How to Use Industrial Policy to Sustain Trade Agreements

Philip Sauré

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Philip Sauré †

Swiss National Bank

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Abstract

With the help of a simple Ricardian model, this paper explores the role of industrial policy in self-enforcing trade agreements. A first part shows that the optimal self-enforcing trade agreement includes subsidies to inefficient, import-competing sectors. Second, when by some exogenous or endogenous force the comparative advantage deepens, subsidies go to declining industries. Key assumptions driving these results are: essentiality of imported goods and a high flexibility of the countries' industrial structure. A final part relaxes the latter assumption and shows that under rigid industrial structures subsidies favoring import competing sectors actually destabilize trade agreements.

Keywords: Trade Agreement, Self-enforceability, Industrial Policy.

JEL Classifications: F10, F13.

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†Swiss National Bank, Börsenstrasse 15, CH-8022 Zurich, Switzerland. (E-mail: Philip.Saure@snb.ch). The views expressed in this paper are the author's and do not necessarily represent those of the Swiss National Bank.

1 Introduction

The achievements of trade liberalization in recent decades notwithstanding, governments across the globe continue to spend huge sums to promote comparatively disadvantaged and declining industries. While policymakers like to justify such actions by appealing to the strategic value of the industries in question, economists, concerned about efficiency, tend to discard these claims and blame interest groups for incurring deadweight losses. The present paper argues that under a some preconditions the protection of inefficient and declining sectors may indeed be welfare improving. It shows that active industrial policy constitutes an efficient way to make countries respect trade agreements and is therefore part of optimal trade agreements.

To frame the case, a two-country model of repeated trade is developed[1]. Key to the model is the self-enforcement requirement, which international agreements need to satisfy. This assumption reflects that sovereign countries cannot be forced into international cooperation but respect only those agreements that appear beneficial to them. Now it is well known that large countries have an incentive to cheat on free trade agreements by unilaterally erecting trade barriers, thereby reaping gains via improved terms of trade. Countries refrain from doing so only in presence of the credible threat of a breakdown of cooperation that would follow unilateral defections. A trade war with uncooperative actions from all countries constitutes such a credible punishment. Forward-looking governments weigh the transitional gains from defection against future losses from trade war. Trade agreements, which all members voluntarily choose to respect are said to be self-enforcing.

When temptation to defect on free trade grows too strong, free trade ceases to be self-enforcing. Yet there is remedy in this situation, too. It is well understood that countries can use trade barriers in order to reduce foreign defection incentives. Previous literature has focused on the use of tariffs as such instruments. The present paper analyzes the case where governments set, in addition to tariffs, subsidies to reduce foreign defection incentives and optimally choose an efficient mix of both. The paper shows that when imported goods are essential, subsidies are always part of the constrained optimal trade agreement. Intuitively, the more a country is vulnerable to hostile foreign trade policy, the more defecting trade partners can

[1] The conceptual framework relies on Dixit (1987), the model's formal structure follows Devereux (1997) who in turn strongly builds on Kennan and Riezman (1988).

gain and the stronger are their temptations to defect. The importer's vulnerability and the exporter's incentive to cheat are two sides of the same coin. In order to reduce foreign defection incentives a country that imports essential goods optimally chooses not to rely entirely on imports but produces some of its imported goods at home. Finally, since local production is not internationally competitive the domestic production of imported goods requires subsidies.

A first extension of the model introduces a simple form of learning by doing within sectors and provides a rationale for the protection of declining industries. The extension starts from the above statement that subsidies to import-competing sectors are part of optimal trade agreements. When the pattern of comparative advantage deepens, the value of cooperation increases relative to the value of defection and the self-enforcement constraint is relaxed, which in turn leads to a reduction of tariffs and subsidies. Trade liberalization is gradual, since anticipated *future* gains from cooperation relax the *present*'s self-enforcement constraint and allow a partial liberalization today already. Thus, during the liberalization process, initially protected sectors slowly shrink due to less and less protection. The reason for such gradual liberalization does not stem from the desire to cushion incomes or avoid political resistance - it is an optimal policy to run along the path of a binding self-enforcement constraint.

A second extension severely qualifies and partially reverses the basic findings. It introduces rigidities in industrial structure, considering a world where production capacities take time to build and output patterns are slow to change, so that countries depend on imports even after trade agreements break down. This extension of the dependence on imports beyond the period of defection implies that any defection is followed by a particularly tough trade war. Under such harsh punishment of defection, mutual dependence now proves to be beneficial. In fact, the deliberate creation of dependence constitutes a way to commit to free trade, making free trade more likely to be self-enforceable. In this scenario, subsidies to import competing sectors can undermine the commitment device and make cooperation harder.

Up to very recently, economic theory has widely neglected the role of subsidies in trade agreements - despite their prominent role in international trade negotiations. Bagwell and Staiger (2004) and (2006) address this issue for the first time, concluding that a ban on all subsidies may go too far and the strict "WTO subsidy rules may ultimately do more harm than good to the multilateral trading system".

The present paper conditionally confirms this finding in the scenario where the self-enforcement is the prime constraint in trade negotiations. It further shows that subsidies optimally go to comparatively disadvantaged sectors, which is broadly consistent with empirical work on protection and trade policy: Lee and Swagel (1997) write that "nations tend to protect industries that are weak, in decline, [...] or threatened by import competition". Trefler's (1993) estimates show that a higher import-penetration is associated with greater protection, and Goldberg and Maggi (1999) find that "within the group of non-organized sectors, protection tends to increase with import penetration". The theory of trade agreements typically views protectionism as the outcome of political activity and lobbying in particular. Rodrik (1995) provides an overview of this literature. He claims, however, that "we lack a good explanation of the universal preference for trade restricting policies over trade promoting ones". Political economy has difficulties in justifying this anti-trade bias in trade policies and previous explanations addressing the issue are scarce and rely on rather specific assumptions (see Limao and Panagariya (2002)). The present paper takes a different route and argues that an anti-trade bias may be precisely what welfare-maximizing governments optimally do to grant that trade agreements are self-enforcing.

The remainder of the paper contains five sections. Section 2 develops the basic model of non-cooperative trade. Section 3 then considers repeated trade and cooperative behavior, highlights the role of the self-enforcement constraint, and presents the basic finding of the paper. Section 4 introduces learning by doing to explain gradualism and the protection of declining industries, while section 5 introduces rigidities in the industrial structure of the countries. Finally, section 6 concludes.

2 The Basic Model

There are two countries, Home and Foreign (Foreign variables denoted by *), which produce two goods x, y with a constant returns to scale technologies and labor as the single factor. Countries have equal size of labor force, normalized to unity: $L = L^* = 1$. Assume that Home's (Foreign's) productivity in x- (y-) production equals b while its productivity in the y- (x-) production is equal to 1. With $b > 1$, this means that Home is the natural exporter of x. Technologies are disembodied and, for a start, exogenous:

$$x = bL_x \qquad y = L_y \qquad\qquad x^* = L_x^* \qquad y^* = bL_y^* \tag{1}$$

Each period, consumers enjoy the momentary utility (simply called utility in the following) of Cobb-Douglas type, symmetric in the two goods[2]

$$u(c_x, c_y) = \sqrt{c_x c_y}. \tag{2}$$

There is no capital and no saving technology so that, at every point in time, individuals maximize (2) subject to their momentary budget constraint. Markets are competitive and only subject to distortions from government policies specified below.

Notice that the countries are entirely symmetric and the analysis of the model will concentrate on symmetric equilibria throughout the paper.

The Integrated Economy and Free Trade

The integrated economy is a world where goods and factors can cross borders without costs. In this world symmetry implies that relative price of goods equals unity ($p_x/p_y = 1$). All goods are produced competitively using the most efficient technology available, i.e. productivity in both sectors is b. Normalizing world price p_x to one, individuals face the budget constraint $c_x + c_y \leq I = b$, which implies that utility of a representative consumer in either of the two countries is

$$u^F = b/2. \tag{3}$$

This utility level reflects the efficient outcome of the integrated economy. It is replicated by a world economy where trade in goods is free and costless but factors - that is labor - is bound to stay within national borders. In this world of free trade there is complete international specialization, the relative price is unity, and citizens enjoy utility (3).

