T^*) = 0}. \tag{17}$$

Using (17) in (16), we have

$$\nabla_{\mathbf{T}} C_i^0(\mathbf{T^0}; \mathbf{T}^*) = \nabla_{\mathbf{T}} \mathbf{W_i(T^0, T^*)} \; \forall \, \mathbf{i \in L}. \tag{18}$$

Expression (18) shows that each lobby group sets its contribution schedule in such a manner that a marginal change in campaign contributions (or marginal cost for it) due to a change in home policy for any given foreign policy equals the change in gross welfare of the lobby due to the policy change, which is akin to the arbitrage condition for each lobby. This has been referred to as the local truthfulness property of equilibrium contribution schedules (Grossman and Helpman, 1994).

Summing (18) over all i and using (17), we get

$$\Sigma_{i\in L}\nabla_{\mathbf{T}}W_i(\mathbf{T^0},\mathbf{T}^*)+\mathbf{a}\nabla_{\mathbf{T}}\mathbf{W}(\mathbf{T^0},\mathbf{T}^*)=\mathbf{0}\,\forall\,\mathbf{i}\in\mathbf{L}. \tag{19}$$

In case of the foreign country, we have

$$\Sigma_{i\in L^*}\nabla_{\mathbf{T}^*}W_i^*(\mathbf{T}^{*\mathbf{0}},\mathbf{T})+\mathbf{a}^*\nabla_{\mathbf{T}^*}\mathbf{W}^*(\mathbf{T}^{*\mathbf{0}},\mathbf{T})=\mathbf{0}\,\forall\,\mathbf{i}\in\mathbf{L}^*. \tag{20}$$

Conditions (19) and (20) give us equilibrium policy responses $\mathbf{T^0}$ and $\mathbf{T}^{*\mathbf{0}}$ and hence $\{C^0_{i\,i\in L}\}$ and $\{C^{*0}_{i\,i\in L^*}\}$ such that $\{C^0_{i\,i\in L},\mathbf{T^0}\}$ is the equilibrium response to $\mathbf{T}^{*\mathbf{0}}$ and $\{C^{*0}_{i\,i\in L^*},\mathbf{T}^{*\mathbf{0}}\}$ is the equilibrium response to $\mathbf{T^0}$.

Now, let us solve for the Nash equilibrium for sector i. We begin by computing the effect given by the first term of the left-hand side of condition (19) for any sector j.

$$\frac{\partial W_i(\bullet)}{\partial T_j}=\frac{\partial \Pi_i(\bullet)}{\partial T_j}+\alpha_i\left[\frac{\partial r(\bullet)}{\partial T_j}+\frac{\partial e(\bullet)}{\partial T_j}+\frac{\partial S(\bullet)}{\partial T_j}\right]; \tag{21}$$

where

$$\frac{\partial \Pi_i(\bullet)}{\partial T_j}=0\,\forall\,i\neq j;$$

which implies that any change in trade policy chosen for sector j does not affect the rents of specific input owners in sector i. This indirectly follows from the envelope theorem.

In the next section, we compute marginal effects of a change in trade policy for each component of the political welfare function.

2.6.1 Marginal effects of a change in trade policy

Using chain rule, we derive the marginal effects of a change in trade policy on each of the components of welfare of each political action group:

$$\underbrace{\frac{\partial \Pi_i(T_i\omega_i)}{\partial T_i}}_{\substack{\text{effect of trade policy on residual}\\ \text{rent of the sector specific input}}}=\frac{\partial \Pi_i(T_i\omega_i)}{\partial p_i}.\frac{\partial p_i}{\partial T_i}=X_i(p_i)\frac{\partial p_i}{\partial T_i};$$

$$\underbrace{\frac{\partial r(\mathbf{T}\boldsymbol{\omega})}{\partial T_i}}_{\substack{\text{effect of trade policy on the}\\ \text{revenue generated from the trade policy}}}=\frac{\partial r(\mathbf{T}\boldsymbol{\omega})}{\partial p_i}.\frac{\partial p_i}{\partial T_i};$$

$$\underbrace{\frac{\partial e(\mathbf{T}\boldsymbol{\omega})}{\partial T_i}}_{\substack{\text{effect of trade policy on pollution tax}\\ \text{revenue net of environmental damages}}}=\frac{\partial e(\mathbf{T}\boldsymbol{\omega})}{\partial p_i}.\frac{\partial p_i}{\partial T_i};$$

$$\underbrace{\frac{\partial S(\mathbf{T}\boldsymbol{\omega})}{\partial T_i}}_{\substack{\text{effect of trade policy on}\\ \text{consumer surplus}}} = \frac{\partial S(\mathbf{T}\boldsymbol{\omega})}{\partial p_i}.\frac{\partial p_i}{\partial T_i};$$

where

$$\underbrace{\frac{\partial p_i}{\partial T_i}}_{\substack{\text{effect of trade policy on the}\\ \text{domestic price of the tradable good}}} = \omega_i + T_i\frac{\partial \omega_i}{\partial T_i}; \tag{22}$$

i.e., individual countries being large enough to influence world (offshore) prices, their trade policies generate terms of trade effects captured by the second term on the right-hand side of expression (22), besides standard gains from trade and changes in environment damages/benefits and changes in utility due to tariff/tax revenues. Apart from the effect of a change in domestic price, the signs of these marginal effects would depend on the sign of expression (22) which further depends on whether the country in question is an importer or exporter of the traded good. We consider one of such cases in a subsequent section of this paper.

From equation (5), any change in consumer surplus for the entire range of non-numeraire goods is equivalent to a change in the indirect utility for a given level of income.

$$\frac{\partial S(\mathbf{T}\boldsymbol{\omega})}{\partial p_i} = \frac{\partial V(\mathbf{T}\boldsymbol{\omega}, I)}{\partial p_i}.$$

Using Roy's identity, we have

$$\frac{\frac{\partial V(\mathbf{T}\boldsymbol{\omega}, I)}{\partial p_i}}{\frac{\partial V(\mathbf{T}\boldsymbol{\omega}, I)}{\partial I}} = -d_i(p_i).$$

Partial differentiation of tariff revenue, pollution tax revenue and consumer surplus with respect to trade policy in sector i yields

$$\frac{\partial r(\mathbf{T}\boldsymbol{\omega})}{\partial T_i} = \omega_i M_i + (T_i - 1)M_i\frac{\partial \omega_i}{\partial T_i} + (T_i - 1)\omega_i\frac{\partial M_i}{\partial p_i}\left(\omega_i + T_i\frac{\partial \omega_i}{\partial T_i}\right). \tag{23}$$

Expression (23) shows that marginal effects on revenue from trade policy encompasses first-order effects (given by the first and the second term on the right-hand side) and a second-order effect (given by the third term on the right-hand side). Therefore, any change in domestic trade policy alters tariff revenue directly for a given level of imports and through a change in imports driven by a change in domestic price.

The marginal impact of trade policy in sector i on pollution tax revenue is given by

$$\frac{\partial e(\mathbf{T}\boldsymbol{\omega})}{\partial T_i} = (\tau_i - \theta_i)\frac{\partial N_i}{\partial p_i}\left(\omega_i + T_i\frac{\partial \omega_i}{\partial T_i}\right). \tag{24}$$

Any change in domestic trade policy for sector i induces a change in demand for the sector-specific environmental resource via the domestic price change.

Finally, Roy's identity gives us the expression for marginal effects of domestic trade policy in sector i on consumer surplus, i.e.,

$$\frac{\partial S(\mathbf{T}\boldsymbol{\omega})}{\partial T_i} = -d_i(p_i)\left(\omega_i + T_i\frac{\partial \omega_i}{\partial T_i}\right). \tag{25}$$

Next we derive the expressions for equilibrium outcomes corresponding to a trade war in the presence of political action groups and regulation over the use of environmental resources.

2.6.2 Equilibrium trade policy response

Substituting the results obtained in the previous section on the right-hand side of equation (21) yields

$$\begin{aligned}\frac{\partial W_i}{\partial T_j} = (\psi_{ij} - \alpha_i) X_j \left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right) + \alpha_i \Bigg[(T_j - 1)\omega_j \frac{\partial M_j}{\partial p_j}\left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right) \\ - M_j \frac{\partial \omega_j}{\partial T_j} + (\tau_j - \theta_j)\frac{\partial N_j}{\partial p_j}\left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right)\Bigg]; \end{aligned} \tag{26}$$

where

$$\psi_{ij} = \begin{cases} 0, & \text{if } i \neq j \\ 1, & \text{otherwise.} \end{cases}$$

Expression (26) shows the overall effect of a change in domestic trade policy on the welfare (gross of contributions) of lobby in sector i which may be positive or negative. Again, this would typically depend on whether the sector in question is an importable sector or an exportable sector, organised or unorganised, the level of environmental regulations it is subjected to, and the environmental damage generated from the sector.

Summing over the entire set of organised sectors, the overall impact on gross welfare in response to a change in domestic trade policy is given by

$$\begin{aligned}\Sigma_{i\in L}\frac{\partial W_i}{\partial T_j} = (\Gamma_L - \alpha_L) X_j \left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right) + \alpha_L \Bigg[(T_j - 1)\omega_j \frac{\partial M_j}{\partial p_j}\left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right) \\ - M_j \frac{\partial \omega_j}{\partial T_j} + (\tau_j - \theta_j)\frac{\partial N_j}{\partial p_j}\left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right)\Bigg]; \end{aligned} \tag{27}$$

where

$$\Gamma_L = \begin{cases} 0, & \text{if the sector is unorganised} \\ 1, & \text{otherwise;} \end{cases}$$

and $\alpha_L = \Sigma_{i\in L}\alpha_i$ denotes the fraction of voters who are members of a lobby group.

Next, the second-term on the left-hand side of condition (19), which shows a marginal change in social welfare for the population in general is expressed as

$$\frac{\partial W(\bullet)}{\partial T_j} = \underbrace{\frac{\partial \Pi_i(\bullet)}{\partial T_j}}_{\text{effect (i)}} + \underbrace{\frac{\partial r(\bullet)}{\partial T_j} + \frac{\partial e(\bullet)}{\partial T_j}}_{\text{effect (ii)}} + \underbrace{\frac{\partial S(\bullet)}{\partial T_j}}_{\text{effect (iii)}}; \tag{28}$$

which reduces to

$$\frac{\partial W}{\partial T_j} = (T_j - 1)\omega_j \frac{\partial M_j}{\partial p_j}\left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right) - M_j \frac{\partial \omega_j}{\partial T_j} + (\tau_j - \theta_j)\frac{\partial N_j}{\partial p_j}\left(\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}\right). \tag{29}$$

Therefore, the marginal change in overall welfare on account of a change in domestic trade policy comprises the following marginal effects: (i) change in rents of the set of political action groups; (ii) change in lumpsum transfers from the government through tariff revenue and pollution tax revenue net of environmental damage; and (iii) change in consumer surplus, given by expression (28). It is important to note that the first effect reduces to zero since any change in trade policy chosen for sector j does not affect the rents of specific input owners in sector i. Each of these effects are illustrated by the first, second, third and fourth terms on the right-hand side of expression (28), which simplify further to yield expression (29).

Using results in (27) and (29) and substituting them in the first-order condition (19), we get

$$(\Gamma_L - \alpha_L)X_j + (a + \alpha_L)\left[(T_j - 1)\omega_j \frac{\partial M_j}{\partial p_j} - \frac{M_j \frac{\partial \omega_j}{\partial T_j}}{\omega_j + T_j \frac{\partial \omega_j}{\partial T_j}} + (\tau_j - \theta_j)\frac{\partial N_j}{\partial p_j}\right] = 0. \tag{30}$$

The effect of change of home policy on world prices of goods produced in a particular sector can be computed from the world market clearing condition. We differentiate the world market clearing condition (14) with respect to the domestic trade policy in sector i in order to obtain the terms of trade effect of domestic trade policy. Therefore, we have

$$\frac{\partial M_i}{\partial p_i}\left(\omega_i + T_i \frac{\partial \omega_i}{\partial T_i}\right) + T_i^* \frac{\partial M_i^*}{\partial p_i^*}\frac{\partial \omega_i}{\partial T_i} = 0;$$

which gives

$$\frac{\partial \omega_i}{\partial T_i} = -\frac{\omega_i \frac{\partial M_i}{\partial p_i}}{T_i \frac{\partial M_i}{\partial p_i} + T_i^* \frac{\partial M_i^*}{\partial p_i^*}}; \tag{31}$$

as the effect of change of domestic trade policy on the offshore price for sector i. Without loss of generality, if the home country is an importer of the non-numeraire good produced by sector i, and its government imposes an import tariff, there is a resultant reduction in the offshore price of the good. Both the numerator and the denominator on the right-hand side of expression (31) would be negative in this case.

Substituting the result in (31) in the first-order condition (30) for any sector i, we have

$$(\Gamma_L - \alpha_L)X_i + (a + \alpha_L)\left[(T_i - 1)\omega_i \frac{\partial M_i}{\partial p_i} + \frac{M_i \omega_i \frac{\partial M_i}{\partial p_i}}{T_i^* \omega_i \frac{\partial M_i^*}{\partial p_i^*}} + (\tau_i - \theta_i)\frac{\partial N_i}{\partial p_i}\right] = 0.$$

Further, the world market clearing condition $M_i = -M_i^*$ can be used to simplify the expression as

$$(\Gamma_L - \alpha_L)X_i + (a + \alpha_L)\left[(T_i - 1)\omega_i \frac{\partial M_i}{\partial p_i} - \frac{\omega_i \frac{\partial M_i}{\partial p_i}}{\eta_i^*} + (\tau_i - \theta_i)\frac{\partial N_i}{\partial p_i}\right] = 0; \tag{32}$$

where

$$\eta_i^* = \frac{T_i^* \omega_i}{M_i^*}\frac{\partial M_i^*}{\partial p_i^*};$$

denotes the elasticity of foreign import demand when M_i^* is positive or export supply when M_i^* is negative.

We obtain an analogous expression for the foreign country

$$(\Gamma_L^* - \alpha_L^*)X_i^* + (a^* + \alpha_L^*)\left[(T_i^* - 1)\omega_i \frac{\partial M_i^*}{\partial p_i^*} - \frac{\omega_i \frac{\partial M_i^*}{\partial p_i^*}}{\eta_i} + (\tau_i^* - \theta_i^*)\frac{\partial N_i^*}{\partial p_i^*}\right] = 0 \tag{33}$$

where

$$\eta_i = \frac{T_i \omega_i}{M_i}\frac{\partial M_i}{\partial p_i};$$

denotes the elasticity of home import demand when M_i is positive or home export supply when M_i is negative.

Solving for the Nash equilibrium trade policies, we get

$$T_i^0 - 1 = -\frac{\Gamma_L - \alpha_L}{a + \alpha_L}\frac{X_i}{\omega_i \frac{\partial M_i}{\partial p_i}} + \frac{1}{\eta_i^*} - (\tau_i - \theta_i)\frac{\frac{\partial N_i}{\partial p_i}}{\omega_i \frac{\partial M_i}{\partial p_i}} \tag{34}$$

and

$$T^{*0}_i - 1 = -\frac{\Gamma_L^* - \alpha_L^*}{a^* + \alpha_L^*}\frac{X_i^*}{\omega_i \frac{\partial M_i^*}{\partial p_i^*}} + \frac{1}{\eta_i} - (\tau_i^* - \theta_i^*)\frac{\frac{\partial N_i^*}{\partial p_i^*}}{\omega_i \frac{\partial M_i^*}{\partial p_i^*}} \tag{35}$$

It is seen that equilibrium trade policies in each country are expressed as a sum of three components in the right-hand side of expressions (34) and (35), namely the political support, the terms of trade motive and net pollution tax revenue gains (losses) from trade intervention. The result is at variance with the G-H model in terms of the third component. However, the pollution tax revenue gains (losses) disappear in case the exogenous rate of pollution tax is set equal to the marginal damage, i.e., a Pigouvian tax and the standard G-H model result holds.

