INTERNATIONAL ECONOMIC REVIEW
Vol. 38, No. 3, August 1997

GROWTH, SPECIALIZATION, AND TRADE LIBERALIZATION*

BY MICHAEL B. DEVEREUX[†1]

University of British Columbia, Canada

This paper examines a two-way interaction between trade liberalization and economic growth. Through increasing returns to specialization, international trade can increase world growth rates. But growth alters patterns of comparative advantage, changing the incentives to levy tariffs in a dynamic tariff game between governments. Two types of equilibria are analyzed. In a *Tariff War* equilibrium, growth rates are low, tariffs are high and rising, the ratio of exports to income, the trade ratio, is low, and falls to zero asymptotically. In a *Trade Liberalization* equilibrium, growth rates are high, tariffs are low and falling, the trade ratio is higher, and is increasing over time.

1. INTRODUCTION

This paper develops a simple dynamic model of tariff setting in which economic growth and specialization are the main driving forces behind ongoing trade liberalization. Trade liberalization is interpreted in a noncooperative sense, as an equilibrium of a dynamic tariff game between governments, in which tariff rates tend to fall over time. Depending on conditions, tariffs will either fall to zero, so that free trade is sustained, or will fall gradually to a low but positive minimum level, representing the greatest amount of trade liberalization that can be supported. The central idea in the model is to highlight a force by which economic growth encourages gradual trade liberalization. When countries begin to liberalize trade restrictions, economic growth is stimulated by the reallocation of factors along the lines of comparative advantage. Growth is then able to sustain lower and lower tariff rates in the dynamic game between governments. This scenario, however, need not always occur. The model contains another, *tariff war* equilibrium, in which growth rates are low and tariffs are high and rising over time.

There is substantial evidence relating economic growth, both at the world level and for individual countries, to growth in the volume of international trade (e.g., World Bank Report 1987). Table 1 gives data on export and GDP growth rates for a sample of industrial economies going back to the eighteenth century. In all but the twentieth century interwar period, growth in exports exceeds economic growth.

* Manuscript received November 1993.

† E-mail: *devm@unixg.ubc.ca*

1 I thank Dan Bernhardt, Hal Cole, Wilfred Ethier, Bentley Macleod, and Alan Stockman for comments on a previous version of this paper. Thanks also to Katharine Neiss and Scott Taylor for suggestions. The comments of two anonymous referees also improved the paper. Financial Support from the Social Science and Humanities Research Council of Canada is gratefully acknowledged.

TABLE 1*
GDP AND EXPORT GROWTH 1720–1985

Years	1720–1820	1821–1870	1871–1913	1914–1950	1951–1973	1974–1979	1980–1985
GDP	1	1.9	2.25	1.85	5.2	2.5	2
Exports	1.75	4.5	4.3	.45	9.3	6	3.5

*Average for Japan, Germany, Italy, France, U.K., and U.S.A. (World Bank Report 1987).

TABLE 2*
U.S. IMPORT TARIFF: 1930 AND POSTWAR (PERCENTAGE AD VALOREM EQUIVALENT TARIFF RATE)

Year	1930	1947–56	1967	1979	1987
Dutiable Imports	53	25	12	8.3	5.8
Total Imports	18	9	7	6.2	4.3

*Whalley 1985, Table 1.3. World Bank Report 1987.

While the interwar era was extremely unfavorable for international trade,[2] the post-second-world war period saw dramatic multilateral tariff reductions among industrial countries, stimulated by both GATT (now WTO) and the European Community. Table 2 compares average US import tariffs in 1930 with those following the successful GATT rounds in the postwar period. In the post-1973 period, growth rates of industrial countries fell significantly, as did growth in world trade. While tariffs have continued to fall since then, the momentum of trade liberalization has been slowed down by an upsurge of nontariff barriers (Bhagwati 1988).

This evidence suggests that there may be a link between economic growth and successful trade liberalization. The model presented here attempts to capture this link. In the model, if income growth rates are too low (after opening up to trade), trade liberalization cannot be sustained. Tariffs will be high and rising over time, with the growth of international trade lower than that of income. By contrast, high income growth rates sustain continued trade liberalization and are associated with growth in trade volume that exceeds growth in income.

The essential feature of the model is the presence of increasing returns to specialization that arise from learning-by-doing economies that are external to the firm. This framework is taken from international models of *endogenous growth* set out by Lucas (1988) and Krugman (1987).[3] The focus here is on a symmetric version of the model in which international trade tends to increase growth rates of all countries. But trade itself tends to reinforce patterns of comparative advantage over time. This can be thought of as a form of *dynamic gains from trade*: unit costs in exportables production falls persistently relative to unit costs in importables. In this

[2] The writers of the time talked of the 'diminishing importance of international trade' (see Viner 1950).

[3] Other papers on the relationship between international trade and economic growth are Grossman and Helpman (1990, 1991a, b), Romer and Rivera-Batiz (1991), Taylor (1994). Backus, Kehoe and Kehoe (1993) examine the empirical support for these models.

way, trade can generate a growing interdependence among trading partners. A trade liberalization scheme is a vehicle by which this interdependence fosters growing tariff cooperation between countries.

Two types of equilibria to the tariff game are identified. In one, strategies depend only on current state variables. These are called *Markov-Perfect* equilibria. In the second, referred to as a *Trade Liberalization* equilibrium, strategies may be history-dependent, depending upon the actions played in the past. There are two Markov-perfect equilibrium outcomes: autarky, specifying prohibitive tariffs forever, and a tariff equilibrium that allows for trade but with imperfect specialization. The latter equilibrium is Pareto superior to autarky. It is characterized by growth rates higher than autarky, but lower than under trade liberalization. The restricted trade equilibrium also has the characteristics of a *tariff war* in that tariffs tend to rise over time.

The *Trade Liberalization* equilibrium has very different characteristics. The method of construction is to specify a sequence of tariffs that are chosen along an equilibrium path, with any defection being followed by a punishment phase. The maximal credible punishment, in the sense of Abreu (1988), is autarky forever (see Dixit 1987). This supports the maximal degree of implicit cooperation. The key result of the paper is that with learning-by-doing effects of specialization, the threat of autarky tends to grow relative to the incentive to defect, since autarky involves diverting resources to the high-cost importable sector. This means that the lowest sustainable tariffs fall progressively over time. If government discount rates are sufficiently low, this leads to unrestricted trade in finite time. Otherwise, tariffs fall to an irreducible minimum.

The trade liberalization equilibrium is more likely to be sustainable, the higher is productivity growth, the lower is the extent of international spillovers of knowledge, and the lower are subjective discount rates. Initial conditions, in the form of differences between countries in the sectoral composition of knowledge capital, are also important. If trade liberalization cannot be sustained, then the best that can be attained is a tariff war equilibrium. But because the tariff war equilibrium involves increased specialization, there is the possibility of an endogenous switch to a trade liberalization path at some future date. With low productivity in learning-by-doing, however, this potential move to tariff cooperation will take a very long time to occur.

The model captures some aspects of the interwar international trade experience, as well as the progressive multilateral tariff reduction of the postwar world. For example, the interwar period was characterized by low income growth rates. Many European countries maintained tariffs to protect industries that matured during World War I. Thus, two preconditions for the trade liberalization, namely high income growth and differences in initial conditions among trading partners, were not in place. By contrast, the postwar period saw high rates of economic growth. In accordance with the model set out below, this is precisely the kind of environment that fosters trade liberalization.