Yet, countries have an incentive to distort the world economy by erecting trade barriers and thereby manipulate the terms of trade to their favor. These incentives will be analyzed next.

[2] To save notation, here and whenever there is no risk of confusion time indices are dropped.

Trade War

When two large countries cannot commit to free trade, they will try to manipulate the terms of trade to their favor. The result is a trade war with typically all sides loosing - the tariff game is subject to a classical prisoner's dilemma. The present paper's symmetric model is no exception: the net effects of the terms of trade manipulation entirely cancel out and the world economy is left with the distortions only.

Throughout the paper the government of each country is assumed to employ two policy instruments, import tariffs and production subsidies, in order to maximize their citizens utility. The gross ad valorem import tariffs T and T^* drive a wedge between local and international prices of the imported goods. Throughout the paper, world price of good x is normalized to one and world price of good y will be called p. This means that local prices are $p_x^{Home} = 1$, $p_y^{Home} = Tp$, $p_x^{Foreign} = T^*$, and $p_y^{Foreign} = p$.

Independently of tariffs, governments hand out production subsidies to one or both sectors. These subsidies are assumed to generate a minimum output of the target sector, e.g. Home's government subsidizes y-production up to the level $\bar{y}$, in which case domestic output of good y is

$$y \in \begin{cases} \{\bar{y}\} & if\ p^{Home} < b \\ [\bar{y}, 1] & if\ p^{Home} = b \\ \{1\} & if\ p^{Home} > b. \end{cases}$$

Notice that the subsidized level $\bar{y}$ is assumed to be independent of relative prices. The actual design of the subsidy may be thought of as a price guarantee the government gives a set of firms and which applies up to the target quantity $\bar{y}$. Alternatively, the government hands out per unit subsidies up to the targeted quantity $\bar{y}$ and distributes these randomly among competitive firms.[3] In either case the aggregate effect of this policy is a minimum output level in the relevant sector. Abusing terminology for the sake of brevity, these minimum levels $(\bar{x}, \bar{y}, \bar{x}^*, \bar{y}^*)$ will be simply referred to as *subsidies.*

[3]Notice that positive profits might accrue in such a scenario. This is irrelevant for the present paper's results since income distribution does not affect aggregate demand in case of homothetic preferences.

The Timing

Tariffs and subsidies obviously impact the countries' production structure. How exactly policies affect decentralized production depends on the timing of events. Throughout the paper I assume that within a period all decisions concerning production are taken simultaneously – i.e. governments fix tariffs and subsidies while firms make output decision at the same time. Once these supply side decisions are taken, goods are traded and individuals consume.

In equilibrium firms take governments decisions as given and consequently, when Home and Foreign subsidize the quantities $(\bar{x}, \bar{y}, \bar{x}^*, \bar{y}^*)$ and set tariffs T, and T^* domestic output is

$$y \in \begin{cases} \{\bar{y}\} & if\ pT < b \\ [\bar{y}, 1 - \frac{\bar{x}}{b}] & if\ pT = b \\ \{1 - \frac{\bar{x}}{b}\} & if\ pT > b \end{cases} \qquad x \in \begin{cases} \{b(1-\bar{y})\} & if\ pT < b \\ [\bar{x}, b(1-\bar{y})] & if\ pT = b \\ \{\bar{x}\} & if\ pT > b \end{cases}$$

$$x^* \in \begin{cases} \{\bar{x}^*\} & if\ bp/T^* > 1 \\ [\bar{x}^*, 1 - \frac{\bar{y}^*}{b}] & if\ bp/T^* = 1 \\ \{1 - \frac{\bar{y}^*}{b}\} & if\ bp/T^* < 1 \end{cases} \qquad y^* \in \begin{cases} \{b(1-\bar{x}^*)\} & if\ bp/T^* > 1 \\ [\bar{y}^*, b(1-\bar{x}^*)] & if\ bp/T^* = 1 \\ \{\bar{y}^*\} & if\ bp/T^* < 1. \end{cases} \tag{4}$$

When deciding on tariffs and subsidies, government are assumed to maximize their citizens' utility (2). The next step is to derive an expression for the equilibrium utility and to compute the individually optimal policies.

The costs of subsidies are covered by lump-sum taxes and tariff revenues are distributed in a lump sum way. Thus, Home's per capita income equals its average income which is $I = x + pTy + (T-1)p(c_y - y)$. Expenditure shares are constant and one half ($pTc_y = c_x = I/2$) so that Home's income takes the form

$$I = (x + py)\frac{2T}{T+1}$$

and Home's utility is

$$u = \frac{x + py}{\sqrt{p}} \cdot \frac{\sqrt{T}}{T+1}. \tag{5}$$

Note that in the case of symmetry (the important one in the following) relative prices are one ($p = 1$), so that

$$u = (b(1-y) + y)\frac{\sqrt{T}}{T+1}$$

This equation reveals that, not surprisingly, globally optimal policies are unique and consist of no distortions at all ($T = 1$ $\bar{y} = 0$, $\bar{x} = b$), which implies complete specialization ($x = b$, $y = 0$). In this case (5) equals (3). But it will become clear shortly that the Nash Equilibrium generates other outcomes.

Calculations parallel to those above give Foreign's income

$$I^* = (x^* + py^*)\frac{2T^*}{T^* + 1}$$

and with the trade balance $x - c_x = p(c_y - y)$ one solves for the world price for good y

$$p = \frac{x^*T^*(T+1) + x(T^*+1)}{yT(T^*+1) + y^*(T+1)}. \tag{6}$$

When setting their policies, Home's and Foreign's governments take into account their impact on world prices (6). In particular, governments use tariffs and subsidies to distort world prices to their favor with the ultimate goal to maximize their citizens' utility. Thus, the uncooperative, static maximization problem is

$$\max_T \frac{x + py}{\sqrt{p}} \cdot \frac{\sqrt{T}}{T+1} \qquad s.t.\ (6) \tag{7}$$

where Foreign's tariffs and production structures are taken as given. The optimality condition[4] for the tariffs gives rise to the best response functions

$$T^{BR} = \sqrt{\frac{y^*}{x^*} \cdot \frac{x^* + x(1 + 1/T^*)}{y^* + y(T^*+1)}}. \tag{8}$$

Under symmetry, the best response function leads to

$$T^N = T^{*N} = \sqrt{\frac{x}{y}}. \tag{9}$$

Optimal subsidies are $\bar{y}^N = 1/(b+1)$ (see Appendix) so that the full Nash Equilib-

[4]These equations constitute an extension of the results in Kennan and Riezman (1988). See appendix for a proof of (8).

rium is characterized by the strategies

$$\begin{array}{lll} \bar{y}^N = 1/(b+1) & \bar{x}^N = 0 & T^N = b \\ \bar{x}^{*N} = 1/(b+1) & \bar{y}^{*N} = 0 & T^{*N} = b. \end{array} \tag{10}$$

Under these Nash strategies (10) individuals obtain the Nash utility

$$u^N = \frac{b^2+1}{(b+1)^2}\sqrt{b}. \tag{11}$$

Expression (11) reflects the utility of citizens living in a world where governments non-cooperatively choose import tariffs, exploiting their market power in the world market. The respective market power is smaller, the less foreigners are vulnerable to domestic tariff setting. Consequently, in order to be less exposed to tariffs, foreigners produce some of their import good domestically. Overall, tariffs may thus be said to represent the offensive part of the trade policy by which countries try to change the terms of trade, while subsidies reflect a defensive move that shields countries from foreign actions. Both policies distort the economy and induce efficiency losses.

To sum up this section's main result, countries engage in distorting policies to improve their terms of trade, but these attempts mutually neutralize and the sole effects are utility losses on all sides. The governments' game is subject to a prisoners' dilemma and as such the inefficiencies can be cured through reputation building in a repeated game. Infinite repetition of the stage game described above is the subject of the next section.