The analysis becomes interesting when pollution taxes do not reflect true marginal damage. Under such circumstances, several sub cases can be studied: (a) Pollution tax rate exceeds marginal damage from pollution in both countries, i.e., environmental regulations are relatively stringent; (b) Pollution tax exceeds marginal damage from pollution at home and it equals the Pigouvian tax in the foreign country; (c) Pollution tax exceeds marginal damage from pollution at home and it is lower than the marginal damage abroad; (d) Pollution tax rate falls short of marginal damage in both countries, i.e., environmental regulations are laxer; (e) Pollution tax rate is lower than the marginal damage at home and it is higher than the marginal damage abroad; (f) Pollution tax rate falls short of the marginal damage at home and it is equal to the Pigouvian tax abroad; (g) Pollution tax rate equals Pigouvian tax at home and exceeds the marginal damage abroad; (h) Pigouvian tax prevails at home and the pollution tax in the foreign country is set below the Pigouvian tax.

From (34), we get

$$T_i^0 - 1 = \{T_i^G - 1\} - (\tau_i - \theta_i)\frac{\frac{\partial N_i}{\partial p_i}}{\omega_i \frac{\partial M_i}{\partial p_i}}. \tag{36}$$

When pollution tax exceeds marginal damage, i.e., $(\tau_i - \theta_i) > 0$, an organised import competing sector is characterised by a protective tariff which is higher than the tariff in the G-H model, given by $(T_i^G - 1)$. This wedge is driven by the net gains from pollution tax revenue which rises due to increased production of the importable in the home country (captured by the last term on the right-hand side of expression (36)). The total revenue from environmental regulations exceeds the total environmental damage generated from a change in domestic price as a response to a change in import tariff, called the net gain from pollution tax. Utilising the sign restrictions for the numerator and the denominator, this term turns out to be positive. Under an alternative scenario where the country's environmental regulations are less stringent, the optimal trade policy would be lower than that of the G-H model. In case the second term is a highly negative in magnitude, equilibrium trade policy would be an import subsidy.

Proposition 2: *In case of too stringent (too lax) environmental regulations at home (foreign), the optimal trade policy for an organised import competing sector is higher (lower) than that of the G-H model.*

An interesting result may emerge in case of an unorganised export industry at home. Unlike in case of the G-H model, this industry may not always suffer from an export tax. In (34), the first two terms on the right-hand side are negative. This is because the sector in question is an exportable sector in the home country and it is unorganised. Total environmental damage from a change in production driven by a change in the domestic price of the exportable is given by the expression, $\theta \frac{\frac{\partial N_i}{\partial p_i}}{\omega_i \frac{\partial M_i}{\partial p_i}}$, is also negative. On the contrary, total tax revenue from environmental regulation imposed in the sector $\left(\text{given by } \tau \frac{\frac{\partial N_i}{\partial p_i}}{\omega_i \frac{\partial M_i}{\partial p_i}}\right)$ is positive. The third term on the right-hand side gives the difference of the above two effects, also called the net gain from pollution tax. In case the gain from pollution tax revenue from an export subsidy outweighs (a) the loss of contribution at margin due to increase in domestic production in the exportable sector on account of an export subsidy; (b) the adjustment in dead weight loss from a trade tax/subsidy (the second term on the right-hand side) and thereby affecting foreign import demand; and (c) the environmental damage from increased domestic production in the exportable sector driven by an export subsidy, the exportable sector would enjoy an export subsidy. Interestingly, such a situation might arise even when the weight attached to pure social welfare approaches to infinity ($a \to \infty$) i.e, the policy maker is not politically motivated. However, in cases of organised export industry and unorganised import industry, ambiguity in terms of export subsidy/tax and import subsidy/tax respectively, remains. For instance, for an organised export industry, prospects for securing an export subsidy are better the greater the industry output, the smaller the price sensitivities of domestic supply and demand and lower the weight attached by the politicians to average welfare. Ceteris paribus, the home government would be more inclined to choose an export tax and raise the world price when the foreign import elasticity of demand would be less elastic. Finally, the home government's proclivity for an export subsidy is increasing in the price sensitivity of demand for the environmental resource. A rise in domestic price of the exportable would lead to an increase in demand for the environmental resource, which is an input to production, and hence raise the net pollution tax revenue accruing to the home government. Hence, the trade policy adopted would depend on the relative strengths of each of these effects.

In case, pollution tax is less than marginal damage, an unorganised export industry at home suffers an export tax. The interesting case arises for an organised import industry. An organised import industry may suffer an import subsidy if the total environmental damage from production of the importable exceeds (a) the gain from political support (in terms of campaign funds from the organised sector); (b) the adjustment in dead weight loss from a trade tax/subsidy (given by the second term on the right-hand side of (34)); and (c) the revenue gain from environmental taxation.

We derive and discuss each of these cases later in the paper.

In order to provide a comprehensive exposition of the trade war equilibrium, we consider a special case of constant import demand elasticities and export supply elasticities in the next section.

2.6.3 Trade war equilibrium under constant trade elasticities

In this section, we assume a special case of constant trade elasticities and derive explicit solutions for the results given by (34) and (35). This would enable us to explain the trade war equilibrium graphically. We proceed by assuming constant trade elasticities as in the G-H model and compare our results with the trade war equilibrium derived by Johnson (1953) and Grossman and Helpman (1995). Let us assume that industry i at home is the importer of X_i. Consequently, X_i is being exported by the foreign country. By dropping industry subscript i, we postulate the home import demand function as $M = m(T\omega)^{-\epsilon}$, with $m > 0$ and $\epsilon = -\eta_i > 1$. The foreign export supply function is given by $-M^* = m^*(T^*\omega)^{\epsilon^*}$, with $m^* > 0$ and $\epsilon^* = \eta_i^* > 0$.

From the world market clearing condition, equilibrium world price is given by

$$\omega(T,T^*) = \left(\frac{m}{m^*}\right)^{\frac{1}{\epsilon+\epsilon^*}} \left(\frac{1}{T}\right)^{\frac{\epsilon}{\epsilon+\epsilon^*}} \left(\frac{1}{T^*}\right)^{\frac{\epsilon^*}{\epsilon+\epsilon^*}}. \tag{37}$$

The figure shows the Johnson's equilibrium at point J. Owing to constant trade elasticities, the best response functions are straight lines. BB is the reaction function of the home country which is parallel to the vertical axis measuring trade policy of the foreign country. B^*B^* is the reaction function of the foreign country, parallel to the horizontal axis measuring home trade policy. This indicates that both T and T^* are independent of each other. Equilibrium trade policies turn out to be $T_J = 1 + \frac{1}{\epsilon^*} > 1$ at home and $T_J^* = 1 - \frac{1}{\epsilon} < 1$ at foreign, respectively. Therefore, home country imposes an import tariff and foreign country imposes an export tax. This equilibrium is driven by the motive of terms of trade gain. While the home country tariff drives down the world price of its imports, the foreign country attempts to pull its exports prices up through an export tax.

Now, let us characterise the trade war equilibrium when environmental regulations are in place. With constant trade elasticities as postulated earlier, the Nash equilibrium trade policies in expressions (34) and (35) become

$$T = \left(1 + \frac{1}{\epsilon^*}\right)\left[1 - \frac{\Gamma_L - \alpha_L}{a + \alpha_L}\frac{X(T\omega)}{\epsilon m(T\omega)^{-\epsilon}} - (\tau - \theta)\frac{\frac{\partial N(T\omega)}{\partial p}}{\epsilon m(T\omega)^{-\epsilon}}\right]^{-1}; \tag{38}$$

and

$$T^* = \left(1 - \frac{1}{\epsilon}\right)\left[1 - \frac{\Gamma_L^* - \alpha_L^*}{a^* + \alpha_L^*}\frac{X^*(T^*\omega)}{\epsilon^* m^*(T^*\omega)^{\epsilon^*}} - (\tau^* - \theta^*)\frac{\frac{\partial N^*(T^*\omega)}{\partial p^*}}{\epsilon^* m^*(T^*\omega)^{\epsilon^*}}\right]^{-1}. \tag{39}$$

In contrast, the non-cooperative equilibrium trade policies in the G-H model are given by

$$T_G = \left(1 + \frac{1}{\epsilon^*}\right)\left[1 - \frac{\Gamma_L - \alpha_L}{a + \alpha_L}\frac{X(T\omega)}{\epsilon m(T\omega)^{-\epsilon}}\right]^{-1}; \tag{40}$$

and

$$T_G^* = \left(1 - \frac{1}{\epsilon}\right)\left[1 - \frac{\Gamma_L^* - \alpha_L^*}{a^* + \alpha_L^*}\frac{X^*(T^*\omega)}{\epsilon^* m^*(T^*\omega)^{\epsilon^*}}\right]^{-1}. \tag{41}$$

Comparing (38) and (39) with the (40) and (41), respectively, it is evident that the last term in the denominator of the reaction functions in (38) and (39) appear as an additional effect of trade policy change on the net revenue (pollution tax revenue minus the avoided marginal environmental damages) generated from regulating the use of the environmental/natural resource. Apparently, this effect is absent in the G-H (1995) model.

We, now, divide equation (38) by (40) and equation (39) with (41) and get

$$T = \frac{1 - \frac{\Gamma_L - \alpha_L}{a + \alpha_L}\frac{X(T\omega)}{\epsilon m(T\omega)^{-\epsilon}}}{1 - \frac{\Gamma_L - \alpha_L}{a + \alpha_L}\frac{X(T\omega)}{\epsilon m(T\omega)^{-\epsilon}} - (\tau - \theta)\frac{\frac{\partial N(T\omega)}{\partial p}}{\epsilon m(T\omega)^{-\epsilon}}} T_G; \tag{42}$$

and

$$T^* = \frac{1 - \frac{\Gamma_L^* - \alpha_L^*}{a^* + \alpha_L^*}\frac{X^*(T^*\omega)}{\epsilon^* m^*(T^*\omega)^{\epsilon^*}}}{1 - \frac{\Gamma_L^* - \alpha_L^*}{a^* + \alpha_L^*}\frac{X^*(T^*\omega)}{\epsilon^* m^*(T^*\omega)^{\epsilon^*}} - (\tau^* - \theta^*)\frac{\frac{\partial N^*(T^*\omega)}{\partial p^*}}{\epsilon^* m^*(T^*\omega)^{\epsilon^*}}} T_G^*. \tag{43}$$

Expressions (42) and (43) suggest that the optimal levels of trade policy might deviate from those in the G-H model. For instance, in case of stringent environmental regulations in both countries, both T and T^* would be greater than the best responses T_G and T_G^*, for any given level of T^* and T respectively. Apart from gains/losses from political support and the deadweight loss from trade policy induced price distortions, there is additional revenue generated from environmental regulations owing to the marginal change in output driven by trade policy. The converse is true when environmental taxes set by the government are much lower than the marginal damage from pollution. This also proves Proposition 2.

In the next section, we trace out the reaction functions (given by expressions (38) and (39)) corresponding to each country's trade policy when environmental regulations are in place.

2.6.4 Derivation of the pollution tax ridden reaction functions

Since our primary motive is to capture the political economy effects of trade policies in the presence of environmental regulations, we consider the scenario where trade takes place across sectors which are organised, i.e., $\Gamma_L = \Gamma_L^* = 1$.

Now, using the world price function from expression (37), we can derive home and foreign prices as

$$p = T\omega = \left(\frac{m}{m^*}\right)^{\frac{1}{\epsilon+\epsilon^*}} \left(\frac{T}{T^*}\right)^{\frac{\epsilon^*}{\epsilon+\epsilon^*}}. \tag{44}$$

Similarly,

$$p^* = T^*\omega = \left(\frac{m}{m^*}\right)^{\frac{1}{\epsilon+\epsilon^*}} \left(\frac{T}{T^*}\right)^{-\frac{\epsilon}{\epsilon+\epsilon^*}}. \tag{45}$$

These are obtained by multiplying T and T^* with ω from expression (37).

It is evident that home prices rise as the ratio of advalorem trade taxes of home relative to foreign rises, i.e., $\frac{\partial p}{\partial\left(\frac{T}{T^*}\right)} > 0$. On the contrary, foreign prices are inversely affected by a rise in $\left(\frac{T}{T^*}\right)$. These follow from the large country assumptions on home and foreign.

From the implicit form of reaction functions, we try to explain the strategic relationships between home and foreign trade policies through the channel of price change at home and the foreign country, respectively. The implicit functional form of the reaction functions, we cannot express one nation's trade policy exclusively as a function of the others. Instead, expressions (38) and (39) are functions of the ratio of trade policies, i.e., $\left(\frac{T}{T^*}\right)$. Therefore, from (38) and (39), we have

$$T = T\left(\frac{T}{T^*}\right); \tag{38'}$$

and

$$T^* = T^*\left(\frac{T}{T^*}\right). \tag{39'}$$

Instances where nations use trade restrictions to redistribute income among the population, the immediate impact is a change in domestic prices. We use this channel of change to trace out the reaction functions. From (38') and (39'), we look at the impact of a price change both at home and in foreign on $\left(\frac{T}{T^*}\right)$ and the subsequent effect on the left-hand side of equations (38), (38'), (39) and (39'). The movement of the terms on the left-hand side of these equations in response to a change in $\left(\frac{T}{T^*}\right)$ would help us tracing out the trade policy reaction functions. The following section is devoted to the derivation of the reaction functions for each country under two alternative scenarios: (a) environmental regulations are too stringent; and (b) environmental regulations are less stringent.

2.6.5 Case I: Pollution taxes exceed the marginal damage from pollution in both countries

In the present case, both home and foreign countries are characterised by stringent environmental regulations. Such situations emerge when trading nations are developed economies, say, trade between the United States (US) and the European Union (EU).

In order to derive the shape of the foreign country's reaction curve, we start with a change in foreign price. Assuming that $(\tau^* - \theta^*) > 0$, a rise in p^* would result in a rise in both the numerator and denominator of the second and the third terms of the denominator of the T^* function in (39). This would have a first-order effect on foreign output and demand. While foreign output rises, foreign demand falls. Now, exports being the difference between foreign output and demand, rise. Moreover, the rise in exports (a first-order effect) would be higher than the rise in output as well as the rise in the demand for the environmental resource (both being second-order effects). Higher exports would require higher production in foreign, and hence a higher use of the environmental resource there. Consequently, the denominator of (39) rises resulting in a fall in $T^*\left(\frac{T}{T^*}\right)$. Hence, a rise in foreign price results in a fall in $T^*\left(\frac{T}{T^*}\right)$, i.e., $\frac{dT^*\left(\frac{T}{T^*}\right)}{dp^*} < 0$. Furthermore, comparing expression (39) with (41), we find that the fall in $T^*\left(\frac{T}{T^*}\right)$ would be more than the fall in $T^*_G\left(\frac{T_G}{T^*_G}\right)$ owing to the additional revenue generating effect when environmental regulation is too stringent.

