ENDOGENOUS BEHAVIOUR OF THE TARIFF RATE IN A POLITICAL ECONOMY

Abstract

How would the tariff rate in a political economy respond to changes in exogenous environment? To answer this question a bargain-theoretic approach is adopted and a tariff-endogenous general equilibrium model of a small open political economy is derived. A comparative static analysis of the model shows that the bargained tariff rate changes to compensate, at least in part, for the relative loss of the loser arising from changes in the exogenous environment - be it the domestic factor endowment or the international terms of trade.

Key Words: endogenous-tariff, comparative statics, Nash-bargaining games, CGE models and political economy.

JEL Classification: C68, C78, and F13.

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Introduction

Imagine a small open political economy where tastes, technologies and the factor endowment are given and where the government trades tariff protection for political support and citizens trade political support for higher real income. How would the tariff rate in such a political economy respond to changes in the factor endowment or the international terms of trade? Is there any factor endowment configuration that makes the import competing sector ready to accept lower protection? Does the tariff rate rise as the price of importable falls in the world market? The answers to these questions are important in determining the general position of a country's trade negotiator towards trade liberalization. They will also help us understand whether a given country would be prepared to offer unilateral trade liberalization even without any change in the world market conditions. This paper answers these questions in the framework of a fully consistent and operational general equilibrium model of a political economy.

Tariff determination is viewed as a bargaining problem between the gainers and the losers from a tariff change and employs the generalized Nash solution to solve the bargaining problem. By doing so, we avoid the risk of analyzing the behaviour of a sub-optimal tariff rate determined at an equilibrium of a non-cooperative game. We also avoid the well-known logical problems associated with assuming that each agent is individually rational and at the same time assuming that the government (a collection of individuals) is a social welfare maximizer.[1]

This approach allows us to combine the condition characterizing a Nash bargaining solution in the political sphere with the conditions of equilibrium in a Ricardo-Viner type model of the economic sphere to derive a set of necessary conditions of general equilibrium in a tariff-endogenous model of a political economy. The vector of endogenous variables, including the tariff rate, that emerges at the

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[1] On the conceptual problem of defining social welfare itself see Ng (1981), Yaari(1981) and Sen (1979).

solution of this model simultaneously satisfies all conditions of equilibrium in both the spheres and therefore yields the general equilibrium of the political economy. A study of the comparative static behaviour of the tariff rate around this equilibrium point suggests that the tariff rate changes to compensate, at least partly, for the relative loss of the loser (compared to that of the other player) arising from changes in the exogenous environment. In particular, it is found that if the endowment of the factor used intensively or specific to the import competing sector increases, ceteris paribus, the equilibrium tariff rate falls. This result is not only consistent with the prediction of models with a support maximizing government, but also is consistent with the prediction of models with governments that maximize a conservative social welfare function (Corden, 1974). A straightforward corollary of this result is that if capital accumulation (or sector-specific technical progress for that matter) takes place in the import competing sector at a faster rate, then the country may opt for a unilateral trade liberalization.

The questions addressed by this study have also been examined by Magee, Brock and Young (1989). Our study, however, differs from theirs in two respects. First, we employ a Ricardo-Viner model to describe the economic sphere rather than the Heckscher-Ohlin model and second, we view the political process of tariff determination as a *cooperative* rather than a non-cooperative game.[2] Such a shift in the modelling strategy is warranted because tariffs often do change within a single term of a

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[2] Several other studies have viewed the process of tariff determination in the context of a non-cooperative lobbying game. See, for example, Grossman and Helpman (1994), Hall and Nelson (1992), Coggins, et al., (1991), Coggins (1989), Wellisz and Willson (1986), Findlay and Wellisz (1984, 1983, 1982), Feenstra and Bhagwati (1982). They have not, however, examined the comparative static properties of the endogenous tariff rate.

government and the incumbent government has the power and motivation to enforce any cooperative agreements reached by the groups affected by such changes. [3]

The rest of the paper is divided into four sections. Section two derives a rent transformation frontier on the basis of a two-good three-factor Ricardo-Viner model of the economic sphere. In section three we define a bargaining problem in the political sphere using the rent transformation frontier and derive the condition for a Nash solution to the bargaining problem which, in turn, characterizes the equilibrium in the political sphere. In section four, we first identify the disagreement payoffs with players' minimum expectation and then using the linearized conditions for equilibrium in both the spheres we derive and explain the comparative static properties of the tariff rate. Finally, the paper is summarized in section five.

2 The Economic Sphere of a Political Economy and the Rent Transformation Frontier

In this section we describe a simplified model of the economic sphere of a small open political economy. This model (of the economic sphere) is similar to any conventional Walrasian type general equilibrium model in that government policies are treated as exogenously given.

We consider an economic sphere with two industries producing two tradeable goods using mobile and homogenous labour, and sector-specific capital stocks. Their production technologies are characterized by constant returns to scale CES functions. Good 1 is import competing and good 2 is

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3 Other authors who have analysed the comaprative statics of endogenous protection in a closely related framework are Hillman (1982) and Long and Vousden (1991). Hillman (1982), in a partial equilibrium framework, and Long and Vousden (1991), in a general equilibrium framework, have studied the comparative static response of the dometic relative price, chosen by a support maximizing government, to the terms of trade shock. They have shown that domestic relative price moves with the international terms of trade. This result, however, is not sufficient to get an indication of the endogenous response of the tariff rate to the terms of trade shock. Hillman (1982), nevertheless, has shown that if the government maximizes a Stigler-Peltzman type support function, in which political support are based on current real income, then it always adjusts the tariff rate to fully offset the effects of international terms of trade change on the domestic relative price. This result became ambiguous when it was assumed that political support is instead based on the difference of current real income over the free trade level (Hillman, 1982) or on the difference of current welfare over its pre-shock level (Long and Vousden, 1991).

exportable under free trade. In this economy, imported goods are considered as perfect substitutes to home goods. A single tariff rate, which subsumes all trade taxes and restrictions, imposed on the import of good 1, is the only wedge between domestic and world prices. The government transfers the tariff revenue to the household.

The endowment of factors and world prices are exogenous and in this model of the economic sphere the tariff rate (government policies) is also considered as an exogenous variable. The domestic relative price of commodities is unaffected by domestic (demand and supply) conditions of the economic sphere. Therefore, the supply side decisions are unaffected by the demand side decisions. To simplify further, we also assume that a representative consumer receives all national income (value added and tariff revenue) and spends it on the consumption of the two commodities to maximize a Cobb-Douglas utility function. Finally, we also assume that in this economy the net inflow of capital is zero, which forces the trade account, in equilibrium, to balance at foreign prices.

