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ENDOGENOUS MARKET STRUCTURES AND STRATEGIC TRADE POLICY*

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I characterize the optimal export promoting policy for international markets whose structure is endogenous. Contrary to the ambiguous results of strategic trade policy for duopolies, it is always optimal to subsidize exports when entry is endogenous, under both quantity and price competition. With homogenous goods the optimal export subsidy is a fraction $1/\epsilon$ of the price, where ϵ is the elasticity of demand (the exact opposite of the optimal export tax in the neoclassical trade theory). Analogously, I show the general optimality of R&D subsidies and of competitive devaluations to promote exports in foreign markets where entry is endogenous.

1. INTRODUCTION

A wide literature on optimal strategic trade policy and on other forms of strategic export promotion has been developed since the pathbreaking contributions of Brander and Spencer (1985), Eaton and Grossman (1986), and others. A disappointing result of this literature has been that its policy prescriptions on whether and how we should subsidize or tax exports have been largely ambiguous and dependent on the particular assumptions on the market structures under consideration, in particular whether competition is in quantities or prices (see Helpman and Krugman, 1989).[2] This article argues that, independently from the assumptions on the market structures adopted in this literature, any ambiguity on the optimal unilateral export promoting policy vanishes under a single and (possibly) realistic condition. This condition is that entry of firms in the international competition is endogenous (i.e., determined by profit maximizing decisions of the firms). Under this condition, contrary to the traditional results, it is always optimal to subsidize exports under both competition in quantities and in prices. One can apply the same principle to general models of trade policy, R&D policy, and exchange rate policy.

Common wisdom on the benefits of export subsidization largely departs from the implications of trade theory. Although export promotion is often supported by governments, theory is hardly in favor of its direct or indirect implementation. In the standard neoclassical framework with perfect competition, the scope of trade policy is to improve the terms of trade, that is, the price of exports relative to the price of imports, and, as long as a country is large enough to affect the terms of trade, it is optimal to tax exports (because this is equivalent to set a tariff on imports); more precisely, the optimal unilateral export tax can be derived as a fraction $1/\epsilon$ of the price, where ϵ is the elasticity of demand (Lerner, 1934, 1936; Kaldor, 1940). The same outcome emerges under monopolistic competition, as shown by Helpman and Krugman (1989). In case of strategic interactions between few firms, however, a second aim of strategic trade policy is to shift profits toward the domestic firms; therefore a large body of recent literature has studied models with a fixed number of firms competing in a third market with

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[2] Feenstra (2004) provides an updated review of this literature.

positive profits. Here, the optimal unilateral policy is an export tax under price competition or whenever strategic complementarity holds (Eaton and Grossman, 1986). Under quantity competition, an export subsidy can be optimal (Brander and Spencer, 1985), but only under certain conditions.[3] According to a leading trade economist (Bhagwati, 1988), the ambiguity of these results "creates information requirements for policy intervention that appear to many of the architects of this theoretical innovation to be sufficiently intimidating to suggest that policymakers had better leave it alone." [4]

Nevertheless, different forms of direct or indirect export subsidies are widespread. Governments strongly support exporting firms (especially in time of crisis), they often hide forms of export promotion behind nationalistic pride, and they consider the conquer of larger market shares abroad as a positive achievement in itself. The European Union coordinates trade between its members and the rest of the world in a similar spirit and subsidizes exports of agricultural products and the aircraft industry. France has often supported its "national champions" with public subsidies. Italy has a long tradition of public support of the *Made in Italy*, which is quite important for the promotion of fashion, design, and food industries. Japan has adopted a policy of targeted export promotion through its Ministry of Economy, Industry, and Trade. Korea and other East Asian countries have implemented export promoting policies for decades. Heavily protected South American countries have tried to subsidize manufactured products in which they could develop a comparative advantage (and not only those). Even the United States has implemented strong forms of export subsidization through tax exemptions for a fraction of export profits, foreign tax credit,[5] and export credit subsidies.

It appears quite surprising that, in front of this, trade economists do not have clear and unambiguous arguments to explain why export subsidies could be the optimal unilateral trade policy. Building on the recent literature on endogenous market structures (see Etro, 2004, 2006, 2007a,b, 2010), this article provides such an argument, studying a model of trade policy for a foreign market characterized by strategic interactions and endogenous entry of international firms.[6]

In general, a government may tax or subsidize domestic firms that are active in international markets for profit shifting reasons: The right policy allows the government to turn the domestic firm into a leader in the international competition, and to increase the net profits for the country. For instance, when a domestic firm competes against a foreign competitor in a third market, it is typically optimal to tax exports under competition in prices and to subsidize exports under competition in quantities: The reason is that in the former case a tax turns the domestic firm into an accommodating leader that softens price competition and earns higher profits, and in the latter case a subsidy turns the domestic firm into an aggressive leader that increases its production and earns higher profits as well. When entry in the international market is endogenous, the same general principle applies, but the only way for the domestic firm to earn positive profits is by adopting an aggressive strategy, either reducing prices or increasing production so as to conquer market shares and reduce average costs below those of the other firms (any accommodating strategy would end up attracting entry, and profits would vanish). Therefore, it is now unambiguously optimal to subsidize exports to turn the domestic firm into an aggressive leader under both competition in prices and quantities.

[3] These conditions are derived by Dixit (1984) and Klette (1994). See also Horstmann and Markusen (1986) for related results.

[4] The literature has developed other arguments against export subsidies, as in case of asymmetric information between firms and government or in case of retaliation (see Brander, 1995, for reviews of the literature).

[5] See Desai and Hines (2008).

[6] Notice that free entry is a realistic assumption because a foreign country without a domestic firm in the market can only gain from allowing free entry of international firms (see Boone et al., 2006, for a related discussion). Moreover, endogenous entry is the standard assumption of the new trade literature based on monopolistic competition (Krugman, 1980); therefore it is surprising that it has not been used in the strategic trade literature. For a review of the applications of the endogenous market structures approach to trade and dynamic issues, see Etro (2009, Ch. 3–4) and Etro and Colciago (2010). For an important work that endogenizes the number of firms and of the exporting firms in a general equilibrium framework, see Ghironi and Melitz (2005).

This article characterizes the optimal unilateral trade policy for a large class of models and analyzes a few examples. In the case of homogenous goods, U-shaped cost functions, and competition in quantities, the optimal unilateral export subsidy is a fraction $1/\epsilon$ of the price, where ϵ is again the elasticity of demand: Notice that this is the exact opposite of the traditional neoclassical optimal policy. Product differentiation and competition in prices tend to reduce the optimal export subsidy.

The same argument can be applied to other forms of indirect export promotion, as policies that boost demand or decrease transport costs for the exporting firms, R&D subsidies (or strengthening of IPRs protection) for domestic firms competing in global markets, and competitive devaluations of the nominal exchange rate for firms active in foreign markets with endogenous entry: As long as these policies increase the marginal profitability of the domestic firms, there is a strategic incentive to use them unilaterally.