Next, we try plot the reaction function of the foreign country. This would show the response in T^* due to a change in T. In the preceding paragraph, it is evident that a rise in p^* would lead to a fall in T^* on the left-hand side of equation (39). Now, we capture the direction of movement of $\left(\frac{T^*}{T}\right)$ due to a fall in T^* in equation (39). This helps us to establish the relationship between T^* and T. In other words, this would give us different pairs of T and T^* such that the left hand side of (39) (or (39')) falls on account of a rise in p^*. In all, a fall in T^* on the left-hand side of (39) (or (39')) is associated with a change in $\left(\frac{T}{T^*}\right)$ $\left(\text{or } \left(\frac{T^*}{T}\right)\right)$ on the right-hand side of (39) (or (39')). Given that T^* is falling and the consequent change in $\left(\frac{T^*}{T}\right)$, we can trace out the direction of movement of T, which would give us the reaction function for the foreign country.

The above considerations yield the following possibilities:

(a) $\left(\frac{T^*}{T}\right)$ falls as T rises and T^* falls;

(b) $\left(\frac{T^*}{T}\right)$ falls as T remains unchanged and T^* falls; and

(c) $\left(\frac{T^*}{T}\right)$ falls as both T and T^* fall but the fall in T^* exceeds the fall in T.

These can be expressed formally as:

$$d\left(\frac{T^*}{T}\right)\begin{cases} < 0, & \text{if } dT^* < 0 \text{ and } dT > 0 \\ < 0 & \text{if } dT^* < 0 \text{ and } dT = 0 \\ > 0, & \text{if } dT^* < 0 \text{ and } dT < 0 \text{ but } |dT^*| > |dT|. \end{cases} \tag{46}$$

Now suppose each of the above alternatives hold. From expression (45), it is clear that the p^* is increasing in $\left(\frac{T^*}{T}\right)$. Therefore, the first two cases where $d\left(\frac{T^*}{T}\right) < 0$ are not compatible with a rise in p^* since $\frac{\partial p^*}{\partial\left(\frac{T}{T^*}\right)} < 0$, i.e., $\frac{\partial p^*}{\partial\left(\frac{T^*}{T}\right)} > 0$. These two cases are contradictory to the relationship in (45). This indicates that we must have $d\left(\frac{T^*}{T}\right) > 0$, which implies that both home and foreign trade policies are positively related and the slope of the reaction function is greater than one. This gives an upward sloping reaction function of the foreign country denoted by the curve E^*E^* (Figure 1).

Similarly, the reaction curve for the home country can be derived. A rise in home price $p = T\omega$ results in a rise in both the second and the third terms of the denominator of expression (38) and (38'), i.e., $(T\omega)^{\epsilon}X(T\omega)$ and $(T\omega)^{\epsilon}\frac{\partial N(T\omega)}{\partial p}$. Resultantly, the denominator of (38) falls when p rises, which results in a rise in $T\left(\frac{T}{T^*}\right)$, i.e., $\frac{dT\left(\frac{T}{T^*}\right)}{dp} > 0$. Again, comparing (38) with (40) shows that the rise in $T\left(\frac{T}{T^*}\right)$ is higher than the rise in $T_G\left(\frac{T_G}{T_G^*}\right)$.

Now, let us capture the direction of movement of $\left(\frac{T}{T^*}\right)$ in response to a rise in T. Again, we can list three possibilities:

(a) $\left(\frac{T}{T^*}\right)$ rises as T^* falls and T rises;

(b) $\left(\frac{T}{T^*}\right)$ rises as T^* remains unchanged and T rises; and

(c) $\left(\frac{T}{T^*}\right)$ rises as both T and T^* rise but the rise in T exceeds the rise in T^*.

These can be expressed formally as:

$$d\left(\frac{T}{T^*}\right)\begin{cases} > 0, & \text{if } dT > 0 \text{ and } dT^* < 0 \\ > 0 & \text{if } dT > 0 \text{ and } dT^* = 0 \\ > 0, & \text{if } dT > 0 \text{ and } dT^* > 0 \text{ but } |dT^*| < |dT|. \end{cases} \tag{47}$$

Here, all the above cases are compatible with a rise in p since $\frac{\partial p}{\partial\left(\frac{T}{T^*}\right)} > 0$. Consequently, the home reaction curve could have both upward sloping as well as downward sloping sections. Further, from (38), we can see that the reaction function $T(T^*)$ has a horizontal asymptote given by $\underset{T^*\to\infty}{lim} T(T^*) = 1 + \frac{1}{\epsilon^*}$, which is given by the line BB and an oblique asymptote given by a ray through the origin as $T \to \infty$. The second and the third terms of the denominator of (38) are increasing functions of $T\omega$ which gives unique values of $T\omega$ and hence $\left(\frac{T}{T^*}\right)$ as T grows large. Given the relationship between T and T^*, there are no vertical asymptotes to $T(T^*)$. Thus, the reaction function of the home country is given by a U-shaped curve.

The foreign reaction function, given by $T^*(T)$ in (39) originates from the point, which is given by $\underset{T\to 0}{lim} T^*(T) = 1 - \frac{1}{\epsilon}$, i.e., the line B^*B^*. Hence, this curve, being positively sloped, would always lie above B^*B^*. Furthermore, from (42) and (43), it is clear that the slope of the foreign reaction function is higher than the slope of the home reaction function when both T and T^* are positively related.

Before we provide an intuitive explanation for the shapes of the reaction functions in the later sections of the paper, let us draw comparisons with the results of the standard G-H model.

2.6.6 Comparison of reaction functions with the G-H model

The PP and the P^*P^* curves represent the reaction curves of the home and the foreign country respectively in the standard G-H model of trade wars. For our case, the pollution tax ridden reaction functions are given by EE and E^*E^* for the home and the foreign country respectively. Owing to the higher responsiveness of T and T^* to changes in p and p^* makes the curve E^*E^* steeper than P^*P^* and EE flatter than PP when PP is falling and steeper than PP when it is rising. This is evident from (38) and (43). When T and T^* are inversely related, i.e., they are strategic substitutes, the rise in $T(T^*)$ is higher due to the additional effect of environmental regulations on home's response function. This results in a flatter reaction curve given by EE. On the contrary, when T and T^* move in the same direction, i.e., they act as strategic complements, EE curve rises faster than PP. This is because the rise in home trade tax/subsidy being higher than that of the G-H model, T^* can rise more than T_G in order to ensure a rising $\left(\frac{T}{T^*}\right)$.

Figure 1 shows the equilibrium levels of trade policies in each country. The Johnson equilibrium and the G-H trade war equilibrium points are given by J and W respectively. Point K denotes the trade war equilibrium in the presence of too stringent environmental regulations in both countries. It can be seen that point K lies to the north-east of point W. Furthermore, as the reaction curve of the foreign country is steeper than that of the G-H model, the equilibrium trade policy (tax/subsidy) in the foreign country rises (i.e., a fall in an export tax/import subsidy and equivalently a rise in export subsidy/import tariff) at the cost of home country's trade policy. When demand for the environmental resource becomes highly sensitive to output price changes, the policy maker gains more from charging a tax on the use of the environmental resource. Under such circumstances, the exporting country (here, the foreign country), finds it profitable to subsidise exports and enjoy the gain from pollution tax revenue from an export subsidy which outweighs (a) the adjustment in dead weight loss from a trade tax/subsidy and thereby affecting foreign import demand; and (b) the environmental damage from increased domestic production in the exportable sector. Also, the revenue gains from a pollution tax outweigh the gains from driving up the world price with an export tax. It must be noted that an export subsidy is a rising function of the price sensitivity of the environmental resource. As an export subsidy raises the domestic price of the exportable, production in the exportable sector expands which drives up the demand for the environmental resource input.

Proposition 3: *In case the environmental regulations are too stringent in both countries, the optimal trade tax/subsidy is higher than the case when environmental regulations are absent as is found in the G-H model. Also, the optimal trade tax/subsidy coincides with the G-H result when pollution taxes are set at the Pigouvian level.*

Following Proposition 2, the equilibrium responses of trade war can be derived when at most one country is characterised by pollution taxes exceeding marginal environmental damage, while the other country sets a Pigouvian tax. Suppose, the foreign country chooses a pollution tax equal to the marginal damage from pollution and the home country has relatively stringent environmental regulations. Therefore, reaction functions of the home and the foreign country are given by EE and P^*P^*, respectively. The equilibrium point is given by K', which is at the north-east of W. Therefore, equilibrium tariff levels are higher than the case when the pollution tax equals marginal environmental damage. While the home country has an additional incentive to raise import tariffs in order to capture the pollution tax revenue gain from increased production of the importable, the foreign country suffers a terms of trade loss owing to a fall in export tax (which may translate into an export subsidy), thereby reducing the price of exports

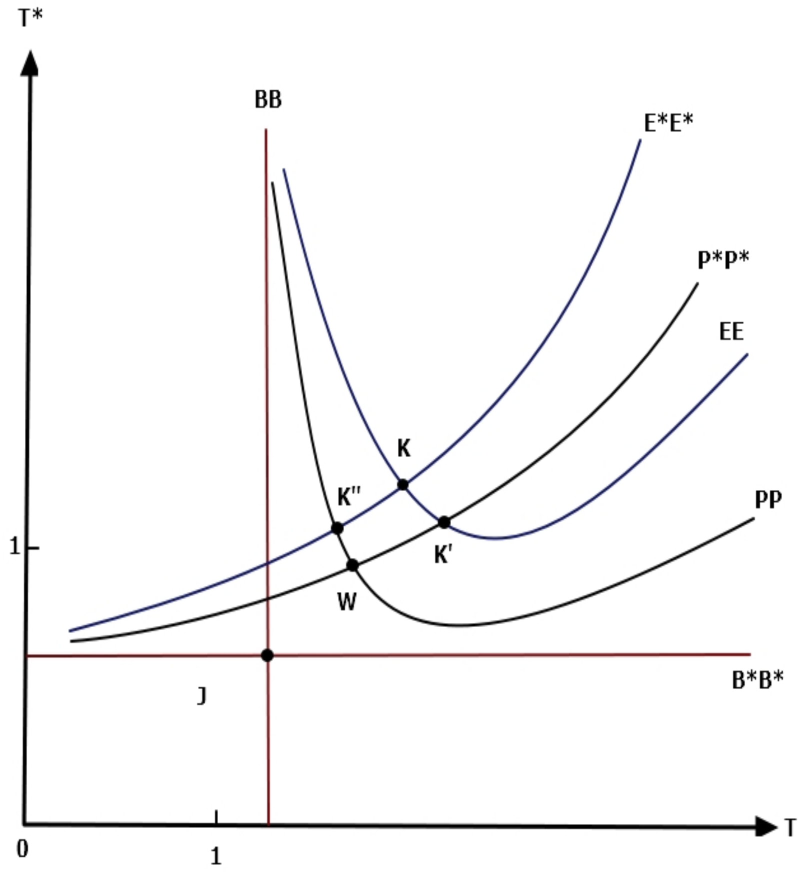

Figure 1: Trade war equilibrium when pollution tax exceeds marginal damage in both countries

in the world market. This is because both of these points, W and K', lie on the upward sloping P^*P^* curve. The reverse happens when the home country chooses a Pigouvian tax for regulating the use of the environmental resource and the foreign country is characterised by a pollution tax higher than the marginal damage from pollution. Now, the reaction functions for the home and the foreign country are PP and E^*E^*, respectively. The equilibrium point, denoted by K'' lies to the north-west of W. It must be noted that these points lie on the downward sloping portion of the PP curve. Equilibrium trade policy in the foreign country is characterised by a lower export tax (or even a higher export subsidy) as compared to the situation where the foreign country sets a Pigouvian tax in order to regulate the production externality. The home country suffers due to a reduction in contributions from political action groups and a terms of trade loss due to a fall in import tariff. The foreign country gains from the additional revenue generated from pollution tax besides higher campaign contributions from political action groups. A reduction in export tax also contributes to a terms of trade loss to the foreign country. Although, the environmental damage rises on account of expansion of the exportable sector driven by a reduction in export tax, stringent environmental regulations outweigh the deterioration in environmental quality. In fact, the foreign government may also subsidise its exports if the gain in pollution tax revenue outweighs the terms of trade loss from reduction in export tax. Finally, the relative gain or loss from such trade policies would be contingent upon the slopes of the reaction curves. The gain from pollution tax revenue is rising in the slope of the E^*E^* curve.

Corollary 1: *When the environmental regulation is stricter in the home country and it is equal to the Pigouvian tax in the foreign country, the home country imposes a higher import tariff as opposed to the case when environmental regulations are absent. The foreign country suffers a terms of trade loss owing to a fall in export tax or rise in export subsidy.*

Corollary 2: *When the environmental regulation is too stringent in the foreign country and it is equal to the Pigouvian tax in the home country, the home country chooses a lower import tariff as opposed to the case when environmental regulations are absent. The foreign country experiences a fall in export tax or rise in export subsidy emanating from revenue gains from the pollution tax.*

2.6.7 Derivation of slopes of the reaction functions: A mathematical approach

In this section, we derive slopes of the reaction functions given in (38) and (39) and a mathematical exposition for the shape of the reaction curves under alternative specifications regarding environmental regulations.

Expressions (38) and (39) can be re-written as

$$T\left[1-\frac{1}{M\left(\frac{T}{T^*}\right)}\left\{AX\left(\frac{T}{T^*}\right)+BN'\left(\frac{T}{T^*}\right)\right\}\right]=C; \tag{48}$$

where $A=\frac{I_L-\alpha_L}{\epsilon(a+\alpha_L)}$, $B=\frac{1}{\epsilon}(\tau-\theta)$, $C=1+\frac{1}{\epsilon^*}$ and $N'\left(\frac{T}{T^*}\right)\equiv\frac{\partial N\left(\frac{T}{T^*}\right)}{\partial p}$; and

$$T^*\left[1-\frac{1}{-M^*\left(\frac{T^*}{T}\right)}\left\{A^*X^*\left(\frac{T^*}{T}\right)+B^*N^{*\prime}\left(\frac{T^*}{T}\right)\right\}\right]=C^*; \tag{49}$$

where $A^*=\frac{I_L^*-\alpha_L^*}{\epsilon^*(a^*+\alpha_L^*)}$, $B^*=\frac{1}{\epsilon^*}(\tau^*-\theta^*)$, $C^*=1-\frac{1}{\epsilon}$ and $N^{*\prime}\left(\frac{T^*}{T}\right)\equiv\frac{\partial N^*\left(\frac{T^*}{T}\right)}{\partial p^*}$.