One implication of the model is that trade liberalization tends to be irreversible. This seems to be somewhat at odds with recent events in which trade policy appears to be cyclical, with episodes of trade liberalization sometimes being followed by an escalation of barriers to trade. In the conclusion, I suggest some extensions that might allow the model to capture these elements.

Section 2 sets out the basic model. Section 3 constructs the world competitive equilibrium for given tariff regimes. Section 4 then looks at the two types of equilibria to the dynamic tariff game and examines their characteristics. Some discussion and conclusions follow.

2. THE MODEL

There are two countries, called Home and Foreign. Foreign variables are denoted by an asterisk. There is a measure one of consumers in each country with identical preferences defined over consumption of goods 1 and 2. Consumers have period utility functions given by

$$U_t = c_{1t} c_{2t} \tag{1}$$

$$U_t^* = c_{1t}^* c_{2t}^* \tag{2}$$

As long as tariffs are not prohibitive, consumers have the option to trade in commodities with residents of the other country. International capital markets are ruled out. In the symmetric model below, these markets would not be used in equilibrium anyway.[4]

Let governments in each country discount their residents' future consumption at rate δ (< 1). Lifetime utility from period 0 onwards is then $\Sigma_0^\infty \delta^t U_t$ and $\Sigma_0^\infty \delta^t U_t^*$ for Home and Foreign, respectively.

Production technologies are Ricardian, with a fixed labor supply.

$$y_{1t} = a_t l_{1t}, \qquad y_{2t} = b_t l_{2t}, \qquad l_{1t} + l_{2t} = 1 \tag{3}$$

$$y_{1t}^* = b_t l_{1t}^*, \qquad y_{2t}^* = a_t l_{2t}^*, \qquad l_{1t}^* + l_{2t}^* = 1 \tag{4}$$

where y_{it} is Home production of good i in period t and l_{it} is the fraction of the labor force, the total of which is normalized to unity, that is devoted to the production of good i. Foreign production technologies are analogous.

Labor productivity depends upon the current state of technical knowledge. This knowledge is sector-specific, and accrues only through production of the good, that is, through learning-by-doing. Knowledge may be communicated across international borders, through either reverse engineering or direct communication.[5] This is

[4] The absence of international capital markets is in line with previous literature on dynamic tariff games. See, for instance, Dixit (1987).

[5] See Lucas (1988) and Krugman (1987). From (5), learning-by-doing continues forever, as long as production is taking place. This is a simple way to allow for continual growth, but is counterfactual in the literal sense, since the learning curve for any individual commodity would be expected to flatten out at some point. Stokey (1988) and Young (1991, 1993) develop models in which learning-by-doing takes place sequentially along a continuum of goods, with goods of a lower quality or technical sophistication being produced first.

modeled in the following way:

(5a) $$a_t = \alpha h_{at} \qquad h_{at} = h_{at-1}(1 + \sigma l_{1t-1} + \sigma\theta l^*_{1t-1})$$

(5b) $$a^*_t = \alpha h^*_{at} \qquad h^*_{at} = h^*_{at-1}(1 + \sigma l^*_{2t-1} + \sigma\theta l_{2t-1})$$

(5c) $$b_t = \beta h_{bt} \qquad h_{bt} = h_{bt-1}(1 + \sigma l_{2t-1} + \sigma\theta l^*_{2t-1})$$

(5d) $$b^*_t = \beta h^*_{bt} \qquad h^*_{bt} = h^*_{bt-1}(1 + \sigma l^*_{1t-1} + \sigma\theta l_{1t-1})$$

where h_{it} represents the aggregate stock of *specialist human capital* that has been accumulated in activity i at date t, for $i = a, b$. A higher h_{it} raises labor productivity in activity i linearly. Stocks of human capital are distinguished by the letters a and b. In Home (Foreign), the $h_{at}(h^*_{at})$ represents human capital specialized in the production of good 1 (good 2) and $h_{bt}(h^*_{bt})$ the corresponding stock for good 2 (good 1). Initial conditions are chosen so that in a trading equilibrium, countries tend to specialize in the good corresponding to the 'a' subscripted human capital stock.

The dynamics of human capital are determined by the share of the fixed factor devoted to the production of the good. The more a country specializes in the production of a particular good, the higher is the growth rate of human capital specialized in producing that good, where the underlying growth potential is determined by the productivity factor σ. International spillovers of technological knowledge within a sector are introduced by the parameter θ. As long as θ is between 0 and 1, an increase in world specialization always leads to an increase in growth rates.

I also restrict attention to symmetric strategies in a tariff game. In any equilibrium of the symmetric game, Home and Foreign residents have equal welfare. I think of this as trade liberalization between *similar* countries (e.g., between industrial countries, rather than between industrial and nonindustrial economies, where learning-by-doing may differ substantially across goods).

I assume that spillovers continue to take place in autarky. Although no reverse engineering occurs in autarky, there may be other forms of indirect communication of technical knowledge. Since I have modeled spillovers as being invariant to the level of international trade, the assumption that they cease under autarky would impart a discontinuity to the growth process. It will be shown, however, that this assumption has no important effect on any of the results.

Learning-by-doing effects are considered to be an industry-wide phenomenon, completely external to any firm. Firms behave competitively, maximizing profits atemporally. I characterize the competitive equilibrium, conditional on tariff rates, and then address the choice of optimal tariff rates in a game between governments. An important restriction is placed on the structure of moves within a period.

At the start of each period, workers disperse between sectors, anticipating wage rates in each sector. After that, workers are in place, unable to move until the start of the next period. Given labor allocation across sectors, at the end of the period goods markets clear, determining prices and wages, and governments choose tariff rates. In equilibrium, with rational expectations, anticipated and actual wage rates will coincide. The important point about this setup is that at the time governments choose tariffs, the sectoral allocation of resources is taken as given. This assumption builds into the model an incentive to impose tariffs that cannot be avoided by ex-post factor reallocation between sectors.[6]

3. COMPETITIVE EQUILIBRIUM FOR GIVEN TARIFFS

In this section I derive world competitive equilibrium solutions for situations of autarky, free trade, and positive but nonprohibitive tariffs. To ensure finite levels of welfare assume that $\delta(1+\sigma)^2 < 1$ holds in the remaining analysis. In addition, assume that $h_{a0} = h^*_{a0}$ and $h_{bo} = h^*_{bo}$, and $\beta h_{bo}/\alpha h_{ao} < 1$. The first two conditions are for symmetry, while the third condition ensures that Home (Foreign) has an incentive to specialize in good 1 (2).

3.1. Autarky. Agents in Home choose consumption so that $P_t^A c_{1t} = c_{2t}$, for any time t, where P_t^A is the autarky relative price of good 1. If both goods are to be produced in autarky, wage rates must be equal in each sector, so $P_t^A = (b_t/a_t)$. By market clearing, $c_{1t} = a_t l_{1t}$ and $c_{2t} = b_t l_{2t}$. Combining gives $l_{1t} = l_{2t} = \frac{1}{2}$.

Period utility from autarky is $\frac{1}{4}a_t b_t$. Given $l_{it} = \frac{1}{2}$, and since the same solution holds for Foreign, the (gross) growth rate of output is $(1 + (\sigma/2)(1+\theta))$ in each sector, which is also the growth rate of national income.