3 Repeated Trade and Cooperation

The previous section has shown that in a one-shot trade game countries are tempted to reap gains by charging tariffs unilaterally. Yet, in a repeated game, such actions can be prevented when they come at the cost of future cooperation. Following standard assumptions, transitional gains from defection are supposed to come at the cost of a breakdown of trust and future cooperation. If the threat from future trade war is severe enough, free trade is dynamically optimal and said to be self-enforcing. If countries heavily discount future utility, however, this is not the case. In such a situation, it is possible to sustain *some* degree of, though not *complete* trade liberalization. In this case the natural question arises which of the trade barriers should be removed preferably and which should stay to keep agreements self-enforcing. This section explores the efficient mix of tariffs and subsidies that induces the least distortions while keeping the trade agreement sustainable. The next part prepares the ground and illustrates the conditions under which free trade is self-enforcing. Later, these conditions will be assumed to be violated and the optimal mix of policy functions is analyzed.

Sustaining Free Trade

Assume that the one-shot trade game of the previous section is repeated infinitely often. Let β be the factor the two countries discount the flow of utilities (2) with and consider the following strategies. Both countries do not charge tariffs and do not engage in subsidies ($T = T^* = 1$ and $y = x^* = 0$) as long as both did so in every period in the past. If one country defects and deviates from this pattern the other cannot react in the same period. Following the period of defection, however, both countries will play Nash strategies, receiving the Nash utility (11). Under these assumptions cooperation is self-enforcing if at each time s the future discounted flow of utilities under cooperation is bigger than that of defection, i.e. if condition

$$V_s^{Cooperate} = \sum_{t \geq s} \beta^t u_t^C \geq u_s^D + \sum_{t \geq s+1} \beta^t u_t^N = V_s^{Defect} \qquad \forall s \tag{12}$$

is satisfied where, u_t^C stands for the cooperation utility, u_t^N for the Nash utility (11), and u_t^D for defection utility. Inequality (12) represent the self-enforcement constraints (SEC) and plays a central role in the following analysis. The present section's main objective is to explore when it binds and how to use tariffs and subsidies optimally to satisfy the SEC.

A good starting point of the analysis are the conditions under which free trade is self-enforceable in a time-invariant game. Under time-invariance the time-indices of utilities can be dropped and conditions (12) are equivalent to

$$\beta \geq \frac{u^D - u^C}{u^D - u^N}. \tag{13}$$

Observe that utilities under cooperation and under trade war are as specifies by (3) and (11), respectively. To derive the defection utility u^D recall that not only the foreign country's government but also firms worldwide are taken by surprise when the local government deviates to off-equilibrium policies. Just like foreign tariffs and subsidies, domestic and foreign firms cannot respond to the change before the next period and output patterns are fixed within the period of defection. Adopting the terminology from above (i.e. identifying subsidies with the output levels) a deviating government defects on tariffs only and not on subsidies. Thus, to compute u^D one takes the limit $x^* \to 0$ in (5) under prices (6) and the best response tariff (8) while setting $T^* = 1$ and $y = 0$. These computations deliver to the defection utility $u^D = b/\sqrt{2}$. With (3) and (11) free trade turns out to be self-enforceable whenever

$$\beta \geq \frac{\sqrt{2} - 1}{\sqrt{2} - 2u^N/b} \tag{14}$$

holds. Note with the expression of the Nash utility (11) that u^N/b is decreasing in b and so is the expression on the right of (14). As the differences in productivity grow larger, the more likely free trade is sustainable, since an increase in b makes the value of cooperation grow faster than the value of defection. Intuitively, an increase in b raises world productivity uniformly across secotrs but productivity of a single country only partially. This biased productivity growth on a country level increases dependence on imports and trade wars become tougher. Consequently, the rise in b increases the trade war utility relatively less that it increases cooperation utility and since finally the value of defection is a composite of the instantaneous gains and the following trade war, the rise in b makes cooperation relatively more attractive, thus relaxing the self-enforcement constraint. This mechanism will play a central role in Section 4.

Whenever countries heavily discount future utility, condition (14) is violated - the threat of a trade war does not suffice to discipline the countries to respect free trade. For the rest of the paper this will be assumed to be the case [5]. It is well understood that when free trade is not self-enforcing, it is nevertheless possible to sustain a limited degree of cooperation. In the framework of the present paper with two policy instruments - tariffs and subsidies - the natural question arises which of them should be reduced to what extend. This question will be addressed in the following paragraphs.

[5] Seeking remedy from this inefficiency, some scholars follow Dixit (1987) and assume autarky as a harsher threat which also constitutes a Nash equilibrium. This change makes cooperation on free trade more likely but does not guarantee it. The results below do not depend on the choice of (11) as the threat.

Sustaining Constrained Trade Agreements

Assume that countries are impatient so that (14) is violated and free trade is not self-enforcing. In this case, starting from the trade war level, a *partial* reduction of tariffs and subsidies is still self-enforcing. The idea is to keep small amounts of trade barriers to reduce incentives to defect, making such limited cooperation possible[6]. The inefficiencies these policies create are the price to pay for avoiding larger losses of a trade war. To compute the optimal policies denote the tariff and subsidies implemented by an agreement $\bar{y}^A$, $\bar{x}^A$, and T^A. The optimal static, symmetric, self-enforcing trade agreement is then the solution of

$$\max_{T,\bar{x}^A,\bar{y}^A} u(\bar{y}^A,\bar{x}^A,T^A) \qquad s.t.\ \beta \geq \frac{u^D(\bar{y}^A,\bar{x}^A,T^A) - u^C(\bar{y}^A,\bar{x}^A,T^A)}{u^D(\bar{y}^A,\bar{x}^A,T^A) - u^N}. \tag{15}$$

Note that the quantities $\bar{y}^A$ $\bar{x}^A$ refer to Home's subsidies of the import and export sectors, respectively, while formally Foreign's utility and constraint is absent. By symmetry of the setup, however, the solution of (15) maximizes both countries' utility subject to both constraints. The efficient, symmetric, time-invariant trade agreement is described by the optimal policy functions $(\bar{y}^A,\bar{x}^A,T^A)$ that solve (15).

Cooperation utility is $u^C = (x^A + y^A)\sqrt{T^A}/(T^A + 1)$ according to (5) and the uncooperative outcome of trade war is again the Nash utility u^N from (11). To compute Home's defection utility u^D note that the arguments of u^D are the cooperation policies that are defected on (T^A, y^A, x^A) since Foreign tariffs and world output structures do not react on the spot. The actual defection tariff is defined by equation (8).

As shown above, for large β the solution to this problem is unconstrained and consists of no political intervention at all. In the other extreme, if $\beta = 0$, the future is not valued at all and the outcome is a trade war as in section 2. For any intermediate range of β, the self-enforcement constraint does bind and one can formulate the following

Proposition 1 *Any efficient, symmetric, and self-enforcing trade agreement that does not implement free trade includes positive import tariffs $T^A > 1$ and positive subsidies, which favoring import competitors $\bar{y}^A > 0$.*

[6] The reason for this result is that small deviations of the policy functions around the Nash levels have a first-order impact on the cooperation utility but a second order effect on the defection utility.

Proof. Prove in a first step that the optimal trade agreement includes $T^A > 1$ and $y^A > 0$, i.e. positive output of the import competing sector. Show in a second step that positive subsidies to the import competing sector are needed to induce the optimal quantity, i.e. $y^A = \bar{y}^A$.

Step 1. Write the Lagrangian of the maximization problem (15) as

$$\mathcal{L} = u^C + \lambda \left[\beta + \frac{u^C - u^N}{u^D - u^N} - 1 \right]$$

while the arguments of the respective utilities are dropped. Notice that $T = T^* = T^A$ and $y = x^* = y^A$ in a symmetric trade agreement. Now check with (5) and $p = 1$ that

$$\left. \frac{du^C}{dT^A} \right|_{T^A=1} = 0$$

and use (5), (6), and (8) to check

$$\left. \frac{du^D}{dT^A} \right|_{T^A=1} < 0$$

Together, both expressions imply

$$\left. \frac{d\mathcal{L}}{dT^A} \right|_{T^A=1} > 0.$$

whenever $\lambda > 0$. Consequently, $T^A > 1$ holds for the constrained solution of (15).

