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FOREIGN MONOPOLY AND SELF-ENFORCING TARIFF AGREEMENTS UNDER INTEGRATED MARKETS: PRICES *VERSUS* QUANTITIES

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This paper studies the stability of a tariff agreement among the importers of a monopolized good that is sold in an integrated market. The tariff agreement formation is modelled as a two-stage game. In the first stage, each importer decides whether or not to sign the agreement, and in the second stage the signatories choose cooperatively their tariffs whereas the non-signatories and the monopoly act in a non-cooperative way. Our findings show that the agreement consists of three countries regardless of whether the monopolist chooses the quantity or the price and the number of importers, provided that the parties to the agreement act as a leader in the second stage of the game.

Keywords: Self-enforcing tariff agreements, integrated markets, rent-shifting hypothesis.

(*JEL* D42, F13)

1. Introduction

Some world markets, as the world oil market, are markets where large producers face large importers. In this framework, as it has been shown by Bergstrom (1982) and Karp and Newbery (1991), an excise tax or an import tariff can be advantageous for the importing countries. Bergstrom (1982) analyzes the case of a price-setting monopolist, whereas Karp and Newbery (1991) focus on quantity-setting

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oligopolists. This positive effect of an import tariff on consumers' welfare appears because although the tariff increases the consumer price, it also causes a decrease in the international price of the commodity so that the loss in consumers' surplus caused by the increase in the national price is more than compensated by the gain in tariff revenues.

The aim of this paper is to extend this analysis to investigate whether the cooperation among the importing countries could enhance their market power when there is only one producer. Although we develop this analysis in a theoretical setting, we think that it is an issue that could be very relevant for the world oil market if the large importers decide finally to set up a carbon tax to curb climate change under the umbrella of an international environmental agreement as the Kyoto Protocol. In this context, it would be useful to know which could be the scope of cooperation among large importers.

To address this issue, we model the tariff agreement formation of the importing countries as a two-stage game. In the first stage each importer decides whether or not to sign the agreement, and in the second stage the signatories choose cooperatively their tariff whereas the non-signatories choose their tariff and the monopoly sets up the quantity or the price both in a non-cooperative way. In this second stage, we also consider two possibilities, that all the players take their decisions simultaneously or that the signatories enjoy a first mover advantage. Finally, we assume that signing the agreement acts as a commitment device that guarantees compliance in the second stage, i.e. if a country decides to sign the agreement in the first stage, it will select the tariff that maximizes the aggregate welfare of the agreement in the second stage.

Using a symmetric-linear model we analyze the profitability and stability of the different levels of participation in the agreement. The concept of stability used in the paper is borrowed from the literature on cartel stability, see d'Aspremont *et al* (1983).[1] This concept establishes that an agreement is stable (self-enforcing) if any signatory is at least as well off staying in the agreement as quitting, and any non-signatory is at least as well off remaining a non-signatory as joining the agreement.

[1] This concept has been applied as well to the analysis of the international environmental agreement stability, see for instance Barrett (1994).

Our findings establish that the welfare of signatories increases with the level of participation *only* when the signatories act jointly as a leader in the second stage of the game, regardless of whether the monopolist chooses the quantity or the price. Thus, a first mover advantage is a necessary and sufficient condition to make profitable a tariff agreement under an integrated market. However, it is not enough to guarantee stability. Our analysis shows that the unique self-enforcing tariff agreement consists of two importers when there are only two large importers in the market, and of three importers when there are three or more importers also regardless of whether the monopolist chooses the quantity or the price. The explanation is that as non-signatories select a tariff lower than the tariff selected by the signatories, they obtain a greater welfare that moreover increases more quickly that the signatories' welfare. The consequence is that the incentives to deviate from the agreement, given by the difference between the welfare obtained being a signatory and the welfare obtained being a free-rider of the agreement, also increase with the participation yielding unstable any agreement with a high level of participation.

The idea that rent can be extracted from a foreign monopoly through a tariff was first developed by Katrak (1977) and Svedberg (1979) for the case of linear demand, and in a more general setting by Brander and Spencer (1984).[2] Since the publication of these seminal papers, others papers have addressed the issue of trade policy towards a foreign monopoly. De Meza (1979) demonstrates that a price ceiling equal to the monopolist's constant marginal cost welfare-dominates the optimal tariff defined by Katrak. Jones (1987) shows that Brander and Spencer's (1984) result that a country may find it optimal to subsidize imports is, in general, correct in a general equilibrium framework where income effects are taken into account; but specific and ad *valorem* forms of taxation may yield different results. Spencer and Jones (1992) consider home country tariff and subsidy policies in a setting where a home firm is partially dependent on a foreign vertically integrated firm for supplies of a key input, and show that a tariff on final product imports may cause the foreign vertically integrated firm to reduce the price charged for the input under circumstances where a simple monopoly supplier of the input would increase its price. Other papers examine the effects of trade policy on the composition and the

[2] They show that in the case of highly convex demand an import subsidy might be optimal. See Brander (1995) for a nice survey on strategic trade policy.

quality of imports which are supplied by a foreign monopolist[3] or the optimal trade policy when information is incomplete[4]. However, no contribution, to our knowledge, has addressed the issues analyzed in this paper.

On the other hand, the issue of the stability of preferential tariff agreements has been extensively studied in the literature. See for instance Bagwell and Staiger (1990), Kennan and Riezman (1990), Riezman (1991), Yi (1996), Macho-Stadler *et al.* (1998) and more recently Bond *et al.* (2004). However, the trade models used in this literature are different from the one we use. In this paper, we focus on a tariff agreement levied on a foreign monopolist and we do abstraction of the trade between the importers of the monopolized good.

The paper is organized as follows. In the next section, the case of a quantity-setting monopolist is studied. First, in Part 1 of Section 2 we present the elements of the basic model used to study this case. Basing on these elements in Part 2 of Section 2 we set up the two-stage game used to analyze the stability of a tariff agreement and we show that without leadership a tariff agreement is not profitable for the signatories. With the analysis of the self-enforcing tariff agreements with leadership in Part 3 of Section 2 we close the first part of the paper. The second part, Section 3, is devoted to the study of the case of a price-setting monopolist. This part begins with the presentation in Part 1 of Section 3 of the elements of the basic model used to study this case to turn directly to the analysis of the self-enforcing tariff agreements with leadership in Part 2 of Section 3. Finally, in Section 4, the self-enforcing tariff agreement when the monopolist chooses the quantity is compared to the self-enforcing tariff agreement when the monopolist chooses the price. Concluding remarks and issues for future research end the paper.

2. The case of a quantity-setting monopolist

2.1 The basic model

In this section we present the elements of a tariff agreement formation game in an integrated international market with a foreign monopolist.

[3] See Falvey (1979), Krishna (1987), Das and Donnenfeld (1987) and Donnefeld (1988).

[4] See Prusa (1990), Gresik and Nelson (1994), Collie and Hviid (1994), Bond and Gresik (1996) and Kolev and Prusa (1999).