Table 1

A Tariff-exogenous Model of The Economic Sphere

Of a Stylized Political Economy

(a) The Goods Market:

The supply functions of domestic production sectors:

$$Y_j = K_j \beta_j^{-1/\rho_j}\left[1-\alpha_j^{1/(1+\rho_j)}\left(W / P_j\right)^{\rho_j/(1+\rho_j)}\right]^{1/\rho_j}; \qquad j = 1, 2. \qquad (1)$$

Consumer demand functions:

$$C_i = \left(\delta_i \;/\; P_i\right)\left[\sum_{i=1}^{2} P_i Y_i + T_1 \; P_1^{*} M_1\right]; \qquad i = 1, 2. \qquad (2)$$

Equilibrium in the market of good 1.

$$C_1 = Y_1 + M_1. \qquad (3)$$

(b) The Foreign Exchange Market:

Trade balance constraint:

$$P_1^{*} M_1 + P_2^{*} M_2 = 0 \qquad (4)$$

(c) The Labour Market:

Sectoral labour demand:

$$L_j = K_j \alpha_j^{1/(1+\rho_j)} \beta_j^{-1/\rho_j}\left[\left(P_j \;/ W\right)^{\rho_j/(1+\rho_j)} - \alpha_j^{1/(1+\rho_j)}\right]^{1/\rho_j}, \quad j = 1,2. \qquad (5)$$

Labour market equilibrium:

$$L = \sum_{j=1}^{2} L_j . \qquad (6)$$

Domestic price determination:

$$P_1 = \Phi P_1^{*}(1+T_1 \;). \qquad (7a)$$

$$P_2 = \Phi P_2^{*}. \qquad (7b)$$

Virtual rental rates:

$$R_j = \beta_j^{-1/\rho_j}\left(P_j^{\rho_j/(1+\rho_j)} - \alpha_j^{1/(1+\rho_j)} W^{\rho_j/(1+\rho_j)}\right)^{(1+\rho_j)/\rho_j}, \qquad j = 1,2 \qquad (8)$$

Total number of equations = 13. Total number of variables = 20 of which 7 are exogenous.

Under the above assumptions, we derived a set of conditions for the optimal behaviour of price-taking producers and consumers in the economic sphere. These conditions were then solved to derive demand, supply and rental functions at given commodity prices, wage rate and factor endowment.[4] These functions together with instantaneous market clearing conditions define a Walrasian system, which is listed in Table 1, of 13 equations in 20 variables. The variables used in Table 1 are defined as follows: Y_i, C_i, M_i, P_i, and P_i^* are respectively sectoral output, domestic demand, net import, domestic and world price of commodity i (i= 1,2); L_j, K_j and R_j represent employment of labour; stock of sector-specific capital and rental rates of capital in industry j (j=1,2) respectively; L is the total stock of labour in the economy, *W* is the wage rate; T_1 is the tariff rate on good 1 and Φ is the exchange rate.

This model contains eight parameters, of which $\sigma_j = 1/(1+\rho_j)$ represents the elasticity of factor substitution, α_j and β_j are share parameters of the CES production function in sector *j* that sum to unity and δ_j is the share of commodity *j* in the budget of the representative consumer.

The system of equations given in Table 1 can be read as follows: Equations (5) and (6) describe a simple labour market. Equation (5) gives the demand for labour resulting from the cost minimizing behaviour of the production sectors at given commodity prices and the factor endowment; and equation (6) requires that the labour market clear for a given supply of labour. The wage rate adjusts to clear the labour market, and sectoral employment of labour is then determined by (5). Equation (1) then yields sectoral output supply at these prices, and equation (2) yields domestic consumption of the two commodities that maximize a household utility function. Equations (3) and (4) yield quantities of net imports of the two commodities, which are two of the three market-clearing conditions - two for commodities and one for foreign exchange. Invoking Walras law, the market clearing condition for commodity 2 has been omitted. Equation (8) yields the rental rates at which existing stocks of sector-specific capital are optimal to produce output levels determined by equation (1).

Besides taking the endowment variables, world prices and the tariff rate as given, this system is closed by using the homogeneity property of the demand and supply functions (1), (2), and (5), and choosing commodity 2 as the numeraire (and setting its price equal to unity in all markets). Thus the seven exogenous variables of the model are: sector-specific capital stocks, K_j, economy wide stock of labour, *L*, world prices, P_i^*, domestic price of the numeraire commodity P_2, and the tariff rate T. This closure sets number of endogenous variables to 13 which is just equal the number of the equations describing the economic sphere as listed in Table 1. As a result of price normalization, the exchange rate remains fixed at unity by (7b) and in what follows we have omitted the exchange rate variable and equation (7b) from the discussion. It must be noted that the normalization has no consequence in

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4 Details of the derivation of these results can be found in Pant (1992).

determining the "real" quantities of the model as far as the behavioural equations satisfy the homogeneity condition.

The rent transformation function

Definition 1 (RTF) *The locus of the combinations of equilibrium rental incomes (or rates) in units of own output corresponding to each tariff rate (or domestic relative price), while all other exogenous variables are held fixed, is defined as the Rent Transformation Frontier (RTF). A function that describes the locus is the Rent Transformation Function*.

By eliminating the wage rate variable from the two sectoral-rental functions given by equation (8) the rent transformation function can be expressed as

$$\Pi_1 = K_1 P_1^{-1} \beta_1^{-\frac{\sigma_1}{1-\sigma_1}} \left[P_1^{1-\sigma_1} - \alpha_1^{\sigma_1} \alpha_2^{-\frac{\sigma_2(1-\sigma_1)}{1-\sigma_2}} \left(1 - \beta_2^{\sigma_2} \left(\frac{\Pi_2}{K_2} \right)^{1-\sigma_2} \right)^{\frac{1-\sigma_1}{1-\sigma_2}} \right]^{\frac{1}{1-\sigma_1}} \tag{9}$$

where, for each i= 1, 2 $\Pi_i = K_i R_i / P_i$ (10)

is the normalized (in units of own output) profit or rental income to the owner of the specific factor employed in sector *i*. This idea of rent transformation frontier is a general equilibrium analogue of the Gardner's idea of the surplus transformation frontier (Gardner, 1983; 1987).

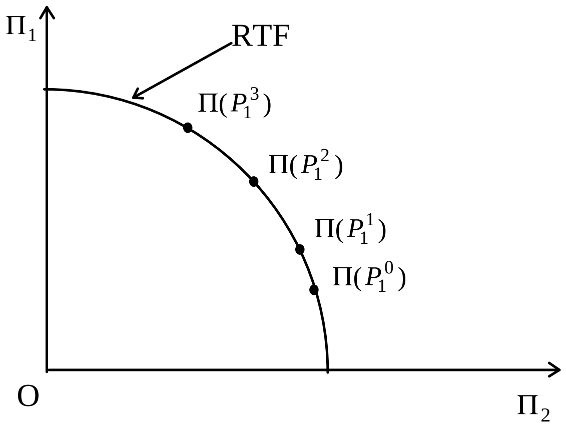

Figure 1: Price movements along the RTF

The graph of equation (9) can be plotted with the help of equations (5)-(8) and (10). For each tariff rate a unique set of domestic prices is determined by equation (7) and the wage rate can then be determined by equations (5) and (6). Using these prices and the wage rate a unique combination of real rental incomes can be determined by equations (8) and (10). Thus, we can always find a unique combination of real rental income, (Π_1, Π_2), for each tariff rate at the equilibrium of the economic sphere.

It has been shown in the appendix that $d\Pi_1 / d\Pi_2 < 0$, and that a sufficient condition for $d^2\Pi_1 / d\Pi_2^2 < 0$ is $\sigma_i \geq 1$ for each i = 1, 2. In this study we consider only those production functions satisfying the restriction $\sigma_i \geq 1$. So, the *rent transformation frontier* certainly slopes downward to the right and is concave to the origin in the rental-plane as illustrated in Figure 1.

The rent transformation frontier (or function) is a useful device to see how a change in domestic relative price effects a transfer of rents, in equilibrium, between the owners of capital in the two sectors. It shows a well known result that as the relative price of the import-competing good increases, the real rental income in sector 1 (the import-competing sector) increases and the real rental income in sector 2 falls (see, for example, Jones, 1971; Mussa, 1974, Neary, 1978).