Total differentiation of (48) and (49) yields

$$\frac{dT}{dT^*}=\frac{-\left(\frac{T}{T^*}\right)^2\frac{1}{M^2}[M(AX'+BN'')-M'(AX+BN')]}{1-\frac{1}{M}(AX+BN')-\frac{T}{T^*}\frac{1}{M^2}[M(AX'+BN'')-M'(AX+BN')]}; \tag{50}$$

and

$$\frac{dT^*}{dT}=\frac{-\left(\frac{T^*}{T}\right)^2\frac{1}{(-M^*)^2}[(-M^*)(A^*X^{*\prime}+B^*N^{*\prime\prime})-(-M^{*\prime})(A^*X^*+B^*N^{*\prime})]}{1-\frac{1}{(-M^*)}(A^*X^*+B^*N^{*\prime})-\frac{T^*}{T}\frac{1}{(-M^*)^2}[(-M^*)(A^*X^{*\prime}+B^*N^{*\prime\prime})-(-M^{*\prime})(A^*X^*+B^*N^{*\prime})]}; \tag{51}$$

where $M'\equiv\frac{\partial M}{\partial p}$; $X'\equiv\frac{\partial X}{\partial p}$ and $N''\equiv\frac{\partial N'}{\partial p}$. Similarly, $M^{*\prime}\equiv\frac{\partial M^*}{\partial p^*}$; $X^{*\prime}\equiv\frac{\partial X^*}{\partial p^*}$ and $N^{*\prime\prime}\equiv\frac{\partial N^{*\prime}}{\partial p^*}$.

Expressions (50) and (51) give the respective slopes of the best response functions of the home and the foreign country. (51) can be further written as

$$\frac{dT^*}{dT} = \frac{-\overbrace{\left(\frac{T^*}{T}\right)^2 \frac{1}{(-M^*)}}^{(+)} \left[\overbrace{A^*X^{*\prime}\left(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{X^{*\prime}}{X^*}}\right)}^{(-)} + \overbrace{B^*N^{*\prime\prime}\left(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{N^{*\prime\prime}}{N^{*\prime}}}\right)}^{(-)}\right]}{\underbrace{1-\frac{1}{(-M^*)}(A^*X^*+B^*N^{*\prime})}_{(+)} - \underbrace{\frac{T^*}{T}\frac{1}{(-M^*)}}_{(+)}\left[\underbrace{A^*X^{*\prime}\left(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{X^{*\prime}}{X^*}}\right)}_{(-)} + \underbrace{B^*N^{*\prime\prime}\left(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{N^{*\prime\prime}}{N^{*\prime}}}\right)}_{(-)}\right]}. \tag{52}$$

Given the functional properties of import demand and export supply, the reaction function of the foreign country is upward sloping for all levels of $\left(\frac{T^*}{T}\right)$. Since foreign exports which are given by the difference between foreign supply and demand, are more sensitive to changes in foreign price than each of foreign supply and the slope of the resource demand with respect to foreign price, the numerator of (52) is unambiguously non-negative.[4] This holds true for an organised export industry in the foreign country, i.e., $A^* > 0$ and for a relatively stringent environmental regulation ($B^* > 0$). Further, foreign supply and exports vary positively with foreign price, i.e, $X^{*\prime} > 0$ and $(-M^{*\prime}) > 0$ respectively. Demand for the environmental resource and its slope are non-decreasing in output prices ($N^{*\prime} \geq 0$ and $N^{*\prime\prime} \geq 0$). The first two terms of the denominator are identical to the denominator obtained in (39) which are non-negative in order to ensure that $T^* \geq 0$. The third term in the denominator is non-negative. Consequently, the foreign reaction curve is monotonically non-decreasing for all levels of $\left(\frac{T^*}{T}\right)$. From (39), the optimal trade tax/subsidy for the foreign country would be higher than the one obtained by Grossman and Helpman (1995) (expression (41)). This ensures that the E^*E^* curve always lies above the P^*P^* curve. Intuitively, a rise in home tariffs raises the home price which leads to an improvement of the terms of trade for home. However, the resultant fall in the offshore price (which is evident from (37)) pulls both the home price and the foreign price downwards (see (44) and (45)). A fall in the foreign price leads to a contraction in output and input demand, which causes export supply in the foreign country to fall. Owing to higher sensitivity of export supply as compared to output and change of input demand alone, the output and the slope of the input demand with respect to output price fall less proportionately than the export supply. Hence, the prospects of gains from political contribution and pollution tax revenue result in reduction of export tax or increase in export subsidy.

Proposition 4: *An organised export industry (here, foreign) subject to stricter environmental regulations, responds with a higher export subsidy/lower export tax to a higher import tariff by the importing home country.*

If we compare the slope of the foreign reaction function with the one in the G-H (1995) model, we see that the elasticity of T^* with respect to T is higher in case of the our model. In (52), putting $N^{*\prime} = 0$ and $N^{*\prime\prime} = 0$, we get the slope of the foreign reaction function in Grossman and Helpman (1995) as

$$\frac{dT_G^*}{dT_G} = \frac{-(\frac{T_G^*}{T_G})^2 \frac{1}{(-M^*)}\left[A^*X^{*\prime}\left(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{X^{*\prime}}{X^*}}\right)\right]}{1-\frac{1}{(-M^*)}(A^*X^*) - \frac{T_G^*}{T_G}\frac{1}{(-M^*)}\left[A^*X^{*\prime}\left(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{X^{*\prime}}{X^*}}\right)\right]} \tag{53}$$

[4] We know that, $(-M^*) = X^* - D^*$, where D^* denotes foreign demand. As p^* rises, X^* would rise and D^* would fall. Therefore, $(-M^*)$ rises more than the rise in X^* and the rise in $N^{*\prime}$ alone.

Comparing (52) with (53) we get

$$\frac{dT_G^*}{dT_G}.\frac{T_G}{T_G^*} \leq \frac{dT^*}{dT}.\frac{T}{T^*} \tag{54}$$

The additional terms in the numerator of (52) exceed those included in the denominator, i.e., $(-\frac{T^*}{T})\frac{1}{-M^*}\Big[B^*N^{*\prime\prime}\Big(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{N^{*\prime\prime}}{N^{*\prime}}}\Big)\Big] > -\frac{1}{(-M^*)}(B^*N^{*\prime}) - (\frac{T^*}{T})\frac{1}{-M^*}\Big[B^*N^{*\prime\prime}\Big(1-\frac{\left(\frac{-M^{*\prime}}{-M^*}\right)}{\frac{N^{*\prime\prime}}{N^{*\prime}}}\Big)\Big]$. The rise in T^* is higher since the revenue generating effect from pollution tax reinforces the lobby effect.

Proposition 5: *The pollution tax reaction function of the foreign country is more responsive to changes in home tariffs as opposed to a situation where environmental regulations are absent as in case of the G-H model.*

The reaction function of the home country exhibits a non-monotonic relationship. From (50), it is evident that the numerator is unambiguously negative. Hence, the sign of the derivative depends on the denominator of (50). Accordingly, we have,

$$\frac{dT}{dT^*}\begin{cases} <0, & \text{if } \frac{T}{T^*} < \widetilde{\left(\frac{T}{T^*}\right)} \\ =\infty & \text{if } \frac{T}{T^*} = \widetilde{\left(\frac{T}{T^*}\right)} \\ >0, & \text{if } \frac{T}{T^*} > \widetilde{\left(\frac{T}{T^*}\right)} \end{cases} \tag{55}$$

where $\widetilde{\left(\frac{T}{T^*}\right)} \equiv \frac{1-\frac{1}{M}(AX+BN')}{\frac{1}{M^2}[M(AX'+BN'')-M'(AX+BN')]} \geq 0$, given that $M'<0$ and $1-\frac{1}{M}(AX+BN')>0$ for positive T (from (48)).

A rise in export subsidy (or a fall in export tax) in the foreign country, given by a rise in T^* induces a rise in the price of the exportable in the foreign country. Further, it has an immediate effect on the offshore price, ω. From (37), it is evident that the offshore price falls. The decline in the offshore price lowers both p and p^* (see (44) and (45)). Therefore, the rise in the foreign price is less than the trade tax/subsidy. The domestic price, on the other hand, keeps falling in response to a rise in T^*. Since the ratio $\left(\frac{T}{T^*}\right)$ directly affects the domestic price (see (44)), it is evident that $\left(\frac{T}{T^*}\right)$ must be falling. From (55), we obtain a critical value of the ratio $\left(\frac{T}{T^*}\right)$. Values of $\left(\frac{T}{T^*}\right)$ less than the critical value, $\widetilde{\left(\frac{T}{T^*}\right)}$, correspond to lower values of p in comparison to values greater than the critical value. Therefore, lower values of the domestic price leads to (a) a fall in voting support on account of a fall in domestic output and the resultant stakes of the organised import competing sector; (b) reduction in demand for the environmental resource used as an input in the production of the importable, thereby, causing a decline in revenue collected from the environmental regulation in the sector; (c) an improvement in the environmental quality due to the resultant fall in production. For all values of $\left(\frac{T}{T^*}\right)$ below the critical value, the gains in voting support and pollution tax revenue are outweighed by the gain from improvement in the environmental quality. Consequently, the incentive to raise home import tariff falls and the reaction curve is downward sloping. Home import tariff declines in response to a rise in foreign export subsidy (or fall in export tax) for all values of $\left(\frac{T}{T^*}\right)$ lower than the critical value. The converse holds true for values of $\left(\frac{T}{T^*}\right)$ exceeding the critical value. When the gain from an import tariff exactly equals the loss, the slope of the home reaction function is equal to infinity.

Proposition 6: *The home reaction function is U-shaped and exhibits a non-monotonic relationship with the ratio* $\left(\frac{T}{T^*}\right)$.

2.6.8 Case II: Pollution taxes fall short of the marginal damage from pollution in both countries

Lax environmental regulation is one of the perceptible characteristics of less developed economies. These nations are deeply entrenched in poor institutional framework and bureaucratic corruption and thus lay less emphasis on environmental clean-up. For instance, countries like Bangladesh, Afghanistan, Myanmar, etc. may engage in trade with each other under lenient regulations as far as environmental damage is concerned.

In this case, both $B = \tau - \theta$ and $B^* = \tau^* - \theta^*$ are strictly negative. Following expressions (48)-(52), there are three possibilities associated with the increase in trade tax: *one*, for an organised import competing sector, the lobby effect owing to higher domestic output exceeds the welfare loss from rise in environmental damage from increased production net of tax revenue, i.e., $AX + BN' > 0$ and $A^*X^* + B^*N^{*\prime} > 0$; *two*, the positive lobby effect exactly equals the negative impact from environmental damage; *three*, the welfare loss from environmental damage exceeds the lobby effect from increased production ($AX + BN' < 0$ and $A^*X^* + B^*N^{*\prime} < 0$). Reaction functions in the former case draw an analogy from the situation when pollution taxes exceed marginal damage. In this case, the reaction functions of home and foreign lie below the PP and the P^*P^* curves respectively. While, the home reaction curve is steeper when it slopes downwards and flatter in its upward sloping segment, the upward sloping foreign reaction curve gets flatter with a fall in $\left(\frac{T^*}{T}\right)$ ratio. In the second case, the Johnson's equilibrium is restored. Invoking the latter possibility, some interesting results emerge.

Observing the slopes of the reaction functions, given by expressions (50)-(52), it is evident that the sign of slopes of the reactions functions cannot be ascertained unambiguously. A rise in domestic price driven by an import tariff hike would increase the stakes of the inputs owners of the organised import competing sector due to a rise in output. Consequently, the prospects of tariff hike would be higher. On the contrary, this production expansion augments demand for the environmental resource. Owing to relatively lenient environmental regulations, the welfare loss from environmental damage rises. This effect works in the opposite direction reflected in lower import tariffs. Hence, the change in home import tariff would depend on the relative strengths of these two opposing effects. From (48), the marginal effects of a rise in domestic price from increased tariffs on the second and the third term on the left-hand side of (38) can be derived as

$$\frac{\partial}{\partial p}\left(\frac{AX + BN'}{M}\right) = \frac{1}{M^2}[M(AX' + BN'') - (AX + BN')M']. \tag{56}$$

Similarly, for the organised export sector in the foreign country, we have

$$\frac{\partial}{\partial p^*}\left(\frac{A^*X^* + B^*N^{*\prime}}{(-M^*)}\right) = \frac{1}{(-M^{*2})}[(-M^*)(A^*X^{*\prime} + B^*N^{*\prime\prime}) - (A^*X^* + B^*N^{*\prime})(-M^{*\prime})]. \tag{57}$$

This result is obtained by differentiating the second and the third term on the left-hand side of expression (49).

Now, these net marginal effects of price change at home and in the foreign country (given by expressions (56) and (57), respectively) can be either positive, zero or negative. It must be noted that these effects appear in both the numerator and the denominator expressions (50) and (51). The case when there are positive marginal effects for the home country and negative marginal effects for the foreign country have been already discussed. We are more interested in tracing out the reaction functions when the net marginal effects are of the opposite sign. In this situation, for the home country, $\frac{dT}{dT^*}$ is unambiguously positive, i.e.,

$$\frac{dT}{dT^*} = \frac{-(\frac{T}{T^*})^2 \frac{1}{M^2}[M \overbrace{(AX' + BN'')}^{(-)} - \overbrace{M'}^{(-)} \overbrace{(AX + BN')}^{(-)}]}{1 - \underbrace{\frac{1}{M}(AX + BN')}_{(-)} - \frac{T}{T^*}\frac{1}{M^2}\underbrace{[M(AX' + BN'') - M'(AX + BN')]}_{(-)}} > 0. \tag{50'}$$

When the foreign country raises (lowers) its export subsidy (tax), there is a rise in the foreign price, p^*, which in turn drags down the world price as well as the price of the importable at home. This induces a reduction in home output as well as the demand for the environmental resource. Owing to the assumption of negative net marginal effects of a price change at home (in this case, a fall in the domestic price), the reduction in welfare loss from environmental damage exceeds the fall in welfare gain from contraction of production of the output in the organised import competing sector. Therefore, the home government raises the import tariff in order to compensate for the net marginal loss in welfare originating from a terms of trade gain by the foreign country on account of a higher export subsidy chosen by the foreign government. This results in a rise in home import tariffs.

Proposition 7: *The home government chooses higher import tariffs in response to higher export subsidies by the foreign country even if the environmental regulations are extremely lax in the organised import competing sector (at home) and the welfare loss generated from imposing an import tariff exceeds the gain from political support.*

Next, we derive the shape of the reaction curve for the foreign country.

The reaction function of the foreign country behaves in the following manner:

$$\frac{dT^*}{dT} \begin{cases} < 0, & \text{if } \frac{T}{T^*} < \overline{\left(\frac{T^*}{T}\right)} \\ = \infty & \text{if } \frac{T}{T^*} = \overline{\left(\frac{T^*}{T}\right)} \\ > 0, & \text{if } \frac{T}{T^*} > \overline{\left(\frac{T^*}{T}\right)}; \end{cases} \tag{58}$$

where

$$\overline{\left(\frac{T^*}{T}\right)} \equiv \frac{1 - \frac{1}{(-M^*)}(A^*X^* + B^*N^{*\prime})}{\frac{1}{(-M^*)^2}[(-M^*)(A^*X^{*\prime} + B^*N^{*\prime\prime}) - (-M^{*\prime})(A^*X^* + B^*N^{*\prime})]} \geq 0;$$

given that

$$(A^*X^* + B^*N^{*\prime}) < 0;$$

and

$$\frac{1}{(-M^{*2})}[(-M^*)(A^*X^{*\prime} + B^*N^{*\prime\prime}) - (A^*X^* + B^*N^{*\prime})(-M^{*\prime})] > 0.$$

Now, under the situations where $AX + BN' < 0$ and $A^*X^* + B^*N^{*\prime} < 0$, from (48) and (49), we have $0 \leq T \leq 1 + \frac{1}{\epsilon^*}$ and $\lim_{T^* \to \infty} T(T^*) = 1 + \frac{1}{\epsilon^*}$; and $0 \leq T^* \leq 1 - \frac{1}{\epsilon}$ and $\lim_{T \to \infty} T^*(T) = 0$, respectively.