Autarky conditions for Foreign are exactly analogous, except that the Foreign autarky price is $P_t^{*A} = a_t/b_t$. Now, using (3), (4), and (5), period 0 welfare (for each country) under autarky is

$$V^A = \sum_0^\infty \delta^t U_t = \frac{\frac{1}{4}\alpha\beta h_{a0} h_{b0}}{1 - \delta\left(1 + \frac{1}{2}\sigma(1+\theta)\right)^2} \tag{6}$$

3.2. Free trade. Trade patterns will depend upon productivity, which in turn depends upon past production. For the assumptions on initial conditions, opening up trade at $t = 0$ will lead Home to specialize in good 1 and Foreign to specialize in good 2. World output of each good will be a. Each country will consume half of this, and per period utility for each is $\frac{1}{4}a_t^2$. The equilibrium world price of good 1 is unity and the rate of growth of world income is $(1+\sigma)$. Again, using (3), (4), and (5), total welfare under free trade is

$$V^F = \sum_0^\infty \delta^t U_t = \frac{\frac{1}{4}\alpha^2 h_{a0}^2}{1 - \delta(1+\sigma)^2} \tag{7}$$

There are two types of gains from trade. The first is seen by comparing the expression $a^2 h_{a0}^2$ in (7) with $\alpha\beta h_{a0} h_{b0}$ in (6). This is the static gain from specialization. In addition, the effective discount factor under free trade, $\delta(1+\sigma)^2$, is greater

[6] Lapan (1988) and Staiger and Tabellini (1987) have pointed out that with temporary fixity of factors, we can define a *time consistent* tariff that is in general higher than the classic *optimal tariff*. Here we are, in Lapan's terminology, dealing with *time-consistent tariffs*.

than the corresponding autarky discount factor, $\delta(1+\frac{1}{2}\sigma(1+\theta))^2$, as long as spillovers of knowledge are incomplete. This captures the *dynamic gains from trade*. These dynamic gains will be crucial for a successful trade liberalization.

3.3. Tariff-distorted equilibrium. Now we analyze trading equilibria with positive but nonprohibitive tariffs. Without loss of generality, and to simplify notation, time subscripts are omitted for the rest of this section.

For given sectoral outputs (after labor supply has been allocated), Home consumers face the constraint $Pc_1 + \tau c_2 = Py_1 + \tau y_2 + R$, where τ is the gross tariff rate and P is the world price of good 1. It is assumed that all tariff revenue is distributed back to consumers in the form of a lump-sum transfer. For Home, this is given by R, so that $R = (\tau - 1)(c_2 - y_2)$. It is easy to show that consumers' demand functions are

$$c_1 = \left(\frac{\tau}{(1+\tau)P}\right)(Py_1 + y_2), \qquad c_2 = \left(\frac{1}{(1+\tau)}\right)(Py_1 + y_2) \tag{8}$$

$$c_1^* = \left(\frac{1}{(1+\tau^*)P}\right)(Py_1 + y_2), \qquad c_2^* = \left(\frac{\tau^*}{(1+\tau^*)}\right)(Py_1^* + y_2^*) \tag{9}$$

where τ^* is the foreign tariff rate, and so forth.

For a fixed labor allocation, world production of each good is given. Then without any loss of generality let Home produce a share k (where $0 < k < 1$) of total world output of good 1, and $1 - m$ (where $0 < m < 1$) of good 2. Competitive equilibrium implies a world market clearing price given by

$$P = \frac{(\tau(1+\tau^*)(1-m) + (1+\tau)m)Y_2^w}{((1+\tau^*)k + \tau^*(1+\tau)(1-k))Y_1^w} \tag{10}$$

where Y_i is the world output of good i.

Labor supply is determined according to the inequalities[7]

$$\text{(11a)} \quad (i)\ Pa > b\tau \Rightarrow l_1 = 1, \quad (ii)\ Pa = b\tau \Rightarrow 0 \le l_1 \le 1, \quad (iii)\ Pa < b\tau \Rightarrow l_1 = 0$$

$$\text{(11b)} \quad (i)\ Pb\tau^* < a \Rightarrow l_2^* = 1, \quad (ii)\ Pb\tau^* = a \Rightarrow 0 \le l_2^* \le 1, \quad (iii)\ Pb\tau^* > a \Rightarrow l_2^* = 0$$

In order to determine whether specialization actually occurs one has to know the equilibrium tariff rates. Notice though, that in a symmetric equilibrium where $P = 1$, each country specializes in its high-productivity good if tariff rates are less than (a/b). In that case we have $k = m = 1$. A competitive equilibrium for a given sequence of tariff rates is then defined as the set $\{c_{it}, c_{it}^*, P_t, l_{it}, l_{it}^*, \tau_t, \tau_t^*\}_{t=1}^{\infty}$, that satisfies consumer maximization, government budget constraints, the factor market

[7] A tariff is defined here as a tax on the import of a good. If the good is not imported, then the tax is zero. Thus a positive tariff with imports does not translate into a subsidy in the event that the good is exported.

equilibrium conditions (11), and market clearing (10). The equilibrium may be derived using (5) and (6) for each period t separately.

4. TARIFF GAMES

The determination of tariffs can be modeled as a repeated game between governments. In any time period, governments take the intersectoral allocation of labor for that period as fixed. Therefore, from the equations in (5), it is clear that the current tariff choice for a fixed labor allocation has no effect on future values of specialist human capital. The current tariff choice has no direct effect on future labor allocation either. Therefore, from the vantage point of the policy maker, there are no physical links between the actions (tariffs) of governments in period t and the state variable (human capital) in period $t+1$. In each period, governments are faced with an identical stage game, differing only in the given values of the state variable.

This feature allows for a very simple identification of at least one subgame-perfect equilibrium to the overall game, which is just a repetition of a one-shot Nash equilibrium in each period. Within the context of this paper, one can think of these as Markov-perfect equilibria, that is to say, strategies that are defined over current states only. I now characterize one-shot Nash equilibria.[8]

4.1. Markov-perfect equilibrium. Again take a representative period and ignore time subscripts. Take factor allocations as given, and substitute (10) into (8) and (9) to get the following expressions for period utility for each country,

$$U(\tau,\tau^*) = Y_1^w Y_2^w \frac{(k+\tau^*(1-m))^2}{\left(1+\tau^*(1-m)+\dfrac{m}{\tau}\right)(\tau^*+\tau^*\tau(1-k)+k)} \tag{12}$$

$$U^*(\tau,\tau^*) = Y_1^w Y_2^w \frac{(m+\tau(1-k))^2}{\left(1+\tau(1-k)+\dfrac{k}{\tau^*}\right)(\tau+\tau^*\tau(1-m)+m)} \tag{13}$$

In a one-shot game tariff rates are determined by the conditions

$$\max_{\tau}, U(\tau,\tau^{*N}) \qquad \max_{\tau^*} U^*(\tau^N,\tau^*) \tag{G}$$

A one-shot Nash equilibrium is the set $\{C_i^N, C_i^{*N}, P^N, l_i^N, l_i^{*N}, \tau^N, \tau^{*N}\}$ that satisfies the conditions (i) of government maximization, given by (G), and (ii) a competitive equilibrium for any time period. This equilibrium can be directly constructed. The construction is the subject of Proposition 1.

[8] The results in the next few paragraphs are related to those of Kennan and Reizman (1988). They look at the equilibrium of the static tariff game and examine the effect of country size. They do not endogenize labor supply.