It is easy to see that any change in the tariff rate or in the international relative price causes a movement along the rent transformation frontier CD and a change in the endowment of factors in the economy brings about a shift in the RTF. An increase in the stock of sector-specific capital shifts the point D rightward or the point C upward, as the case may be, of the RTF. An increase in the stock of the mobile factor shifts the whole frontier outside, the extent of tilt depending on the relative labour intensities of the two sectors.

3 The Political Sphere of a Stylized Political Economy and The Bargaining Problem

This study assumes that any tariff change proposal causes the political sphere to divide itself into four segments. The first segment consists of people who expect to receive higher real income and the second segment consists of people who expect to lose out from the proposed change. The third group consists of people who are unsure of its effects and the fourth group is the government who is responsible for implementing the change and wants to make something “good” out of it. Leaving the government aside, the remaining three groups are identified by their factor ownership in the following way.

The owners of the specific-factors are assumed to maximize their real rental income net of any lobbying (policy-seeking) costs. As the rent transformation frontier shows, the owners of the sector-specific factors have divergent interests with respect to changes in the tariff rate. One of them expects to gain and the other expects to lose from a change in the tariff rate. They will lobby the government accordingly.

We further assume that the owners of the mobile factor are large in number, have sufficiently high organisational and informational cost, suffer from free rider problem, and therefore, are rationally ignorant of the possible impacts of a small change in the government's policies. This situation deters them from behaving strategically by themselves vis a vis the government and other factor owners. Their individual political behaviour, however, is influenced by the lobbying activities (political education) of other strategic agents, namely owners of the sector specific-factors.

Following previous studies (for example, Peltzman, 1976; Hillman, 1982; Cassing and Hillman, 1986; Magee, Brock and Young, 1989; Long and Vousden, 1991), we assume that the government is a political support maximizer.[5] The government and owners of specific-factors are assumed to be organised and fully informed of the political responses of the non-strategic agents to the lobbying efforts and the responses of the economic sphere to policy changes.

Under the above assumptions, the variation in the political support to the government depends on the lobbying behaviour of the specific factor owners. Rental incomes of the specific-factor owners depend on the government's choice of the tariff rate. Thus, we have a gaming situation among the owners of the two specific-factors, and the government. What a player obtains at the end depends not only on his actions but also on the actions of the rest of the players. The government will choose the tariff rate that would maximize its political support while each of the owners of sector specific-factors would choose their lobbying efforts (political activities) to maximize their net real rental incomes. It is further assumed that the political process allows the players to communicate their threats, bluffs, proposals and counter-proposals, and finally, enter into a binding agreement if it is individually rational to do so.

It follows from the above assumptions that if the owners of specific-factors agree on a particular tariff rate, then the best policy for the government is to implement it. This will guarantee the maximum support to the government and the two specific-factor owners will receive the resulting real rental-income as their payoffs. If there is disagreement we assume, however, that the government behaves as a Stackelberg leader vis-a-vis the other two players. The government announces a lobbying sensitive policy (tariff) function to extract maximum political support for it. The other two players behave as Nash players against each other taking the government's policy function as given. The tariff rate that emerges at the Nash equilibrium of the noncooperative game will be implemented. The owners of the specific-factors will receive the resulting rents less the lobbying expenditures as their payoffs.

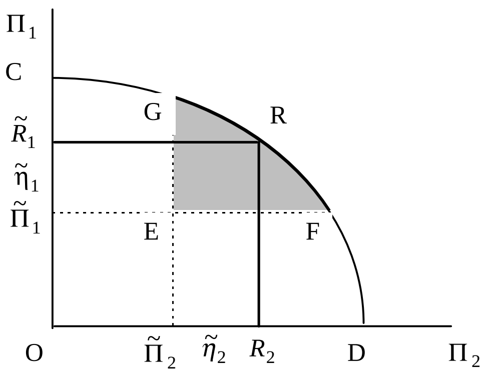

Figure 2: A Bargaining problem in the tariff game

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5 See Baldwin (1987) for analytical similarity between the choices of a support maximizing government and a welfare maximizing government.

To illustrate the point, let us consider Figure 2, where the curve CD represents the rent transformation frontier (RTF). Suppose that the parties could not agree on any tariff rate, and chose to play a noncooperative game. Suppose further that a unique noncooperative Nash equilibrium is obtained at E with lobbying expenditures η_1 and η_2 units of respective outputs which yields a domestic price ratio of P_1. Then the sectoral payoffs, which are rental incomes net of lobbying expenditures, are $\tilde{\Pi}_1$ and $\tilde{\Pi}_2$ for player 1 and player 2 respectively.

However, had the two players been able to negotiate and agree on the same price P_1, and had agreed on not to participate in competitive lobbying, both would have received payoffs represented by the corresponding point R at the frontier. This point represents a combination of higher payoffs than that corresponds to the point E.

Thus, given that some interior point such as E would be the outcome of disagreement, the shaded area EFG represents the set of feasible payoffs in cooperation. The arc FG represents the set of feasible and Pareto efficient payoffs to the two players. The set of feasible outcomes in cooperation that dominate noncooperative outcome(s) is non empty, so long as each noncooperative equilibrium implies positive lobbying by at least one player. Therefore, there is always an incentive to the players to be involved in a bargaining process and search for a mutually acceptable tariff rate.

There are three reasons to believe that all agreements reached in a tariff game will be enforceable. First, playing a noncooperative Nash equilibrium strategy is always a credible threat that can be issued by any player against the other player. This credibility works as a deterrent against possible deviant behaviour of either player. Second, as Subik (1982) argued, constitutional arrangements and the presence of government as the enforcing agency makes players almost incapable of deviating from any agreement. Moreover, if the government is a support maximizer, as we have assumed, then it will also have an incentive to implement such cooperative agreements. Third, the tariff game can be viewed as a periodic game. It is played repeatedly. Cooperative outcomes of repeated games are, in general, self-enforcing (Fudenberg and Maskin, 1986; Friedman, 1986). That is, cooperation can yield better outcomes and cooperative strategies in the Tariff game are enforceable. Thus, a bargain-theoretic approach appears to be a natural way to study the tariff (policy) formation process in the political sphere of a political economy.

Definition 2 (*Bargaining Set)*. For given disagreement payoffs $\Pi^d \equiv (\Pi_1^d, \Pi_2^d)$, let

$$\Re = \Big\{(\Pi_1, \Pi_2) \Big| \Pi_1 \le K_1 P_1^{-1} \beta_1^{-\sigma_1/(1-\sigma_1)} \times$$

$$\left[P_1^{1-\sigma_1} - \alpha_1^{\sigma_1} \alpha_2^{-\sigma_2(1-\sigma_1)/(1-\sigma_2)} (1-\beta_2^{\sigma_2}(\Pi_2 / K_2)^{1-\sigma_2})^{(1-\sigma_1)/(1-\sigma_2)}\right]^{1/(1-\sigma_1)}; \Pi_i \ge \Pi_i^d \Big\},$$

then $\Re$ is a collection of all feasible payoff combinations that are individually rational to both players. $\Re$ is defined as the bargaining set over which the players in the tariff game may bargain. It is not difficult to see that the bargaining set $\Re$ is compact and convex. The pair $(\Re, \Pi^d)$ defines a bargaining problem in a tariff-setting game. Under these conditions, whether the disagreement payoffs are assumed to be predetermined or not (variable), the bargaining problem $(\Re, \Pi^d)$ admits a unique Nash solution (Nash, 1950, 1953 and Harsanyi, 1963).[6]

Generalized Nash Solution to the Bargaining Problem in a Tariff Game

Nash's original solution to a bargaining problem, however, was based on the contention that all significant differences between the players are captured by the differences in the bargaining set and the disagreement payoffs. Subsequent authors have shown several sources of asymmetry on the bargaining powers of the players that are not accounted for by the bargaining set and the disagreement point - the constituents of a mathematical description of a bargaining problem. For example, Kalai (1977) has shown that if an n-person symmetric bargaining game is played by two coalitions of size p and q with p+q=n such that within each coalition players have identical utility functions, then a non-symmetric Nash solution may arise even if the n-person game yields a symmetric Nash solution. In this case the source of apparent 'bargaining power' of the coalition is its membership. This was not envisaged by Nash. Similarly, the other sources of asymmetry are[7]: players having different degrees of risk aversion (Roth, 1979), difference in the time preference rate (Rubinstein, 1982), different probability attached to the risk of breakdown of the negotiation (Binmore, Rubinstein, and Wolinsky, 1986), bargaining skill (Ohyama, 1989) and players possessing imperfect knowledge about each other (Harsanyi and Selton, 1972). In particular, these studies contend that players may well be endowed with uneven bargaining powers or weights and so the original Nash solution is not general.