We shall confine our study to a partial equilibrium model. There are N identical importing countries, $i = 1, ..., N$ where the representative consumer of each country acts as a price-taker. Consumer's welfare can be written as $W_i = aq_i - (q_i^2/2) - (p+t_i)q_i + R_i$. In this expression $aq_i - (q_i^2/2)$ is the consumer's gross surplus, q_i is the consumption of the good, p the international price of the good, t_i the specific tariff, and R_i a lump-sum transfer that the consumer receives from the government. Thus, the demand of the good depends only on the consumer (national) price: $q_i = a - p - t_i$. Then the demand in the international market is

$$Q = \sum_{i=1}^{N} q_i = N(a-p) - \sum_{i=1}^{N} t_i, \qquad [1]$$

and the inverse demand function is given by

$$p = a - \frac{1}{N}\left(Q + \sum_{i=1}^{N} t_i\right),$$

so that for a given quantity, an increase in any of the tariffs reduces the price in the international market.[5] Next, by substitution of the price in the demand function of the importing countries we obtain

$$q_i = \frac{1}{N}\left(Q + \sum_{j=1}^{N} t_j\right) - t_i, \quad i = 1, ..., N.$$

Finally, assuming that tariff revenues are reimbursed to consumers through *lump-sum transfers*, i.e., that $R_i = t_i q_i$, consumer's welfare is given by the following expression

$$W_i = \frac{1}{2N^2}\left(Q + \sum_{j=1}^{N} t_j\right)^2 - \frac{1}{2}t_i^2, \quad i = 1, ..., N, \qquad [2]$$

by substitution of the price and quantity.

On the other side of the market, a profit-maximizing monopoly operates. Profits are given by $\pi = (p(Q,t) - c)Q$ where c is the marginal

[5] We focus on the case of large importers, although we surmise that the results obtained in this paper would not change if the demand from small countries were also taken into account in the analysis. Jones and Takemori (1989) have shown that a tariff can be advantageous for a small open economy facing a foreign monopoly under an integrated market if average demand elasticity abroad is lower than in the small economy.

cost of production. Thus, after substitution of the inverse demand function, the monopolist's profits are given by

$$\pi = \left(a - c - \frac{1}{N} \left(Q + \sum_{i=1}^{N} t_i \right) \right) Q. \qquad [3]$$

In the next part of this Section we analyze basing on these elements the level of participation in a self-enforcing TA.

2.2 Self-enforcing tariff agreements

We model the formation of tariff agreement (TA) as a two-stage game. In the first stage (the membership game) each country decides whether or not to join the TA. In the second stage, the signatories, non-signatories and the monopoly play a non-cooperative simultaneous game that we call the tariff and quantity game. We describe each stage briefly, in reverse order.

- The tariff and quantity game

Suppose that, as the outcome of the first-stage, there are n signatory countries (a representative signatory being denoted by s) and $N - n$ non-signatories (a representative non-signatory being denoted by f). Each non-signatory country takes as given the tariff of all other countries and the quantity of the good and chooses its tariff to maximize its own consumer's welfare. Signatory countries choose tariffs to maximize aggregate consumer's welfare of the n signatories, also taking the tariffs of non-signatories and the quantity of the monopoly as given. Finally, the monopoly chooses the quantity taking the tariffs of all importing countries as given.

The outcome of this game enables us to write the payoffs to signatory and non-signatory countries as a function of the number of signatories: $W_s(n)$ and $W_f(n)$.

- The membership game

We assume that in the first stage, countries play a *simultaneous open membership game with commitment*. In a simultaneous open membership game, the strategies for each country are to sign or not sign and any player is free to join the agreement. Moreover, each country simultaneously chooses one of the two possible strategies and the agreement is formed by all the countries that choose to sign.[6] Finally, we assume

[6] We focus in this paper on the formation of a unique agreement.

that signing the agreement acts a commitment device guaranteeing that signatories do not deviate from the agreement in the second stage. In other words, in our model signing the agreement implies respecting it.

For $2 \leq n \leq N$ we define a self-enforcing TA as follows:

DEFINITION 1 *A TA with n signatories is self-enforcing (stable) if it satisfies that* $W_s(n) \geq W_f(n-1)$ *(internal stability condition) and that* $W_f(n) \geq W_s(n+1)$ *(external stability condition).*

Internal stability simply means that any signatory country is at least as well off staying in the TA as quitting, assuming that all other countries do not change their membership decisions. External stability similarly requires that any non-signatory is at least as well off remaining a non-signatory as joining the TA, again assuming that all other countries do not change their membership decisions.[7] Besides these conditions, the agreement must also be profitable, i.e., the signatories' welfare must be greater or at least equal to the fully non-cooperative equilibrium welfare.

Next, we solve the game beginning for the first stage.

- *The Nash equilibrium of the tariff and quantity game*

Suppose that there are n signatories and $N-n$ non-signatories. Then, the monopolist's profit function [3] must be rewritten as

$$\pi = \left(a - c - \frac{1}{N} \left(Q + \sum_{i=1}^{n} t_{si} + \sum_{j=1}^{N-n} t_{fj} \right) \right) Q.$$

For this expression, the monopolist's reaction function is given by

$$Q = \frac{N}{2}(a-c) - \frac{1}{2} \left(\sum_{i=1}^{n} t_{si} + \sum_{j=1}^{N-n} t_{fj} \right). \qquad [4]$$

[7] We can also think of a stable TA as a Nash equilibrium of the *membership game*. This interpretation of a self-enforcing agreement as a Nash equilibrium of the membership game was first established by Finus and Rundshagen (2003) in the framework of a coalition formation game in global pollution control.

On the other hand, the consumer's welfare function of an importing country [2], when we have to distinguish between signatories and non-signatories, is

$$W_k = \frac{1}{2N^2}\left(Q + \sum_{i=1}^{n} t_{si} + \sum_{j=1}^{N-n} t_{fj}\right)^2 - \frac{1}{2}t_k^2.$$

However, now we have to take into account that country behavior is going to be different depending on whether or not they belong to the agreement. For a non-signatory country, the optimal tariff is given by the maximization of the previous function taking the tariff of the rest of countries and the quantity of the monopolist as given. As a result of this maximization, the reaction function of a non-signatory is obtained yielding

$$\frac{1}{N^2}\left(Q + \sum_{i=1}^{n} t_{si} + \sum_{j=1}^{N-n} t_{fj}\right) = t_{fm}, \quad m = 1, ..., N-n. \qquad [5]$$

For signatories, the optimal tariffs maximize the aggregate welfare of the countries that belong to the agreement taking the tariff of non-signatories and the quantity of the monopolist as given

$$\max_{\{t_{s1},...,t_{sn}\}} W_A = \sum_{l=1}^{n}\left[\frac{1}{2N^2}\left(Q + \sum_{i=1}^{n} t_{si} + \sum_{j=1}^{N-n} t_{fj}\right)^2 - \frac{1}{2}t_{sl}^2\right].$$

The F.O.C. are

$$\frac{n}{N^2}\left(Q + \sum_{i=1}^{n} t_{si} + \sum_{j=1}^{N-n} t_{fj}\right) = t_{sl}, \; l = 1, ..., n. \qquad [6]$$

Comparing the l.h.s. of [5] and [6] we can see that when a country belongs to the agreement, it takes into account the positive effect that an increase in the tariff has on the other signatories through the reduction in the price. Moreover, as the l.h.s of both conditions is the same for all non-signatories and also for all signatories, we can conclude that the equilibrium is symmetric and that $t_s = nt_f$, i.e., that signatories set up a tariff equal to n times the tariff selected by the non-signatories.