PROPOSITION 1. (*i*) *Autarky is a one-shot Nash equilibrium.* (*ii*) *There will never be specialization in a one-shot Nash equilibrium.*

PROOF. (i) The first part of the proposition is quite trivial. If one country imposes a prohibitive tariff, welfare of the other country is independent of that tariff rate.[9] Thus a *best response* in a weak sense is to also impose a prohibitive tariff. Each country is in competitive equilibrium with factor allocations and consumption rates as in autarky. (ii) There also exists a Nash equilibrium to the tariff game where there is trade. Take the first order conditions for (G). These are, for Home and Foreign, respectively,

$$\frac{m}{\tau^2\left[1+(1-m)\tau^*+\dfrac{m}{\tau}\right]}=\frac{(1-k)}{\left[1+(1-k)\tau+\dfrac{k}{\tau^*}\right]}$$

$$\frac{(1-m)}{\left[1+(1-m)\tau^*+\dfrac{m}{\tau}\right]}=\frac{k}{\tau^{*2}\left[1+(1-k)\tau+\dfrac{k}{\tau^*}\right]}$$

Solving these equations gives the tariff solutions

$$\tau=\sqrt{\frac{m}{1-k}}\qquad \tau^*=\sqrt{\frac{k}{1-m}} \tag{14}$$

Now suppose an equilibrium with specialization exists. From (11) this entails

$$Pa>b\tau,\qquad Pb\tau^*<a$$

In addition, $k=m=1$.[10] From (10) this implies that

$$P=\frac{1+\tau}{1+\tau^*}$$

Finally, (14) gives $\tau=\tau^*=\infty$. This violates (11a(*i*)), a contradiction. Therefore specialization cannot occur in a one-shot Nash equilibrium.

With specialization, the demand functions (8) and (9) imply a zero price elasticity of export supply, so that each country desires to set an infinite tariff. With $P=1$, this reduces the return to factors in the specialized sector below that of the other sector. Foreseeing this, agents will never specialize.

Without specialization we have $Pa=b\tau$ and $Pb\tau^*=a$. Given symmetry, $P=1$, so that, from (11a) and (11b), $\tau=\tau^*=a/b$. Using (14), it is then easy to show that

$$l_1=l_1^*=a/(a+b) \tag{15}$$

[9] Dixit (1987) points this out. Autarky is not an equilibrium of the tatonnement process in reaction curve space described in Johnson (1953).

[10] It is easy to see that specialization cannot go the other way either, i.e., the country will not specialize in the good in which it has a comparative disadvantage.

Factor allocations here are between those of autarky and complete free trade. Finally, Home consumption of goods 1 and 2, respectively, is

$$c_1 = \frac{a(a^2+b^2)l}{(a+b)^2}, \qquad c_2 = \frac{b(a^2+b^2)l}{(a+b)^2} \tag{16}$$

Figure 1 illustrates the features of the Nash equilibrium. Domestic relative prices are at their autarky positions. The world price is unity. Each country incompletely specializes in its 'a'-good (high productivity good). There are some gains from trade, but less than under free trade.

Now define a subgame-perfect equilibrium of the overall game as a repetition of this outcome for each time period, conditional on the states at any given time period t, that is, a_t and b_t. Thus, at each time period, future decisions are independent of the current tariff choice. This is therefore a Markov-perfect equilibrium of the repeated tariff game.

Equations (14), (15), and (16) describe the solution for each time period. In terms of Figure 1, the dynamics will lead each country's production possibilities to expand out asymmetrically, as it gets more productive in its export good. Each country will grow faster than under autarky, as the fraction $a_t/(a_t+b_t)(>\frac{1}{2})$ of its labor force is devoted to the low-cost good. Over time the fraction will tend towards one so that in the limit specialization is attained. At the same time tariffs will rise progressively as countries specialize more and more, becoming increasingly monopolistic in the world supply of their export good, and governments will engage in a progressively escalating tariff war.

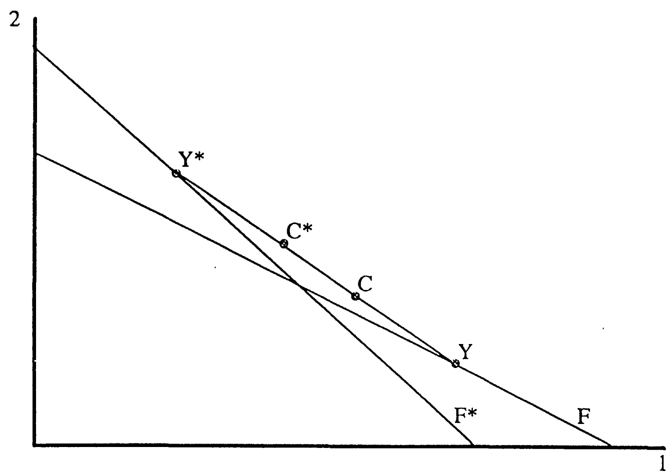

FIGURE 1

F(F*), HOME (FOREIGN) PRODUCTION FRONTIER; Y(Y*), HOME (FOREIGN) PRODUCTION; C(C*), HOME (FOREIGN) CONSUMPTION.

While restricted trade tends to increase growth relative to autarky, growth rates remain less than under free trade. Moreover, growth itself has an anti-trade momentum. The trade ratio (for either country) is

$$\frac{a_t b_t(a_t - b_t)}{(a_t + b_t)(a_t^2 + b_t^2)} = \frac{a_t/b_t(a_t/b_t - 1)}{(a_t/b_t + 1)(a_t^2/b_t^2 + 1)} \tag{17}$$

Starting at a_t/b_t close to 1, the trade ratio first rises, and then falls, approaching zero asymptotically, since (5) and (15) imply that a_t/b_t rises monotonically. If the initial a_t/b_t is large enough however, a_t/b_t will fall monotonically.

While countries specialize to an increasing degree, rising tariffs lead the domestic price of the importable to rise over time. Consumers progressively consume more and more of their export relative to their import good. The process of economic growth tends to eliminate international trade.

The incompleteness of knowledge spillovers is important for the tariff war equilibrium. If $\theta = 1$, spillovers are complete, and specialization has no impact on growth at all. But then by (5) (and symmetry) a_t/b_t is constant, so both specialization and tariffs remain constant over time.

4.2. Equilibrium with trigger strategies. I now focus on strategies that allow for more cooperation than the repeated one-shot Nash equilibrium. Equilibria with tariffs below those of the repeated one-shot Nash equilibrium can be thought of as endogenous, self-enforcing trade agreements. The object is to find the maximal degree of cooperation between countries that can be achieved as a subgame-perfect equilibrium of the game.

Strategies are typically history-dependent. To describe this, let $\tau^t \in R_+^t (\tau^{*t} \in R_+^t)$ denote $(\tau_0, \dots \tau_t)((\tau_0^*, \dots \tau_t^*))$. $H_t = (\tau^t, \tau^{*t})$ is the tariff history up to time t. Define T_{t+1}: $R_+^t \times R_+^t \to R_+$ as the action of the Home government at time $t+1$. That is, $T_{t+1}(\tau^t, \tau^{*t}) \to \tau_{t+1}$. A strategy of the Home government is defined as $\Sigma = (T_i(\cdot))_{i=0}^{\infty}$, and likewise for the Foreign government. Let us focus on symmetric strategies. Let $\tilde{\tau} = (\tilde{\tau}_0, \tilde{\tau}_1, \dots)$ and $\hat{\tau} = (\hat{\tau}_0, \hat{\tau}_1, \dots)$. Then Σ (and Σ^*), denoted Trade Liberalization (TL) strategies, are defined as follows

$$T_{t+1} = \begin{cases} \tilde{\tau}_{t+1}, & \text{if } H_t = (\tilde{\tau}^t, \tilde{\tau}^{*t}) \\ \hat{\tau}_{t+1}, & \text{otherwise}. \end{cases}$$

That is, $\tilde{\tau}$ is interpreted as some cooperative sequence of tariffs, played in each period as long as they have been played in the past. If not, there is a reversion to some *punishment* tariffs $\hat{\tau}$. The punishment must constitute a subgame-perfect equilibrium. Identifying the maximal punishment allows us to characterize the greatest degree of cooperation that can arise endogenously in the tariff game.