Finally, our result on the optimal trade policy holds also in an equilibrium analysis where all the countries can choose optimally their policy, and entry of firms in the international market is endogenous. We verify this in a model of competition in quantities with homogenous goods and increasing marginal costs, and we find out that the Nash equilibrium export subsidy remains the same as the unilateral optimal one for an endogenous number of countries (determined by the size of the international market), whereas the other countries commit to free trade.

The article is organized as follows. Section 2 introduces a general model and determines the strategic incentives to promote exports in the presence of an exogenous number of firms in the international market and with an endogenous market structure. Subsequently, it applies these general results to strategic trade policy, and derives the optimal unilateral export subsidies under competition in quantities and competition in prices. Section 3 develops a Nash equilibrium analysis for the case in which multiple countries can simultaneously choose their strategic trade policy. Section 4 discusses other applications of the optimal unilateral policy: It studies the incentives to adopt R&D subsidies for domestic firms engaged in an international patent race and the role of exchange rate policy in supporting exporters. Section 5 concludes. Technical details are left in the Appendix.

2. THE MODEL

I adopt a general model of market structures introduced in Etro (2006, 2008a), use it to describe competition in an international market, and augment it by introducing export promoting policies.

Consider an international market where n firms from different countries are competing in Nash strategies. Let us assume that each firm chooses a strategic variable x_i, with $i = 1, 2, \ldots, n$, which delivers the net profit function

$$\pi_i = \Pi^i(x_i, \beta_i, s_i) - F, \tag{1}$$

where F is the fixed cost. The function $\beta_i = \sum_{k=1,k\neq i}^{n} h(x_k)$ aggregates the strategies of the other firms, with $h(\cdot)$ positive, differentiable, and increasing. As we will see, the separability property that is assumed in the β_i function is satisfied by a large class of models of competition in quantities and in prices, and in other models as well. I assume that $\Pi(x_i, \beta_i, s_i)$ is quasiconcave in x_i with $\Pi_{11} < 0$.[7] Because the main focus of the analysis will be on free entry equilibria, I assume that an increase in β_i reduces the profits of firm $i : \Pi_2 < 0$. In general Π_{12} could be positive, so that we have strategic complementarity, or negative, so that we have strategic substitutability.

Finally, s_i is the export policy chosen by the government of country i: in my main application, this will be an export subsidy, but I will take in consideration other policies as well. Without loss of generality, an increase in the policy raises profits ($\Pi_3 > 0$); therefore s_i will be defined as an export promotion policy for country i. I allow Π_{13} to be positive or negative: only in the first case,

[7] The subindex of the profit function refers to derivatives with respect to the corresponding argument.

the policy increases marginal profitability. As I verify later, all forms of trade subsidies under quantity and price competition imply $\Pi_{13} > 0$, but other indirect forms of export promotion can be characterized by $\Pi_{13} < 0$.

In general, the welfare of country i depends positively on the profits of the domestic firm and negatively on the cost of its policy s_i, say $C(s_i)$, so that we can express welfare as

$$W(s_i) = \Pi^i(x_i, \beta_i, s_i) - C(s_i) - F. \tag{2}$$

In case of export subsidization, the cost of trade policy is the collection of tax revenue, but this may imply tax distortions or other kinds of costs due to general equilibrium or political considerations. Moreover, in the presence of lobbying activity, the weight given by the politicians to the costs of the policy may be variable. Finally, other forms of export promotion can have different costs for national welfare. Nevertheless, in line with the literature on strategic trade policy, my focus will be mainly on the strategic incentive to export promotion, which will be defined as the indirect marginal benefit of an increase in s_i on the profit:

$$SI^i = \Pi_2^i(x_i, \beta_i, s_i)\frac{\partial \beta_i}{\partial s_i}. \tag{3}$$

As long as this is positive, the government of country i has a strategic reason to promote exports beyond any direct reason that depends on the first-order impact of policy on welfare.[8]

I now present a few examples of market structures that are nested in the general model. As a first example let us consider models of competition in quantities. In particular, allowing for imperfect substitutability between goods, we can adopt an indirect demand for good i as $p_i = p[x_i, \sum_{k=1,k\neq i}^n h(x_k)]$ with $p_1 < 0$ and $p_2 < 0$; of course the case of homogenous goods is a particular case emerging when the inverse demand depends on the total production only, $p_i = p(X)$ with $X = \sum_{k=1}^n x_k$. The cost function, which includes transport costs, can be expressed as $c(x_i)$ with $c'(\cdot) > 0$. It follows that, in the absence of any policy, the general expression for gross profits is given by

$$\Pi^i(x_i, \beta_i, 0) = x_i p(x_i, \beta_i) - c(x_i), \tag{4}$$

where $\beta_i = \sum_{k=1,k\neq i}^n h(x_k)$.

As a second example let us consider a general class of models of price competition. Any model with direct demand $D_i = D[p_i, \sum_{j=1,j\neq i}^n g(p_j)]$, where $D_1 < 0$, $D_2 < 0$, $g(p) > 0$, and $g'(p) < 0$, is nested in my general framework after adopting the monotonic transformation $x_i \equiv 1/p_i$ with $h(x) = g(1/x)$, so that $h'(x) = -g'(1/x)/x^2 > 0$. Under constant marginal costs, gross profits become

$$\Pi^i(x_i, \beta_i, 0) = \left(\frac{1}{x_i} - c\right) D\left(\frac{1}{x_i}, \beta_i\right). \tag{5}$$

We will assume that strategic complementarity typically holds ($\Pi_{12} > 0$).[9] As we will see later on, examples include many well-known demand functions such as the class of demand functions derived by Dixit and Stiglitz (1977), the Logit demand, and the class of demand functions with constant expenditure. An important case that is nested in this specification is the model of price competition with isoelastic demand, which has been widely employed in the new trade theory (Krugman, 1980; Helpman and Krugman, 1985).

In these basic models of the market structure, we can introduce different policies for export promotion. In the rest of this section, I will derive the general results in two crucial cases: in the

[8] In general, the optimal policy satisfies an optimality condition as $\Pi_3^i(x_i, \beta_i, s_i) + SI^i = C'(s_i)$, where the first and the last term represent the direct marginal benefits and costs of the policy.

[9] The condition for strategic complementarity is $D_2 + (p - c)D_{12} > 0$.

first one the foreign market structure is exogenous, in the sense that there is a fixed number of firms (and I replicate the existing results in the literature), in the second one the foreign market is characterized by an endogenous structure, in the sense that entry is free or endogenous.