Then if we focus on the symmetric equilibrium with $t_{s1} = ... = t_{sn} = t_s$ and $t_{f1} = ... = t_{f(N-n)} = t_f$, the Nash equilibrium of this stage can be obtained from the following system of reaction functions

$$Q = \frac{N}{2}(a-c) - \frac{1}{2}\left(nt_s + (N-n)t_f\right), \quad [7]$$

$$t_f = \frac{Q + nt_s}{N^2 - N + n}, \quad [8]$$

$$t_s = \frac{n(Q + (N-n)t_f)}{N^2 - n^2}. \quad [9]$$

By visual inspection it can be established that the tariffs are *strategic complementaries* to each other but *strategic substitutes* of the quantity.

The solution to this system is

$$Q = \frac{(a-c)N(N(N-1) - n(n-1))}{N(2N-1) - n(n-1)}, \quad [10]$$

$$t_f = \frac{(a-c)N}{N(2N-1) - n(n-1)}, \quad [11]$$

$$t_s = \frac{(a-c)nN}{N(2N-1) - n(n-1)}. \quad [12]$$

From [11] it is clear that t_f is increasing with respect to n so that cooperation leads to higher tariffs both for the signatories and non-signatories. However, the quantity decreases when the number of signatories increases[8]

$$\frac{\partial Q}{\partial n} = -\frac{(a-c)N^3(2n-1)}{(N(2N-1) - n(n-1))^2} < 0.$$

Finally, we calculate the payoffs of the game for a given number of signatories

$$\pi = \frac{(a-c)^2 N(N(N-1) - n(n-1))^2}{(N(2N-1) - n(n-1))^2}, \quad [13]$$

$$W_f = \frac{(a-c)^2 N^2(N^2-1)}{2(N(2N-1) - n(n-1))^2}, \quad [14]$$

$$W_s = \frac{(a-c)^2 N^2(N^2-n^2)}{2(N(2N-1) - n(n-1))^2}, \quad [15]$$

[8] Although n is an integer number, the sign of this derivative is useful to find which is the existing relationship between the monopoly's output and the number of signatories.

where $W_s < W_f$ for $n \geq 2$.

It is easy to check that the monopolist's profits decrease when the number of signatories increases, which confirms the rent-shifting hypothesis, and that consumer's welfare in non-signatory countries increases. However, this is not the case for signatories

$$\frac{\partial W_s}{\partial n} = -\frac{(a-c)^2 N^2 (N(N-n)+n^3)}{(N(2N-1)-n(n-1))^3} < 0.$$

Signatory cooperation benefits non-signatories but is not profitable for themselves. The following proposition captures this result.

PROPOSITION 1 *A tariff agreement in an integrated market with a foreign monopoly is not profitable for the signatories.*

For this reason we must not expect importing countries to be interested in signing a TA in this case. The explanation of this result is given by the fact that the tariff increases with the number of signatories causing an increase in the national price that finally has a negative effect on welfare because of the reduction in consumption. A tariff is advantageous for the importing countries because the part of the profits that is captured through the tariff more than compensates the loss in welfare caused by the reduction in consumption. However, as the tariff increases with the number of signatories this surplus decreases so that although the tariff is advantageous for the importing countries independently of the number of signatories, the welfare of the signatories decreases with the number of signatories. This negative effect of cooperation will deter the importing countries from forming a TA.

Nevertheless, each importer will be interested in setting a tariff that we can calculate making n equal to one or zero in [11]. This is the tariff of the fully non-cooperative Nash equilibrium

$$t = \frac{a-c}{2N-1}. \qquad [16]$$

Thus, we find that the greater the number of importers and the higher the marginal cost, the lower the tariff, whereas the larger the country, the higher the tariff.

COROLLARY 1 *Without cooperation among the importing countries, the optimal trade policy is to set up a tariff equal to [16].*

This result clarifies that although cooperation is not profitable, the importing countries in an integrated international market with a foreing monopolist can use a tariff to capture a part of the monopolist's profits and reduce the international price of the good.

2.3 Self-enforcing tariff agreements with leadership

In this section we investigate whether a first mover advantage can make a TA profitable for signatories. We begin by clarifying the structure and timing of the game for this case. Now, we model the formation of a TA as a three-stage game. As before, in the first stage (the membership game) each country decides whether or not to join the TA. In the second stage, the signatories determine their trade policy, and in the third stage the non-signatories determine their trade policy and the monopolist its quantity. Thus, the countries first play a simultaneous game, the membership game, and given the outcome of this game they play a sequential game including the monopolist that we call again the tariff and quantity game. Next, we describe briefly the two stages of this game in reverse order.

- *The tariff and quantity game*

In the third-stage, non-signatories and the monopolist choose simultaneously their tariffs and the quantity taking as given the number of signatories and the signatories' tariffs. Using symmetry, this will define a non-signatory reaction function linking the tariff of the representative non-signatory to the tariff of the representative signatory, and a monopolist's reaction function linking the quantity of the monopolist to the tariff of the representative signatory. In the second-stage, signatories choose tariffs to maximize the aggregate welfare of the signatories, recognizing how this will affect tariffs of non-signatories and the quantity of the monopolist. Thus, we argue at this point that the signature of a TA acts as a form of commitment device that not only guarantees the compliance of the agreement as we have pointed out in part 2 of Section 2 but also gives a strategic advantage to signatories whose consequences we evaluate calculating the Stackelberg equilibrium of the tariff and quantity game. Our justification of this assumption is that commitment gives a first-mover advantage to the countries in the agreement turning the signatories into the leader of the game. Anyway, beyond this argument, the aim of this section is to investigate what could be the effect of leadership on the profitability

of the agreement independently of how this leadership could be built by the signatories.

- The Stackelberg equilibrium of the tariff and quantity game

As in the previous section we have n signatories and $N-n$ non-signatories who choose the tariffs, and the monopolist that chooses the quantity. However now we assume that the signatories move first and that given the signatories' tariff the followers, the non-signatories and the monopolist, play a simultaneous game. If the parties to the agreement become the leader of the game, we can write from reaction functions [7] and [8]

$$Q = \frac{(a-c)N(N^2-(N-n))-N^2nt_s}{2N^2-(N-n)}, \quad [17]$$

$$t_f = \frac{(a-c)N+nt_s}{2N^2-(N-n)}. \quad [18]$$

Then the countries in the agreement choose a tariff to maximize their aggregate welfare

$$W_A = n\left(\frac{1}{2N^2}\left(Q+nt_s+(N-n)t_f\right)^2-\frac{1}{2}t_s^2\right),$$

subject to conditions [17] and [18].