It is clear that the maximal punishment that can be inflicted is an infinite reversion to autarky. Autarky is a subgame-perfect equilibrium. If there was a subgame-perfect equilibrium which delivered payoffs worse than autarky forever, then, in this equilibrium, any country could unilaterally prohibit trade forever and by doing so make itself better off. Thus the stated punishment could not be a subgame-perfect equilibrium.[11] $\tilde{\tau}$ is then derived as the sequence that just removes the incentive to defect, when the punishment for defection is autarky forever.

Without loss of generality, I focus on tariff equilibria that allow for complete specialization, that is, equilibria for which $\tau_t < a_t/b_t$. In a symmetric equilibrium, the lowest tariff which induces diversification, at any time t, is unique, that is, a_t/b_t. But these are equilibria of the one-shot Nash equilibrium in any case. If any cooperation in excess of this can be supported, it must involve lower tariffs and therefore specialization.

A trade liberalization equilibrium is defined as (i) a subgame-perfect equilibrium in the game between governments, using the trade liberalization strategies, and (ii) a competitive equilibrium. The requirements for (ii) are first that if any defection occurs, private agents will predict prohibitive tariffs for future periods, and second, that the tariff sequence actually be consistent with specialization. The first condition is clearly a rational prediction for private agents, providing governments play trade liberalization strategies.[12] The second condition must be checked. I proceed by examining directly the conditions necessary to ensure that no government would ever wish to defect from trade liberalization. Under the proposed strategies, given no defection, period utility of *either* country can be written as

$$U_t^{\mathrm{TL}} = a_t^2 \frac{\tilde{\tau}_t}{(1+\tilde{\tau}_t)^2} \tag{18}$$

The one-period return to deviation is

$$U_t^{\mathrm{CH}} = a_t^2 \frac{1}{(1+\tilde{\tau}_t)} \tag{19}$$

Therefore the gain from cheating is

$$\frac{a_t^2}{(1+\hat{\tau}_t)^2} \tag{20}$$

The cost of cheating at any time t is the discounted welfare from the trade liberalization equilibrium less the discounted welfare from autarky, both starting in period $t+1$. The discounted welfare of the trade liberalization equilibrium from

[11] The qualitative results would be unchanged by the use of the tariff-war equilibrium as a punishment. What is important is that the punishment get worse and worse over time relative to the trade liberalization equilibrium. Since the tariff war equilibrium involves diversification of resources among sectors this requirement is satisfied with the use of the tariff war as punishment. Also note that the equilibrium described in this section, as in most applications of supergames to international trade, e.g., Dixit (1987), and Bagwell and Staiger (1990), is not necessarily renegotiation-proof in the sense of Farrell and Maskin (1987), for instance.

[12] The private sector, while acting competitively, actually participates in the punishment. This issue is discussed in Chari, Kehoe and Prescott (1989).

period $t+1$ on, evaluated in period t, can be written as

$$\delta a_t^2 \sum_{i=0}^{\infty} \left(\delta(1+\sigma)^2\right)^i \frac{\tilde{\tau}_{t+1+i}}{\left(1+\tilde{\tau}_{t+1+i}\right)^2} \tag{21}$$

The discounted value of autarky forever, beginning next period is

$$(1/4)\frac{\delta a_t b_t (1+\sigma)(1+\sigma\theta)}{\left(1-\delta\left(1+\frac{1}{2}\sigma(1+\theta)\right)^2\right)} \tag{22}$$

From (5) I can use the fact that $a_t \equiv \alpha h_{at}$ and so forth, and that $h_{at} = h_{a0}(1+\sigma)^t$, and $h_{bt} = h_{b0}(1+\sigma\theta)^t$, in which case the trade liberalization sequence is defined by the conditions that ensure that the benefits from cheating, given in (20), are exactly offset by the future costs of cheating (i.e., (21) less (22)) for every period beginning at time-0. That is,

$$\frac{1}{\left(1+\tilde{\tau}_t\right)^2} = \delta_1\left[\sum_{i=0}^{\infty} \delta_1^i \frac{\tilde{\tau}_{t+1+i}}{\left(1+\tilde{\tau}_{t+1+i}\right)^2} - \frac{1}{4}\frac{\beta h_{b0}}{\alpha h_{a0}}\left(\frac{(1+\sigma\theta)}{(1+\sigma)}\right)^{t+1}\frac{1}{(1-\delta_2)}\right] \tag{23}$$

In equation (23) I simplify notation by letting $\delta_1 = \delta(1+\sigma)^2$ and $\delta_2 = \delta(1+\frac{1}{2}\sigma(1+\theta))^2$. It is apparent from (23) that the solution for the tariff sequence is nonstationary when $\theta < 1$. To characterize the trade liberalization tariff sequence there are two cases. In case A, $\delta_1 > \frac{1}{2}$, while in case B, $\delta_1 < \frac{1}{2}$. These conditions determine whether or not unrestricted free trade is attainable in the long run. In case A, free trade is eventually attainable in a trade liberalization equilibrium. To see this, note that for $\theta < 1, (1+\sigma\theta)/(1+\sigma) < 1$, so that the second term on the right-hand side of (23) must tend toward zero. Therefore zero tariffs are eventually attainable. Moreover, it must be the case that for some time period $T < \infty$, the tariffs necessary to sustain free trade, for all $t > T$, must be zero. The $(\tilde{\tau}_T, \tilde{\tau}_{T+1}, \dots) = (1, 1, \dots)$. Moreover, T is unique, since it is the smallest integer for which

$$1 < \delta_1\left[\frac{1}{(1-\delta_1)} - \frac{1}{4}\frac{\beta h_{b0}}{\alpha h_{a0}}\left(\frac{(1+\sigma\theta)}{(1+\sigma)}\right)^{T+1}\frac{1}{(1-\delta_2)}\right] \tag{24}$$

T represents the first time period following trade liberalization at time 0 for which undistorted free trade can be supported by a threat to revert to autarky. The intuition behind this is quite clear; under trade liberalization, growth effects of specialization are gained immediately. With imperfect international spillovers of knowledge, the cost of reverting to autarky then increases progressively over time relative to the benefits of cheating since autarky involves diversifying resources back towards the import sector, which is becoming less and less productive relative to the export sector. Utility under autarky relative to free trade tends towards zero. Then, if the discount factor satisfies case A, it must be that free trade can be supported eventually.

T is higher, the lower is the discount factor δ_1, the lower is the initial relative productivity differential between sectors ($\beta h_{b0}/\alpha h_{a0}$ close to 1), and the higher is the extent of the spillover of learning-by-doing across countries θ. The first result is obvious, the second arises because for very similar initial productivities the cost of autarky is less, and therefore a longer time span must elapse in order to generate the necessary productivity differential to support free trade. The third result holds because for high knowledge spillovers the productivity wedge between sectors grows only very slowly.