A *generalized Nash solution* to a bargaining problem was obtained by Roth (1979), who allowed players to differ in their relative bargaining power for whatever the reasons. In solving the bargaining problem in the tariff game we follow Roth (1979) and define the bargaining problem by $(\Re, \Pi^d, \Theta)$ where $\Theta \equiv (\Theta_1, \Theta_2)$ is the vector of normalized bargaining powers. As Roth (1979) showed the generalized Nash solution to the bargaining problem $(\Re, \Pi^d, \Theta)$ is the solution to the following maximization problem:

$$\max \left[\Pi_1 - \Pi_1^d\right]^{\Theta_1} \left[\Pi_2 - \Pi_2^d\right]^{\Theta_2} \qquad (11)$$

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6 For the robustness of Nash solution with respect to various perturbations to its assumptions see Binmore, Rubinstein and Wolinsky (1986), van Damme (1986), Chun (1988), Chun and Thomson (1990), Carlson (1991), which justify our choice of Nash solution against others.

7 Further references of the works that have independently obtained asymmetric Nash bargaining solutions can be found in Binmore (1987: p.94).

subject to $(\Pi_1, \Pi_2) \in \Re.$ (12)

Since the bargaining set $\Re$ is compact and convex, and the maximand (the generalized Nash product) is concave over the bargaining set $\Re$, the necessary condition also becomes the sufficient condition for a unique generalized Nash solution to the bargaining problem. This condition can be written as

$$\frac{\Pi_1 - \Pi_1^d}{\Pi_2 - \Pi_2^d} = -\frac{\Theta_1}{\Theta_2}\frac{d\Pi_1}{d\Pi_2}\Bigg|_{RTF}. \qquad (13)$$

It can be deduced from the system of equations given in Table-1 (see Appendix 1) that

$$\frac{d\Pi_1}{d\Pi_2}\Bigg|_{RTF} = -\frac{\Pi_1}{\Pi_2}\left(\frac{\sigma_2 Y_2}{\sigma_1 Y_1 P_1}\right), \qquad (14a)$$

which can also be expressed as

$$\frac{d\Pi_1}{d\Pi_2}\Bigg|_{RTF} = -\frac{\sigma_2 S_{K1}}{\sigma_1 S_{K2} P_1} \qquad (14b)$$

where $S_{Ki} = \Pi_i / Y_i$ is the distributive share of capital in the output of sector *i*. substituting the expression for the slope of the RTF from equation (14a) into the equilibrium condition (13) we get

$$\frac{\Pi_1 - \Pi_1^d}{\Pi_2 - \Pi_2^d} = \frac{\Theta_1}{\Theta_2}\frac{\Pi_1}{\Pi_2}\left(\frac{\sigma_2 Y_2}{\sigma_1 Y_1 P_1}\right) \qquad (15)$$

Alternately, equation (15) may also be written as

$$\frac{\Pi_1 - \Pi_1^d}{\Pi_2 - \Pi_2^d} = \frac{\Theta_1}{\Theta_2}\left(\frac{\sigma_2 S_{K1}}{\sigma_1 S_{K2} P_1}\right). \qquad (16)$$

The condition (16) can be explained as follows. Since Π_1 is a strictly increasing function of P_1 and Π_2 is a strictly decreasing function of P_1, the left-hand side of equation (16) is a strictly increasing function of P_1 for given a value of Π^d. We know that S_{K1} is nonincreasing and S_{K2} is nondecreasing (constant in the Cobb-Douglas case) in P_1; for a given distribution of bargaining power, the right-hand side of equation (16) is a strictly decreasing function of P_1. Thus, a unique domestic relative price satisfies the necessary and sufficient condition for the solution to the bargaining problem. The existence problem is solved, however, by the compact and convex nature of the bargaining set and concavity of the maximand - generalized Nash product.

At the solution of any Nash bargaining problem, as first shown by Aumann and Kurz (1977) and subsequently refined by Roth (1979) and Svejnar (1986) that, players' fear of ruin relative to their bargaining power are equalized. A player's fear of ruin is the inverse of the maximum probability of disagreement (ruin) per unit of additional gain which the player is prepared to tolerate, for a very small potential gain (Aumann and Kurz, 1977 and Svejnar, 1986). We will see shortly that the equilibrium condition (13) shows that this equality holds in the tariff game as well. This condition not only identifies the Nash solution to a bargaining problem but also provides an intuitive explanation of why such a solution is obtained. This condition forcefully puts forward Zuthen's (1930) explanation that during a bargaining process the player who fears most concedes. In the following discussion this condition will be used extensively.

In the case of a tariff game, where the players may be viewed as bargaining over the magnitude of the relative price of commodity 1, it can be easily seen that player 1's fear of ruin, f_1, is given by[8]

$$f_1(P_1) = \frac{\Pi_1(P_1) - \Pi_1^d}{d\Pi_1 / dP_1}, \tag{17a}$$

and player 2's fear of ruin, f_2, is given by

$$f_2(P_1) = -\frac{\Pi_2(P_1) - \Pi_2^d}{d\Pi_2 / dP_1}. \tag{17b}$$

Intuitively, the fear of ruin is measured by the loss per unit of potential gain. The numerators in (17a) and (17b) measure the current gains over the conflict payoffs while the denominators measure potential gains from favourable unit changes in the relative price of good 1.

It follows from condition (13) and equation (17) that at the point of Nash solution to the bargaining problem, $f_1 / \Theta_1 = f_2 / \Theta_2$, that is, players' fears of ruin relative to their bargaining powers are equalized.

Any shock that disturbs this equality places the system out of equilibrium and makes either one of the players more fearful of ruin. One who fears the most concedes during the following bargaining process and the political process will again be in equilibrium.

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8 See Pant (1992) for the derivations of the expressions for fear of ruin.

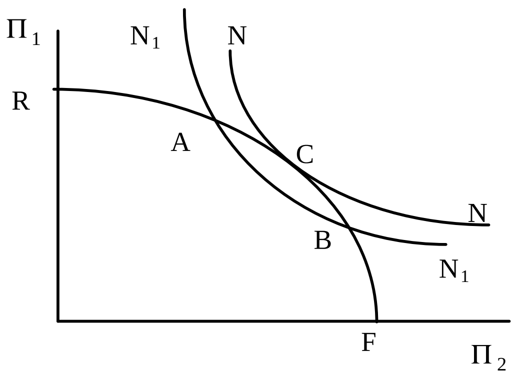

Figure 3: Stability of the Nash Solution

This process is illustrated with the help of Figure 3. In this figure a level curve, labelled NN, of the generalized Nash product is tangent to the curve RF, representing the boundary of the bargaining set $\Re$, at point C. Let P_1 be the domestic price ratio and $\Pi(P_1)$ be the payoff combination at the point C. We know that at point C the generalized fear-of-ruins are equalized across the players. Suppose that, for some reason, the equilibrium is disturbed and the political economy is at the point B. Given the values of the exogenous variables, the relative price should rise and the economy should move to point C if the Nash solution at point C is a stable one.