2.1. *Strategic Policy with Exogenous Market Structures*. Let us briefly summarize the results on the optimal unilateral trade policy for a foreign market with a fixed number of firms. More specifically, assume that $s_i = 0$ for all firms except the domestic one, whose policy s is chosen by the government of its home country at an initial stage. Consider the second stage after a policy s has been chosen and assume that a unique Nash equilibrium exists with the same strategy for the foreign firms, say x, and a different strategy for the domestic one, say z, depending on the policy s. The first-order equilibrium conditions are[10]

$$\Pi_1[x, (n-2)h(x) + h(z), 0] = 0, \tag{6}$$

$$\Pi_1^H[z, (n-1)h(x), s] = 0, \tag{7}$$

which provide the equilibrium strategies of the domestic firm and of the international ones as functions of the policy. Changes in the domestic policy affect the strategies of all the firms. For instance, in case $\Pi_{13}^H > 0$ (which will always be the case when the policy is export subsidization), one can verify that an increase in s is always going to increase the domestic strategy z and to increase the strategy of the international firms x if and only if strategic complementarity ($\Pi_{12} > 0$) holds.

In the initial stage, the government chooses the policy to maximize welfare taking these reactions into account. In the Appendix, I derive the strategic incentive to export promotion as

$$SI^H = \frac{(n-1)h'(x)h'(z)\Pi_2^H \Pi_{12} \Pi_{13}^H}{\Delta}, \tag{8}$$

where $\Delta > 0$ is the determinant of the equilibrium system. When $\Pi_{13}^H > 0$ this effect is positive under strategic substitutability ($\Pi_{12} < 0$) and negative under strategic complementarity ($\Pi_{12} > 0$): In the former case an increase in the policy is going to reduce the strategies of the international firms and increase the profits of the domestic one, and in the latter case the opposite holds. All the results are inverted when $\Pi_{13} < 0$. It is now immediate to conclude with:

PROPOSITION 1. *When the number of firms is exogenous in the foreign market, (a) if the export policy increases the marginal profitability of the domestic firm, there is (not) a strategic incentive to promote exports if strategic substitutability (complementarity) holds; (b) if the export policy decreases the marginal profitability of the domestic firm, the opposite holds.*

Notice that with just one domestic firm, the kind of policy does not depend on the number of international firms. The optimal policy implies an aggressive firm under strategic substitutability and an accommodating one under strategic complementarity. However, the result is sensitive to the number of domestic firms: If this is large enough, there is a bias against export promotion (Dixit, 1984; Klette, 1994). In conclusion, the results on the optimal export policy are ambiguous when the market structures are exogenous.

2.2. *Strategic Policy with Endogenous Market Structures*. From the previous section we can infer that in standard models of competition in quantities and in prices, the foreign country gains from an increase in the number of international firms whenever this increases production

[10] Given the symmetric equilibrium, I will drop the index i for the international firms and use the index H for the domestic one.

or reduces the equilibrium prices. Therefore, it is interesting to investigate what happens when we allow for free entry in the foreign market.

I assume that the number of potential entrants is great enough that a zero profit condition pins down the effective number of firms competing in the foreign market.[11] The equilibrium conditions are the two first-order conditions, (6) and (7), and the zero profit condition that binds on the international firms (because these do not profit from the optimal export policy):

$$\Pi[x, (n-2)h(x) + h(z), 0] = F. \tag{9}$$

Totally differentiating the system (6)–(9), we obtain a fundamental result for what follows (see the Appendix):

PROPOSITION 2. *Under free entry in the foreign market, a change in the export policy does not affect the equilibrium strategy of all the other firms but only their equilibrium number.*

When the domestic policy is changed, the marginal profitability of the strategy of the domestic firm changes, and its optimal strategy changes as well. Nevertheless, the policy change does not affect the marginal profitability for the other firms, and any impact on the market structure emerges through an impact on the number of competitors.[12]

More specifically, notice that optimization by the foreign firms and the free entry condition constraining their number pin down both the strategy of each firm and the level of spillovers that each firm receives from the strategies of the other international firms and the domestic firm, namely, both x and β, which are therefore both independent from s. Because the domestic policy affects the strategy of the domestic firm but not the aggregate statistics $\beta = (n-2)h(x) + h[z(s)]$, it follows that the number of firms must be influenced by the domestic policy. In particular, we have

$$\frac{dn}{ds} = \frac{h'(z)\Pi_{13}^H/h(x)}{\Pi_{11}^H - h'(z)\Pi_{12}^H} \lesseqgtr 0 \text{ if } \Pi_{13}^H \gtreqless 0,$$
$$\frac{dz}{ds} = -\frac{\Pi_{13}^H}{\Pi_{11}^H - h'(z)\Pi_{12}^H} \gtreqless 0 \text{ if } \Pi_{13}^H \gtreqless 0.$$

A policy that makes the domestic firm more aggressive must reduce the number of international firms that can profitably be active in equilibrium, and vice versa.

In the initial stage, the government will choose the policy to maximize welfare. Using the envelope theorem and the previous results, we obtain the new strategic incentive to promote exports:

$$SI^H = \frac{h'(z)\Pi_2^H \Pi_{13}^H}{\Pi_{11}^H - h'(z)\Pi_{12}^H}. \tag{10}$$

Its sign is simply the sign of Π_{13}, therefore we can conclude with:

PROPOSITION 3. *Under free entry in the foreign market, when the export policy increases (decreases) the marginal profitability of the domestic firm, there is (not) a strategic incentive to promote exports.*

[11] As customary, we consider n as a natural number in all the article (except when dealing with entry deterrence).
[12] This result depends on the symmetric properties of the profit functions.

Notice that the result would not change in the presence of more than one domestic firm, as long as some entry of foreign firms takes place in equilibrium.[13]

In conclusion, governments would always gain from unilateral commitments to implement export promoting policies that induce an aggressive behavior of domestic firms active in global markets that are open to entry.[14] Notice that the above analysis takes as given the policies of the other countries: Later, I will present an equilibrium analysis in which all countries choose their policies independently.

In the rest of this section I will apply my general results to the theory of strategic trade policy. I will derive the optimal strategic unilateral trade policy in different models. The focus will be on specific subsidies, but similar results could be obtained with ad valorem subsidies.

2.2.1. *Optimal export subsidy with Cournot competition.* Consider the general model of quantity competition that allows for imperfect substitutability between goods and general cost functions. The gross profit of the domestic firm in the presence of a specific export subsidy is

$$\Pi^H = z[p(z, \beta_H) + s] - c(z), \tag{11}$$

where we remember that z is the production of the domestic firm, $p(\cdot)$ is the inverse demand depending on the spillovers from the production of other firms, β_H, $c(\cdot)$ is the cost function, and s is the subsidy. This profit function is clearly characterized by $\Pi_{13}^H = 1 > 0$. The equilibrium first-order conditions in the second stage where Nash competition takes place in the foreign market are

$$p(x, \beta) + xp_1(x, \beta) = c'(x),$$
$$s + p(z, \beta_H) + zp_1(z, \beta_H) = c'(z),$$

where $\beta = (n-2)h(x) + h(z)$ is the spillover received by an international firm from the strategies of all the other firms in the market and $\beta_H \equiv (n-1)h(x)$ is the spillover received by the domestic firm.