Let us proceed under the assumption that case A holds. To determine the trade liberalization tariff sequence, write out condition (23) for period $T-1$. Since tariffs are zero after T, this gives one equation in $\tilde{\tau}_T$

$$\frac{1}{(1+\tilde{\tau}_{T-1})^2} = \frac{\delta_1}{4}\left[\frac{1}{(1-\delta_1)} - \frac{\beta h_{b0}}{\alpha h_{a0}}\left(\frac{(1+\sigma\theta)}{(1+\sigma)}\right)^T \frac{1}{(1-\delta_2)}\right]$$

or

$$\tilde{\tau}_{T-1} = -1 + \left(\frac{\delta_1}{4}\left[\frac{1}{(1-\delta_1)} - \frac{\beta h_{b0}}{\alpha h_{a0}}\left(\frac{(1+\sigma\theta)}{(1+\sigma)}\right)^T \frac{1}{(1-\delta_2)}\right]\right)^{-1/2} \tag{25}$$

By the definition of $T, \tilde{\tau}_{T-1}$ must exceed unity. The tariff rate necessary to eliminate the temptation to defect must be positive. Now, moving back to time $T-2$, using (25), we may compute $\tilde{\tau}_{T-2}$ in the same way. This is given by

$$\tilde{\tau}_{T-2} = -1 + \frac{1}{4}\left(\delta_1\left[4\frac{\tilde{\tau}_{T-1}}{(1+\tilde{\tau}_{T-1})^2} + \frac{\delta_1}{(1-\delta_1)} - \frac{\beta h_{b0}}{\alpha h_{a0}}\left(\frac{(1+\sigma\theta)}{(1+\sigma)}\right)^{T-1}\frac{1}{(1-\delta_2)}\right]\right)^{-1/2} \tag{26}$$

This must exceed $\tilde{\tau}_{T-1}$ for two reasons. First, since $\tilde{\tau}_{T-1} > 1$, the discounted utility of remaining on the trade liberalization sequence from time $T-1$ onwards is reduced relative to the utility of remaining on trade liberalization from time T onwards. Second, $((1+\sigma\theta)/(1+\sigma))^{T-1} > ((1+\sigma\theta)/(1+\sigma))^T$. This raises the utility of autarky from time $T-1$ onward relative to the utility of autarky from time T onwards. Both factors reduce the implicit threat of a reversion to autarky at time $T-2$ relative to time $T-1$, and so must be offset with a higher period $T-2$ tariff as part of the trade liberalization sequence. Continuing on in this manner, one can compute $\tilde{\tau}_{T-3}$, $\tilde{\tau}_{T-4}$, $\tilde{\tau}_{T-5}$, and so on. Moreover, by the same arguments as in the previous paragraph, these must satisfy $\tilde{\tau}_{T-1} < \tilde{\tau}_{T-2} < \tilde{\tau}_{T-3} < \tilde{\tau}_{T-4} \ldots$.

While this characterizes the trade liberalization sequence, I have omitted one detail. Are the tariffs consistent with international specialization? This requires only that the initial tariff in the sequence allows for specialization, that is, $a_0 > b_0\tilde{\tau}_0$. This condition will depend upon all the parameters of the model, and must be checked individually. If $\tilde{\tau}_0 > a_0/b_0$, then the trade liberalization sequence does not exist, since the maximal degree of cooperation that can be achieved is inconsistent with specialization at time 0. The effect of alternative parameter values on $\tilde{\tau}_0$ is explored below.

What if case A is not satisfied? In case B, the discount factor is so low that free trade is never sustainable, even when utility under autarky relative to free trade falls to zero. The minimum sustainable tariff is

$$\bar{\tau} = \frac{(1 - \delta_1)}{\delta_1} \tag{27}$$

To obtain (27) take (25) and let $T \to \infty$. Since the incentive condition becomes stationary, I impose a constant tariff rate. How is the trade liberalization equilibrium characterized in case B? Following the logic set out above, it is apparent that tariffs will be declining over time, asymptotically approaching (27). Thus, trade liberalization will continue forever.[13] Again, trade liberalization is an equilibrium in case B only if the sequence of tariffs allows for specialization in the initial period.

The arguments of the last three pages can be summarized as follows.[14]

PROPOSITION 2. *(i) The trade liberalization sequence* $= \{\tilde{\tau}\}_0^T$ *exists if* $a_0 > \tilde{\tau}_0 b_0$. *(ii) Case A trade liberalization leads to eventual free trade, and Case B trade liberalization leads tariffs to converge to* $\bar{\tau}$. *(iii) Trade liberalization implies a declining sequence of tariffs.*

The trade liberalization equilibrium sharply contrasts with the tariff war equilibrium in the previous section. Tariffs are always lower in a trade liberalization equilibrium. Tariffs fall rather than rise over time. Growth rates of income are higher. The trade ratio is now $1/(1 + \tilde{\tau}_t)$. Since $\tilde{\tau}_t < a_t/b_t$, the trade ratio exceeds (17), the trade ratio in a tariff war. Moreover, the trade ratio rises progressively, as tariffs fall.

In this equilibrium trade liberalization is gradual. The two countries begin trading at the beginning of the game, specializing immediately. However, unrestricted free trade cannot be supported at this time because the incentives to deviate outweigh the maximal punishment. A high level of protection remains in place, so the initial

[13] The constructive procedure for choosing the tariff sequence in case A is no longer available in case B, because there does not exist an integer T satisfying (26). The following approximate procedure can be employed, however. Take any integer T′. Impose on (25) the condition that for $t > T'$, tariffs are constant. Then use the backwards recursive method above to compute the sequence of tariffs for all $t < A'$. As T' gets larger and larger, this method more closely approximates the exact trade liberalization tariff sequence for case B. Moreover, it is easy to see that the tariff sequence is declining over time for the same reasons as in case A.

[14] It can now be verified that the assumption of continuing spillovers in autarky is not crucial to the argument. The alternative assumption, that the spillovers are eliminated under autarky, would merely entail changing the discount factor under autarky from $(1 + \frac{1}{2}\sigma(1 + \theta))^2\delta$ to $(1 + \sigma/2)^2\delta$. This leaves the content of Proposition 2 qualitatively unaltered.

trade volume is relatively low. But specialization cumulatively raises the costs of reverting to autarky. The higher cost of the punishment in turn allows for lower and lower tariffs required to prevent a deviation. In contrast to a tariff war equilibrium, economic growth here has a distinctly pro-trade bias.

The trade liberalization equilibrium relies on the fact that continued growth, by generating interdependence, raises the cost of deviation relative to the benefits, thus relaxing the incentive constraint over time. The key reason for this lies in the timing structure of tariff setting; that is, tariffs are determined after resource allocation has taken place within a period. As explained in Lapan (1988) and Staiger and Tabellini (1987), this makes the ex-post (after factors are in place) foreign offer curve less elastic than the ex-ante (before factor allocation) offer curve. In the one-shot game, with factors of production in place, governments levy higher tariffs than would be predicted by the standard optimal tariff model.

In the model this implies that the benefits from cheating do not take account of factor relocation (i.e., the right-hand side of (23)). But the costs of cheating, which are incurred only at the beginning of the next period, do take into account the fact that factors will relocate (the left-hand-side of (23)), and thus, in autarky, the country will be using its less productive sector. The worsening of utility under autarky relative to free trade reflects the continuing atrophy of the import sector, as well as the higher cost of cheating relative to the benefits.