The solution to the optimization problem yields the following results

$$Q = \frac{(a-c)N\left[\left(2N^2-N+n\right)\left(N^2-N+n\right)-N^2n^2\right]}{\left(2N^2-N+n\right)^2-N^2n^2}, \quad [19]$$

$$t_f = \frac{(a-c)\,N\left(2N^2-N+n\right)}{\left(2N^2-N+n\right)^2-N^2n^2}, \quad [20]$$

$$t_s = \frac{(a-c)\,nN^3}{\left(2N^2-N+n\right)^2-N^2n^2}, \quad [21]$$

which are positive for $n \leq N$. It is easy to show that t_s is higher than t_f also in this case provided that $N > 2$ and that $n = 0$ in [20] yields the tariff of the fully non-cooperative Nash equilibrium.

Next, we evaluate the effects of a variation in the number of signatories

$$\begin{aligned}
\frac{\partial Q}{\partial n} &= -\frac{(a-c)N^3 g(n)}{((2N^2-N+n)^2-N^2n^2)^2} < 0,\\
\frac{\partial t_f}{\partial n} &= \frac{(a-c)N g(n)}{((2N^2-N+n)^2-N^2n^2)^2} > 0,\\
\frac{\partial t_s}{\partial n} &= \frac{N^3(a-c)((N^2-1)n^2+4N^4-4N^3+N^2)}{((2N^2-N+n)^2-N^2n^2)^2} > 0,
\end{aligned}$$

where

$$g(n) = (N^2-1)n^2+2N(2N^3-N^2-2N+1)n-N^2(4N^2-4N+1) > 0,$$

for $N > 2$ and $n \geq 1$. These signs show that cooperation leads to an increment in the tariff both for signatories and non-signatories. However, the imports of the good decrease.

Finally, we calculate the Stackelberg equilibrium payoffs

$$\pi = \frac{(a-c)^2 N((2N^2-N+n)(N^2-N+n)-N^2n^2)^2}{((2N^2-N+n)^2-N^2n^2)^2}, \quad [22]$$

$$W_f = \frac{(a-c)^2 N^2(N^2-1)(2N^2-N+n)^2}{2((2N^2-N+n)^2-N^2n^2)^2}, \quad [23]$$

$$W_s = \frac{(a-c)^2 N^4}{2((2N^2-N+n)^2-N^2n^2)}, \quad [24]$$

where again $W_s < W_f$ for $n \geq 2$. The first derivatives yield

$$\begin{aligned}
\frac{\partial \pi}{\partial n} &= -\frac{2(a-c)^2N^3((2N^2-N+n)(N^2-N+n)-N^2n^2)g(n)}{((2N^2-N+n)^2-N^2n^2)^3} < 0,\\
\frac{\partial W_f}{\partial n} &= \frac{(a-c)^2N^2(N^2-1)(2N^2-N+n)g(n)}{((2N^2-N+n)^2-N^2n^2)^3} > 0,\\
\frac{\partial W_s}{\partial n} &= \frac{(a-c)^2N^4(2n(N^2-1)-2N(2N-1))}{2((2N^2-N+n)^2-N^2n^2)^2} > 0, \text{ for } n \geq 2.
\end{aligned}$$

Thus, analyzing the Stackelberg equilibrium of the tariff and quantity game shows that leadership makes cooperation among importing countries profitable and that the greater the number of countries in the TA, the higher the tariff and consumers' welfare. Moreover, the rent-shifting hypothesis holds and profits decrease as tariffs increase with

the number of countries. Nevertheless, profitability does not guarantee that a TA will take place. For this reason, we will now analyze the stability of the TA.

- *The Nash equilibrium of the membership game*

According to Definition 1 a TA with n^* signatories is self-enforcing if the stability conditions are satisfied for n^*. Using [23] and [24] we obtain the following result

PROPOSITION 2 *The unique self-enforcing TA consists of two countries when $N = 2$ and of three countries when $N \geq 3$.*

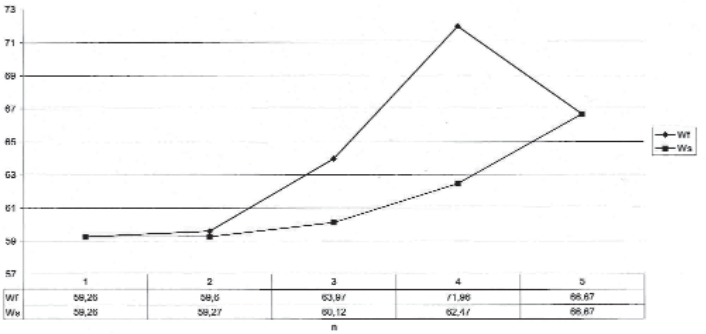
PROOF. See Appendix A1 ■

This result establishes that the stable level of cooperation is very low and that although cooperation is profitable for signatories, the incentives to act as a free-rider of the agreement considerably reduce the possibilities of reaching a TA with a large number of signatories. Thus, we can conclude that in order to reach a broad agreement it is not sufficient to enjoy a strategic advantage even assuming that the signing of the agreement is enough to guarantee its compliance. The problem, as we illustrate below with a numerical example, is that as non-signatories select a tariff lower than the tariff selected by the signatories, they obtain a greater welfare that moreover increases more quickly that the signatories' welfare. The consequence is that the incentives to deviate from the TA, given by the difference between the welfare obtained being a signatory and the welfare obtained being a free-rider of the agreement, also increase with the number of signatories destabilizing any agreement with a high level of participation.

To illustrate this result we present a numerical example that will help the reader to better understand how stability conditions work and why the Nash equilibrium of the membership game yields such a low level of cooperation.