At point B the generalized Nash product is not maximized. Obviously, B is not an equilibrium point. The two players will start bargaining over the domestic relative price (tariff rate). Player 1 would like the price to rise and player 2 would **not** like the price to rise. Since the absolute slope of the RTF is greater than that of the Nash product curve, it can be easily inferred from equations (13) and (17) that $f_2 / \Theta_2 > f_1 / \Theta_1$ holds at B. This means that player 2 will concede during the bargaining process and the domestic relative price will rise. The process will continue until the point C is reached. Here both players are equally fearful, relative to their bargaining power, of each other quitting the negotiation. Similarly, it can be seen that if the economy moves to a point like A, then player 1's fear of ruin will exceed player 2's fear of ruin. Player 1 will concede and the price will fall.

Thus, equation (15) describes an equilibrating mechanism in the political sphere and the RTF provides the interface between the economic and the political spheres. Therefore, equation (15) together with the conditions of general equilibrium of the economic sphere yields the conditions of general equilibrium of the political economy. The system of equations (1) - (8), (10) and (15) describe a general equilibrium of the political economy. It contains 3 more equations and three more variables than the system listed in Table 1. These additional variables are: the tariff rate and real-rental incomes of the two owners of sector-specefic capital stocks. For given values of exogenous variables and model parameters, the system, in principle, can now be solved for the 16 endogenous variables. The solution vector of endogenous variables describes the general equilibrium of the political economy. The tariff rate that emerges at this equilibrium is defined as the bargained tariff rate.

This system demands, naturally, more information than by a conventional policy-exogenous CGE model. The extra information required are on the distribution of the players' bargaining powers and on disagreement payoffs, Π^d. This paper assumes that *the distribution of bargaining power between the players is exogenously given and is unaffected by small changes in exogenous variables.*

4 Identification of Disagreement Payoffs and Comparative Static Results

In this section we first provide an operational definition of disagreement payoffs and then use it to derive comparative static response of the tariff rate by solving the linearized model of the political economy around an "observed" equilibrium point. In so doing, we use lower case to denote the percentage change of the variables written in uppercase so far except the tariff rate, for which a lower case would mean change in percentage points and the uppercase would continue to represent the tariff rate.

4.1 Disagreement and Players' Minimum Expectation in the Tariff Game

Disagreement payoff is the payoff that a player will receive if they fail to reach an agreement. In most situations it simply reflects players' perception of what the disagreement payoffs would be rather than the realization of it since they may not end up in a conflict at all. A natural candidate for this is the payoffs at a noncooperative Nash equilibrium in the tariff game. There are two problems, however, that render it less attractive. First, the possibility of multiple Nash equilibria in a general setting of the game can not be dismissed *a priori,* and there seems no clear way of identifying which one of them will be attained if there is a disagreement. Second, even if there are reasons to believe that a unique Nash equilibrium will be attained, the government's pricing function has to be specified before any Nash equilibrium can be computed. This would further require a knowledge of the government's political support function, which is not an easy task either.

In general, the operational definition of the disagreement payoffs in the theory of bargaining has remained unclear. It has, therefore, been suggested as a matter of modelling judgement (Binmore, Rubinstein, and Wolinsky, 1986). A reasonable candidate for this is the point of minimum expectation, as suggested by Roth (1977). As Thomson (1981) has shown, this point possesses some desirable properties of a reference point to the players. Roth's idea of minimum expectation can be adapted for our purpose as follows:

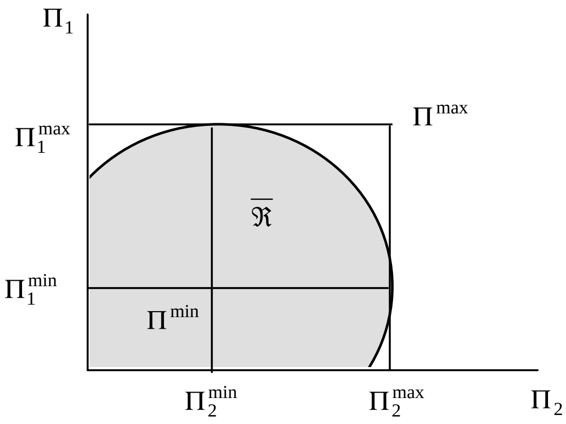

Figure 4: The point of minimum expectation

Definition 3 (*minimum expectation)* Let $\overline{\Re}$ be the set of all feasible payoff combinations. For each player *i*, let

$$\Pi_i^{max} = \max\{\Pi_i \,|(\Pi_i, \Pi_{-i}) \in \overline{\Re}\}; \text{ and } \Pi_i^{min} = \max\{\Pi_i \,|(\Pi_i, \Pi_{-i}^{max}) \in \overline{\Re}\}.$$

Then the payoff combination $\Pi^{min} \equiv (\Pi_1^{min}, \Pi_2^{min})$ is a combination of the minimum expectations of the players and the payoff combination $\Pi^{max} \equiv (\Pi_1^{max}, \Pi_2^{max})$, which is also called the ideal point, is a combination of the aspiration levels[9] of the players (see figure 4).

One attractive feature of the point of minimum expectation is that it represents the payoff to each player when the bargaining opponent has been able to obtain the best possible outcome for herself, say by forming a coalition with the government or by pre-emptive lobbying. The payoff combination Π^{min} therefore represents the worst outcome for each player. No rational player will choose a strategy that yields his opponent a payoff less than that corresponding to Π^{min} because such strategy would bring no benefit, possibly would lead to a reduction, in his own payoff. In other words, for each player, the payoff combination Π^{min} corresponds to the opponent's dictatorial solution.

Roth (1977) has shown that the Nash solution to the class of bargaining problems in which the disagreement payoff is given by Π^{min} satisfies all the axioms as satisfied by the original Nash solution. The only difference between the two is that Nash's solution is independent of irrelevant alternatives (axiom of independence) other than the disagreement point, whereas the new solution will be independent of irrelevant alternatives other than the point of minimum expectation.

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9 See also Friedman (1986) pp. 160-62.

To define the minimum expectation of players in the Tariff game we allow for the possibilities that any one of the players may form a “coalition” with the government. The government then choses a policy that best suits the winning player and balances its budget, if necessary, by taxing the losing player and other nonstrategic agents in the political economy. Given these possibilities, the worst outcome to the losing player would be that he has to surrender all of his rental income to finance the government's budget deficit. This, in turn, implies that the payoff at the minimum expectation of each player is zero.

Though it is very restrictive, the identification of Π^d with $\Pi^{\min} = (0,0)$ is interesting for three reasons. First, it greatly simplifies the model so that analytical results are possible. It can be used to illustrate the mechanism of endogenous determination of the tariff rate. Second, it corresponds to a *potentially* dictatorial type of government. The results, therefore, will show the behaviour of bargained tariff rates under a particular political environment where the government can be captured by one of the bargaining party if no agreement is reached during the bargaining process. Third, more interestingly, $\Pi^d = 0$ corresponds to Brock, Magee, and Young's **economic black hole**[10] and could be considered as the worst possible noncooperative Nash equilibrium outcome in the tariff game.