To see why the timing assumption is important for sustaining trade liberalization take the incentive constraint at the initial period of a trade liberalization. For case A, take condition (23), setting $t = 0$, and write the conditions for sustaining free trade immediately (zero tariffs) as

$$\delta_1\left[\frac{1}{(1-\delta_1)} - \frac{\beta h_{b0}}{\alpha h_{a0}}\left(\frac{1+\sigma\theta}{(1+\sigma)}\right)\frac{1}{(1-\delta_2)}\right] \geq 1 \tag{28}$$

If there are only small gains from trade initially (i.e., $\beta h_{b0}/\alpha h_{a0}$ is close to one), and spillovers (θ) are quite high, then the cost of defecting is negligible since the highest that the costs can be is to remove all the gains from trade. But given that factors are in place, the gains to one government from a surprise tariff are large, since this surprise tariff would not induce factor diversification. As a result, free trade may not be sustainable by even the *maximal* punishment threat. The trade liberalization equilibrium allows for gains from trade to be deepened to the point where free trade is sustainable. Exactly analogous arguments can be made for case B. This makes clear why the 'dynamic gains from trade' become critical to the success of trade liberalization. The Appendix demonstrates that if tariffs are set *before* factors are in place, then either complete free trade (as in case A) or the maximum level of tariff cooperation (as in case B) are sustainable *immediately* in a trade liberalization equilibrium. Thus, the gradual nature of trade liberalization is dependent upon the timing of tariff setting.

If governments were to set tariffs before the allocation of factors, the gains from cheating in trade liberalization will be limited, due to the fact that if the deviating tariff gets too high it will encourage domestic factors to relocate within the period. As shown in the Appendix, this limits the benefits of cheating, and in essence, makes the benefits of cheating depend upon the productivity of the import sector in the same way as the costs of cheating do in the above discussion. This means that, for the dynamics of the incentive constraint (the analogous constraint to (23)), it does not matter that the importable sector is getting progressively less competitive over time, since both the costs and benefits of cheating rise proportionally. Therefore, with tariff setting before factor allocation, there are no dynamics in the maximum sustainable tariff rates.

By numerically checking part (i) of Proposition 2 for a range of parameter values, one can investigate the conditions under which the trade liberalization equilibrium is sustainable. This is omitted here to save space. However, it is intuitively easy to see that the trade liberalization equilibrium is more likely, (i) the higher are the growth rates of human capital, (ii) the greater is the initial comparative advantage among countries, and (iii) the lower are discount rates.

If the trade liberalization equilibrium does not exist then governments must choose tariffs according to one of the one-shot Nash equilibria. A feature of the tariff war equilibrium is that specialization increases despite relatively high tariffs and low growth rates. Each country is altering its pattern of comparative advantage to such an extent that the trade liberalization path becomes sustainable at some future date. At this date we can have an endogenous switch from the one-shot Nash equilibrium with rising tariffs to the trade liberalization equilibrium. However, if growth rates are low, it may take an extremely long time for this to occur.

4. CONCLUSION

The trade liberalization equilibrium in this paper might be thought of as corresponding to the progressive postwar multilateral tariff reductions generated through GATT. The key conditions for tariff reduction, namely high rates of underlying productivity growth, were satisfied during this time. Tariffs fell during this period, and trade ratios rose. On the other hand, the interwar experience might be more akin to the tariff war equilibrium. In this case, income growth rates were very low. Tariffs rose, especially in the 1930s, and trade ratios fell.

In the 1970s and 1980s, the decline in tariff rates was countered by growth in nontariff barriers. While the model is not rich enough to explain this, it does imply that periods of low growth will tend to arrest the momentum of trade liberalization. According to Bhagwati (1988, 1991), the slowdown of the process of liberalization in the post-1973 period was intimately connected with the slowdown in growth rates following the oil shocks and recessions of the mid-1970s.

While the model might capture some of the key forces involved in trade liberalization, it is counterfactual in some respects. In particular, it implies that trade liberalization should be irreversible. In a trade liberalization equilibrium tariffs should be falling progressively, or obtain free trade and remain zero after that. The recent experience of increasing trade restrictions suggests that trade liberalization puts into doubt this hypothesis. In particular, there seem to be distinct episodes of rising and falling protectionism over time.

It may be possible to generalize the model to allow for this, however. One approach might be to construct a model in which countries continually adopt new types of goods in which learning-by-doing must begin over again. In this case, new types of goods would require high tariffs until comparative advantage was built up in particular products. This is left for further research.

APPENDIX

Assume, in contrast to the assumption in the text, that tariffs may be set in advance of factor allocation; that is, governments can *commit* to tariffs. Then we may show:

PROPOSITION A1. *When tariffs are set before factor allocation takes place, (i) in case A (i.e., when $\delta_1 > \frac{1}{2}$) free trade may be established immediately in a trade liberalization equilibrium; (ii) in case B, (i.e., when $\delta_1 < \frac{1}{2}$), the minimum sustainable tariff rate $\bar{\tau}$ may be achieved immediately in a trade liberalization equilibrium.*

PROOF. Again assume complete symmetry so that $a_t = a_t^*$ and $b_t = b_t^*$. To prove the proposition we must construct the benefits and costs of cheating on the trade liberalization equilibrium, in the case when tariffs are set before labor is allocated. Take case A first. Ask whether free trade is sustainable at any date t following a trade liberalization at date 0. Then the period utility for any time t, given no defection, is (to simplify the notation, I use the original terms a_t instead of αh_{at}, etc.)

$$U_t^{\mathrm{TLC}} = \frac{a_t^2}{4} \tag{A1}$$

Say that the Home country defects on free trade. Then it will set a tariff high enough so that it removes all the gains from trade for the Foreign country, but low enough so that both countries continue to specialize. A tariff any higher than this would be counterproductive for Home since it cannot get a higher terms of trade, and it would just reduce trade volume. Home will thus set a tariff so that the world price of good 1 is equal to the Foreign autarky price a_t/b_t. Thus, from (10) in the text, the tariff will given implicitly by:

$$P = \frac{1+\tau_t}{2} = \frac{a_t}{b_t}. \tag{A2}$$

Thus, $\tau_t = 2(a_t/b_t) - 1$. This leads to Home consumption of $a_t - b_t/2$ and $a_t/2$ and Foreign consumption of $b_t/2$ and $a_t/2$, for good 1 and good 2, respectively. (Figure A1 illustrates this allocation for any time period t. Foreign faces its Autarky price but continues to specialize and trade with the Home country.)

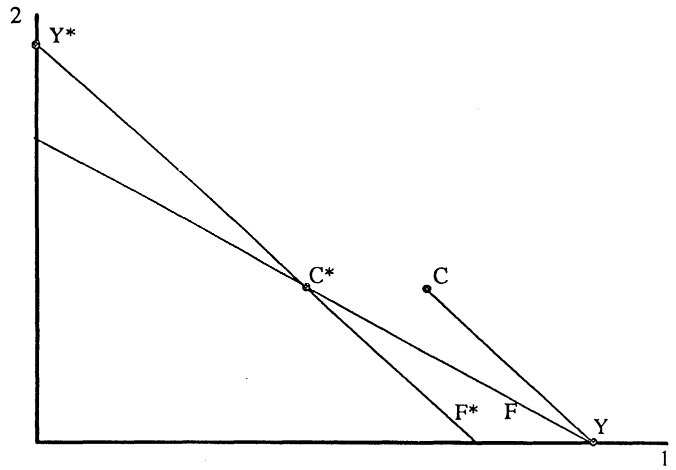

FIGURE A1

F(F*), HOME (FOREIGN) PRODUCTION FRONTIER; Y(Y*), HOME (FOREIGN) PRODUCTION; C(C*), HOME (FOREIGN) CONSUMPTION.