FIGURE 1

Participation in a TA, N=5. Quantity-setting Monopolist. a=30, c=10



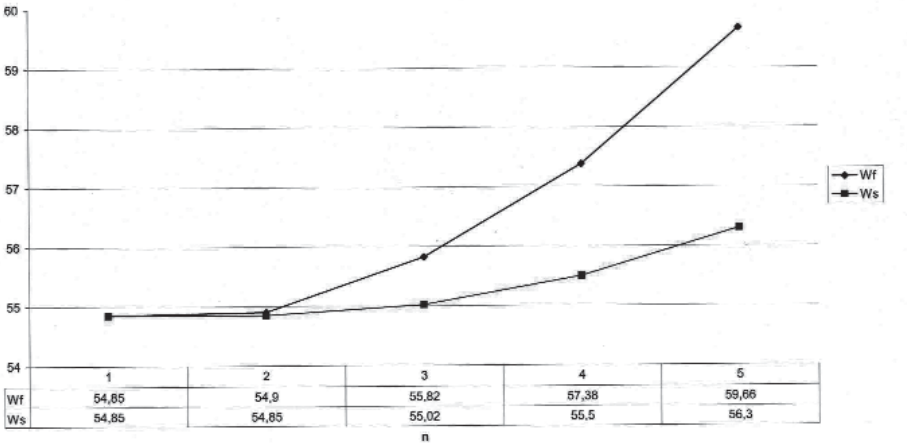
In Figure 1, the welfare of the importing countries for different level of participation, $a = 30,\ c = 10$ and $N = 5$ is showed. In the figure, $n = 1$ stands for the fully non-cooperative Nash equilibrium, $n = 2$ for the Stackelberg equilibrium when the agreement consists of two countries, $n = 3$ for the Stackelberg equilibrium when the agreement consists of three countries and so on.[9] The figure shows that both the welfare of signatories and non-signatories increase with the level of signatories and that non-signatories always obtain a greater welfare with a lower tariff. The figure also explains clearly why the grand coalition is unstable: the unilateral deviation of all countries increases welfare. If a country belongs to the grand coalition it gets 66.67 whereas quitting the agreement it would get 71.96. See the table at the bottom of the figure. Thus, countries have incentives to not sign the agreement and be a free-rider of the agreement signed by the other countries. For an agreement consisting of four countries the same argument applies. A signatory gets 62.47 whereas by quitting the agreement and playing as a free-rider of an agreement of three countries it would get 63.97. However, for three signatories the argument is the contrary. A signatory gets 60.12 whereas quitting the agreement it would get 59.60. Thus, an agreement consisting of three countries is internally stable. Moreover, the agreement is also externally stable since a non-signatory gets 63.97 whereas joining an agreement of four countries it would get 62.47. Finally, we check the stability of a bilateral agreement. For $n = 2$, a non-signatory gets 59.60 whereas joining the agreement it would get 60.12. Thus, a bilateral agreement is not stable since the non-signatories would be interested in joining the agreement. The result is that only an agreement consisting of three countries is self-enforcing since both the internal and external stability conditions are satisfied.

Figure 2 also shows the welfare of the importing countries but for $N = 10$. The properties of the curves are the same than in the previous case although we have not represented the welfare corresponding to all levels of participation to better differentiate in the figure the welfare associated with the low levels of participation. As in the previous case, the grand coalition is unstable because it is not internally stable. The

[9] Notice that, as we have already pointed out, [20] is equal to [16] for $n = 0$. This means that we are assuming that leadership is associated to the formation of the agreement. i.e. only when the countries belong to the agreement can they enjoy a leadership position. This assumption does not affect the results but simplifies their presentation and interpretation.

same occurs for all the levels of participation higher than three but for three the stability conditions hold and the TA is self-enforcing as the reader can easily check using the figures that appears at the bottom of the figure.

FIGURE 2
Participation in a TA, N=10
Quantity-setting Monopolist
a=30, c=10



3. The case of a price-setting monopolist

3.1 The basic model

The basic elements of the model are the same than in the case of a quantity-setting monopolist. However, now as the monopolist chooses the price, the consumer's welfare function is obtained directly by substitution of the national demand function in the welfare function:

$$W_i = a(a - p - t_i) - \frac{1}{2}(a - p - t_i)^2 - p(a - p - t_i),$$

that developing terms yields

$$W_i = \frac{1}{2}\left((a - p)^2 - t_i^2\right), \; i = 1, ..., N. \qquad [25]$$

On the other hand, the monopolist's profit function is obtained by substituting in the profits function the quantity by the demand in the international market [1]:

$$\pi = (p - c)\left(N(a - p) - \sum_{i=1}^{N} t_i\right). \qquad [26]$$

It is pretty obvious from [25] that if importers do not enjoy a first mover advantage the optimal tariff is zero when the monopolist chooses the price, as, given the price, any tariff will reduce consumer's welfare. Moreover, this result is independent of the degree of cooperation among the importers. Notice also that the nature of the game changes when the monopolist sets the price as it can be easily checked comparing [2] and [25]. In the case of a quantity-setting monopolist, an increase in the tariff of an importing country, given the quantity, can have a positive effect on consumer's welfare and has a positive effect on the welfare of the rest of importing countries through the effect that the tariff has on the price. However, if the monopolist selects the price, this interdependence among the importing countries disappears and the Nash equilibrium specific tariff is zero.

3.2 Self-enforcing tariff agreements with leadership

However, if the importers build up an agreement with n signatories that acts as a leader, the nature of the game between the monopolist and the importers changes and consequently so does the optimal commercial policy. Next, we analyze this case.

- The Stackelberg equilibrium of the tariff and price game

As in Part 3 of Section 2 the signatories move first and given the signatories' tariff, the non-signatories and the monopolist play a simultaneous game. This means that, according to the argument we have just presented, non-signatories do not charge a tariff on imports. Then according to [26] the monopolist's profits are

$$\pi = (p - c)\left(N(a - p) - \sum_{i=1}^{n} t_i\right),$$

so that the monopolist's reaction function is

$$p = \frac{1}{2N}\left[N(a + c) - \sum_{i=1}^{n} t_i\right],$$

which establishes that a tariff is a *strategic substitute* of the price.

Then substituting this reaction function in the consumer's welfare function [25] of the signatory countries we obtain the following expression

$$W_i = \frac{\left(N(a-c) + \sum_{i=1}^{n} t_i\right)^2}{8N^2} - \frac{t_i^2}{2},$$

so that the optimal trade policy for signatories is given by the solution to the following optimization problem:

$$\max_{\{t_1,\ldots,t_n\}} W_A = \sum_{i=1}^{n} \left(\frac{\left(N(a-c) + \sum_{i=1}^{n} t_i\right)^2}{8N^2} - \frac{t_i^2}{2} \right).$$

The F.O.C. are

$$\frac{n\left(N(a-c) + \sum_{i=1}^{n} t_i\right)}{4N^2} = t_i, \quad i = 1, ..., n,$$

which establishes that the optimal policy is to set up the same tariff for all the signatories of the agreement.

Taking into account this result, we calculate the symmetric solution that is given by

$$t = \frac{(a-c)nN}{4N^2 - n^2}, \quad p = \frac{a(2N^2 - n^2) + 2cN^2}{4N^2 - n^2}. \qquad [27]$$

It is immediately clear from these expressions that the tariff increases with the number of signatories, whereas the price decreases.