Let us now consider free entry. In the second stage we have also the zero profit condition

$$xp(x, \beta) = c(x) + F.$$

The equilibrium system expresses production levels and the number of firms as functions of the subsidy s, but we know from Proposition 2 that the production of foreign firms x and their spillovers β are actually unaffected by changes in the subsidy, whereas $z(s)$ and $\beta_H(s)$ depend on it. Consequently, we can write the welfare of the domestic country (2) as the profits of the domestic firm net of the tax revenue necessary to finance the subsidy

$$\begin{aligned} W(s) &= z(s)p(z(s), \beta_H(s)) - c[z(s)] - F \\ &= z(s)p[z(s), \beta + h(x) - h(z)] - c[z(s)] - F \end{aligned} \tag{12}$$

whose maximization has an interior solution (without entry deterrence) if goods are imperfect substitutes or/and if marginal costs are increasing enough. If such an interior solution exists, it

[13] Actually, it is immediate to verify that with n_H domestic firms, the equilibrium strategy of each firm would not change and the strategic incentive to promote exports would just be $SI(n_H) = n_H SI(1)$. Under free entry there is not a terms of trade effect induced by an export promoting policy (which is present with entry barriers; see Dixit, 1984).

[14] The result holds for markets in which a single domestic firm is active and subsidized. One should keep in mind that when other domestic firms are subsidized and endogenously enter in the market, entry would drive net domestic profits to zero. Venables (1985) studies a particular example of this case. See also Markusen and Venables (1988). Brander (1995) summarizes the results on entry for the reciprocal-markets model.

must satisfy the first-order condition

$$p\,(z(s),\beta_H)+z(s)\,[p_1(z(s),\beta_H)-p_2(z(s),\beta_H)h'(z)]=c'[z(s)], \tag{13}$$

which is a complicated implicit expression. However, if we substitute this in the equilibrium first-order condition for the domestic firm, we can derive the following expression for the optimal export subsidy:

$$s_H^*=[-p_2(z,\beta_H)h'(z)]\,z>0. \tag{14}$$

It is interesting to derive the optimal subsidy for the case of homogenous goods: In such a case, an interior solution exists only if the marginal costs of production are increasing enough. When this is the case, the equilibrium price $p(X)$ is independent from the production of the domestic firm and from the subsidy because free entry for the international (not subsidized) firms determines total production (and the price) independently from both of them. Given this, the optimal subsidy simplifies to

$$s_H^*=\frac{p}{\epsilon}>0, \tag{15}$$

which is decreasing in the elasticity of demand (with respect to domestic production) $\epsilon \equiv -p/zp'$.[15] It is important to remark that our expression for the optimal export subsidy is the exact opposite of the traditional neoclassical optimal trade policy for markets with homogenous goods. The latter requires an export tax inversely proportional to the elasticity of demand, so as to increase the price of exports compared to that of imports, i.e., to improve the terms of trade (Lerner, 1934). In our framework, an export subsidy of the same magnitude reduces the price of exports to conquer market shares in the foreign market and raise profits. The intuition behind these two specular results is simple: In both cases the distortions due to the policy increase with demand elasticity; therefore high elasticity recommends lower intervention. However, the optimal neoclassical policy is aimed at increasing the price of exports, whereas the optimal policy in our case of endogenous market structures is aimed at decreasing the price of exports.

Notice that the optimal policy implies that the domestic firm produces until its marginal cost equates the equilibrium price ($p=c'(z)$) and enjoys positive profits because returns to scale are decreasing at its production level.[16] Nevertheless, when the elasticity of foreign demand increases, the optimal subsidy decreases. In the limit case of a perfectly elastic demand, which matches the case of a small open economy whose policy does not affect international equilibria, we reach the traditional outcome for which free trade is the optimal policy.

As an example, consider the case of a linear inverse demand $p=a-X$, where X is total production, and a convex cost function that we assume to be quadratic for simplicity, with $c(x)=x^2/2$. Looking at the Cournot equilibrium between n firms for a given subsidy s for the domestic one and imposing the free entry condition, we obtain the equilibrium production for each international firm:

$$x=\sqrt{\frac{2F}{3}}$$

and the number of firms:

$$n=(a-s/2)\sqrt{3/2F}-2,$$

[15] Notice that p is independent from the production of the domestic firm and from the subsidy because free entry for the international (not subsidized) firms determines total production (and the price) independently from both of them.

[16] Notice that the optimal subsidy would be the same in the presence of other domestic firms: There is not a terms of trade effect because the equilibrium price is independent from the subsidy, whereas domestic firms crowd out foreign firms.

which imply total production $X = a - \sqrt{8F/3}$ and price $p = \sqrt{8F/3}$. Consistently with Proposition 2, the subsidy does not affect the individual production of the other firms, but decreases their number. The equilibrium production of the subsidized firm is instead $z(s) = \sqrt{2F/3} + s/2$, which generates net profits $\pi_H = (3/8)(s + \sqrt{8F/3})^2 - F$. The government maximizes profits net of the tax revenue necessary to finance the subsidies:

$$W(s) = z(s)\sqrt{\frac{8F}{3}} - \frac{z(s)^2}{2} - F. \tag{16}$$

This welfare function is maximized by

$$s_H^* = \sqrt{\frac{8F}{3}} > 0, \tag{17}$$

which implies that the domestic firm produces the double than any other international firm. Its net profits are $\pi_H = 3F$ and domestic welfare is $W = F/3$.[17] We will return to this example in the next section.

When the welfare maximization has a corner solution, the optimal subsidy is high enough to deter entry of international firms. It is easy to verify that this outcome emerges in the relevant case of homogenous goods and constant marginal costs of production.[18] Intuitively, the same outcome will occur for high levels of substitutability between products or/and the cost function is not increasing too much with the production level.

The prohibitive subsidy is the one that eliminates profits for any potential entrant. Formally, because we defined n as the total number of firms including the domestic one, the prohibitive subsidy must be (an epsilon larger than) the one that induces exactly zero profits for a single entrant, that is, the one satisfying $n = 2$. Therefore, the prohibitive subsidy is implicitly given by the following condition:[19]

$$xp\left[x, z(s_H^*)\right] - c(x) = F. \tag{18}$$

The intuition for the optimality of the prohibitive subsidy is the following. Free entry pins down the equilibrium price level as long as some of the foreign firms enter. This implies that the choice of the subsidy does not affect the equilibrium price at which the domestic firm will sell its

[17] Notice that when the fixed cost of entry decreases, the level of concentration in the market is reduced and the optimal subsidy goes down: In the limit case of perfect competition (zero fixed costs) we obtain the traditional result for which free trade is optimal.