Therefore, the utility available to Home from defecting upon free trade is.[15]

$$U_t^{\mathrm{CH/TLC}} = \frac{a_t^2}{2} - \frac{a_t b_t}{4} \tag{A3}$$

Thus the net benefit from cheating is

$$\frac{a_t^2}{4} - \frac{a_t b_t}{4} \tag{A4}$$

The costs of defection on free trade are identical to those in the text (i.e., (21) less (22) with $\tilde{\tau}_t = 1$). Thus, the costs of defection are

$$\delta_1\left[\frac{a_t^2}{4}\frac{1}{(1-\delta_1)} - \frac{1}{4}b_t a_t \frac{(1+\sigma\theta)}{(1+\sigma)}\frac{1}{(1-\delta_2)}\right] \tag{A5}$$

where, as in the text,

$$\delta_1 = \delta(1+\sigma)^2 \text{ and } \delta_2 = \delta\left(1+\tfrac{1}{2}\sigma(1+\theta)\right)^2.$$

[15] Unlike expression (19) of the text, this depends upon b_t, the productivity of the imported good sector. This is because the level of b_t puts a limit on the tariff that Home can impose when it defects upon free trade.

Therefore, free trade is sustainable if (A5) exceeds (A4) or

$$\text{(A6)} \qquad 1 - \frac{b_t}{a_t} < \frac{\delta_1}{(1-\delta_1)}\left[1 - \frac{b_t}{a_t}\frac{(1+\sigma\theta)}{(1+\sigma)}\frac{(1-\delta_1)}{(1-\delta_2)}\right]$$

Since the expression

$$\frac{(1+\sigma\theta)}{(1+\sigma)}\frac{(1-\delta_1)}{(1-\delta_2)}$$

must be less than unity, given $\delta_1 > \delta_2$ and $\theta < 1$, condition (A6) is satisfied whenever $\delta_1 > \frac{1}{2}$ (noting that $b_t/a_t < 1$). Thus, free trade is sustainable at time t. But since t is arbitrary here, it must be that free trade is *immediately sustainable* in a trade liberalization equilibrium.

Case B. In the case where $\delta_1 < \frac{1}{2}$, free trade can never be sustained. But the condition that the minimum tariff $\bar{\tau} = 1 - \delta_1/\delta_1$ can be sustained is (using the same arguments as in case A).

$$\frac{1}{(1+\bar{\tau})^2}\left(1 - \frac{b_t}{a_t}\bar{\tau}\right) < \frac{\delta_1}{(1-\delta_1)}\left[\frac{\bar{\tau}}{(1+\bar{\tau})^2} - \frac{1}{4}\frac{b_t}{a_t}\frac{(1+\sigma\theta)}{(1+\sigma)}\frac{(1-\delta_1)}{(1-\delta_2)}\right]$$

or

$$\text{(A7)} \qquad \left(1 - \frac{b_t}{a_t}\bar{\tau}\right) < \frac{\delta_1}{(1-\delta_1)}\bar{\tau}\left[1 - \frac{(1+\bar{\tau})^2}{4\bar{\tau}}\frac{b_t}{a_t}\frac{(1+\sigma\theta)}{(1+\sigma)}\frac{(1-\delta_1)}{(1-\delta_2)}\right]$$

Since by definition, $\bar{\tau} = (1-\delta_1)/\delta_1$, this amounts to

$$\frac{(1+\bar{\tau})^2}{4\bar{\tau}^2}\frac{(1+\sigma\theta)}{(1+\sigma)}\frac{(1-\delta_1)}{(1-\delta_2)} < 1$$

or

$$\text{(A8)} \qquad \frac{1}{4}\frac{(1+\sigma\theta)}{(1+\sigma)}\frac{1}{(1-\delta_1)(1-\delta_2)} < 1$$

Since in this case, $\delta_1 < \frac{1}{2}$ and $\delta_2 < \delta_1$, condition (A8) is always satisfied.

Again, because t is arbitrary, it follows that $\bar{\tau}$ can be supported *immediately* in a trade liberalization equilibrium.

Thus, the proposition establishes that when governments set tariffs in advance of labor allocation the incentive constraint in a trade liberalization is stationary, and the maximum feasible degree of trade liberalization can be attained immediately.

REFERENCES

ABREU, D., "On the Theory of Infinitely Repeated Games with Discounting," *Econometrica* 56 (1988), 383–396.

BACKUS, D., P.J. KEHOE, AND T.J. KEHOE, "In Search of Scale Effects in Trade and Growth," *Journal of Economic Theory* 58 (1993), 377–411.

BAGWELL, K. AND R. STAIGER, "A Theory of Managed Trade," *American Economic Review* 80 (1990), 779–795.

BHAGWATI, J., *Protectionism* (Massachusetts: MIT Press 1988).

——, *The World Trading System at Risk* (Princeton: Princeton University Press 1991).

CHARI V., P.J. KEHOE, AND E.C. PRESCOTT, "Time Consistency and Policy," in R.J. Barro, ed., *Modern Business Cycle Theory* (Boston: Harvard University Press 1989).

DIXIT, A., "Strategic Aspects of Trade Policy," in T. Bewley ed., *Advances in Economic Theory, Proceedings of the 5th World Congress of the Econometric Society* (Cambridge: Cambridge University Press 1987).

FARRELL, J. AND E. MASKIN, "Renegotiation in Repeated Games," Discussion Paper 8759, (1987) Berkeley.

GROSSMAN, G. AND E. HELPMAN, "Quality Ladders in the Theory of Growth," *Review of Economic Studies*, 58 (1991a) 43–61.

——, *Innovations and Growth in the Global Economy* (Massachusetts: MIT Press 1991b).

——, "Comparative Advantage and Long Run Growth," *American Economic Review*, 80 (1990), 796–815.

JOHNSON, H., "Optimum Tariffs and Retaliation," *Review of Economic Studies*, 21 (1953), 142–153.

KENNAN, J. AND R. REIZMAN, "Do Big Countries Win Tariff Wars?" *International Economic Review*, 29 (1988), 81–85.

KRUGMAN, P., "The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher," *Journal of Development Economics*, 27 (1987), 41–55.

LAPAN, H., "The Optimal Tariff, Production Lags, and Time Consistency," *American Economic Review*, 78 (1988), 395–401.

LUCAS, R.E., "On the Mechanics of Economics Development," *Journal of Monetary Economics*, 21 (1988), 3–42.

ROMER, P. AND L. RIVERA-BATIZ, "Economic Integration and Endogenous Growth," *Quarterly Journal of Economics*, 106 (1991), 531–553.

STAIGER, R. AND G. TABELLINI, "Discretionary Policy and Excessive Protection," *American Economic Review*, 77 (1988), 823–837.

STOKEY, N., "Learning-by-Doing and the Introduction of New Goods," *Journal of Political Economy*, 96 (1988), 701–717.

TAYLOR, S., "Once-Off and Continuing Gains From Trade," *Review of Economic Studies*, 61 (1994), 589–601.

VINER, J., "Prospects for Foreign Trade in the Postwar World" in *Readings in the Theory of International Trade*, American Economic Association, Blakistan Press 1950.

YOUNG, A., "Learning-by-doing and the Dynamics Effects of International Trade," *Quarterly Journal of Economics*, 106 (1991), 369–405.

——, "Invention and Bounded Learning-by-doing," *Journal of Political Economy*, 101 (1993), 443–472.