Next, we calculate the payoffs for the monopolist, the representative non-signatory and the representative signatory

$$\pi = \frac{(a-c)^2 N(2N^2 - n^2)^2}{(4N^2 - n^2)^2}, \qquad [28]$$

$$W_f = \frac{2(a-c)^2 N^4}{(4N^2 - n^2)^2}, \; W_s = \frac{(a-c)^2 N^2}{2(4N^2 - n^2)} \qquad [29]$$

where $W_s < W_f$ for $n \geq 2$. From these expressions it is easy to check that consumer's welfare, both for non-signatories and for signatories, increases with the number of signatories, even when there is only one leader, as $W_s(1) < W_s(2)$. On the other hand, the rent-shifting hypothesis works and profits decrease with the number of countries in the agreement as the tariff increases.

$$\frac{\partial \pi}{\partial n} = -\frac{8(a-c)^2 n N^3 (2N^2 - n^2)}{(4N^2 - n^2)^3} < 0.$$

- The Nash equilibrium of the membership game

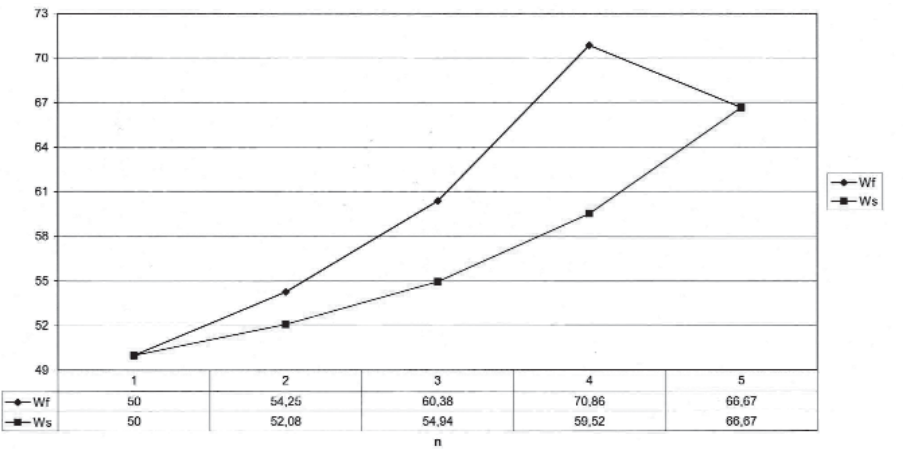
According to Definition 1 [29] allows us to conclude that

PROPOSITION 3 *The unique self-enforcing TA consists of two countries when* $N = 2$ *and of three countries when* $N \geq 3$.

PROOF. See Appendix A2 ■

Thus, we obtain the same result than in the previous case when the monopolist chooses the quantity. Moreover, the logic behind this result is the same and we shall not insist on this. Nevertheless, to complete the exposition of this second case, next we present the results of the numerical example.

FIGURE 3
Participation in a TA, N=5
Price-setting Monopolist
a=30, c=10



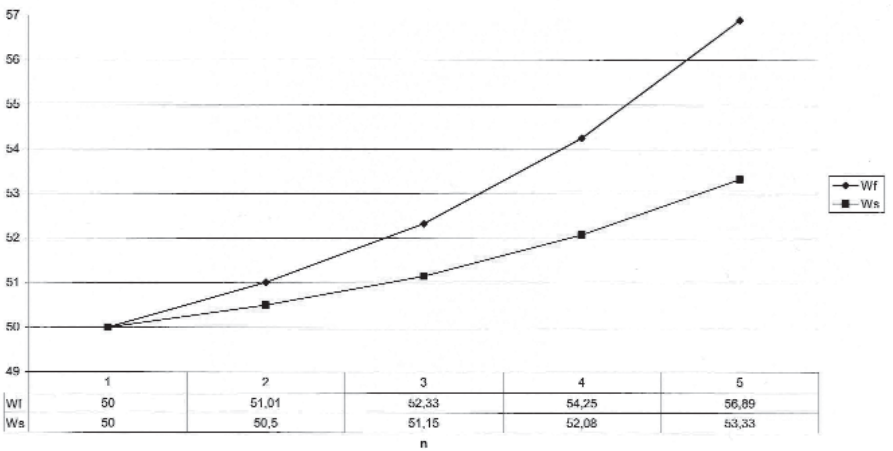
	1	2	3	4	5
Wf	50	54,25	60,38	70,86	66,67
Ws	50	52,08	54,94	59,52	66,67

In Figure 3, the welfare of the importing countries for different level of cooperation, $a = 30$, $c = 10$ and $N = 5$ is showed. As in Figure 1, $n = 1$ stands for the fully non-cooperative Nash equilibrium that in this case coincides with the monopolist's equilibrium, since when the monopolist sets up the price, the free trade is the optimal policy.[10] $n = 2$ stands for the Stackelberg equilibrium when the agreement consists of two countries, $n = 3$ for the Stackelberg equilibrium when the

[10] Notice that the optimal tariff given by [27] is zero for $n = 0$.

agreement consists of three countries and so on. Firstly, notice that the properties of the curves represented in the figure are the same that in the case of a quantity-setting monopolist. Moreover, from the figures in the table, it can be checked that for an agreement with five or four signatories, the internal stability condition is not satisfied and that for $n = 2$ the external stability condition is not satisfied. Thus, both conditions hold only for $n = 3$ and the agreement is self-enforcing, i.e. no signatory is interested in leaving the agreement and no non-signatory is interested in joining the agreement as it occurs in the case of a quantity-setting monopolist. The last figure shows the results for $N = 10$. As in Figure 2 we have not represented the welfare corresponding to all levels of participation but only the corresponding to n from one to five to better distinguish in the graphical representation the welfare associated with the low levels of participation.[11] The participation in a self-enforcing TA is the same that in the previous case and also the same that in the case of a quantity-setting monopolist. Thus, we can conclude that the strategic variable used by the monopolist does not have any effect on the level of participation in a TA in an international integrated market with a foreign monopolist.

FIGURE 4
Participation in a TA, N=10
Price-setting Monopolist
a=30, c=10



n	1	2	3	4	5
Wf	50	51,01	52,33	54,25	56,89
Ws	50	50,5	51,15	52,08	53,33

[11] Observe that given the symmetry of the model, the price and welfare of the importing countries do not depend for the fully non-cooperative Nash equilibrium on the total number of large importers.

4. Comparing the two equilibria: The optimal policy of the monopolist

In this last section we explore the differences between both equilibria in order to establish how the optimal trade policy of importers is affected by the strategic variable of the monopolist and what the optimal policy of the monopolist is. One first comment to point out is that there is no difference between the two equilibria for the grand coalition. In this case, all signatories charge the same tariff on imports so that the aggregate demand function that the monopolist faces is the same regardless of the monopolist's strategic variable. The result is that the Stackelberg equilibrium of the tariff and price game is identical to the Stackelberg equilibrium of the tariff and quantity game. Nevertheless, the grand coalition is unstable regardless of the variable chosen by the monopolist for $N > 3$. In fact, any coalition is unstable except the TA consisting of three countries (see Props. 2 and 4) when $N > 3$. For this reason, in this Section, we develop the comparative analysis for a TA signed by three countries with $N > 3$.[12]

Using the results obtained in the previous sections we first compare the tariffs, the prices, both the international price and the national price, and the quantity.[13]

$$\begin{aligned}
t_s^Q - t^p &= \frac{3(a-c)N(4N^3-13N^2+6N-9)}{((2N^2-N+3)^2-9N^2)(4N^2-9)} > 0,\\
p^Q - p^p &= -\frac{(a-c)N^3(4N^3-14N^2+21N-45)}{(N(2N^2-N+3)^2-9N^3)(4N^2-9)} < 0,\\
p^Q + t_s^Q - (p^p + t^p) &= -\frac{(a-c)N^2(4N^4-26N^3+60N^2-63N+27)}{(N(2N^2-N+3)^2-9N^3)(4N^2-9)} < 0,\\
p^Q + t_f^Q - p^p &= \frac{(a-c)N^2(4N^4+10N^3-27N^2+54N-27)}{(N(2N^2-N+3)^2-9N^3)(4N^2-9)} > 0,\\
Q^Q - Q^p &= -\frac{(a-c)N^3(4N^3-14N^2+21N-45)}{((2N^2-N+3)^2-9N^3)(4N^2-9)} < 0.
\end{aligned}$$

These signs establish that the optimal tariff for signatories is higher when the monopolist chooses the quantity but that, just as one might

[12] Notice that when $N = 2, 3$ the grand coalition is stable and there is no difference between the two equilibria.