4.2 Comparative Static Behaviour of the Endogenous Tariff Rate

Substituting $\Pi^d = 0$ into equation (15) and solving for P_1 we obtain

$$P_1 = \left(\frac{\Theta_1 \sigma_2}{\Theta_2 \sigma_1}\right)\frac{Y_2}{Y_1}. \qquad (18)$$

Linearizing equation (18) around the ‘observed’ general equilibrium point we obtain

$$p_1^o = (\theta_1 - \theta_2) + (y_2^o - y_1^o) \qquad (19)$$

At unchanged bargaining powers, whatever they may be, equation (19) reduces to

$$p_1^o = (y_2^o - y_1^o). \qquad (20)$$

Equation (20) shows that if some exogenous shock led the outputs of the two sectors to grow at different rates, then the relative price of the commodity growing at a faster rate will fall. To get a more precise meaning out of equation (20), we linearize the rest of the equations listed in Table 1 and obtain

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10 Magee, Brock and Young have defined in the context of a long-run model an economic black hole as a situation in which all of the economy's factor endowment is exhausted in predatory lobbying. See Magee, Brock and Young (1989: 223). A short-run analogue of their economic black hole can be defined as a situation in which all rental incomes are exhausted in predatory lobbying and the tariff rate that emerges at this equilibrium could be defined as the black hole tariff rate.

the linearized version of the policy endogenous general equilibrium model (PEGEM) that is listed in Table 2. We have omitted four equations - namely, equations (10), (2), (3), and (4) - which are of no consequence to the following analysis. Note that the equations (21) - (25) are the linearized versions of the equations (1), (5), (6), (7) and (8) respectively. As a notational convention, superscript “o” indicates that the shares or the variable has been defined around the observed (base year) equilibrium point.

The system of equations listed in Table 2 contains 9 equations in 9 endogenous variables, including the tariff rate. The system can be solved and the elasticity formulae can be obtained for each of the endogenous variables with respect to each of the exogenous variables.

Table 2

Linearized Version of the Model of a Small Open Political Economy

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The Economic Sphere:

Output supply functions:

$$y_j^o = k_j + \sigma_j \left(\frac{S_{Lj}^o}{S_{Kj}^o} \right) (p_j^o - w^o); \qquad j = 1, 2. \tag{21}$$

Labour demand functions:

$$l_j^o = k_j + \frac{\sigma_j}{S_{Kj}^o} (p_j^o - w^o); \qquad j = 1, 2. \tag{22}$$

The labour market equilibrium condition:

$$l = \sum_{j=1}^{2} \lambda_j^o l_j^o. \tag{23}$$

Price equations:

$$p_1^o = p_1^* + \tau^o \; t, \tag{24a}$$

and, $p_2^o = 0$. (24b)

Sectoral rental rates:

$$r_j^o = \frac{1}{S_{Kj}^o} (p_j^o - S_{Lj}^o w^o); \qquad j = 1, 2 \quad . \tag{25}$$

The Political Sphere:

Condition for Nash bargaining equilibrium:

$$p_1^o = (y_2^o - y_1^o). \tag{20'}$$

4.2.1 Comparative Static Responses of the Tariff Rate

First we solve equations (22) and (23) for changes in the wage rate, and then we use it in equation (21) to solve for the response of sectoral outputs to changes in factor endowment variables and the domestic relative price. These results are then used in (20') to obtain

$$p_1^o = B^{-1}\left[\left(\frac{\lambda_1^o\sigma_1}{S_{K1}^o} + \frac{\lambda_2^o\sigma_1 S_{L1}^o}{S_{K1}^o} + \lambda_2^o\sigma_2\right)k_2 - \left(\frac{\lambda_2^o\sigma_2}{S_{K2}^o} + \frac{\lambda_1^o\sigma_2 S_{L2}^o}{S_{K2}^o} + \lambda_1^o\sigma_1\right)k_1 + \left(\frac{\sigma_2 S_{L2}^o}{S_{K2}^o} - \frac{\sigma_1 S_{L1}^o}{S_{K1}^o}\right)l\right]; \quad (26)$$

where $$B = \frac{\lambda_1^o\sigma_1}{S_{K1}^o} + \frac{\lambda_2^o\sigma_2}{S_{K2}^o} + \left(\frac{\sigma_2 S_{L2}^o}{S_{K2}^o}\frac{\lambda_1^o\sigma_1}{S_{K1}^o} + \frac{\sigma_1 S_{L1}^o}{S_{K1}^o}\frac{\lambda_2^o\sigma_2}{S_{K2}^o}\right) > 0.$$

Recalling that the wedge between the domestic relative price and the world relative price is the tariff rate (see equation (24a) in Table 2) it further follows from equation (26) that

$$\tau^o\ t = -p_1^* + B^{-1}\left[\left(\frac{\lambda_1^o\sigma_1}{S_{K1}^o} + \frac{\lambda_2^o\sigma_1 S_{L1}^o}{S_{K1}^o} + \lambda_2^o\sigma_2\right)k_2 - \left(\frac{\lambda_2^o\sigma_2}{S_{K2}^o} + \frac{\lambda_1^o\sigma_2 S_{L2}^o}{S_{K2}^o} + \lambda_1^o\sigma_1\right)k_1 + \left(\frac{\sigma_2 S_{L2}^o}{S_{K2}^o} - \frac{\sigma_1 S_{L1}^o}{S_{K1}^o}\right)l\right]. \quad (27)$$

Some interesting results follow from equation (27). Before we discuss those results, recall the definitions of some of the variables and parameters involved in these results. First, $\tau^o = 1/(1+T_1^o)$, where T_1 is the tariff rate and $t = 100\times dT_1$ is the change in the percentage point (not the percentage change in the tariff rate) of the tariff rate. If we exclude the possibility of subsidizing imports or taxing exports at rates greater than 100% as practically implausible, then τ is always positive. Furthermore, the share parameters $\lambda_1, \lambda_2, S_{K1}, S_{K2}, S_{L1}$ and S_{L2} are always positive. The elasticities of factor substitution σ_1 and σ_2 are also positive.

By setting any three of the four exogenous variables - p_1^*, k_1, k_2 and l , equal to zero in turn we can obtain the direction of comparative static responses of the tariff rate as follows:

$$\frac{\tau^o t}{p_1^*} = -1 < 0; \quad (28)$$

$$\frac{\tau^o\ t}{k_1} = -B^{-1}\left(\frac{\lambda_2^o\sigma_2}{S_{K2}^o} + \frac{\lambda_1^o\sigma_2 S_{L2}^o}{S_{K2}^o} + \lambda_1^o\sigma_1\right) < 0; \quad (29)$$

$$\frac{\tau^o\ t}{k_2} = B^{-1}\left(\frac{\lambda_1^o\sigma_1}{S_{K1}^o} + \frac{\lambda_2^o\sigma_1 S_{L1}^o}{S_{K1}^o} + \lambda_2^o\sigma_2\right) > 0; \tag{30}$$

and

$$\frac{\tau^o\ t}{l} = B^{-1}\left(\frac{\sigma_2 S_{L2}^o}{S_{K2}^o} - \frac{\sigma_1 S_{L1}^o}{S_{K1}^o}\right) \gtrless 0 \ as\ \frac{\sigma_2 S_{L2}^o}{S_{K2}^o} \gtrless \frac{\sigma_1 S_{L1}^o}{S_{K1}^o}. \tag{31}$$

These results can be summarized as follows. For small changes, other things remaining the same:

Result 1 Any change in the relative price of the import competing good in the world market is exactly compensated by domestic tariff changes leaving the domestic relative price unchanged;

Result 2 If a sector experiences an exogenous increase in the stock of its specific factor, then the rate of protection awarded to this (growing) sector will decline and the rate of protection awarded to the other sector will rise;

Result 3 An exogenous increase in the supply of the mobile factor (labour) in the economy may lead to a fall or a rise in the rate of protection awarded to a sector depending on the relative ease of factor substitution and factor intensity between the two sectors.