[18] In order to verify this, notice that for low values of the subsidy that allow entry of international firms, welfare (12) becomes $W(s) = z(s)p(X) - cz(s) - F$, where the equilibrium price is independent from the subsidy and c is the constant marginal cost of production. Given this, welfare is always increasing in the subsidy (because $p(X) > c$) and it is optimal to set it high enough to deter entry.

[19] For instance, let us consider the case of homogenous goods with a linear demand $p = a - X$ and constant marginal cost c. Imagining that there is entry in equilibrium and imposing the free entry condition for a given subsidy s, we obtain the equilibrium production for each international firm $x = \sqrt{F}$ and the number of firms $n = (a - c - s)/\sqrt{F} - 1$, which imply total production $X = a - c - \sqrt{F}$. The equilibrium production of the subsidized firm is $z(s) = \sqrt{F} + s$. The government maximizes profits net of the tax revenue necessary to finance the subsidies

$$W(s) = \sqrt{F}(\sqrt{F} + s) - F.$$

Because this is always an increasing function of s, it is optimal to increase subsidization as long as there is entry. But entry is deterred for any subsidy larger than

$$s_H^* = a - c - 3\sqrt{F} > 0,$$

which makes it impossible for a single entrant to be active (with $n \geq 2$, the single entrant obtains non-positive profits). This prohibitive subsidy is the optimal one and generates total production $z = a - c - 2\sqrt{F}$, which is below the free trade level.

production, but it does increase its market share. Because there are fixed costs of production, an increase in the market share reduces average costs, and therefore it increases net profits. Consequently, it is optimal to raise the market share as much as possible, which amounts to full entry deterrence.

Summing up, we have

PROPOSITION 4. *Under competition in quantities with free entry, the optimal unilateral trade policy requires always a positive export subsidy. With homogenous goods and increasing marginal costs, the optimal subsidy is a fraction* $1/\epsilon$ *of the price, where* ϵ *is the elasticity of the international demand.*

2.2.2. *Optimal export subsidy with Bertrand competition.* Consider our general model of price competition with a (specific) export subsidy, so that the gross profit function for the domestic firm is

$$\Pi^H = (p_H - c + s)D(p_H, \beta_H), \tag{19}$$

where we remember that $D(\cdot)$ is the direct demand depending on the price of the domestic firm p_H and on the spillovers from the prices of the other firms β_H. This profit function clearly satisfies $\Pi_{13}^H = -p_H^2 D_1 > 0$.

As pointed out first by Eaton and Grossman (1986), the optimal trade policy under barriers to entry requires an export tax. Here, however, we will focus on the case of free entry, in which the equilibrium conditions in the second stage and the zero profit condition are

$$\begin{aligned} (p - c)D_1(p, \beta) + D(p, \beta) &= 0 \\ (p_H - c + s)D_1(p_H, \beta_H) + D(p_H, \beta_H) &= 0 \\ (p - c)D(p, \beta) &= F, \end{aligned}$$

where $\beta = (n-2)g(p) + g(p_H)$ is the spillover received by an international firm from the strategies of all the other firms in the market and $\beta_H = (n-1)g(p)$ is the spillover for the domestic firm. This system expresses prices and the number of firms as functions of the subsidy s, but we know from Proposition 2 that the price of foreign firms p and their spillovers β are independent from the subsidy, whereas $p_H(s)$ and $\beta_H(s)$ depend on it. Therefore, assuming that the cost of the subsidy is simply given by the tax revenue necessary to finance it, we can write the welfare of the domestic country (2) as

$$\begin{aligned} W(s) &= [p_H(s) - c]D[p_H(s), \beta_H(s)] - F \\ &= [p_H(s) - c]D[p_H(s), \beta + g(p) - g(p_H)] - F, \end{aligned} \tag{20}$$

which is maximized by a subsidy satisfying the first-order condition

$$D(p_H, \beta_H) + (p_H - c)[D_1(p_H, \beta_H) - D_2(p_H, \beta_H)g'(p_H)] = 0. \tag{21}$$

If we now substitute this in the equilibrium first-order condition for the domestic firm, we can derive the following expression for the optimal export subsidy:

$$s_H^* = \frac{(p_H - c)D_2(p_H, \beta_H)g'(p_H)}{[-D_1(p_H, \beta_H)]} > 0. \tag{22}$$

Also this is an implicit expression, because on the right-hand side p_H depends on the optimal subsidy; however this expression makes clear our main point: The optimal export subsidy must be positive.

Summarizing, under price competition and free entry, an export subsidy is always optimal, because it helps the domestic firm to lower its price in the foreign market. The result overturns common wisdom for models with strategic complementarity and barriers to entry. An accommodating behavior is not anymore optimal because it would just induce new firms to enter. The only chance for the government to increase the profits of the domestic firm is to induce an aggressive behavior: The domestic firm undercuts its competitors, gains market shares, and spreads a low markup over a large portion of the market, leaving the few remaining firms with zero profits. This outcome can only be reached with an export subsidy. Summing up, we have:

PROPOSITION 5. *Under competition in prices with free entry, the optimal unilateral trade policy requires always a positive export subsidy.*

An explicit characterization can be obtained in the case of a Logit demand,

$$D_i = \frac{Ye^{-\xi p_i}}{\sum_{j=1}^{n} e^{-\xi p_j}},$$

with $Y > 0$ representing total demand in the sector and with $\xi > 0$. In this case, international firms choose the price $p = c + F/Y + 1/\xi$, and it is easy to derive that the optimal subsidy must induce a price for the domestic firm equal to $p_H(s_H^*) = c + 1/\xi$, which requires an optimal export subsidy equal to

$$s_H^* = \frac{F}{Y} > 0. \tag{23}$$

Notice that when the size of the fixed costs relative to the size of the market decreases, the endogenous level of concentration in the market is reduced and the optimal subsidy is lower.

Another explicit result for the optimal export subsidy can be derived in models with isoelastic demand that can be microfounded in a standard way and are widely used in international trade theory. Consider a Dixit and Stiglitz (1977) demand function as[20]

$$D_i = \frac{Yp_i^{-\frac{1}{1-\theta}}}{(1+\alpha)\sum_{j=1}^{n} p_j^{-\frac{\theta}{1-\theta}}},$$

In this case the optimal export subsidy, derived in the Appendix, determines an equilibrium price $p_H(s_H^*) = c/\theta$ for the domestic firm that is lower than the equilibrium price of the other international firms $p = cY/\theta[Y - F(1+\alpha)]$. However, one can verify that the reduction in the number of these international firms maintains the price index at the same level as under free trade.

[20] This can be derived from the utility function:

$$U = C_0^{\alpha}\left[\sum_{j=1}^{n} C_j^{\theta}\right]^{\frac{1}{\theta}},$$

with $\theta \in (0, 1)$ and $\alpha > 0$, to be maximized under the budget constraint $C_0 + \sum_{j=1}^{n} p_j C_j = Y$, where C_0 is the numeraire.