Concerning quantities y^A, use equations (5), (6), and (8), to compute

$$\frac{d}{dy^A} \ln \left[u^D(T^A, y^A) \right] = -\frac{c_o}{\sqrt{y^A}} + o\left((y^A)^{-1/2} \right) \tag{16}$$

where c_o is positive and constant in y^A. Further, take the derivative

$$\begin{aligned} \frac{d\mathcal{L}}{dy^A} &= \frac{du^C}{dy^A} + \lambda \frac{d}{dy^A} \frac{u^C - u^N}{u^D - u^N} \\ &= \frac{du^C}{dy^A} + \lambda \left(\frac{1}{u^D - u^N} \frac{du^C}{dy^A} - \frac{u^C - u^N}{(u^D - u^N)^2} \frac{du^D}{dy^A} \right). \end{aligned}$$

By (16) and since du^C/dy^A is finite at $y^A = 0$ this leads to

$$\lim_{y^A \to 0} \frac{d\mathcal{L}}{dy^A} = +\infty$$

whenever $\lambda > 0$. Consequently, $y^A > 0$ holds for the constrained solution of (15).

Step 2. Check that T^A, the tariff prevailing in an optimal trade agreement satisfies $T^A < b$. To this aim set

$$\begin{aligned} \Delta^C(y^A, T^A) &= u^C(y^A, T^A) - u^N \\ \Delta^D(y^A, T^A) &= u^D(y^A, T^A) - u^N. \end{aligned}$$

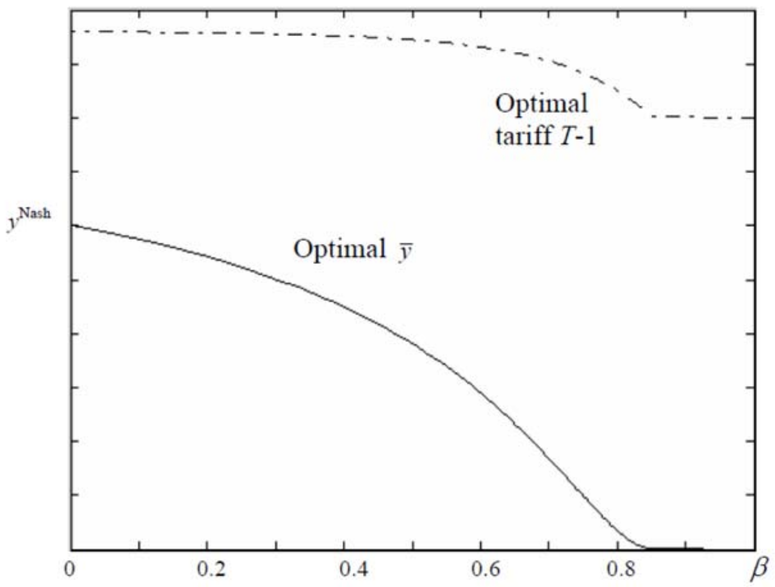
Since solutions are interior when the SEC binds (i.e. when $\Delta^C/\Delta^D = (1-\beta)$) one can take derivatives

$$\frac{dT^A}{d\beta} = -\left[\frac{d}{dT^A}\left(\frac{\Delta^C}{\Delta^D}\right)\right]^{-1} = \lambda\left[\frac{du^C}{dT^A}\right]^{-1}$$

The last equation holds by the optimality condition $d\mathcal{L}/dT^A = 0$. Since the $du^C/dT^A < 0$ and $\lambda > 0$ this proves that $dT^A/d\beta < 0$. Finally, (13) requires $\lim_{\beta\to 0}(u^D - u^C) = 0$ so that the optimal tariff approaches the Nash level $T^N = b$ as $\beta \to 0$. Thus, $T^A < b$ for $\beta \in (0, 1)$. Since relative world price $p = 1$ in the symmetric equilibrium, this implies that domestic relative import prices in Home and Foreign are $p^{Home}, p^{Foreign} < b$ and by (4) all output in the import competing sectors must be subsidized. ■

Figure 1 illustrates the finding of the proposition. On the horizontal axis the discount factor β runs from zero to one. For large β, inequality (14) is satisfied and free trade is sustainable. Consequently, no tariffs are charged and there is no import competing production under the optimal trade agreement. As soon as β drops below the threshold in (14) the optimal trade agreement includes positive, subsidized y-production. As the discount factor approaches zero, both countries ignore future benefits, and consequently the optimal trade policies $(\bar{y}^A, T^A)$ approach the Nash levels (10).

Proposition 1 shows that subsidies to import competing sectors are efficient in reducing defection incentives of foreign countries so subsidies are positive whenever the SEC binds. For the intuition of this result assume that, say, Home does not produce its import good y at all. As Foreign is the only supplier of the essential y, Home strongly depends on Foreign's supply and is willing to pay a ot for it so that Foreign's potential gains from defection are large. But even small amounts of y-production in Home already break Foreign's quasi-monopolistic position and substantially reduce its ability to extract output from Home. Thus, positive domestic



The optimal trade agreement implements free trade if the discount factor β is large. For small β optimal tariffs and government subsidies to the import good are both strictly positive ($T > 1$; $\overline{y} > 0$).

Figure 1: Optimal Trade Agreement (Flexible Output)

production of the imported good is part of any trade agreement that does not implement free trade. – Taking this result for granted, one may ask further why domestic markets fail to provide the quantity $\overline{y}^A > 0$ of the optimal trade agreement. A quick look at relative prices answers this question. Under optimal tariffs, relative prices for imported goods are too low to encourage domestic production. The very success of trade agreements wipes out the market for domestic producers. Without subsidies firms would make losses when providing the optimal level of import-competing output that insures a country against foreign defection. Profit-maximizers do not incur such losses for the social benefit of sustained cooperation. Consequently, the government has to step in and subsidize import-competing production.

It is worth to dig a bit deeper into the intution of Proposition 1. From the government's perspective the incentive to set a unilaterally optimal tariff can be decomposed in the following way. An authority that cares about domestic producers gains but not about foreign consumers' losses will try to replicate monopoly markups in the export market and set tariffs to this end. According standard theory, monopoly markups depend on the elasticity of demand σ through the factor $1/(\sigma - 1)$. Since Cobb-Douglas utility exhibits an elasticity of substitution of one, this translates into an infinite markup. But by engaging in production of the import good, a country *increases* its import elasticity and thereby reduces the markup dramatically (from infinity to a finite value). For this reason import competing production is extremely efficient in reducing the defection utility. This observation shows that the choice of the utility is not innocent for the results but the general argument applies for essential goods only.

Proposition 1 states that subsidies can be efficient in reducing vulnerability to dicey suppliers. Some aspects during and following the energy crisis of the 1970s can be read in the light of that finding: when the OPEC imposed an embargo on western industrialized countries, these latter spent a substantial amount of public money to set up national energy programs. The stated aim of these programs was to reach some degree of self-sufficiency and reduce the vulnerability to the countries that just had demonstrated their ability to collude to a cartel of suppliers. More surprisingly, industrial countries continued and intensified these subsidies after international oil prices dropped in the counter-oil shock 1986 (see Kohl (1991)). A common objection to such politics is that energy reserves are not to be depleted in times of low international prices but should rather be preserved for periods when world markets are tighter. Yet, these strategies can be justifies by Proposition 1. As the model shows, subsidized energy production might precisely be the move that prevents a renewed tightening of import supply by cutting the incentives of oil-producers to collude. The key observation here is that supply shortages are endogenous and can be prevented by artificial domestic competition. Thus, the seemingly lobby-oriented policy may - in the light of Proposition 1 - eventually be socially optimal.

Finally note that present paper's model predicts that optimal protection is favoring import-competing sectors. Rodrik (1995) identifies an "anti-trade bias" in trade policy and convincingly argues that this observation contradicts the standard political economy mechanisms (see Limao and Panagariya (2002) for a rare exceptions). In contrast to existing literature, Proposition 1 suggests that this anti-trade bias may be exactly what welfare maximizing governments do to make trade agreements self-enforcing.

4 Dynamic Comparative Advantage

The present section analyzes how a deepening of the comparative advantage affects the cooperation incentives. As pointed out in connection with equation (14) in the previous section, a more pronounced comparative advantage (a larger parameter b) raises the value of cooperation more than the value of defection and makes free trade more likely. This section shows that a carving in of the comparative advantage leads to gradual trade liberalization, in the process of which governments optimally protect declining industries.