Proposition 8: *Unlike the home country, the foreign reaction function exhibits a non-monotonic relationship with the* $\left(\frac{T^*}{T}\right)$ *ratio.*

Figure 2 shows the trade war equilibrium where HH and H^*H^* are the reaction curves of the home and the foreign country respectively. Point R represents a stable equilibrium as opposed to point Q which is unstable. For any given level of T in and around the point corresponding to equilibrium point Q, the level of T^* determined through the non-cooperative game seems to drift away from Q. On the other hand, any level of T for a given T^* and vice-versa seem to converge to point R. At R, the home country imposes an import tariff which is less than the tariff in case of the G-H (1995) model. In fact, the tariff is lower than that obtained in Johnson's equilibrium. This is because of the high welfare loss from environmental damage induced from increased use of the environmental resource in order to feed the input demand in the more protected domestic importable sector. It must be noted that we cannot rule out the possibility of an import subsidy in case the home reaction function becomes steeper and point R lies to the left of the horizontal axis where $T = 1$. For the foreign country, the trade war leads to an export tax being imposed which is higher than those obtained in Johnson's equilibrium and G-H model. Unlike the earlier cases, lax environmental regulations in the exporting country and the assumption of negative marginal effect of a rise in foreign price on the second and the third terms of the denominator on the left-hand side of (39), the foreign government adopts an export tax to drive down the price of the exportable in the foreign country. An export tax contains the welfare loss from environmental damage on account of contraction of production in the exportable sector. This effect outweighs the loss in campaign funding support from political action groups and the reduction in revenue generated from environmental regulations.

Finally, we can also study the case where trade takes place between the home country with lax environmental regulations and the foreign country with relatively stringent regulations (Figure 3). Trade war equilibrium is given by point S where the reaction curves HH for home and E^*E^* for the foreign country intersect. Equilibrium trade policy at home would always be lower than the level associated with the Johnson's equilibrium at J. This is because higher levels of import tariff increases the welfare loss on account of less stringent environmental regulations. The foreign country chooses an export tax or subsidy depending on the elasticity of the reaction curve E^*E^*. However, there is no equilibrium if the reverse holds true. In this case, the home reaction curve $T(T^*)$ lies above the B^*B^* line and to the right of BB. In contrast, the foreign reaction curve lies below the B^*B^* line (Figure 4). With constant trade elasticities, the foreign country would always suffer a welfare loss if the government decides to subsidise exports, given that environmental regulations are too lax. On the contrary, the non-monotonic behaviour of the home reaction function guarantees that it does not intersect the foreign reaction function for any level of T and T^*.

2.7 Trade talks equilibrium

The political equilibrium of the non-cooperative game is characterised by economic inefficiency owing to two factors, namely, political support and environmental damage. Trade taxes set by each country are relatively higher in a political equilibrium than the those associated with the taxes set by benevolent policy makers. For an importing country, this is coupled with higher import protection when polluting industries face higher compliance costs owing to environmental degradation. Owing to these inefficiencies, governments can participate in multilateral negotiations and mitigate the losses emanating from non-cooperation. A lumpsum transfer payment R (positive or negative)[5] is paid by the foreign government to the home government as a part of the bilateral negotiation. In case the foreign government makes a positive transfer payment to the home government, it must guarantee at least the reservation utility[6] of the foreign government. Now, both domestic and foreign lobby groups make contributions contingent upon the levels of both T and T^*.

[5] Our results do not change when the value of R is constrained to zero.

[6] The utility guaranteed to the foreign government in case it does not participate in the trade negotiation.

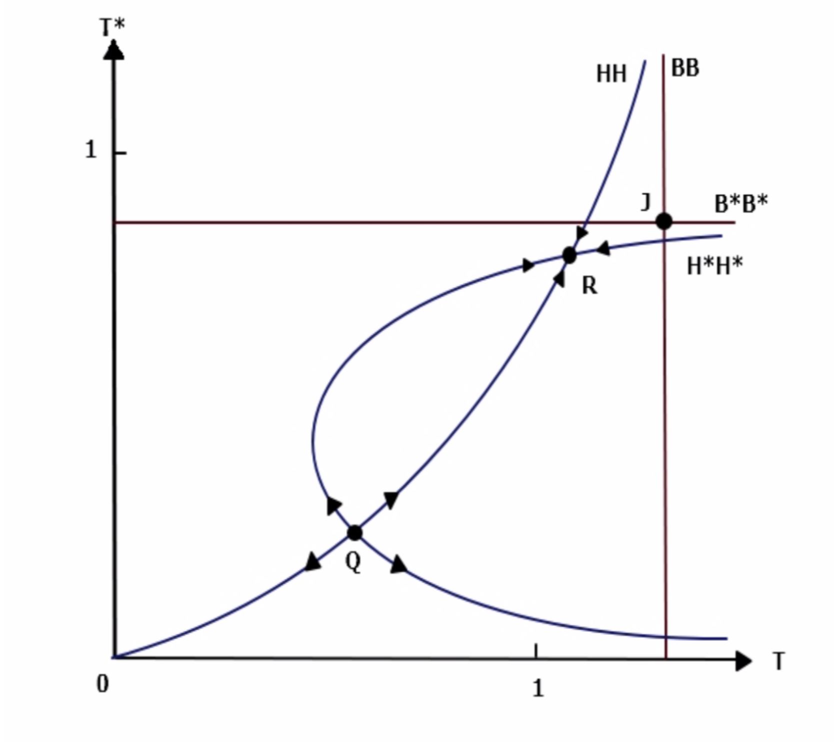

Figure 2: Trade war equilibrium when pollution tax is less than marginal damage in both countries

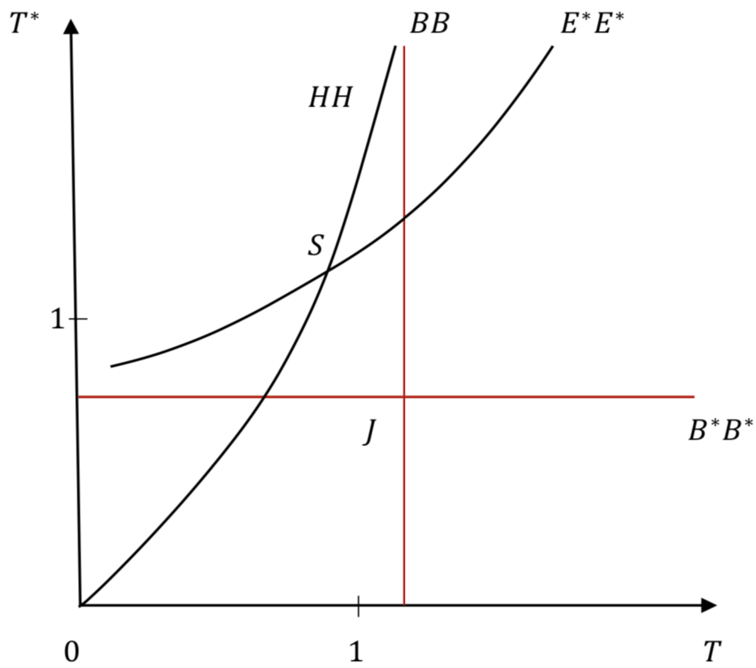

Figure 3: Trade war equilibrium for laxer environmental regulations at home and stringent environmental regulations abroad

The home and the foreign government bargain over the following objective functions:

$$G = \Sigma_{i \in L} C_i(\mathbf{T}, \mathbf{T^*}) + a\Big(W(\mathbf{T}, \mathbf{T^*}) + R\Big) \quad a \geq 0; \tag{59}$$

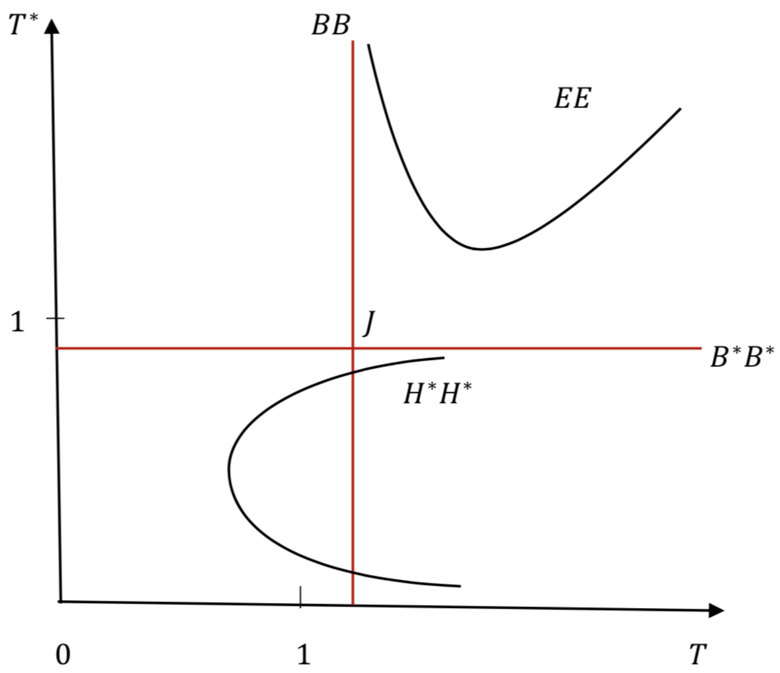

Figure 4: Trade war equilibrium for stringent environmental regulations at home and laxer environmental regulations abroad

$$G^* = \Sigma_{i \in L^*} C_i^*(\mathbf{T^*}, \mathbf{T}) + a^* \Big(W^*(\mathbf{T^*}, \mathbf{T}) - R \Big) \quad a^* \geq 0; \tag{60}$$

The two equations show that the government's objective function is a weighted sum of total campaign contributions by the political support groups and the per capita pure social welfare added with the transfer payment R. We assume that the additional revenue/cost generated through transfers is also distributed among the population in a lumpsum fashion.

The equilibrium policy vectors under cooperation must maximise the weighted sum of the objective functions of the policy makers in each country, which is given by

$$\begin{aligned} A^*G + AG^* = A^* \Big[\Sigma_{i \in L} C_i(\mathbf{T}, \mathbf{T^*}) + a \Big(W(\mathbf{T}, \mathbf{T^*}) + R \Big) \Big] \\ + A \Big[\Sigma_{i \in L^*} C_i^*(\mathbf{T^*}, \mathbf{T}) + a^* \Big(W^*(\mathbf{T^*}, \mathbf{T}) - R \Big) \Big]; \end{aligned} \tag{61}$$

where $A = a + \alpha_L$ and $A^* = a^* + \alpha_L^*$.[7]

2.7.1 Stages of the game

The game takes place in three stages. In the first stage, political action groups offer a menu of campaign schedules linked to the policy platforms chosen by the governments non-cooperatively that maximises their welfare. This is plausible because the environmental damages are confined to the country of origin and do not spill over to the partner country. Faced with the contribution schedules, governments in each country participate in a bilateral negotiation and bargain over trade policies in the second stage. A hypothetical mediator at home maximises the objective function given in (59). At this stage the campaign

[7]The multiplication by A and A^*, respectively ensures that home and foreign government's objectives are expressed in the same units (Schleich and Orden, 2000)

contributions are operated and all markets clear and production and consumption take place.

Proposition 9: *A cooperative equilibrium comprises a set of policy vectors* $\mathbf{T^0}$ *and* $\mathbf{T^{*0}}$ *and contribution schedules* $[C_i^0]_{i\in L}$ *and* $[C^{*0}_i]_{i\in L^*}$ *such that*

(a) $(\mathbf{T^0}, \mathbf{T^{*0}}) = \underset{(\mathbf{T},\mathbf{T^*})}{\arg} \max \mathbf{A^*\Sigma_{i\in L}C_i^0(T, T^*)} + \mathbf{A\Sigma_{i\in L^*}C^{*0}_i(T^*, T)} + \mathbf{A^*a[W(T, T^*) + R]} + \mathbf{Aa^*[W^*(T^*, T) - R]}$*; and*

(b) there does not exist any feasible contribution function $C_i(\mathbf{T}, \mathbf{T^*})$ *and a pair of trade policy vectors* $(\mathbf{T^i}, \mathbf{T^{*i}})$ *for every organised interest group* $i \in L$ *such that*

(i) $(\mathbf{T^i}, \mathbf{T^{*i}}) = \underset{(\mathbf{T},\mathbf{T^*})}{\arg} \max \mathbf{A^*[\Sigma_{i\in L}C_i(T, T^*)} + \mathbf{\Sigma_{j\neq i, j\in L}C_j^0(T, T^*)]} + \mathbf{A\Sigma_{i\in L^*}C^{*0}_i(T^*, T)} + \mathbf{A^*a[W(T, T^*) + R] + Aa^*[W^*(T^*, T) - R]}$*; and*

(ii) $\mathbf{W_i(T^i, T^{*i}) - C_i(T^i, T^{*i}) > W_i(T^0, T^{*0}) - C_i(T^0, T^{*0})}$*;*

(c) there does not exist any feasible contribution function $C_i^*(\mathbf{T^*}, \mathbf{T})$ *and a pair of trade policy vectors* $(\mathbf{T^{*i}}, \mathbf{T^i})$ *for every organised interest group* $i \in L^*$ *such that*

(i) $(\mathbf{T^i}, \mathbf{T^{*i}}) = \underset{(\mathbf{T},\mathbf{T^*})}{\arg} \max \mathbf{A^*\Sigma_{i\in L}C_i^0(T, T^*)} + \mathbf{A[\Sigma_{i\in L^*}C_i^*(T^*, T)} + \mathbf{\Sigma_{j\neq i, j\in L^*}C^{*0}_j(T^*, T)]} + \mathbf{A^*a[W(T, T^*) + R] + Aa^*[W^*(T^*, T) - R]}$*; and*

(ii) $\mathbf{W_i^*(T^{*i}, T^i) - C_i^*(T^{*i}, T^i) > W_i^*(T^{*0}, T^0) - C_i^*(T^{*0}, T^0)}$.

Condition (a) shows that the policy vector chosen by the two governments through negotiations maximises their joint welfare, condition (b) states that any home lobby group i is unable to raise its welfare by unilaterally revising its contribution schedule from $C_i^0(\mathbf{T^0}, \mathbf{T^{*0}})$, and condition (c) shows that the same as in condition (b) holds true for the foreign country.