4.2.2 Discussion of the Results

Result 1 states that the domestic economy will be fully insulated against terms of trade shocks by compensatory tariff adjustments. No reallocation of resources will take place. Why do we get this result?

To illustrate, suppose that $\Pi(P_1^*)$ represent the distribution of rents at free trade, and $\Pi(P_1^o)$ represent the payoffs at the initial Nash bargaining equilibrium. So at $\Pi(P_1^o)$ players' generalized fears of ruin are equal. Suppose further that, other things the same, the price of the home exportable good rises in the world market. Let the new world relative price of the import competing good be $\overline{P}_1^*$ such that $\overline{P}_1^* < P_1^*$.

At an unchanged tariff rate the relative price of the import competing good in the domestic market will fall at the same proportional rate as it did in the world market. Let the new domestic relative price be $\overline{P}_1$. A conventional policy-exogenous general equilibrium model would, in this case, predict that the rental income of the import competing sector will fall and that of the exporting sector will rise. Thus, the players will slide from the point $\Pi(P_1^o)$ to the point $\Pi(\overline{P}_1)$ along the RTF (see Figure 5). As a result, relative to the reference point (origin), the gain of player 1 declines and that of player 2 increases.

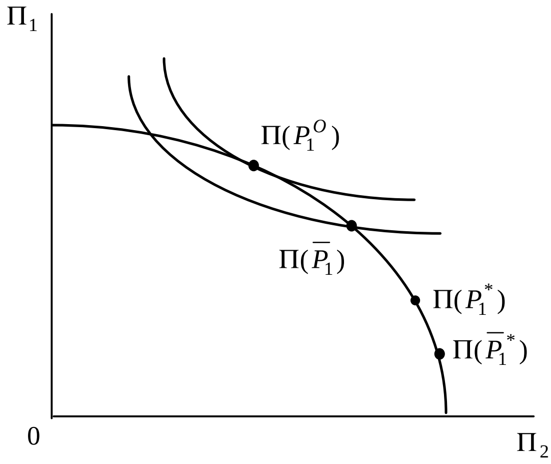

Figure 5: Terms of trade gain and the tariff rate

Since each player's fear of ruin (disagreement) depends directly on the size of the gain relative to his minimum expectation, it follows that at $\overline{P}_1$ player 2 will be more fearful of player 1 declaring disagreement than player 1 fears of player 2 declaring disagreement. This inequality causes disequilibrium in the political market. To restore equality in players' generalized fear of ruin player 2's payoff has to be reduced and/or that of player 1 has to be raised by tariff changes. Therefore, in the new sequence of bargaining process, prompted by the world price change, player 2 will ultimately concede, and the tariff rate will rise in the new equilibrium. The new tariff rate will be such that the induced domestic relative price remains unaffected. This is so because the RTF and the level curves of the generalized Nash product are unaffected by changes in the international terms of trade, and therefore, the equilibrium point will also remain unaffected.

Result 2 The following explanation can be given to the result that an exogenous increase in the stock of the specific factor in the import competing sector would lead to a fall in the tariff rate and/or a rise in the export subsidy. The remaining part of Result 2 (ie., the effect of an increase in the stock of the specific factor in the exporting sector) and Result 3, (ie., the effect of an increased supply of the mobile factor) can be explained in a similar way.

To simplify the diagrammatic exposition, we have assumed in Figure 6 that production functions are Cobb-Douglas in both sectors. Suppose that E_0 is the initial equilibrium of the tariff game. Suppose further that the capital stock in sector 1 increases exogenously and the RTF shifts upwards to C'D. A policy-exogenous general equilibrium model would predict that, at an unchanged tariff rate and hence at an unchanged domestic relative price, the output and rental income of sector 1 will increase and the output and rental income of sector 2 will fall. Employment in sector 2 falls as the wage rate is pushed up by increased activity in sector 1. Let E_1 describe the combination of the rental incomes (in economic equilibrium) of the two sectors at unchanged commodity prices.

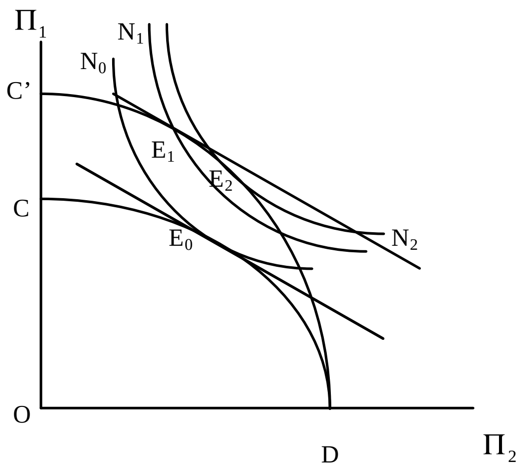

Figure 6: Capital accumulation in the import competing sector and the tariff rate

The slopes of the frontiers at E_0 and at E_1 should be equal because it follows from equation (14b) that with Cobb-Douglas production functions the slope of the RTF depends only on the relative price. The absolute slope of the Nash product curve at E_1, however, will exceed the slope of the Nash product curve at E_0 (by homotheticity[11], see the curve labelled N_1). Therefore, the curve N_1 will not be tangent to the frontier C'D at E_1. The difference in the absolute values of the slopes indicates that at E_1 player 1's fear of ruin will exceed player 2's fear of ruin. Therefore, in the new bargaining process, induced by the shock, player 1 will concede and the tariff rate will fall, leading to a fall in the relative price of commodity 1 in the domestic market. The new bargained equilibrium will be attained at E_2 on C'D where both players are equally fearful of ruin. Employment, output and real-rental income of the exporting sector may very well increase, as shown in the Figure by point E_2, as a result of capital accumulation in the import-competing sector.

5 Summary

This paper attempted to study the endogenous response of the tariff rate to changes in exogenous variables such as world price and domestic factor endowment. In so doing it employed a bargain-theoretic framework to derive an operational general equilibrium model of a political economy. A comparative static exercise did reveal that the tariff rate will change to fully offset the effects of terms of trade changes on domestic prices, and will fall if domestic factor endowment change leads to an increase in the relative rental income of the protected sector. The key to this result is held by changes in the relative fear of ruin. Whether be it in the world price or the domestic factor endowment, if a given exogenous change causes the rental income of the protected sector to rise relative to that of the

11 When the payoffs at the point of minimum expectation are zero for both players, then the generalized Nash product reduces to a Cobb-Douglas type function. So, the generalized Nash product is clearly homothetic for the same reason as the Cobb-Douglas production function is - that the slope of the level curves at any point depend only on the ratio of the payoffs at that point.

unprotected sector, then the protected sector becomes more fearful of ruin (breakdown of agreement) and is prepared to forego some rental income rather than risk the whole gain over his minimum expectation. As a result the tariff rate will fall.