The comparative advantage is first assumed to deepen exogenously through a single anticipated jump in productivities b. This jump then leads to a gradual reduction of trade barriers that sets in before the date of the technology change. Under the optimal dynamic agreement the output of import-competing shrinks in that period. In this sense, protection of declining industries is part of an optimal trade agreement. The increase in the comparative advantage is then assumed to be generated endogenously, stemming from a basic learning by doing process. In this way, the results of this section integrate in and relate to the wider literature on learning by doing and international trade (e.g. Krugman (1987), Young (1991), Devereux (1997)).

In a repeated game where future gains form cooperation make players respect agreements at present, all upcoming events enter the present self-enforcement constraint. If for example some event increases gains from cooperation from next year on, tomorrow's cooperation will be deeper and more beneficial. But these benefits also increase the present value of respecting the agreement which, in turn, relaxes the present self-enforcement constraint and allows a partial improvement of cooperation today already. As time goes by the increased future gains approach and cooperation gradually improves. To explore this argument formally, assume that the productivity in the exporting sector, b, increases with a single exogenous jump at a future date t_0. This assumption is captured in the process of technologies

$$b_t = \begin{cases} \underline{b} & if\ t < t_0 \\ \bar{b} & if\ t \geq t_0 \end{cases} \tag{17}$$

with $\bar{b} > \underline{b} > 1$. Rational agents anticipate this jump. To save notation define the gain from, respectively, defection and cooperation relative to Nash outcome as

$$\begin{aligned}\delta(T^A, y^A; b) &= u^D(T^A, y^A, b) - u^N(b) \\ \xi(T^A, y^A; b) &= u^C(T^A, y^A, b) - u^N(b).\end{aligned}$$

Both expressions depend on the parameter b. The participation constraint at time s can then be written as

$$\delta(T_s^A, y_s^A; b_s) \leq \sum_{\tau \geq s} \beta^{\tau - s} \xi(T_{s+\tau}^A, y_{s+\tau}^A; b_{s+\tau})$$

where time indices are now added to the policies of the trade agreement. Remember that an increase in b was shown to relax the static free trade self-enforcement constraint (13). Consequently, one can assume that free trade is sustainable under $\bar{b}$ but not under $\underline{b}$:

$$\delta(1, 0; \bar{b}) \leq \frac{1}{1-\beta} \xi(1, 0; \bar{b}) \qquad \delta(1, 0; \underline{b}) > \frac{1}{1-\beta} \xi(1, 0; \underline{b})$$

Further, as long as t_0 is in the distant future, free trade can be assumed not to be sustainable at $t = 0$. Thus, there must be a time $t_1 \leq t_0$ so that free trade is sustainable at t_1 and ever after

$$\delta(1, 0; b_{t_1}) \leq \frac{1 - \beta^{t_0 - t'}}{1 - \beta} \xi(1, 0; \underline{b}) + \frac{\beta^{t_0 - t'}}{1 - \beta} \xi(1, 0; \bar{b}) \qquad t' \geq t_1$$

but at $t_1 - 1$ it is not

$$\delta(1, 0; b_{t_1 - 1}) > \frac{1 - \beta^{t_0 - t' + 1}}{1 - \beta} \xi(1, 0; \underline{b}) + \frac{\beta^{t_0 - t' + 1}}{1 - \beta} \xi(1, 0; \bar{b}).$$

Suppose again that countries always implement the efficient symmetric trade agreement. This means that from time t_1 onwards laisser-faire policies $(T, y) = (1, 0)$ prevail. At time $t_1 - 1$, the optimal trade agreement maximizes cooperation utility $u^C(T_{t_1 - 1}, y_{t_1 - 1})$ subject to

$$\delta(T_{t_1-1}^A, y_{t_1-1}^A; \underline{b}) - \xi(T_{t_1-1}^A, y_{t_1-1}^A; \underline{b}) \leq \beta \sum_{\tau \geq 0} \beta^\tau \xi(1, 0; b_{t_1 + \tau}). \tag{18}$$

Note that by construction of t_1 the constraint must be binding so that the value function of this maximization problem is less than under laisser-faire, $u^C(1, 0)$, and consequently the gains from cooperation will be less

$$\xi(T^A_{t_1-1}, y^A_{t_1-1}; \underline{b}) < \xi(T^A_{t_1}, y^A_{t_1}; \underline{b}) = \xi(1, 0; \underline{b}). \tag{19}$$

The outcome of the maximization problem deliver the policy functions $(T^A_{t_1-1}, y^A_{t_1-1})$ for time $t_1 - 1$. At time $t_1 - 2$, governments take $(T^A_{t_1-1}, y^A_{t_1-1})$ as given to calculate the optimal sustainable trade agreement, maximizing $u^C(T^A_{t_1-2}, y^A_{t_1-2})$ s.t.

$$\begin{aligned}\delta(T^A_{t_1-2}, y^A_{t_1-2}; \underline{b}) - \xi(T^A_{t_1-2}, y_{t_1-2}; \underline{b}) \leq\ & \beta\xi(T^A_{t_1-1}, y^A_{t_1-1}; \underline{b}) \\ & + \beta^2 \sum_{\tau \geq 0} \beta^\tau \xi(1, 0; b_{t_1+\tau}).\end{aligned} \tag{20}$$

Note that by (19) the RHS of (20) is smaller than the RHS of (18) so the self-enforcement constraint at time $t_1 - 2$ (20) is tighter than at time $t_1 - 1$ (18). Consequently, the trade agreement at time $t_1 - 2$ (T_{t_1-2}, y_{t_1-2}) is less liberal than the one at $t_1 - 1$ (T_{t_1-1}, y_{t_1-1}). An induction argument completes the proof that, starting from t_1 and going *backwards* in time the trade agreement gets gradually *less* liberal. This leads to the following

Proposition 2 *An anticipated exogenous deepening of comparative advantage at time t_o increases the anticipated gains from the trade agreement. Thereby, it relaxes the self-enforcement constraint even before date t_o and consequently trade is liberalized gradually. During the liberalization period declining industries are protected.*

Proof. By (18), (20) and an induction argument, it remains to be shown that a gradually relaxing SEC translates into a gradual reduction of traiffs and subsidies. Now, the SEC at time t is

$$\delta(T^A_t, y^A_t; b_t) - \xi(T^A_t, y^A_t; b_t) \leq \sum_{\tau \geq t+1} \beta^\tau \xi(T^A_{t+\tau}, y^A_{t+\tau}; b_{t+\tau}).$$

Let the expression on the right be denoted with B_t. B_t is increasing in t. The optimal agreement solves the program

$$\max_{T^A_t, y^A_t} u^C(T^A_t, y^A_t) \qquad s.t. \quad \delta(T^A_t, y^A_t; b_t) - \xi(T^A_t, y^A_t; b_t) \leq B_t. \tag{21}$$

For $t < t_1$ the constrained solution satisfies

$$\delta(T^A_t, y^A_t; b_t) - \xi(T^A_t, y^A_t; b_t) - B_t = 0.$$

Implicit derivatives lead to

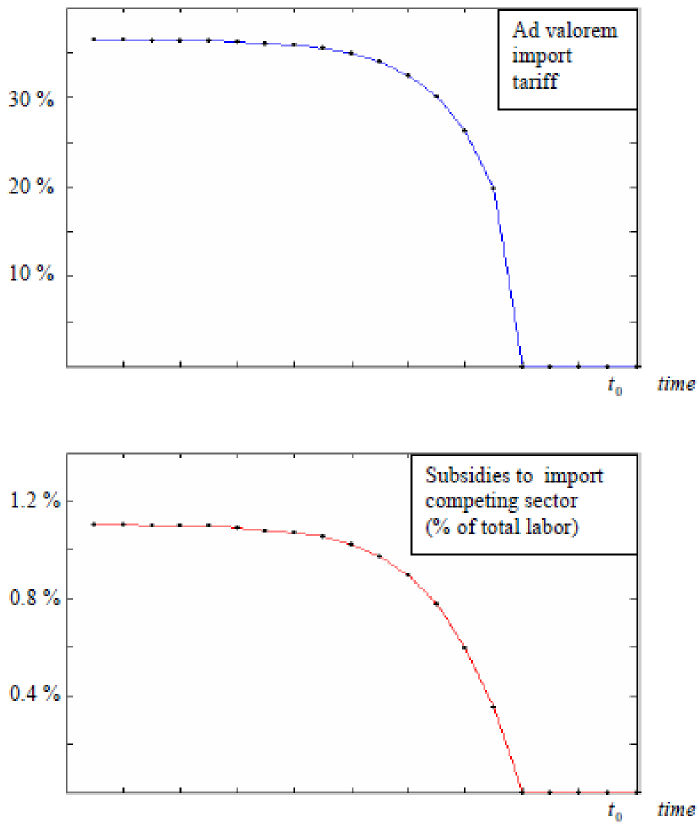
$$\begin{aligned}\frac{dT_t^A}{dB_t} &= \left[\frac{d}{dT_t^A}\left(u^D(T_t^A, y_t^A, b) - u^C(T_t^A, y_t^A, b)\right)\right]^{-1} \\ &= \left[-\frac{1}{\lambda_t}\frac{d}{dT_t^A}u^C(T_t^A, y_t^A, b)\right]^{-1} < 0\end{aligned}$$

where λ_t is the Lagrange multiplier of (21). Thus, T_t^A is decreasing in time. The proof that $dy_t^A/dB_t < 0$ for $t < t_1$ is identical. ■