Ideally, a cooperative outcome must maximise the joint welfare of each organised lobby group as well as the hypothetical mediator, assuming that the contribution schedules of all other lobbies are given. Taken together, (a), (b) and (c) imply

$$\begin{aligned}(\mathbf{T^0}, \mathbf{T^{*0}}) = \underset{(\mathbf{T},\mathbf{T^*})}{\arg} \max \mathbf{A^*[W_j(T, T^*) - C_j^0(T, T^*)] + A^*\Sigma_{i\in L}C_i^0(T, T^*)} \\ \mathbf{+A\Sigma_{i\in L^*}C^{*0}_i(T^*, T) + A^*a[W(T, T^*) + R] + Aa^*[W^*(T^*, T) - R]\ \forall\, j \in L};\end{aligned} \tag{62}$$

and,

$$\begin{aligned}(\mathbf{T^{*0}}, \mathbf{T^0}) = \underset{(\mathbf{T},\mathbf{T^*})}{\arg} \max \mathbf{A[W_j^*(T^*, T) - C^{*0}_j(T^*, T)] + A\Sigma_{i\in L^*}C^{*0}_i(T^*, T)} \\ \mathbf{+A^*\Sigma_{i\in L}C_i^0(T, T^*) + A^*a[W(T, T^*) + R] + Aa^*[W^*(T^*, T) - R]\ \forall\, j \in L^*}.\end{aligned} \tag{63}$$

We assume that the contribution schedules as well as the pure social welfare functions are differentiable around the point of equilibrium. The first-order conditions for maximisation of (62) and (63) as well as condition (a) of Proposition 9 yield

$$\begin{aligned}\mathbf{A^*[\nabla_T W_j(T^0, T^{*0}) - \nabla_T C_j^0(T^0, T^{*0})] + A^*\Sigma_{i\in L}\nabla_T C_i^0(T^0, T^{*0}) + A\Sigma_{i\in L^*}\nabla_T C^{*0}_i(T^{*0}, T^0)} \\ +A^*a\nabla_{\mathbf{T}}[W(\mathbf{T^0}, \mathbf{T^{*0}}) + \mathbf{R}] + \mathbf{Aa^*\nabla_T[W^*(T^{*0}, T^0) - R] = 0\ \forall\, i \in L};\end{aligned} \tag{64}$$

$$\begin{aligned}\mathbf{A[\nabla_{T^*} W_j^*(T^{*0}, T^0) - \nabla_{T^*} C^{*0}_j(T^{*0}, T^0)] + A\Sigma_{i\in L^*}\nabla_{T^*} C^{*0}_i(T^{*0}, T^0) + A^*\Sigma_{i\in L}\nabla_{T^*} C_i^0(T^0, T^{*0})} \\ +A^*a\nabla_{\mathbf{T^*}}[W(\mathbf{T^0}, \mathbf{T^{*0}}) + \mathbf{R}] + \mathbf{Aa^*\nabla_{T^*}[W^*(T^{*0}, T^0) - R] = 0\ \forall\, i \in L^*};\end{aligned} \tag{65}$$

$$\begin{aligned} & A^*\Sigma_{j\in L}\nabla_{\mathbf{T}}C_j^0(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{A}\boldsymbol{\Sigma}_{\mathbf{j}\in\mathbf{L}^*}\nabla_{\mathbf{T}}\mathbf{C}^{*\mathbf{0}}_{\mathbf{j}}(\mathbf{T^{*0}},\mathbf{T^0}) \\ & + A^*a\nabla_{\mathbf{T}}[W(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{R}] + \mathbf{Aa}^*\nabla_{\mathbf{T}}[\mathbf{W}^*(\mathbf{T^0},\mathbf{T^0}) - \mathbf{R}] = \mathbf{0}; \end{aligned} \tag{66}$$

$$\begin{aligned} & A^*\Sigma_{j\in L}\nabla_{\mathbf{T}^*}C_j^0(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{A}\boldsymbol{\Sigma}_{\mathbf{j}\in\mathbf{L}^*}\nabla_{\mathbf{T}^*}\mathbf{C}^{*\mathbf{0}}_{\mathbf{j}}(\mathbf{T^{*0}},\mathbf{T^0}) \\ & + A^*a\nabla_{\mathbf{T}^*}[W(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{R}] + \mathbf{Aa}^*\nabla_{\mathbf{T}^*}[\mathbf{W}^*(\mathbf{T^0},\mathbf{T^0}) - \mathbf{R}] = \mathbf{0}; \end{aligned} \tag{67}$$

Using (66) and (67) in (64) and (65), respectively, we have

$$\nabla_{\mathbf{T}}C_i^0(\mathbf{T^0},\mathbf{T^{*0}}) = \nabla_{\mathbf{T}}\mathbf{W_i}(\mathbf{T^0},\mathbf{T^{*0}})\ \forall\ \mathbf{i}\in\mathbf{L}; \tag{68}$$

$$\nabla_{\mathbf{T}^*}C^{*0}_i(\mathbf{T^{*0}},\mathbf{T^0}) = \nabla_{\mathbf{T}^*}\mathbf{W}^*_{\mathbf{i}}(\mathbf{T^{*0}},\mathbf{T^0})\ \forall\ \mathbf{i}\in\mathbf{L}^*. \tag{69}$$

The conditions in (68) and (69) depict the local truthfulness condition which says that a marginal change in campaign contributions due to a change in home policy and foreign policy, respectively, equals the change in gross welfare of the lobby due to the policy change.

Summing the above over all i and using (66) and (67), we get

$$\begin{aligned} & A^*\Sigma_{i\in L}\nabla_{\mathbf{T}}W_i(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{A}\boldsymbol{\Sigma}_{\mathbf{i}\in\mathbf{L}^*}\nabla_{\mathbf{T}}\mathbf{W}^*_{\mathbf{i}}(\mathbf{T^{*0}},\mathbf{T^0}) \\ & + A^*a\nabla_{\mathbf{T}}[W(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{R}] + \mathbf{Aa}^*\nabla_{\mathbf{T}}[\mathbf{W}^*(\mathbf{T^0},\mathbf{T^0}) - \mathbf{R}] = \mathbf{0}; \end{aligned} \tag{70}$$

$$\begin{aligned} & A^*\Sigma_{i\in L}\nabla_{\mathbf{T}^*}W_i(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{A}\boldsymbol{\Sigma}_{\mathbf{i}\in\mathbf{L}^*}\nabla_{\mathbf{T}^*}\mathbf{W}^*_{\mathbf{i}}(\mathbf{T^{*0}},\mathbf{T^0}) \\ & + A^*a\nabla_{\mathbf{T}^*}[W(\mathbf{T^0},\mathbf{T^{*0}}) + \mathbf{R}] + \mathbf{Aa}^*\nabla_{\mathbf{T}^*}[\mathbf{W}^*(\mathbf{T^0},\mathbf{T^0}) - \mathbf{R}] = \mathbf{0}. \end{aligned} \tag{71}$$

In order to solve the cooperative equilibrium, we utilise the results from (21)-(31) for the home country. In addition to these, we compute the impact of change in home trade policy on the gross welfare of the foreign lobby as well as the aggregate welfare of the foreign country population in general.

The change in gross welfare of the foreign lobby in sector i in response to a change in domestic trade policy is given by

$$\frac{\partial W_i^*(\bullet)}{\partial T_j} = \frac{\partial \Pi_i^*(\bullet)}{\partial T_j} + \alpha_i^*\left[\frac{\partial r^*(\bullet)}{\partial T_j} + \frac{\partial e^*(\bullet)}{\partial T_j} + \frac{\partial S^*(\bullet)}{\partial T_j}\right]; \tag{72}$$

where

$$\frac{\partial \Pi_i^*(\bullet)}{\partial T_j} = 0\ \forall\ i \neq j;$$

which implies that any change in trade policy chosen for sector j does not affect the rents of specific input owners in sector i in the foreign country. Any change in trade policy in sector j in the home country would affect the domestic price of the output X_j and hence the rents accruing to the sector specific inputs used in sector j at home alone.

Using chain rule, we derive the marginal effects of a change in home trade policy on each of the components of welfare of each political action group operating in the foreign country. They are as follows:

$$\underbrace{\frac{\partial \pi_i^*(T_i^*\omega_i)}{\partial T_i}}_{\substack{\text{effect of trade policy on residual} \\ \text{rent of the sector specific input}}} = \frac{\partial \Pi_i^*(T_i^*\omega_i)}{\partial p_i^*}.\frac{\partial p_i^*}{\partial T_i};$$

$$\underbrace{\frac{\partial r^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial T_i}}_{\substack{\text{effect of trade policy on the} \\ \text{revenue generated from the trade policy}}} = \frac{\partial r^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial p_i^*}.\frac{\partial p_i^*}{\partial T_i};$$

$$\underbrace{\frac{\partial e^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial T_i}}_{\substack{\text{effect of trade policy on pollution tax} \\ \text{revenue net of environmental damages}}} = \frac{\partial e^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial p_i^*} \cdot \frac{\partial p_i^*}{\partial T_i};$$

$$\underbrace{\frac{\partial S^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial T_i}}_{\substack{\text{effect of trade policy on} \\ \text{consumer surplus}}} = \frac{\partial S^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial p_i^*} \cdot \frac{\partial p_i^*}{\partial T_i};$$

where

$$\underbrace{\frac{\partial p_i^*}{\partial T_i}}_{\substack{\text{effect of trade policy on the} \\ \text{foreign price of the tradable good}}} = T_i^* \frac{\partial \omega_i}{\partial T_i};$$

which captures the impact of home trade policy on the price level in the foreign country. This effect prevails on account of the large country assumption. The signs of the above marginal effects would depend on how a change in home trade policy affects the price prevailing in the foreign country. For example, if home is an importer of the non-numeraire good (and the foreign country is an exporter of the good), a rise in home import tariff would lead to a reduction in the offshore price and hence the price of the exportable good in the foreign country, for any given level of foreign trade policy.

Based on the assumptions of the consumption side of trading nations, any change in consumer surplus for the entire range of non-numeraire goods is equivalent to a change in the indirect utility for a given level of income.

$$\frac{\partial S^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial p_i^*} = \frac{\partial V^*(\mathbf{T}^*\boldsymbol{\omega}, I^*)}{\partial p_i^*}.$$

Using Roy's identity,

$$\frac{\frac{\partial V^*(\mathbf{T}^*\boldsymbol{\omega}, I^*)}{\partial p_i^*}}{\frac{\partial V^*(\mathbf{T}^*\boldsymbol{\omega}, I^*)}{\partial I^*}} = -d_i^*(p_i^*).$$

The partial differentiation of tariff revenue, pollution tax revenue and consumer surplus of the foreign country with respect to trade policy at home in sector i yields

$$\frac{\partial r^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial T_i} = (T_i^* - 1)\left[\omega_i \frac{\partial M_i^*}{\partial p_i^*}\left(T_i^* \frac{\partial \omega_i}{\partial T_i}\right) + M_i^* \frac{\partial \omega_i}{\partial T_i}\right]; \tag{73}$$

Expression (73) shows that marginal effects on revenue from trade policy in the foreign country encompasses only second-order effects which are driven by the change in foreign price in response to a change in home trade policy.

Now, the marginal impact of home trade policy in sector i on pollution tax revenue abroad is given by

$$\frac{\partial e^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial T_i} = (\tau_i^* - \theta_i^*)\frac{\partial N_i^*}{\partial p_i^*}\left(T_i^* \frac{\partial \omega_i}{\partial T_i}\right); \tag{74}$$

Any change in domestic trade policy for sector i induces a change foreign price which affects the demand for sector-specific environmental resource in the foreign country.

Finally, Roy's identity gives us the expression for marginal effects of domestic trade policy in sector

i on consumer surplus abroad, i.e.,

$$\frac{\partial S^*(\mathbf{T}^*\boldsymbol{\omega})}{\partial T_i} = -d_i^*(p_i^*)\left(T_i^*\frac{\partial \omega_i}{\partial T_i}\right). \tag{75}$$

Substituting the above results corresponding to the terms on the right-hand side of equation (72) yields

$$\begin{aligned}\frac{\partial W_i^*}{\partial T_j} = (\psi_{ij}^* - \alpha_i^*)X_j^*\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right) + \alpha_i^*\Bigg[(T_j^*-1)\omega_j\frac{\partial M_j^*}{\partial p_j^*}\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right)\\ -M_j^*\frac{\partial \omega_j}{\partial T_j} + (\tau_j^*-\theta_j^*)\frac{\partial N_j^*}{\partial p_j^*}\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right)\Bigg];\end{aligned} \tag{76}$$

where

$$\psi_{ij}^* = \begin{cases} 0, & \text{if } i \neq j \\ 1, & \text{otherwise.}\end{cases}$$

Expression (76) shows the overall effect of a change in domestic trade policy on the welfare (gross of contributions) of the foreign lobby in sector i.

Summing over all organised sectors in the foreign country, the overall impact on the gross welfare in response to a change in domestic trade policy is given by

$$\begin{aligned}\Sigma_{i\in L^*}\frac{\partial W_i^*}{\partial T_j} = (\Gamma_{L^*}^* - \alpha_L^*)X_j^*\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right) + \alpha_L^*\Bigg[(T_j^*-1)\omega_j\frac{\partial M_j^*}{\partial p_j^*}\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right)\\ -M_j^*\frac{\partial \omega_j}{\partial T_j} + (\tau_j^*-\theta_j^*)\frac{\partial N_j^*}{\partial p_j^*}\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right)\Bigg];\end{aligned} \tag{77}$$

where

$$\Gamma_L^* = \begin{cases} 0, & \text{if the sector is unorganised} \\ 1, & \text{otherwise;}\end{cases}$$

and $\alpha_L^* = \Sigma_{i\in L^*}\alpha_i$ denotes the fraction of voters who are members of a lobby group in the foreign country.

Considering the impact of change of home trade policy on welfare of the foreign population in general, we have the following:

$$\frac{\partial W^*(\bullet)}{\partial T_j} = \frac{\partial \Pi_i^*(\bullet)}{\partial T_j} + \frac{\partial r^*(\bullet)}{\partial T_j} + \frac{\partial e^*(\bullet)}{\partial T_j} + \frac{\partial S^*(\bullet)}{\partial T_j}; \tag{78}$$

which reduces to

$$\frac{\partial W^*}{\partial T_j} = (T_j^*-1)\omega_j\frac{\partial M_j^*}{\partial p_j^*}\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right) - M_j^*\frac{\partial \omega_j}{\partial T_j} + (\tau_j^*-\theta_j^*)\frac{\partial N_j^*}{\partial p_j^*}\left(T_j^*\frac{\partial \omega_j}{\partial T_j}\right). \tag{79}$$

Therefore, the marginal change in overall welfare of the foreign population on account of a change in domestic trade policy comprises the following marginal effects: (a) change in rents of the set of political action groups; (b) change in lumpsum transfers from the government abroad through tariff revenue and pollution tax revenue net of environmental damage; and (c) change in consumer surplus. It is important to note that the first effect reduces to zero since any change in trade policy chosen for sector j at home does not affect the rents of specific input owners in sector i of the foreign country. Each of these effects are illustrated by the first, second, third and fourth term on the right-hand side of expression (78), which simplify further to yield expression (79).

Using (27), (29), (77) and (79) in the first-order condition (70), we get

$$\begin{aligned} A^*\Bigg[(\Gamma_L-\alpha_L)X_j+(a+\alpha_L)\Bigg((T_j-1)\omega_j\frac{\partial M_j}{\partial p_j}+(\tau_j-\theta_j)\frac{\partial N_j}{\partial p_j}\Bigg)-\frac{M_j\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}}\Bigg]+A\Bigg[(\Gamma_L^*-\alpha_L^*)X_j^* \\ +(a^*+\alpha_L^*)\Bigg((T_j^*-1)\omega_j\frac{\partial M_j^*}{\partial p_j^*}+(\tau_j^*-\theta_j^*)\frac{\partial N_j^*}{\partial p_j^*}\Bigg)\Bigg(\frac{T_j^*\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}}\Bigg)-(a^*+\alpha_L^*)\frac{M_j^*\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}}\Bigg]=0. \end{aligned} \tag{80}$$

From (31), we have

$$\frac{\partial\omega_j}{\partial T_j}=-\frac{\omega_j\frac{\partial M_j}{\partial p_j}}{T_j\frac{\partial M_j}{\partial p_j}+T_j^*\frac{\partial M_j^*}{\partial p_j^*}}.$$

We, now, make a few substitutions for the terms

$$\frac{T_j^*\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}},\quad \frac{M_j\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}},\quad \text{and}\ \frac{M_j^*\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}};$$

which appear in expression (80) and simplify it further.