Though consistent with general intuition and some of previous studies in terms of the direction and magnitude, the insulating response of the tariff rate with respect to terms of trade changes is very strong. It should be noted, however, that the magnitudes of these results are subject to the choice of origin as the point of minimum expectation of the barganing parties. This choice made the maximand (the Nash product) to depend only on the level of current rental incomes which can easily be seen as a parallel expression to a Stigler-Peltzman type political support function and hence, the insular result. As indicated by Hillman (1982) result or Long and Vousden (1991) result, the endogenous response of the tariff rate to a terms of trade shock can be weakened by a suitable choice of the reference point. What would be the appropriate point of reference in this kind of game is a topic for future research.

The most important finding of this study is that the endognous response of the tariff rate to domestic factor endowment change is predictable. The tariff rate falls if any change in factor endowment causes the protected sector to gain relatively more than the unprotected sector at the going tariff rate. The implication of this result is that a country would be prepared for unilateral or multi-lateral tariff reduction if its import-competing sector has experienced a substantial accumulation of capital stock or has experienced a substantial growth in factor productivity or has experienced a growth in labour force if its import-competing sector is more labour-intensive. An attempt to liberalize trade without any such changes in the economic environment can be expected to meet strong opposition in the political sphere. Another obvious implication of this study is that long-term forecasts based on models that treat policy variables as exogenously given have to be treated with caution.

Appendix 1: Derivation of the First and Second Order Derivatives of the RTF

Setting $k_1 = k_2 = l = 0$ and solving equations (21) to (25) listed in Table 2, which describe changes in the economic sphere of the political economy, we obtain the following elasticity formulae:

$$\frac{r_1^o}{p_1^o} = A^{-1}\left(\frac{\lambda_1^o\sigma_1}{S_{K1}^o} + \frac{\lambda_2^o\sigma_2}{S_{K1}^o S_{K2}^o}\right) > 1, \tag{A1}$$

$$\frac{r_2^o}{p_1^o} = -A^{-1}\frac{\lambda_1^o\sigma_1}{S_{K1}^o}\frac{S_{L2}^o}{S_{K2}^o} < 0, \tag{A2}$$

$$\frac{l_1^o}{p_1^o} = A^{-1}\frac{\lambda_2^o\sigma_1\sigma_2}{S_{K1}^o S_{K2}^o} > 0, \tag{A3}$$

$$\frac{l_2^o}{p_1^o} = -A^{-1}\frac{\lambda_1^o\sigma_1\sigma_2}{S_{K1}^o S_{K2}^o} < 0, \tag{A4}$$

$$\frac{w^o}{p_1^o} = A^{-1}\frac{\lambda_1^o\sigma_1}{S_{K1}^o} > 0, \tag{A5}$$

$$\frac{s_{L1}^o}{p_1^o} = (\sigma_1 - 1)\left(1 - A^{-1}\frac{\lambda_1^o\sigma_1}{S_{K1}^o}\right) \geq 0 \quad if \ \sigma_1 \geq 1 \tag{A6}$$

$$\frac{s_{L2}^o}{p_1^o} = -(\sigma_2 - 1)A^{-1}\frac{\lambda_1^o\sigma_1}{S_{K1}^o} \leq 0 \quad if \quad \sigma_2 \geq 1 \tag{A7}$$

and $$A = \frac{\lambda_1^o\sigma_1}{S_{K1}^o} + \frac{\lambda_2^o\sigma_2}{S_{K2}^o} > 0. \tag{A8}$$

Where, all the lower case roman letters are percentage changes of the corresponding variables written in upper case. s_{Lj}^o represents percentage change in the distributive share of labour, S_{Lj}^o, in industry *j* around the observed equilibrium whereas λ_j represents the share (not its percentage change) of industry *j* in total employment of labour and σ_s represents elasticity of factor substitution in sector j.

We will use these elasticity results to derive the slope and curvature properties of the RTF.

A change in the rental income can arise only if the domestic relative price changes, since other exogenous variables are held fixed. We, therefore, have

$$\begin{aligned}\frac{d\Pi_1}{d\Pi_2} &= \frac{K_1}{K_2}\left(\frac{d(R_1 / P_1)}{dP_1}\bigg/\frac{dR_2}{dP_1}\right) \\ &= \frac{K_1}{K_2}\frac{R_1 / P_1}{R_2}\left(\frac{r_1^o / p_1^o - 1}{r_2^o / p_1^o}\right)\end{aligned} \tag{A9}$$

Using (A1) and (A2) in (A9) we obtain

$$\frac{d\Pi_1}{d\Pi_2} = -\frac{\Pi_1}{\Pi_2}\left(\frac{\lambda_2^o \sigma_2 S_{L1}^o}{\lambda_1^o \sigma_1 S_{L2}^o}\right) < 0 \tag{A10}$$

Which can also be written as

$$\frac{d\tilde{R}_1}{dR_2} = -\frac{\tilde{R}_1}{R_2}\left(\frac{\lambda_2^o \sigma_2 S_{L1}^o}{\lambda_1^o \sigma_1 S_{L2}^o}\right). \tag{A11}$$

where, $\tilde{R}_1 = R_1 / P_1$.

Differentiating both sides of (A11) with respect to R_2 yields, on further simplification,

$$\frac{d^2\tilde{R}_1}{dR_2^2} = -\frac{\tilde{R}_1}{R_2^2}\left(\frac{\lambda_2^o \sigma_2 S_{L1}^o}{\lambda_1^o \sigma_1 S_{L2}^o}\right)\times \left[\left(\frac{R_2 d\tilde{R}_1}{\tilde{R}_1 dR_2} - 1\right) + R_2\left\{\left(\frac{d\lambda_2^o}{\lambda_2^o dR_2} - \frac{d\lambda_1^o}{\lambda_1^o dR_2}\right) + \left(\frac{dS_{L1}^o}{S_{L1}^o dR_2} - \frac{dS_{L2}^o}{S_{L2}^o dR_2}\right)\right\}\right] \tag{A12}$$

Using equation (A11), equation (A12) can be re-written as

$$\frac{d^2\tilde{R}_1}{dR_2^2} = -\frac{\tilde{R}_1}{R_2^2}\left(\frac{\lambda_2^o \sigma_2 S_{L1}^o}{\lambda_1^o \sigma_1 S_{L2}^o}\right)\times \left[-(\sigma_2\lambda_2^o S_{L1}^o + \sigma_1\lambda_1^o S_{L2}^o) + \sigma_1\sigma_2 + (1-\sigma_1)(\sigma_2\lambda_2^o - \sigma_2\lambda_2^o S_{L1}^o) + (1-\sigma_2)(\sigma_1\lambda_1^o - \sigma_1\lambda_1^o S_{L2}^o)\right] \tag{A13}$$

Upon a further simplification of equation (A13), using the adding up properties of the distributive and employment shares, we get

$$\frac{d^2\tilde{R}_1}{dR_2^2} = -\frac{\tilde{R}_1}{R_2^2}\left(\frac{\lambda_2^o \sigma_2 S_{L1}^o}{\lambda_1^o \sigma_1 S_{L2}^o}\right)\times \left[\sigma_2\lambda_2^o S_{L1}^o(\sigma_1 - 1) + \sigma_1\lambda_1^o S_{L2}^o(\sigma_2 - 1) + \sigma_1\lambda_1^o S_{K2}^o + \sigma_2\lambda_2^o S_{K1}^o\right] \tag{A14}$$

Thus, it is clear from the right hand side of equation (A14) that $\sigma_i \geq 1$ for each *i* is sufficient for $\frac{d^2\tilde{R}_1}{dR_2^2} < 0$. In other words, this means a sufficient condition for $\frac{d^2\Pi_1}{d\Pi_2^2} < 0$ is $\sigma_i \geq 1$ for each *i*.

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