[13] In the following expressions Q stands for the Stackelberg equilibrium when the monopolist chooses the quantity and p for the Stackelberg equilibrium when the monopolist chooses the price.

expect, the international price is lower. However, the quantity is greater when the monopolist chooses the price. This is explained by the fact that the national price in non-signatory countries is lower in that case, which compensates the effect on quantity of the higher national price paid by the consumers in signatory countries.

Finally, we compare the payoffs of the players.

$$\pi^Q - \pi^p = -\frac{(a-c)^2 N^3 A(N)}{((2N^2-N+3)^2-9N^2)^2(4N^2-9)^2} < 0,$$

where

$$\begin{aligned} A(N) &= 64N^9 - 304N^8 + 448N^7 - 444N^6 - 324N^5 + 2763N^4 - 3186N^3 \\ &\quad +4131N^2 - 8262N + 7290 > 0 \text{ for } N > 3. \end{aligned}$$

$$W_f^Q - W_f^p = \frac{(a-c)^2 N^2 B(N)}{2((2N^2-N+3)^2-9N^2)^2(4N^2-9)^2} > 0,$$

where

$$\begin{aligned} B(N) &= 64N^9 - 336N^8 + 576N^7 - 932N^6 + 396N^5 + 441N^4 - 162N^3 \\ &\quad +486N - 729 > 0 \text{ for } N > 3. \end{aligned}$$

$$W_s^Q - W_s^p = \frac{(a-c)^2 N^2 (8N^3 - 26N^2 + 12N - 18)}{2((2N^2-N+3)^2-9N^2)(4N^2-9)} > 0.$$

These signs clearly allow us to conclude that a tariff is going to be more advantageous for the importers when the monopolist chooses the quantity than when it chooses the price. The rent-shifting hypothesis works in both cases but on selecting the price, the monopolist can reduce the importers' capacity to appropriate part of the monopolist's rent. Thus, the optimal policy of the monopolist is to select the price.

5. Conclusions

In this paper we have studied the optimal trade policy for a foreign monopoly under integrated markets distinguishing two cases. In one case we have assumed that the strategic variable of the monopolist is quantity and, in the other case, that it is price. We have also analyzed whether cooperation among importers of the monopolized good through a tariff agreement can improve the welfare of the importers and whether this kind of agreement is stable. In order to assess stability we have modelled tariff agreement formation as a two-stage game.

In the first stage each importer decides whether or not to be part of the agreement and in the second stage the signatories and non-signatories choose their tariff whereas the monopoly chooses the quantity or the price. In the second stage we have taken into account two possibilities as well, that all the players take their decisions simultaneously or that the signatories enjoy a first mover advantage. Finally, we have assumed that signing the agreement works as a commitment device to set up the tariffs stipulated by the agreement and that any country can join the agreement.

Our main findings reveal that the maximum level of cooperation that can be reached by a self-enforcing tariff agreement is very low, in fact only an agreement consisting of three countries is self-enforcing, regardless of the strategic variable selected by the monopolist and the number of large importers in the market. Thus, we find that enjoying a strategic advantage is sufficient to guarantee the profitability of a broad agreement but it does not guarantee its stability, even assuming that the signing of the agreement implies its full compliance. Finally, we find that if a stable agreement involving three countries is formed, the optimal policy for the monopolist is to choose the price. This does not eliminate the rent-shifting effect of the tariff, but it does reduce the scope of this effect.

There are several issues related to this research that could be addressed in the future. One is to check whether the results hold when an ad *valorem* tariff is used instead of a specific one. A second issue could be to extend the analysis to consider as in Karp and Newbery (1991) paper that there are more than one large importer in the market. It would be also interesting to analyze what happens when the government of the exporting country plays a more active role. In particular, we could consider in a first approach that the government gives support to the monopolist through an export subsidy and in a second step to consider that the government designs its optimal trade policy taking into account the welfare of its own consumers. Finally, we have used a concept of stability in this paper that, among other things, does not contemplate the possibility of repeated interaction as occurs in the stability analysis of trade cooperation developed, for instance, by Bagwell and Staiger (1990) or Riezman (1991) and more recently by Freund (2000) or Ederington and McCalman (2003). Thus, extending our analysis to consider the possibility of repeated interaction among importing

countries could be a third line of research to develop in the future.

A1. Proof of proposition 2

First, we look for values of n that satisfy the internal stability condition that we rewrite as

$$\triangle(n) = W_s(n) - W_f(n-1) \geq 0.$$

Using [23] and [24] in the main text, the welfare of the consumers of the signatory and non-signatories countries are given by the following expressions

$$W_s(n) = \frac{N^4 (a-c)^2}{2((2N^2 - N + n)^2 - N^2 n^2)}, \; W_f(n-1) = \frac{N^2(N^2-1)(a-c)^2 \left(2N^2 - N + n - 1\right)^2}{2((2N^2 - N + n - 1)^2 - N^2(n-1)^2)^2},$$

which yields

$$\triangle(n) = \frac{N^2(a-c)^2}{2} \frac{A(n)}{((2N^2 - N + n)^2 - N^2 n^2)((2N^2 - N + n - 1)^2 - N^2(n-1)^2)^2},$$

where

$$A(n) = a_0(N)n^4 + a_1(N)n^3 + a_2(N)n^2 + a_3(N)n + a_4(N)$$

and the coefficients of the polynomial are

$$\begin{aligned}
a_0(N) &= N^6 - N^4 - N^2 + 1 > 0 \text{ for } N \geq 2, \\
a_1(N) &= -2(4N^6 - N^5 - N^4 - N^3 - 4N^2 + 2N + 1) < 0 \text{ for } N \geq 2, \\
a_2(N) &= -(4N^8 - 4N^7 - 21N^6 + 6N^5 - 4N^4 + 20N^3 + 2N^2 - 6N - 1) < 0 \text{ for } N \geq 3, \\
a_3(N) &= 2N(8N^7 - 8N^6 - 8N^5 - 6N^4 + 11N^3 + 5N^2 - 3N - 1) > 0 \text{ for } N \geq 2, \\
a_4(N) &= -N^2(8N^6 - 23N^4 + 6N^3 + 12N^2 - 2N - 2) < 0 \text{ for } N \geq 2.
\end{aligned}$$

Then given that $(2N^2 - N + n)^2 - N^2 n^2 > 0$ for $n \leq N$ the sign of the internal stability condition depends on the sign of polynomial $A(n)$.