Using (31), we get

$$\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}=\frac{T_j^*\omega_j\frac{\partial M_j^*}{\partial p_j^*}}{T_i\frac{\partial M_j}{\partial p_j}+T_j^*\frac{\partial M_j^*}{\partial p_j^*}}; \tag{81}$$

$$\frac{T_j^*\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}}=-\frac{\frac{\partial M_j}{\partial p_j}}{\frac{\partial M_j^*}{\partial p_j^*}}; \tag{82}$$

$$\frac{M_j\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}}=\frac{\omega_j\frac{\partial M_j}{\partial p_j}}{\eta_j^*}; \tag{83}$$

and

$$\frac{M_j^*\frac{\partial\omega_j}{\partial T_j}}{\omega_j+T_j\frac{\partial\omega_j}{\partial T_j}}=-\frac{\omega_j\frac{\partial M_j}{\partial p_j}}{\eta_j^*}; \tag{84}$$

where

$$\eta_i^*=\frac{T_i^*\omega_i}{M_i^*}\frac{\partial M_i^*}{\partial p_i^*};$$

denotes the elasticity of foreign import demand when M_i^* is positive or export supply when M_i^* is negative.

Substituting (81)-(84) in the first-order condition (80), we obtain

$$\begin{aligned} A^*(a+\alpha_L)\Bigg[\frac{\Gamma_L-\alpha_L}{a+\alpha_L}\frac{X_i}{\omega_i\frac{\partial M_i}{\partial p_i}}+(T_i^0-1)-\frac{1}{\eta_i^*}+(\tau_i-\theta_i)\frac{\frac{\partial N_i}{\partial p_i}}{\omega_i\frac{\partial M_i}{\partial p_i}}\Bigg] \\ =A(a^*+\alpha_L^*)\Bigg[\frac{\Gamma_L^*-\alpha_L^*}{a^*+\alpha_L^*}\frac{X_i^*}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}+(T^{*0}_i-1)-\frac{1}{\eta_i^*}+(\tau_i^*-\theta_i^*)\frac{\frac{\partial N_i^*}{\partial p_i^*}}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}\Bigg]. \end{aligned} \tag{85}$$

The analogous expression owing to a change in foreign trade policy (from the first-order condition (67)) is

$$A(a^*+\alpha_L^*)\left[\frac{\Gamma_L^*-\alpha_L^*}{a^*+\alpha_L^*}\frac{X_i^*}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}+(T^{*0}_i-1)-\frac{1}{\eta_i}+(\tau_i^*-\theta_i^*)\frac{\frac{\partial N_i^*}{\partial p_i^*}}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}\right]$$
$$=A^*(a+\alpha_L)\left[\frac{\Gamma_L-\alpha_L}{a+\alpha_L}\frac{X_i}{\omega_i\frac{\partial M_i}{\partial p_i}}+(T_i^0-1)-\frac{1}{\eta_i}+(\tau_i-\theta_i)\frac{\frac{\partial N_i}{\partial p_i}}{\omega_i\frac{\partial M_i}{\partial p_i}}\right]. \tag{86}$$

Since, $A=a+\alpha_L$ and $A^*=a^*+\alpha_L^*$, both (85) and (86) give us equilibrium trade policy ratio in industry i as

$$T_i^0-T^{*0}_i=\left[\left(-\frac{\Gamma_L-\alpha_L}{a+\alpha_L}\frac{X_i}{\omega_i\frac{\partial M_i}{\partial p_i}}\right)-\left(-\frac{\Gamma_L^*-\alpha_L^*}{a^*+\alpha_L^*}\frac{X_i^*}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}\right)\right]$$
$$+\left[\left(-(\tau_i-\theta_i)\frac{\frac{\partial N_i}{\partial p_i}}{\omega_i\frac{\partial M_i}{\partial p_i}}\right)-\left(-(\tau_i^*-\theta_i^*)\frac{\frac{\partial N_i^*}{\partial p_i^*}}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}\right)\right]; \tag{87}$$

where the second term in parentheses on the right-hand side of (87) is the effect of environmental regulations on trade policies. This term does not appear in the result derived by Grossman and Helpman (1995). Moreover, the second term disappears when both nations are characterised by Pigouvian taxes.

Conditions (85) and (86) show that a trade negotiation between two trading nations results in an equilibrium ratio of trade policies that equalises the weighted welfare change from a change in trade policy of the politically motivated governments in each country. The equilibrium ratio of trade policies determine both domestic and foreign prices which in turn determines equilibrium output, consumer demand, demand for the environmental resource, factor prices, and trade flows in each country.

Apparently, (87) can be expressed as a function of the ratio of T and T^*. This follows as we divide both sides of the expression by T^*. While X_i, $\frac{\partial M_i}{\partial p_i}$ and $\frac{\partial N_i}{\partial p_i}$ are functions of $p_i=T_i\omega_i$, X_i^*, $\frac{\partial M_i^*}{\partial p_i^*}$ and $\frac{\partial N_i^*}{\partial p_i^*}$ are functions of $p_i^*=T_i^*\omega_i$.

Now, (87) can be re-written as

$$T_i^0-T^{*0}_i=\left[\left(-\frac{\Gamma_L-\alpha_L}{a+\alpha_L}\frac{X_i}{\omega_i\frac{\partial M_i}{\partial p_i}}\right)+\left(-(\tau_i-\theta_i)\frac{\frac{\partial N_i}{\partial p_i}}{\omega_i\frac{\partial M_i}{\partial p_i}}\right)\right]$$
$$-\left[\left(-\frac{\Gamma_L^*-\alpha_L^*}{a^*+\alpha_L^*}\frac{X_i^*}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}\right)+\left(-(\tau_i^*-\theta_i^*)\frac{\frac{\partial N_i^*}{\partial p_i^*}}{\omega_i\frac{\partial M_i^*}{\partial p_i^*}}\right)\right]. \tag{88}$$

Here, $T>T^*$, that is $\left(\frac{T}{T^*}\right)>1$ if the first term in parentheses on the right hand side exceeds the second and vice versa. Suppose, the home country is an importer of good X_i. We know that domestic prices are increasing in $\left(\frac{T}{T^*}\right)$. In case, sector i is organised in both countries, the trade agreement benefits the group which has higher stakes in the negotiation, i.e., the level of output X_i and X_i^*. Benefit to the lobby group rises with a decline in the share of specific factor owners (a measure of concentration of political power) who are a part of political action groups as well as the policy maker's preference to pure social welfare. Furthermore, lower the price sensitivity of imports (or exports), higher is the possibility to persuade policy makers to raise protection since this reduces the dead weight loss from price distortions. Consequently, as the divergence between the relative political power increases, one country derives more benefit from cooperation relative to the other.

However, in the present case, the relative gap between T and T^* is also brought about by the differences in net pollution tax revenue gains and losses from trade intervention. The importing country (here, home) gains from the negotiation if relatively stringent environmental laws are in place. The benefits from negotiation are also increasing in the price sensitivity of the environmental resource used in the production process. A rise in domestic price of the importable would increase the demand for the resource and thus increase the revenue, at margin, generated from environmental regulations, given that the marginal environmental damage is a constant. In case of laxer environmental norms, a country would lose out in terms of marginal revenue gains from environmental taxes. If environmental regulations (here, exogenously given) at home exceed that of the foreign, the marginal gains from pollution tax revenue as well as improved environmental quality would be higher at home compared to the foreign country. A higher import tariff at home would lead to an increase in the revenue generated from the environmental tax as well as improve the environmental quality. This shows that trade protection and environmental regulations are used as complementary policies. It is also evident that the terms like inverses import demand elasticities and export supply elasticities are absent since cooperation mitigates dead weight losses emanating from setting up of policies in a non-cooperative fashion for large open economies. Finally, when $T = T^*$, i.e., $\left(\frac{T}{T^*}\right) = 1$ in equation (88), we have equal rates of protection in both countries. The sum of the two effects on the right-hand side of (88), namely, political influence and environmental effect, respectively, in one country tend to neutralise the effects in the other.

Proposition 10: *In case of negotiated trade talks, any difference in trade policies between nations depends on the relative differences in political pressures (captured by the domestic output which is directly linked to the stakes of owners of specific inputs) and environmental regulations.*

It can be seen that trade negotiations may break when a participating country loses from the co-operative bargaining outcome. For instance, an organised sector i in the home country produces more output in comparison to sector i in the foreign country. Now, specific factor owners in this sector would have more political power in the home country relative to the foreign country. The trade negotiation would, in turn, favour the home country at the cost of the foreign country. Hence, the foreign country would not be keen on its participation over the trade agreement. The dominance in political power of the lobby in the home country in comparison to the lobby in the foreign country necessitates the need for a bargaining process that would ensure that the participation constraints of both the parties are met. A potential extension of our analysis would be to design a bargaining contract that would ensure the cooperative outcome to be at least as good as the non-cooperative one.

This completes our complete information model. We construct an incomplete information model in the next section.

2.8 Asymmetric Information

In this section, we consider a situation where political action groups cannot observe the preference of the incumbent government over aggregate social welfare, i.e., the lobby groups do not know precisely how politically inclined the incumbent government is. Such information asymmetries typically arise when the incumbent is newly elected. With its public welfare preferences being private information, the incumbent has an incentive to extract information rents from the lobbies while maximising political welfare. Lobbies, on the other hand, have direct stakes in the public policy (import tariffs/export subsidies) which goes to determine domestic prices and hence rewards to the specific inputs. Unaware of the relative weight attached to aggregate social welfare (benevolence) by the incumbent, lobbies should design offers for campaign funds in such a manner that they ensure truthful revelation of preference by the incumbent. This scenario encapsulates a simple principal-agent problem, where the incumbent government is an agent characterised by hidden type owing to the exclusive private information, and lobbies are principals who find it difficult to comprehend the agent's preference towards social welfare before making campaign contributions. Therefore, it is an adverse selection problem. Notwithstanding the hidden information, lobbies are acquainted with the probability distribution of the type of the incumbent government (in terms of the degree of benevolence). Thus, the probability distribution of the parameter denoting the weight on social welfare is common knowledge which enables them to independently design some incentive schemes or contract for the agent (here the incumbent) and manipulate its behaviour to set trade policies in a manner consistent with their preferences. The optimal contract design must satisfy two constraints, namely, individual rationality and incentive compatibility. Individual rationality represents the participation constraint for the incumbent government which ensures that it receives at least the reservation utility, i.e., the utility if it did not receive any contribution. In contrast, incentive compatibility ensures that the incumbent government always prefers a contract designed for its true type among the menu of contribution schedules.

Our focus is primarily on the home country alone, and we do not go into policy interactions between home and foreign country variables.

2.8.1 A formal analysis

To begin with, we assume that there are two perfectly competitive sectors in each country, one being the clean numeraire sector and the other being the polluting non-numeraire sector which produces the traded good.

2.8.2 Single principal-agent problem

Producers in the non-numeraire sector are owners of specific factors and see their income tied to both trade and environmental policies since both the policies directly affect the domestic price of the good. However, when environmental regulations are exogenously given, factor owners actively lobby for trade policy. In what follows, pollution policy is assumed to be exogenously set. The politically motivated government maximises the following political welfare function

$$G(T(a)) = C(T(a), \bullet) + aW(T(a)), \omega(a)). \tag{89}$$

This is exactly similar to expression (12) where the set of organised sectors, L is a singleton set.

Pure social welfare is compromised as the level of equilibrium tariff rises, which implies that

$$\frac{\partial W(T(a))}{\partial T(a)} < 0. \tag{90}$$

Unlike the incumbent government (agent) who has private information about the *benevolence* parameter, a of its payoff function, the lobby (principal) does not possess any such information. The lobby, however, has a prior knowledge about the distribution of a, which is drawn from $\Upsilon = [0, a^M] \subset \mathbb{R}$ with a cumulative distribution function $F(a)$ and a density function $f(a) > 0$ on $[0, a^M]$, where a^M denotes the strictly positive upper bound of the support of the random variable a. Further, the distribution of a is common knowledge and both parties are risk-neutral. The utility function of the lobby is given by

$$L(T(a)) = V(T(a)) - C(T(a)). \tag{91}$$

For mathematical tractability, we assume that the lobby consists of very few individuals such that the fraction α of population that owns the specific input used in the non-numeraire sector is almost close to zero. Therefore, the payoff (net of contributions) is given by

$$V(T(a)) = l + \Pi(T(a)). \tag{92}$$

Here, the lobby enjoys only a negligible fraction of the surplus from consumption of non-numeraire goods and government transfers comprising tariff revenue and pollution tax revenue net of environmental damage redistributed in a lumpsum fashion. The incumbent government has to announce its type before campaign funds are offered by the lobby. Like rational economic agents, the government tries to extract positive information rent by overstating the parameter a. Therefore, any incumbent who is less politically inclined (or swayed in favour of lobbies) mimic a type who is relatively more politically inclined. In order that the incumbent participates in the contract and reveals its true preference, the optimal contract design that would maximise the lobby's expected payoff must satisfy the individual rationality constraint and the incentive compatibility constraint of each type.

Let the optimal contract be given by

$$\Psi(a) = (T^{**}(a), C^{**}(a)); \tag{93}$$

2.8.3 Stages of the game

The principal-agent game takes places in three stages. In the first stage, the lobby offers an incentive scheme that maps each possible value of the preference parameter, a, to tariffs and hence monetary transfers for electoral campaign. Following this, the incumbent announces its type and accepts the contract. In the second stage, the incumbent chooses the optimal trade policy. The incumbent does not renege but stays committed to the policy that he/she announces. In the last stage, consumption and production take place and world commodity and individual country labour markets clear.

2.8.4 Equilibrium under asymmetric information

In order to achieve the subgame perfect Bayesian Nash equilibrium, the incentive scheme must meet the participation constraint and be Bayesian incentive compatible (BIC).

The participation constraint is given by

$$G(T(a)) \geq G_0(T(a)); \tag{94}$$

where

$$G_0(T(a)) = aW(T(a)); \tag{95}$$

which implies that the the incentive scheme must guarantee at least the reservation utility, G_0 to the incumbent, i.e., the utility it would receive in case it did not accept the contract and hence earn zero contribution.

The BIC constraint ensures that an incumbent would always prefer a contract designed for its true type. The direct revelation mechanisms $(T(\hat{a}), C(\hat{a}))$ being truthful, we have

$$aW(T(a)) + C(a) \geq aW(T(\hat{a})) + C(\hat{a}); \text{ for any } (a, \hat{a}) \in \Upsilon^2; \tag{96}$$

Condition (96) implies

$$aW(T(a)) + C(a) \geq aW(T(a')) + C(a'); \tag{97}$$

and

$$a'W(T(a')) + C(a') \geq a'W(T(a)) + C(a); \tag{98}$$

for any pair $(a, a') \in \Upsilon^2$.