The proposition has two parts, which address gradualism of trade liberalization and the protection of declining sectors. While the finding of gradualism essentially repeats the result of Devereux (1997), the novel part of Proposition 2 is the fact that optimal trade agreements protect declining industries through tariffs *and* subsidies. Figure 2 illustrates the dynamics. The jump of b allows for free trade after the date t_o. The anticipated increase in the gains from cooperation allow trade liberalization already before that date and, as the date t_o approaches, tariffs and subsidies are slowly faded out.

The protection of declining industries is usually explained through political economy arguments (see Grossman and Helpman (1994) and Goldberg and Maggi (1999) for prominent contributions). The contraction of an industry, a standard argument runs, is followed by a decrease in lobbying activity, which in turn leads to less protection and further decline (see Hillman (1982), Cassing and Hillman (1986), and Van Long and Vousden (1991)). In contrast, the present paper's explanation relies on purely welfare-maximizing governments and the reason for a stepwise reduction of protection does not stem from the desire to cushion or reduce political resistance but it is an optimal policy because. The self-enforcement constraint simply impedes to let sectors did at once. Import competing sectors must be protected to the degree that the self-enforcement constraint binds and as the latter stepwise relaxes, industries gradually shrink and die.

A classical way to model a deepening of comparative advantage endogenously is via learning by doing (see Krugman (1987), Young (1997), Devereux (1997)). The following lines will show that the process (17) can be generated by a standard learning by doing process and thus relate the result of Proposition 2 to the literature on learning by doing and international trade. Assume that in each sector there are two technologies available, a basic and an advanced one. The advanced technology has



The parameter of comparative advantage, b, jumps up at date t_0. The jump in b induces free trade after that date. The anticipated gains from cooperation allow gradual liberalization of tariffs (top panel) and subsidies (bottom panel) already before date t_0.

Figure 2: Optimal Trade Agreement with Learning by Doing

a lower unit labor requirement, yet it requires a minimum level of sector specific knowledge κ^z $(z = x, y)$ for production to take place. Denote that minimum knowledge with the variable $\bar{\kappa}^z$, where z indicates the sector. Then, Home's productivity in the two sectors is summarized by

$$b(\kappa^x) = \begin{cases} \bar{b} & if\ \kappa^x \geq \bar{\kappa}^x \\ \underline{b} & else \end{cases} \qquad \text{and} \qquad a(\kappa^y) = \begin{cases} \bar{a} & if\ \kappa^y \geq \bar{\kappa}^y \\ 1 & else \end{cases}$$

where $\bar{b} > \underline{b} > 1$ and $\bar{a} > 1$. Productivity in Foreign depends on its sector-specific knowledge in a symmetric way. Assume further that the sector-specific disembodied knowledge accumulates through learning by doing according to the following process

$$\kappa^x_{t+1} = \kappa^x_t + x_t \qquad \text{and} \qquad \kappa^y_{t+1} = \kappa^y_t + y_t \tag{22}$$

in Home and equivalently in Foreign. When Home and Foreign start with an initial stock of knowledge $\kappa_0^{z,(*)}$ $(z \in \{x, y\})$ satisfying the conditions

$$\begin{aligned} \kappa^x_0 - \bar{\kappa}^x &= \kappa^{y,*}_0 - \bar{\kappa}^{y,*} \\ \kappa^y_0 - \bar{\kappa}^y &= \kappa^{x,*}_0 - \bar{\kappa}^{x,*} \\ \bar{\kappa}^x - \kappa^x_0 &\leq \bar{\kappa}^y - \kappa^y_0 \end{aligned}$$

the specialization pattern during a transition period of gradual trade liberalization induce a faster growth of knowledge in the export sector. Thus, the advanced technology of the export sector is adopted in both countries simultaneously and before the date when adoption of the advanced technology in the import sector is profitable. In this way, learning by doing generates the process (17) with an implicitly defined date of complete trade liberalization t_0.

The previous two sections made a strong case for the use of subsidies in trade agreements, pointing out some beneficial effects it can have in a competitive world. The results are in line with Bagwell and Staiger (2004) and (2006) who argue that the banning of subsidies by the WTO "may ultimately do more harm than good to the multilateral trading system". It is important, however, to stress the qualifications of such reasoning. The next section will do so by highlighting the role of a flexible industrial structure.

5 Rigid Industrial Policy

As discussed above some necessary conditions need to be satisfied for the previous sections' results to go through. In particular, governments are required to heavily discount future gains and import goods need to be essential. Apart from these conditions another, less explicit, assumption turns out to be crucial. This additional assumption concerns the flexibility of industrial policies.

Up to this section, output patterns were assumed to be flexible enough to change from period to period. In particular, the time to change tariffs and subsidies was assumed to be identical. According to the definition of the WTO (1995), however, the term subsidy includes a wide range of governments' activities including the public provision of sector-specific inputs, the production of which needs time to build, is long-lived, and subject to slow adjustment and changes. The present section therefore deals with the case where the time to change a tariffs is significantly shorter than the horizon for changing an entire country's output structure. It shows that this change considerably qualifies the previous results.

Assume in the following that governments have control over a perfectly divisible resource whose amount is normalized to unity and which is a factor of production. Allocation of the resource to one of the sectors makes it become a sector-specific input good. This government input is essential in each industry but exhibits decreasing returns. Further, there is congestion in the use of this publicly provided good, which leads to decreasing returns to labor on the sector level. Each government distributes a fraction γ of it to the exporting and $1-\gamma$ to the importing sector. The following production functions reflect these assumptions

$$x = b(\gamma/L_x)^{\alpha} L_x \qquad\qquad y = ((1-\gamma)/L_y)^{\alpha} L_y$$

for Home and the symmetric counterpart for Foreign. Let $\alpha \in (0,1)$ and $b > 1$. This keeps Home's natural comparative advantage in good x. Atomistic workers produce competitively taking overall productivities $b(\gamma/L_x)^{\alpha}$ and $((1-\gamma)/L_y)^{\alpha}$ as given. Wage equalization leads to

$$L_x = \frac{\gamma}{\gamma + (1-\gamma)(pT/b)^{1/\alpha}} \qquad\qquad L_y = \frac{(1-\gamma)(pT/b)^{1/\alpha}}{\gamma + (1-\gamma)(pT/b)^{1/\alpha}}$$

and the output

$$x = b\frac{\gamma}{(\gamma + (1-\gamma)(pT/b)^{1/\alpha})^{1-\alpha}} \qquad\qquad L_y = \frac{(1-\gamma)(pT/b)^{(1-\alpha)/\alpha}}{(\gamma + (1-\gamma)(pT/b)^{1/\alpha})^{1-\alpha}}.$$

In the limit $\alpha \to 1$, output is equal to $x = b\gamma$ and $y = 1-\gamma$, which will be taken as a benchmark here[7]. In addition, the parameter γ will be retricted to the interval $[0, 1]$ to avoid a reversal of trade flows.

Assume now that governments choose γ once and for all. The last sections' strong assumption that output structure can be changed every period is thus replaced by the opposite assumption that industrial policy is entirely inflexible. Finally, when governments choose their industrial policy γ this choice is assumed to be free from commitment problems[8]. Thus, after the initial period, countries are only able to defect on tariffs.