3. EQUILIBRIUM TRADE POLICY

In this section we provide an equilibrium analysis for the case in which multiple countries choose their export promotion policies.[21] In order to appreciate the importance of this analysis, consider first the traditional case where there are two countries with two firms active in a third market, and both countries independently choose an export subsidy. This situation, studied first by Brander and Spencer (1985) in a model of competition in quantities with strategic substitutability, generates an inefficient symmetric Nash equilibrium in which both countries engage in excessive subsidization of their exports: Although export subsidies are unilaterally optimal, they are jointly suboptimal (for the countries involved) when one considers equilibrium behavior. Analogously, in case of strategic complementarity, the Nash equilibrium is characterized by suboptimal export taxation by both countries.[22] These results depend again on the exogeneity of the market structure.

Let us consider the general case where each one of m countries can subsidize or tax the exports of a single national firm to an international market, but the number of firms that are ultimately active in the market is endogenous. The timing of the game is the following[23]:

(1) m countries independently choose their export subsidies (taxes if negative) $\mathbf{s} = [s_1, s_2, \ldots, s_m]$ maximize their welfare functions W_i—the definition of welfare extends (12) to take in consideration that domestic profits net of the cost of the domestic subsidy may also depend on foreign subsidies;
(2) simultaneous entry of n firms occurs endogenously; and
(3) all the n active firms independently choose their strategies x_i to maximize their profits π_i.

We will provide a constructive approach to the equilibrium analysis focusing on an example of competition in quantities with homogenous goods where the demand is linear, $p = a - X$, and the cost function is quadratic, $c(x) = x^2/2$ (already used in Section 2.2.1). The main intuitions extend to the case of general demand and cost functions.[24]

Solving for the subgame perfect equilibrium in pure strategies by backward induction, we will show that the Nash equilibrium trade policy is characterized by a limited and endogenous number of countries adopting the same unilaterally optimal export subsidy and by the other countries committing to free trade.

Let us consider stage (3) first. The set of subsidies is given and, without loss of generality, we order the countries by decreasing subsidies: $s_1 \geq s_2 \geq \cdots \geq s_m$. At this stage also the number of active firms n is known. The Cournot equilibrium implies production $x_i = (a - X + s_i)/2$ and profits $\pi_i = 3x_i^2/2 - F$ for each one of them. Summing up to obtain total production $X(n, \mathbf{s}) = (an + \sum_{j=1}^{n} s_j)/(2 + n)$, we notice that this is increasing in the number of active firms and in their subsidy. This allows us to express the production level of each firm as

$$x_i(n, \mathbf{s}) = \frac{a}{2+n} + \frac{1}{2}\left(s_i - \frac{\sum_{j=1}^{n} s_j}{2+n} \right). \tag{24}$$

[21] I am extremely thankful to a referee for pointing out this case and leading to its characterization in the case of competition in quantities.

[22] The same happens under competition in prices. As is well known, also competitive devaluations lead to inefficient equilibrium behavior.

[23] We assume that the number of countries (and potential firms) is high enough that $n < m$ in equilibrium. Otherwise, the game would revert to one with an exogenous number of firms. For simplicity, we also assume that when a country cannot induce entry of its firm and cannot improve welfare by means of an active policy (a subsidy or a tax), the country commits to free trade.

[24] The details are available from the author on request.

Let us move to stage (2). As usual in this literature, we neglect the integer constraint on the number of firms: This is a good approximation as long as the equilibrium number of firms is large enough (i.e., a is large enough). The profits of the active firms can be ranked according to their own subsidies: Firms receiving lower subsidies obtain lower profits. As a consequence, there must be a marginal firm obtaining zero profits. The free entry condition determining n is $\pi_n = 0$ and requires that the production of the marginal firm is given by $x_n = \sqrt{2F/3}$ and the total production is $X(s_n) = a + s_n - \sqrt{8F/3}$, which depends positively on the critical subsidy s_n.[25] This generates an equilibrium price depending on the crucial subsidy as follows:

$$p(X(s_n)) = \sqrt{\frac{8F}{3}} - s_n. \tag{25}$$

The equilibrium production for each active firm can be derived as follows:

$$x_i = \sqrt{\frac{2F}{3}} + \frac{s_i - s_n}{2}. \tag{26}$$

Summarizing, given any set of national subsidies, the most subsidized firms must be active in the market, with the marginal firm producing enough to break even and the other firms producing a quantity that is increasing in their subsidy. The number of active firms depends on all the subsidies according to the following relation:

$$n = \frac{2a - \sum_{j=1}^{n} s_j}{\sqrt{\frac{8F}{3}} - s_n} - 2.$$

Finally, let us move to stage (1). In order to characterize the subgame perfect equilibrium we need to find a set of subsidies such that each one maximizes the welfare of the corresponding country (domestic profits net of the cost of the subsidy) taking as given the other subsidies and the equilibrium of the subgames.[26]

We first establish an equilibrium requirement for the countries $i < n$ that are defined by construction as the countries with active firms obtaining positive profits. Using (25) and (26), the welfare W_i of a country $i < n$ can be expressed as

$$\begin{aligned} W(s_i, s_n) &= x_i[p(X(s_n)) + s_i] - \frac{x_i^2}{2} - F - s_i x_i \\ &= \left(\sqrt{\frac{2F}{3}} + \frac{s_i - s_n}{2}\right)\left(\sqrt{\frac{8F}{3}} - s_n\right) - \frac{1}{8}\left(s_i - s_n + \sqrt{\frac{8F}{3}}\right)^2 - F. \end{aligned} \tag{27}$$

[25] This relies on the assumption that the equilibrium number of firms is a natural number. If this was not the case, the equilibrium number should be the smallest integer $n\rceil$ satisfying $x_{n\rceil}(n\rceil, \mathbf{s}) \geq \sqrt{2F/3}$ and $x_{n\rceil+1}(n\rceil + 1, \mathbf{s}) < \sqrt{2F/3}$. Of course, this number would depend on the full set of subsidies.

[26] The characterization of the equilibrium below relies on the assumption that the equilibrium number of firms is a natural number. If this was not the case, the integer number of firms in equilibrium $n\rceil$ would depend on the subsidy of countries $1, 2, \ldots, n\rceil, n\rceil + 1$, and each active country would choose its subsidy to maximize

$$W_i(\mathbf{s}) = 3x_i(n\rceil, \mathbf{s})^2/2 - F - s_i x_i(n\rceil, \mathbf{s})$$

taking as given the other subsidies. Closed form solutions for the equilibrium subsidies are not available. The approximation in the text, which considers n as a natural number, allows us to derive explicitly the equilibrium subsidies, number of firms, and strategies.

Its maximization for s_i taking as given s_n delivers

$$s^*(s_n) = \sqrt{\frac{8F}{3}} - s_n, \tag{28}$$

which depends negatively on the critical subsidy.[27] In equilibrium, each country $i < n$ must adopt this subsidy.