According to Descartes' rule of signs, the polynomial can have three or one positive real roots. Next, we show that in this case $A(n) = 0$ presents three positive real roots that we call n_1, n_2 and n_3.

Firstly, we calculate the following values for the polynomial

$$\begin{aligned} A(1) &= N^2(1-6N+15N^2-22N^3+21N^4-12N^5+4N^6) > 0 \text{ for } N \geq 1, \\ A(3) &= 36-60N+101N^2-94N^3+63N^4-42N^5+29N^6-12N^7+4N^8 > 0 \text{ for } N \geq 0, \\ A(4) &= 144-168N+202N^2-150N^3+12N^4-22N^5+39N^6-8N^8 < 0 \text{ for } N \geq 2. \end{aligned}$$

The sign of these values allows us to conclude that $A(n)$ has three positive real roots since the polynomial presents first positive values and subsequently negative values.[14] Then we can also conclude that $n_1 < 1,\ 3 < n_2 < 4$ and $4 < n_3$.

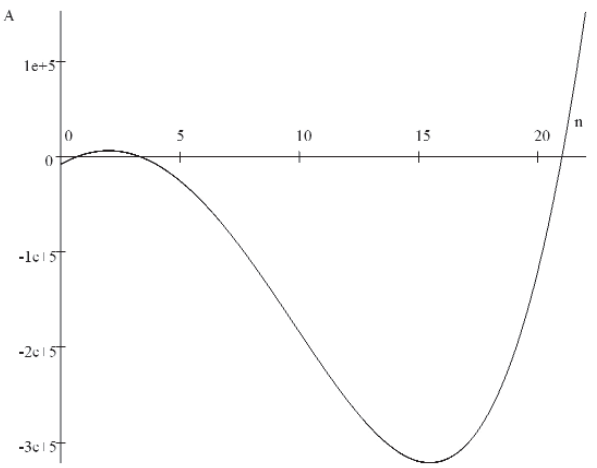
Now, we calculate

$$A(N) = N^2-7N^4+4N^5+16N^6-20N^7-2N^8+12N^9-3N^{10} < 0 \text{ for } N \geq 4,$$

which allows us to establish that $N < n_3$ and consequently that $A(n)$ is negative for $n = 4, 5, ..., N$ for $N \geq 4$.

The following graphical representation illustrates the behaviour of polynomial $A(n)$ for $N = 10$.

FIGURE A1.1



[14] Notice that the independent term of the polynomial is negative. This means that first we have negative values, after that positive values and again negative values to finish with positive values since $a_0(N)$ is positive so that the polynomial must cut the horizontal axis three times.

In this case $n_1 = 0.648,\ n_2 = 3.361$ and $n_3 = 21.012$.

Thus what we have just shown is that this shape is the same for any $N \geq 4$ and that $n_1 < 1,\ 3 < n_2 < 4$ and $N < n_3$ also for $N \geq 4$. Then for $n = 4, ..., N$ as $A(n)$ is negative, the internal stability condition is not satisfied. Now, we check the external stability condition for $n = 2, 3$. For $n = 3$, the external stability condition can be written as $W_f(3) - W_s(4) \geq 0$. We know that the internal stability condition is not satisfied for $n = 4$, i.e., that $W_s(4) - W_f(3) < 0$. Multiplying by -1 we get $W_f(3) - W_s(4) > 0$. Thus, we can conclude that both the external and internal stability conditions are satisfied for $n = 3$ and, consequently, that a TA consisting of three countries is stable.

Finally, we check whether this is the case for $n = 2$. We know that for $n = 3$ $W_s(3) - W_f(2) > 0$ which yields $W_f(2) - W_s(3) < 0$ which means that the external stability condition is not satisfied and that a TA of two countries is not stable.

Summarizing, we have shown that for $N \geq 4$ the unique stable agreement consists of three countries. For the case of $N = 2, 3$ it is easy to check that the grand coalition is the unique self-enforcing for $N = 3$ and that the grand coalition is stable for $N = 2$ although in this case, the internal stability condition is satisfied as a strict equality.

A2. Proof of poposition 3

First, we look for values of n that satisfy the internal stability condition that we rewrite as

$$\triangle(n) = W_s(n) - W_f(n-1) \geq 0.$$

where consumer's welfare in signatory and non-signatory countries are given by [29] in the main text

$$W_s(n) = \frac{(a-c)^2 N^2}{2\left(4N^2 - n^2\right)^2}, \quad W_f(n-1) = \frac{2\,(a-c)^2 N^4}{\left(4N^2 - (n-1)^2\right)^2},$$

which yields

$$\triangle(n) = \frac{(a-c)^2 N^2}{2} \frac{A(n)}{\left(4N^2 - n^2\right)^2 \left(4N^2 - (n-1)^2\right)^2},$$

where

$$A(n) = n^4 - 4n^3 - 2(2N^2 - 3)n^2 + 4(4N^2 - 1)n - 8N^2 + 1,$$

so that the sign of the internal stability condition depends on the sign of polynomial $A(n)$.

According to Descartes' rule of signs, the polynomial can have three or one positive real roots. Next, we show that in this case $A(n) = 0$ presents three positive real roots that we call n_1, n_2 and n_3.

Firstly, we calculate the following values for the polynomial

$$A(1) = 4N^2 > 0,\ A(3) = 4N^2+16 > 0,\ A(4) = 81-8N^2 < 0 \text{ for } N \geq 3.$$

The sign of these values allows us to conclude that $A(n)$ has three positive real roots since the polynomial presents first positive values and subsequently negative values.[15] Then we can also conclude that $n_1 < 1$, $3 < n_2 < 4$ and $4 < n_3$.

Now, we calculate

$$A(N) = -3N^4 + 12N^3 - 2N^2 - 4N + 1 < 0 \text{ for } N \geq 4,$$

which allows us to establish that $N < n_3$ and consequently that $A(n)$ is negative for $n = 4, 5, ..., N$ for $N \geq 4$.

From this point the proof follows step by step the development of the proof of Proposition 2. For this reason we finish the proof of Proposition 3 here. The only difference with Proposition 2 is that now the internal stability condition for $N = 2$ is satisfied as a strict inequality.

[15] Notice that the independent term of the polynomial is negative. This means that first we have negative values, after that positive values and again negative values to finish with positive values since the first coefficient is positive so that the polynomial must cut the horizontal axis three times.

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Resumen

En este artículo se estudia la estabilidad de un acuerdo arancelario entre los países importadores de un bien monopolizado que se vende en un mercado integrado. La formación del acuerdo arancelario se representa como un juego en dos etapas. En la primera etapa, cada importador decide si firma o no el acuerdo, y en la segunda etapa los firmantes eligen cooperativamente sus aranceles mientras que los no firmantes y el monopolista actúan de forma no cooperativa. Nuestros resultados muestran que el acuerdo estará formado por tres países independientemente de si el monopolista elige el precio o la cantidad y del número de importadores, siempre que los países firmantes actúen como un líder en la segunda etapa del juego.

Palabras clave: Acuerdos arancelarios estables, mercados integrados, hipótesis del desplazamiento de la renta.

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