The effect of introducing this additional rigidity can be read one more time from the self-enforcement constraint (12). In particular, and in contrast to the previous section's setup, the initial choice of industrial policy now does affect the utility in future periods - in particular by an increase of the losses from a trade war. When capacities to produce the imported good are set to zero, a trade war appears especially grim. Consequently, countries have an excellent device to commit to free trade by setting the industrial structure γ to zero and the deliberate creation of mutual dependence constitutes a commitment-device for cooperation.

For a formal exposition of this idea, assume that the industrial structure γ is set at the initial period and stays fix forever. In the case of cooperation breakdown, both countries suffer the punishment of a trade war. This punishment utility is[9]

$$u^P = \frac{b\gamma + 1 - \gamma}{\sqrt[4]{b(1-\gamma)/\gamma} + \sqrt[4]{\gamma/b(1-\gamma)}}. \tag{23}$$

Note that the punishment utility is zero at $\gamma = 0$ and that it is increasing in γ in the range $\gamma \in [0, 1/2]$. Clearly, when production of the imported good is zero for

[7] This limit case also represents a world in which firms cannot change output as fast as governments change tariffs. The general model with $\alpha \in (0, 1)$ is numerically solvable and simulations show that all qualitative results below go through.

[8] This assumption may seem inconsistent with the commitment problems from above. But one can easily reconcile it with the general framework by assuming that all actions can be monitored at positive a monitoring cost. Under the adequate monitoring cost, incurring it only once at the start of the trade agreement is rational, while paying it every period is not.

[9] Use the symmetric tariffs (9) and utility (5) with $p = 1$.

all future periods, a trade war leads to zero utility - which is in fact worse than the Nash utility under flexible output patterns (11) ($u^N > u^P = 0$). Consequently, the self-enforcement constraint (12) for free trade, which now becomes

$$\beta \geq \frac{u^D - u^C}{u^D - u^P} = \frac{\sqrt{2} - 1}{\sqrt{2}} \tag{24}$$

is less demanding than the one under flexible output patters (14). The direct consequence of this observation is

Proposition 3 *Other things equal, free trade is more likely to be self-enforceable in a world with rigid output than with flexible one.*

This result applies when output capacities are sufficiently slow to build. The creation of mutual dependence can serve as a commitment device and can make free trade sustainable when it would not be under more flexible output patterns. In this sense the deliberate destruction of capacities in import competing sectors may be an adequate policy by generating this dependency. But can a sovereign country be expected to deliberately enter dependence to other nations? Indeed, this is a standard interpretation of what occurred with the foundation of the European Coal and Steel Community (ECSC), the cooperation that laid the basis of what later became the European Union. The pooling of essential goods (steel, coal, and, to some extend, wheat) was meant to create a mutual dependence between the six western European member nations and aimed to make future cooperation indispensable (see Gillingham (1991)).

The proposition illustrates the beneficial implications of impeding subsidies under rigid output structure for the case where countries are patient and satisfy conditions (24). This result, however, leaves open whether and how subsidies are employed when the self-enforcement constraint binds, which is the case analyzed in the remainder of the section. In particular, it will be shown that Proposition 1 does not generalize to this case and that efficient trade agreements do not always implement positive subsidies for the following reason. Small amounts of domestic production of the essential imported good make a trade war less threatening as can be read from (23). Intuitively, when the adequate production capacities are at hand, an upcoming trade war does not seem too grim and hence the value of defection increases, so that import competing production tends to *tighten* the self-enforcement constraint.

This mechanism remarkably opposes the finding from Proposition 1, where subsidies unambiguously relaxed the self-enforcement constraint. Obviously, the effects which *relax* the constraint and drive Proposition 1 are still be present. It can be shown, however, that at the margin the negative effect prevails and small amounts of import competing production unambiguously tighten the self-enforcement constraint. The consequence is the following

Proposition 4 *Under rigid output patterns, small amounts of industrial policy favoring the import competing sector unambiguously tighten the self-enforcement constraint. Consequently the optimal trade agreement either employs industrial policy in large amounts or not at all.*

Proof. Write the Lagrange function associated with the maximization problem as

$$\mathcal{L} = u^C + \lambda \left(\beta - 1 + \frac{u^D - u^C}{u^D - u^P} \right).$$

It is quick to verify

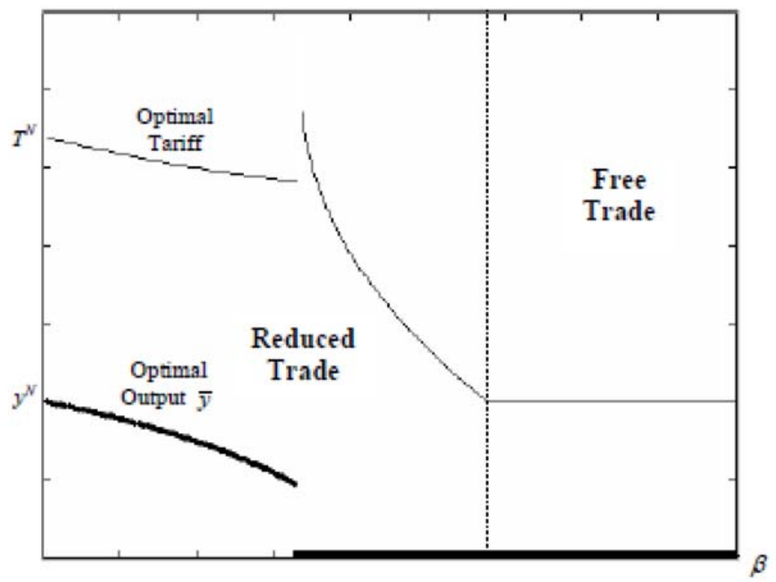
$$\frac{d}{dy^A} \ln \left[u^P(T^A, y^A) \right] = \frac{c_1}{(y^A)^{3/4}} + o\left((y^A)^{-3/4} \right)$$

with c_1 positive and constant in y^A. Thus, as $d\ln(u^D)/dy^A = -c_o/\sqrt{y^A} + o\left((y^A)^{-1/2}\right)$ (see (16)), du^P/dy^A increase at a higher order than du^D/dy^A decreases. This implies that the associated Lagrange function has the derivative

$$\left.\frac{d\mathcal{L}}{dy^A}\right|_{y^A=0} = \left.\frac{du^C}{dy^A}\right|_{y^A=0} + \lambda \left.\frac{d}{dy^A}\left(\frac{u^D - u^C}{u^D - u^P} \right)\right|_{y^A=0} = +\infty$$

whenever $\lambda > 0$ and proves the statement. ■

Figure 3 illustrates the finding of the proposition. There are now three different ranges for the discount factor. At high levels of β the economy is undistorted under the optimal agreement. For intermediate values, free trade is not sustainable but only a moderate relaxation of the self-enforcement constraint (12) is required; for these small relaxations a promotion of the import-competing sectors is inadequate since it optimally is either zero or big time. Consequently, the optimal trade agreement imposes positive tariff but zero subsidies. For the value of β still lower positive tariffs are not enough to make a trade agreement self-enforceable and both, tariffs and industrial policy, are employed in positive quantities.



There are three ranges for the discount factor β. For large β free trade is self-enforcing. In the medium range, only tariffs are used as a tool to relax the self enforcement constraint. For small β tariffs *and* industrial policy are positive in the optimal trade agreement.

Figure 3: Optimal Trade Agreement (Rigid Output)

It is worth noticing that the disciplinary forces in Propositions 1 and 4 are quite distinct. When commercial and industrial policies are equally quick to change, stimulating small quantities of domestic production of the imported good reduce the *foreign* country's incentives to defect on the agreement. In the case of more rigid output patterns, the commitment device aims to tie the hands of the domestic government and is directed against the domestic government's defection incentives. The two effects highlight the fact that to sustain trade agreements, at least one of the two is needed: one-time defection must appear little attractive or future consequences of defection quite severe.