I now claim that the equilibrium must imply $s_i = 0$ for all the countries $i \geq n$ and therefore that there are no profitable deviations from free trade for all of these countries.

Consider the marginal country n. With a slight abuse of notation, we define this country by construction as the country whose subsidy $s_n \in (s_{n+1}, s_{n-1})$ leads its firm to break even in the last stage. This country could only avoid this outcome with a unilateral deviation as $\hat{s} \geq s_{n-1}$ or $\hat{s} < s_{n+1}$.[28] I now show that this country cannot gain from both kinds of deviation. First, consider a deviation with a positive and large subsidy $\hat{s} \geq s_{n-1} = s^*(0)$. Then country n would not be the marginal country anymore. In the subgame equilibrium following the deviation, country $n-1$ would become the marginal country with its subsidy $s^*(0) = \sqrt{8F/3}$. However, from (27) it emerges that $W(\hat{s}, s^*(0)) \leq 0$ for any deviation $\hat{s}$; therefore, such a deviation from the equilibrium strategy cannot be profitable. Second, consider a unilateral deviation with a negative subsidy $\hat{s} < s_{n+1} = 0$. This would lead to the exit of the national firm (in favor of another unsubsidized firm) without inducing any welfare gain compared to the equilibrium strategy; therefore, also this deviation from the equilibrium strategy cannot be profitable.

Consider now the other countries $i > n$. In the proposed equilibrium they choose free trade, but their firms do not enter in the international market. These countries cannot gain from unilateral deviations for analogous reasons to those of the marginal country: A positive subsidy inducing entry of the national firm would reduce welfare, and a negative one would not change the outcome of the game.

In conclusion, the equilibrium generates the same optimal unilateral subsidy found in (17) for an endogenous number of countries and free trade for the others:

$$s_H^* = \sqrt{\frac{8F}{3}} \quad \text{for } i < n, \quad s_H^* = 0 \quad \text{for } i \geq n$$

where n is given by

$$n = \frac{1}{2}\left(a\sqrt{\frac{3}{2F}} - 1\right).$$

In this example, all firms receiving a positive subsidy produce the double of the marginal firm and obtain positive net profits $\pi_i = 3F$ for $i = 1, 2, \ldots, n-1$, but the number of countries able to exploit the advantages of strategic export subsidization is limited by the size of the market. In our example, each one of these countries obtains a welfare gain $W = F/3$ relative to free trade—but notice that the equilibrium price remains at the free trade level $p = \sqrt{8F/3}$ (which shows a Pareto improvement of the allocation of resources).

In general, the welfare gain is identical for all the countries that actively subsidize their firms, and the same as in the case of a unilateral optimal policy—indeed, even through coordination those countries could not reach a better outcome. In other words, in the presence of endogenous market structures, strategic trade policy is not a beggar-thy-neighbor policy in the traditional

[27] Notice that $s^*(s_n) \geq s_n$, as required by construction, if $s_n \leq s^*(s_n)/2$.

[28] This depends again on the assumption that n is a natural number such that the marginal firm breaks even. As a consequence of this, a deviation given by a small increase in the subsidy to $\hat{s} \in (0, s_{n-1})$ does not change the equilibrium strategy and the equilibrium (zero) profits of the national firm, but simply increases the total output and reduces the price. Accordingly, the deviation does not increase net profits but has a welfare cost due to the cost of the subsidy.

sense. Nevertheless, only a limited number of countries can exploit the benefits of this policy: The adoption of export subsidies by some countries induces the exit of international firms compared to the free trade equilibrium.

The result can be easily extended to general demand and cost functions[29]: The important point is that the traditional conclusion for which export promotion is unilaterally optimal but jointly suboptimal does not appear to be robust in the presence of endogenous market structures, at least under Cournot competition. It would be interesting to extend the results to other models.

4. APPLICATIONS

In this section, we apply our general analysis of the optimal unilateral policy to other policies for international markets whose structure is endogenous. Beyond subsidization, many other policies can affect the profits of exporting firms: for instance, policies that increase demand for the domestic product, reduce transport costs for exporting firms, or promote R&D (Spencer and Brander, 1983). In the first subsection, we evaluate the incentives to adopt R&D subsidies or to strengthen IPRs protection, which provides a strategic advantage for domestic firms participating to the competition for international markets. In the following subsection, we evaluate the strategic incentives of the monetary authority of a country to intervene unilaterally on a fixed exchange rate to support domestic firms active abroad.

4.1. *R&D Policy*. In this section, I briefly address the role of R&D policy in supporting domestic firms active abroad. R&D policy is quite relevant for high-tech industries: Its main aspect involves R&D subsidies, but there are other forms of R&D promotion as public investment in complementary R&D or the strengthening of the protection of intellectual property rights (IPRs) for the domestic firms. One can analyze the role of unilateral R&D policy focusing on the competition *for* international markets rather than the competition *in* international markets. Traditional models of patent races are nested in our general framework and can be used to study R&D policy for firms investing in some forms of innovation to conquer foreign markets. For instance, consider a standard international patent race where each firm i invests a flow of investment x_i in the continuous time. This investment delivers innovations according to a standard Poisson stochastic process characterized by an instantaneous arrival rate of innovations $h(x_i)$, which is a positive and concave function. When one of the firms innovates, it obtains a rent V and the race is over. The R&D subsidy s_i is assumed to be proportional to the investment flow. Given a constant interest rate r, the expected profit function for firm i can be expressed as

$$\Pi(x_i, \beta_i, s_i) = \frac{h(x_i)V - x_i(1 - s_i)}{r + h(x_i) + \beta_i}, \tag{29}$$

which is clearly nested in our general functional form (1). Notice that $\Pi^H_{12} > 0$ and $\Pi^H_{13} > 0$; therefore, in case of a fixed number of international firms (Proposition 1), it would be optimal to tax domestic R&D (to slow down the aggregate investment rate), whereas under the assumption of endogenous entry in the international competition for the market (Proposition 3), a positive R&D subsidy is always optimal. Adopting the usual procedure, it is easy to verify that the optimal unilateral R&D subsidy satisfies

$$s^*_H = \frac{1}{1 + \dfrac{V(r + \beta_H)}{h(z)V - z}} \in (0, 1), \tag{30}$$

where the investments of the domestic firm, z, and of the foreign firms, x, satisfy $h'(z)V = h'(x)(V - F) = 1$. Once again, the subsidy allows the domestic firm to commit to a more

[29] The details are available from the author on request.

aggressive strategy, which is now represented by a larger investment flow. Summarizing, we have[30]:

PROPOSITION 6. *In a patent race between international firms, (a) when the number of firms is exogenous it is optimal to set a R&D tax, but (b) when entry of international firms is free the optimal unilateral R&D policy requires always to set a positive R&D subsidy.*

As we noticed, the same point can be made for other aspects of R&D policy. For instance, a strengthening of the domestic protection of IPRs can provide domestic firms with larger incentives to invest in the competition for international markets with endogenous entry.[31] The strong American position in favor of IPRs protection (and against compulsory licensing of IPRs for antitrust purposes) could be interpreted in this sense: It provides U.S. high-tech firms with a strategic advantage in the international competition. Until now, Europe has followed a different path, but a strengthening of IPRs protection at the E.U. level would have positive effects in enhancing the incentives to invest in R&D for the most dynamic European firms.