Adding expressions (97) and (98), we obtain

$$aW(T(a)) + a'W(T(a')) \geq aW(T(a')) + a'W(T(a));$$

which can be simplified as

$$(a - a')[W(T(a)) - W(T(a'))] \geq 0 \tag{99}$$

Expression (99) shows incentive compatibility requires that the social welfare function $W(T(a))$ must be non-decreasing in a, i.e.,

$$\frac{\partial W(a)}{\partial T(a)} . \frac{\partial T(a)}{\partial a} \geq 0. \tag{100}$$

Using the result from (90), (100) would imply that

$$\frac{\partial T(a)}{\partial a} \leq 0; \tag{101}$$

i.e., $T(a)$ must be non-increasing. A rise in parameter a indicates a greater weight assigned to aggregate social welfare relative to campaign contributions. This would imply a lower level of trade protection to the organised import competing/exportable sector. Conditions (100) and (101) show that $T(a)$ is differentiable almost everywhere.

Now, suppose the incumbent of type a announces $\hat{a}$. The utility function is given by

$$G(T(a, \hat{a})) = aW(T(\hat{a})) + C(\hat{a}); \tag{102}$$

where

$$G^{TR}(T(a)) \equiv G(T(a, a)); \tag{103}$$

implies truthful revelation by the incumbent of type a, i.e., $a = \hat{a}$. The first-order condition for optimal response $\hat{a}$ announced by incumbent of type a is given by

$$G(\dot{T}(a)) = a\frac{\partial W(T(\hat{a}))}{\partial T(\hat{a})}\dot{T} + \frac{\partial C(\hat{a})}{\partial T(\hat{a})}\dot{T} = 0; \tag{104}$$

where, for any variable Z

$$\dot{Z} = \frac{\partial Z}{\partial a}.$$

Since the incentive compatibility constraint implies that truth telling is in the best interest for the principal, the first-order condition (104) must hold for all values of a. Differentiating the utility function of the incumbent in case of truth revelation, we get

$$G(\dot{T}(a)) = W(T(a)) + a\frac{\partial W(T(a))}{\partial T(a)}\dot{T} + \frac{\partial C(a)}{\partial T(a)}\dot{T} = 0. \tag{105}$$

Using condition (104) for all values of a in condition (105), we obtain

$$G(\dot{T}(a)) = W(T(a)) > 0; \tag{106}$$

which ensures that the incumbent has a natural temptation to overstate the benevolence parameter in order to extract a higher rent from the lobby. The above results can be summarised in the next proposition.

Proposition 11: *For $a \in [0, a^M]$, a pair of differentiable functions $T(\tilde{a})$ and $G(T(\tilde{a}))$ is incentive compatible if and only if*

$$\dot{T}(a) \leq 0;$$

and

$$G(\dot{T}(a)) = W(T(a)).$$

In what follows is the exercise of expected utility maximisation by the lobby subject to the individual rationality constraint and the incentive compatibility constraint. The lobby's problem can be stated formally as

$$\underset{\{T(a),C(T(a))\}}{Max} E[V(T(a)) - C(T(a))] \tag{107}$$

subject to

$$\dot{T}(a) \leq 0;$$

$$G(\dot{T}(a)) = W(T(a));$$

and

$$G(T(a)) \geq G_0(T(a)).$$

The optimisation problem in (107) can be restated by replacing the contribution schedule using the payoff function of the incumbent in expression (89). This enables us to express the lobby's objective function in terms of the trade policy and the incumbent's information rent.

From (89), we get

$$C(T(a)) = G(T(a)) - aW(T(a)). \tag{108}$$

Using expressions (92) and (108) in the objective function of the optimisation problem (107) give us

$$\underset{\{T(a),G(T(a))\}}{Max} \int_0^{a^M} \Big[\Big\{l + \Pi(T(a)) + aW(T(a))\Big\} - G(T(a))\Big] f(a)da \tag{109}$$

subject to

$$\dot{T}(a) \leq 0;$$

$$G(\dot{T}(a)) = W(T(a));$$

and

$$G(T(a)) \geq G_0(T(a)).$$

The expression in (109) shows that the lobby's objective is to maximise the expected value of contract designed to buy trade protection (the first three terms in the parenthesis) minus the expected rent of the incumbent (the last term in the parenthesis).

The optimisation problem is solved using the following techniques:

Integrating both sides of expression (106), we get

$$\int_0^a \dot{G}(\tilde{a})d\tilde{a} = \int_0^a W(T(\tilde{a}))d\tilde{a};$$

$$\Rightarrow G(a) - G(0) = \int_0^a W(T(\tilde{a}))d\tilde{a};$$

$$\Rightarrow G(a) = G(0) + \int_0^a W(T(\tilde{a}))d\tilde{a}. \tag{110}$$

Next, we compute the expected rent of the incumbent to be given up by the lobby.

Differentiating the product of the rent function of the incumbent and the distribution function of a yields

$$\frac{d}{da}\{G(a).F(a)\} = F(a).\dot{G}(a) + G(a).f(a); \quad \text{[using the product rule]} \tag{111}$$

where

$$\frac{d}{da}F(a) = f(a).$$

Integrating both sides of (111) over the support of a gives

$$\int_0^{a^M} \frac{d}{da}\{G(a).F(a)\}da = \int_0^{a^M} \dot{G}(a).F(a)da + \int_0^{a^M} G(a).f(a)da;$$

$$\Rightarrow \int_0^{a^M} G(a).f(a)da = G(a).F(a)\Big|_0^{a^M} - \int_0^{a^M} \dot{G}(a).F(a)da;$$

$$\Rightarrow \int_0^{a^M} G(a).f(a)da = G(a^M).F(a^M) - G(0).F(0) - \int_0^{a^M} \dot{G}(a).F(a)da.$$

Since $F(0) = 0$ and $F(a^M) = 1$, we have

$$\int_0^{a^M} G(a).f(a)da = G(a^M) - \int_0^{a^M} \dot{G}(a).F(a)da. \tag{112}$$

Using the results from (106) and (110) in (112) yields

$$\int_0^{a^M} G(a).f(a)da = G(0) + \int_0^{a^M} W(T(a))da - \int_0^{a^M} W(T(a)).F(a)da; \tag{113}$$

which gives us the expression for the expected rent of the incumbent.

Substituting the above result in (109) in the objective function yields

$$\underset{\{T(a),G(a)\}}{Max} \int_0^{a^M} \Big[\Big\{l + \Pi(T(a)) + aW(T(a))\Big\}f(a) - G(0) - W(T(a)) + W(T(a)).F(a)\Big]da \tag{114}$$

Now, multiplying both the numerator and denominator of the second and third terms on the right-hand side of expression (113) with $f(a)$ gives us

$$\int_0^{a^M} W(T(a))da - \int_0^{a^M} W(T(a)).F(a)da = \int_0^{a^M} \frac{W(T(a))}{f(a)} f(a)da - \int_0^{a^M} \frac{W(T(a)).F(a)}{f(a)} f(a)da;$$

$$\Rightarrow \int_0^{a^M} W(T(a))da - \int_0^{a^M} W(T(a)).F(a)da = \int_0^{a^M} \left\{\frac{1-F(a)}{f(a)}\right\} W(T(a))f(a)da. \tag{115}$$

Using the result in (115) in (114) simplifies to

$$\underset{\{T(a),G(a)\}}{Max} \int_0^{a^M} \left[\left\{l + \Pi(T(a)) + aW(T(a))\right\} - G(0) - \left\{\frac{1-F(a)}{f(a)}\right\} W(T(a))\right] f(a)da \tag{116}$$

$$\Rightarrow \underset{\{T(a),G(a)\}}{Max} \int_0^{a^M} \left[l + \Pi(T(a)) - G(0) + \left\{a - \frac{1-F(a)}{f(a)}\right\} W(T(a))\right] f(a)da \tag{117}$$

Maximising the objective function in (117) pointwise with respect to $T(a)$, we obtain the following first-order condition

$$\frac{\partial \Pi(T(a))}{\partial T(a)} + \left\{a - \frac{1-F(a)}{f(a)}\right\} \frac{\partial W(T(a))}{\partial T(a)} = 0; \tag{118}$$

where

$$\frac{\partial \Pi(T(a))}{\partial T(a)} = X\left(\omega + T(a)\frac{\partial \omega}{\partial T(a)}\right); \tag{119}$$

and

$$\{T(a) - 1\}\omega \frac{\partial M}{\partial p}\left(\omega + T(a)\frac{\partial \omega}{\partial T(a)}\right) - M\frac{\partial \omega}{\partial T(a)} + (\tau - \theta)\frac{\partial N}{\partial p}\left(\omega + T(a)\frac{\partial \omega}{\partial T}\right). \tag{120}$$

are lifted from expressions (6), (21) and (28) for a single non-numeraire sector.

Conditions (14) and (30) further simplify the first-order condition as

$$X + \left\{a - \frac{1-F(a)}{f(a)}\right\}\left[\{T(a) - 1\}\omega\frac{\partial M}{\partial p} - \frac{\omega \frac{\partial M}{\partial p}}{\eta^*} + (\tau - \theta)\frac{\partial N}{\partial p}\right] = 0; \tag{121}$$

where

$$\eta^* = \frac{T^*(a^*)\omega}{M^*}\frac{\partial M^*}{\partial p^*};$$

denotes the elasticity of foreign import demand when M^* is positive or export supply when M^* is negative.

Solving for $T(a)$ from (121) yields

$$T(a) - 1 = -\frac{1}{a - \frac{1-F(a)}{f(a)}}\frac{X}{\omega\frac{\partial M}{\partial p}} + \frac{1}{\eta^*} - (\tau - \theta)\frac{\frac{\partial N}{\partial p}}{\frac{\partial M}{\partial p}}; \tag{122}$$

which is a special case of equilibrium tariff at home given by equation (34) with $\alpha_L = 0$ and the additional term in the denominator of the first term on the right-hand side, i.e., $\left\{-\frac{1-F(a)}{f(a)}\right\}$ exhibiting a distortion owing to asymmetric information over the benevolence parameter a, assuming that the monotone hazard rate property, $\frac{\partial}{\partial a}\left\{\frac{1-F(a)}{f(a)}\right\} < 0$ holds. Now, the ratio

$$\frac{1-F(a)}{f(a)} = \frac{1-F(\Upsilon \leq a)}{f(a)} = \frac{F(\Upsilon > a)}{f(a)}; \tag{123}$$

gives the probability of coming across a more honest politician, conditional upon having found a politician with a certain degree of preference parameter, say, a. Therefore, the monotone hazard rate property states that this conditional probability is decreasing as the politician becomes more honest.

Equation (122) shows that the equilibrium trade policy at home depends not only on a but also the distribution of a. In comparison to the equilibrium trade policy under complete information, there seems to be an upward bias for all values of $a < a^M$. For $a = a^M$, the solution coincides with that of complete information, otherwise, there is positive information rent accruing to the policy maker irrespective of their preference over aggregate social welfare. The lobby has to give up a positive information rent to the policy maker in order to induce truth-telling, i.e., a less corrupt policy maker has no incentive to mimic a more corrupt policy maker in order to receive more political contributions.

Proposition 12: *Under incomplete information, the optimal tariff is higher than that of complete information.*

Unlike the one-shot principal-agent game, there are possibilities of repeated interaction between lobbies and the policy maker. In case of repeated interactions, lobbies may offer a high powered incentive scheme to the regulator, given that they observe their true preference in the first interaction. This is known as the ratchet effect and it would add to the complexities of the incentive scheme. Such an analysis could be an immediate extension of the above model.

3 Conclusions

As an extension to the seminal work by Grossman and Helpman (1995) on the political economy of trade policy, our analysis draws some alternative conclusions in comparison to the former. Our results differ from the G-H model primarily on account of two reason: (a) the presence environmental regulations in the policy apparatus; (b) information asymmetries between the regulator and special interest groups. To begin with, we compare the standard trade war and trade talk equilibria of the G-H model with their corresponding equilibrium levels when environmental exist in a complete information framework. Alternative specifications where environmental regulations are too stringent; reflect true marginal damage from pollution; and less stringent have been studied. This is followed by a model of incomplete information between the principal (the producer lobby) and the agent (the regulator), over the weight attached to aggregate social welfare in comparison to campaign contributions (i.e., the degree of benevolence of the politically inclined regulator).

Results of the complete information model differs from the G-H model in terms of an additional component as a determinant of equilibrium trade policy, apart from the standard political support and the terms of trade components. This component is referred to as the net pollution tax revenue gain (loss) from trade intervention. The magnitude of this component typically depends the degree of stringency of environmental regulations in relation to the first-best policy.. When environmental regulations reflect true marginal damage from pollution, this term disappears. More interesting implications emerge when environmental regulations are either too stringent or too lax. Trade wars become more pronounced when environmental regulations in each country exceed (fall short of) the marginal damage from pollution.

Under a situation where environmental regulations are stringent, it is observed that the import tariff enjoyed by an organised import competing sector exceeds the corresponding level of import tariff in the G-H model. The higher import tariff is on account of the net marginal gain from pollution tax revenue on account of increased domestic production of the importable in the tariff imposing country. In contrast, if the country is question is an exporter of the polluting good and the exportable sector is unorganised, it may not always suffer from an export tax as in case of the G-H model. An export tax would be an equilibrium trade policy when the marginal gain from increased consumer surplus from reduction in domestic price of the exportable exceeds the marginal loss in pollution tax revenue on account of reduction in production of the exportable driven by the decrease in producer surplus. The ambiguity in terms of export subsidy/tax and import subsidy/tariff remains in case of organised export industry and unorganised import industry, respectively.

If environmental regulations are less stringent, an unorganised export sector suffers from an export tax that is higher than the one of the G-H model. Also, it is not unlikely for an organised import industry to suffer from an import subsidy if marginal gain in consumer surplus outweighs the marginal loss in pollution tax revenue owing to a fall in production in the importable sector.

Apart from differences in political pressures as in the trade talks equilibrium in the G-H model, we observe that even differences in environmental regulations can contribute to differences in trade policies across nations engaging in trade agreements. Without loss of generality, if the home country is an importer of the traded good and the sector producing the particular good is organised in both countries, a trade agreement benefits the group that has higher stakes in protection. An additional source of gain emanates from marginal revenue generated from pollution tax when environmental regulations are stringent. Here, the difference in trade protection is attributed to the difference in responsiveness of demand for the environmental resource input as a result of altered prices in the domestic importable sector on account of a trade policy intervention. Finally, the relative difference in trade policies would be less pronounced when environmental regulations are less stringent in the home country unlike in the foreign country. As a result, the bargaining process must be designed in such a manner that it satisfies the participation constraint of each nation engaging in the trade negotiation.

The principal-agent model under incomplete information suggests that the equilibrium trade policy for a policy maker who attaches a weight on aggregate social welfare relative to campaign contributions, equal to its upper bound in the probability distribution (i.e., he is least corrupt), coincides with that of the one in case of complete information. For any value of the benevolence parameter below the upper bound, there is a divergence between the equilibrium trade policies under complete information and incomplete information, which peters out as the value of parameter keeps rising. Except the case where the policy maker is purely benevolent, there is positive information rent accruing to the policy maker irrespective of their preference over aggregate social welfare for the common interest of the population at large. The optimal contract ensures that a highly corrupt policy maker to choose an equilibrium import tariff that is higher than the one obtained in the complete information model. The analysis would become more complex when there are repeated interactions between the lobby and the policy maker. This would lead to the ratcheting problem.

In sum, the present analysis provides some telling insights on the aspect of trade and environment linkages in the presence of special interest politics and information asymmetries.

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