Before closing the analysis of the rigid output assumption it is worth asking which of the model's predictions apply in the intermediate case where output patterns are neither completely rigid nor entirely flexible. To this aim consider the case between flexible and rigid production. Assume that after defection on tariffs, H periods are required to adapt industrial policy to the new uncooperative environment. In this case, the self-enforcement constraint becomes

$$V^{Cooperate} = \sum_{t\geq 0} \beta^t u^C \geq u^D + \sum_{t=1}^{H} \beta^t u^P + \sum_{t>H} \beta^t u^N = V^{Defect}$$

or

$$u^C - (1-\beta)u^D \geq \beta \left((1-\beta^H)u^P + \beta^H u^N\right). \tag{25}$$

The LHS of (25) tightens with increasing H, varying between (13) and (24) when $H \in \{1, 2, ...\}$. It is further apparent that Proposition 3 still goes through in this somewhat less rigid world: cooperation on free trade is more likely under more rigid output patterns. It is equally quick to check that Proposition 4 still goes through in the somewhat less rigid world. Starting from zero, small increases in $\overline{y}$ unambiguously tighten the self-enforcement constraint and hinder cooperation.

In this sense, the results of Propositions 3 and 4 are, compared with those in Proposition 1, the more robust ones.

6 Conclusion

This paper has argued that in a world where governments maximize social welfare the use of industrial policy can be part of the optimal strategy to make international trade agreements self-enforcing. Optimal interventions must favor comparatively disadvantaged, import-competing sectors The distortions the interventionist policies create are the price that must be paid to prevent severer damage from a trade war. Preconditions for these results are low elasticities of demand of the import-goods, strong discounting of future benefits, and flexibility in the industrial structure of countries. A dynamic extension of the model has introduced a simple learning by doing process and provided a rationale for subsidizing declining industries. A second extension has illustrated the limitations of the argument by emphasizing the role of the flexible industrial structure. When output patterns are slow to change, mutual dependence can serve as a commitment device, encouraging adherence to an agreement. In this case the stimulation of import competing sectors may even undermine trade agreements and the deliberate creation of mutual dependence through a policy that acts against import-competing sectors fosters free trade.

Appendix

Computation of the One-Period Nash Equilibrium. The program is to maximize (5) over T, $\bar{x}$ and $\bar{y}$ s.t. (4) and (6). The proof proceeds in two steps. The first step disregards (4) and assumes that Home's choice variables are T, x and y (fixing the actual output instead of the minimum levels $\bar{x}$ and $\bar{y}$). The second step shows that the original problem has the same solution.

First step. The reduced program is

$$\max_{T,y} \ln\left(\frac{x+yp}{\sqrt{p}}\frac{\sqrt{T}}{T+1}\right) \qquad s.t.\ (6) \text{ and } \quad x = b(1-y) \tag{A1}$$

The FOC w.r.t the tariff T is

$$\left(\frac{py}{x+py}-\frac{1}{2}\right)\frac{d}{dT}\ln(p)+\frac{1}{2T}-\frac{1}{T+1}=0$$

Price (6) renders

$$\frac{d}{dT}\ln(p) = \frac{x^*T^*}{x^*T^*(T+1)+x(T^*+1)} - \frac{y(T^*+1)+y^*}{yT(T^*+1)+y^*(T+1)} \tag{A2}$$

and leads to the result (see Kennan and Riezman (1988))

$$T^{BR}(y,x^*,T^*) = \sqrt{\frac{y^*}{x^*}\cdot\frac{x^*+x(1+1/T^*)}{y^*+y(T^*+1)}} \tag{A3}$$

Whatever the best strategy on the output may be, (A3) establishes the unique best response tariff. Note that the tariff of a symmetric Nash equilibrium must be $T=\sqrt{x/y}$. Note also that (A3) reduces the two-dimensional maximization problem to a one-dimensional when maximizing the utility $u(y,x^*,T^{BR}(y,x^*,T^*),T^*)$ over y. To derive the optimal output (y,x), use $x=b(1-y)$ and the envelope theorem to derive the FOC

$$\frac{-b+p}{x+py}+\frac{1}{2}\left(\frac{py-x}{x+py}\right)\frac{\partial}{\partial y}\ln(p)=0 \tag{A4}$$

The derivative of the world price (6) is

$$\frac{\partial}{\partial y}\ln(p) = \frac{-b(T^*+1)}{x^*T^*(T+1)+x(T^*+1)} - \frac{T(T^*+1)}{yT(T^*+1)+y^*(T+1)} \tag{A5}$$

Equations (A4) and (A5) imply that *if* a symmetric equilibrium (with $y = x^*$, $x = y^*$, $T = T^*$, and $p = 1$) exists, it satisfies

$$\frac{b-1}{x-y} = \frac{1}{2}\frac{b+T}{yT+x}$$

Since $T = \sqrt{x/y}$ in the symmetric equilibrium, the according strategies are

$$y^N = \frac{1}{b+1} \qquad x^N = \frac{b^2}{b+1} \qquad T^N = b \tag{A6}$$

To complete the proof that (A6) in fact describes a Nash Equilibrium, set Foreign variables according to (A6) ($T^* = b$ and $x^* = 1/(b+1)$) and show that (A4) and (A5) imply $y^N = 1/(b+1)$ and $T^N = b$. This is done by using $T^* = b$ and $x^* = 1/(b+1)$ to get with (A3)

$$T^{BR} = b\sqrt{\frac{1+(1-y)(b+1)^2}{b^2+y(b+1)^2}} \tag{A7}$$

Write further the short-hand $p = r_1/r_2$ with

$$\begin{aligned} r_1 &= b + b\frac{1-y}{T^{BR}+1}(b+1)^2 \\ r_2 &= b^2 + y\frac{T^{BR}}{T^{BR}+1}(b+1)^2 \end{aligned}$$

Combining (A5) with the optimality condition (A4) leads to

$$2\,(b-p) = (b+1)^2\left[b + T^{BR}p\right]\left\{\frac{x}{r_1} - \frac{y}{r_2}\right\} \tag{A8}$$

Now, T^{BR} from (A7) is decreasing in y so that the price (6) satisfies $dp/dy = \partial p/\partial y + (\partial p/\partial T)(dT^{BR}/dy) < 0$ and is decreasing in y as well. Thus, the expression on the left is increasing in y. Further, the expression in the square brackets on the right of (A8) is decreasing in y. Finally, write

$$\frac{x}{r_1} = \frac{1}{\frac{1}{1-y} + \frac{(b+1)^2}{T^{BR}+1}} \qquad \text{and} \qquad \frac{y}{r_2} = \frac{1}{\frac{b^2}{y} + \frac{T^{BR}}{T^{BR}+1}(b+1)^2}$$

to see with $dT^{BR}/dy < 0$ that the first term is decreasing and the second term is increasing in y. Thus, the expression in the slanted brackets on the right of (A8) is decreasing in y and so is the whole right hand side of (A8). There is hence an unique solution to (A8), which is the symmetric one from (A6).

Second step. The choice variables are now tariffs and *minimum* levels of output in the sectors ($\bar{x}$ and $\bar{y}$). It remains to show that internalizing (4) in the optimization program renders the Nash strategies (10). To this aim set $(T^*, \bar{x}^*, \bar{y}^*) = (b, 1/(b+1), 0)$ and show that Home does not gain from a deviation form (10).

By the restriction $x^* \geq \bar{x}^*$ there are two possible cases: $x^* = \bar{x}^*$ or $x^* > \bar{x}^*$. In the case $x^* = \bar{x}^*$ Home's best response induce the quantities (A6) and are thus (10). In the case $x^* > \bar{x}^*$ optimal production of Foreign firms implies $T^*p = b$ or simply $p = 1$. With equation (6) and the resource constraints $x = b(1-y)$ and $y^* = b(1-x^*)$ this leads to

$$2b(T+1)x^* = y(T+b)(b+1) + b(T-b) \tag{A9}$$

Equation (A9) shows that an increase in x^* implies an increase on y or in T. (To see the latter statement rewrite (A9) as $2bx^* = [y(T+b)(b+1) + b(T-b)]/(T+1)$ and notice that the right hand expression is increasing in T when the constraint $y \leq 1$ applies.) Finally, $p = 1$ and (5) imply that utility

$$u = (b(1-y) + y)\sqrt{T}/(T+1)$$

is decreasing in y and T. Thus, u is maximized at minimal y and T and hence, by (A9), at minimal x^*. This implies that the Nash equilibrium does not involve strategies inducing $x^* > \bar{x}^*$. Thus, (10) characterizes the Nash equilibrium.

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