4.2. *Exchange Rate Policy*. An important application that deserves more attention is to competitive devaluations adopted with the specific aim of supporting exports. Economic theory is ambiguous on their merits. The traditional Mundell–Fleming model emphasizes the beggar-thy-neighbor effects of unilateral devaluations. However, the recent new open-economy macroeconomics shows that these devaluations can be beggar-thy self policies.[32] In front of this theoretical ambiguity it is difficult to make sense of the common wisdom according to which unilateral devaluations provide a positive strategic advantage on the international markets. In this section, we evaluate the strategic incentives to exchange rate devaluations in a model based on Dornbusch (1987), where the incidence of exchange rate variations on prices is endogenous.

The effects of exchange rate policy for exporting firms crucially depend on the location of production, on whether local currency pricing or producer currency pricing holds,[33] and on the strategic reaction of firms to the policy. In our partial equilibrium context, we will focus on the strategic effects of a devaluation on the domestic firm. Clearly, a devaluation has other consequences in general equilibrium, but the point here is just to understand whether the usual claim that a devaluation gives a strategic advantage to exporting firms is correct. Our focus will be on a particular situation where all firms produce in their domestic country, bear production costs in domestic currency, choose their strategy taking into account the exchange rate, and then export abroad. Under price competition this corresponds to the case of producer currency pricing. Such a case is typical of medium and small firms that are active at a national level, often producing typical domestic products and exporting some of them abroad, but also of larger firms that are not directly active in the foreign market under consideration but sell their goods to distributors in that market.[34] We will study separately the cases of quantity competition and price competition. The bottom line will be that competitive devaluations are always desirable to provide a strategic advantage to domestic firms when entry in the foreign markets is free.[35]

[30] A generalization of the optimal R&D subsidy within a general equilibrium model of endogenous growth can be found in Etro (2008b).

[31] Formally this derives from the fact that $\partial\Pi_1^H/\partial V > 0$.

[32] See Obstfeld and Rogoff (1996) and Corsetti and Pesenti (2001).

[33] See Engel (2000) and Betts and Devereux (2000).

[34] The alternative situation, which is not relevant for our purposes, emerges when international firms produce and compete abroad with independent production units. This is typical of multinational firms that are directly active in other countries where they sell their products.

[35] Potentially, one could extend this framework to derive an optimal competitive devaluation comparing its benefits on the export side with its costs on the import side. However, this remains a partial equilibrium analysis. One should always keep in mind that in general equilibrium and in the absence of pervasive market imperfections, purchasing power parity holds, and it requires automatic adjustments of nominal variables—which undermine the effectiveness of exchange rate policy.

4.2.1. *Competitive devaluations with Cournot competition.* Imagine a foreign market with competition in quantities. Foreign demand for good i is as usual $p_i = p(x_i, \beta_i)$, but revenues in domestic currency are $E_i x_i p_i$ where E_i is the price of the foreign currency in terms of currency of country i, that is, the exchange rate of this country. For expository purposes, imagine an initial situation where, without loss of generality, all the exchange rates (with the foreign country where firms compete) are unitary. If the domestic country can adopt a competitive devaluation and raise the exchange rate to the level E, the profit of the domestic firm becomes

$$\Pi^H = Ezp(z, \beta_H) - c(z), \tag{31}$$

which can be rewritten in our framework as $\Pi^H(z, \beta_H, s)$ where $s = E - 1$, implying $\Pi^H_{13} = p + zp_1 = c'(z)/E > 0$. Hence, our general results apply and tell us that after a devaluation the domestic firm will increase its production level. Under barriers to entry, as long as strategic substitutability holds, the other firms will decrease production so that the market share of the domestic firm increases (as it was shown by Dornbusch, 1987): This creates a strategic incentive to devaluate. Also under free entry the domestic firm expands its market share, but the other firms produce the same as before the devaluation, and some of them exit from the market. Applying Propositions 1 and 3, we have

PROPOSITION 7. *Under quantity competition, (a) when the number of firms is exogenous there is a strategic incentive for competitive devaluations if strategic substitutability holds and (b) when entry is free there is always a strategic incentive for competitive devaluations.*

Notice that a devaluation always increases domestic production and exports.

4.2.2. *Competitive devaluations with Bertrand competition.* The case of price competition is the most interesting, because it is the usual case under study in macroeconomic models and probably the most realistic for our purposes.

Imagine again an initial situation where all the exchange rates are unitary including the price of the foreign currency in terms of domestic currency, E. Notice that, if p^*_H is the price of the domestic good in foreign currency, the price of the same good in domestic currency is $p_H = Ep^*_H$. If the latter is constant, a devaluation (an increase in E) will reduce the price in foreign currency, and an appreciation of the exchange rate will increase it. However, prices in domestic currency for foreign segmented markets can be changed after a devaluation, and our purpose is exactly to check how they are changed.

Because production takes place at home and demand depends on prices in foreign currency, the relevant profit function for the domestic firm is

$$\Pi^H = (p_H - c)D\left[\frac{p_H}{E}, \sum g(p^*_j)\right] = (Ep^*_H - c)\,D\,(p^*_H, \beta_H)\,, \tag{32}$$

which can be rewritten in our framework with $z = 1/p^*_H$ and $s = E - 1$. With such a change of variables, the strategic variable for each firm becomes the price in foreign currency. Clearly, for all the international firms except the domestic one, the price is the same in foreign and domestic currency, $p^*_j = p_j$ for $j \neq H$.

As usual, the incentives to change strategy for the domestic firm depend on the cross effect $\Pi^H_{13} = -p^{*2}_H[D + p^*_H D_1]$, which is positive in equilibrium. Therefore, the price of the domestic firm in foreign currency p^*_H is always decreasing in the exchange rate, that is, after a devaluation. In general, Proposition 1 implies that a competitive devaluation is not strategically desirable under barriers to entry. Such a policy forces the domestic firm to decrease its price in foreign currency, which induces also the other firms to do the same, reducing profits for all the firms.

Actually, there is a strategic incentive to appreciate the currency, which induces the domestic firm to increase its own price in foreign currency and the other firms to do the same.[36]

When entry is free, the domestic firm does not obtain a strategic advantage when induced to increase its own price because this would promote entry in the foreign market. According to Proposition 3, there is a strategic incentive to devaluate the exchange rate. This would reduce the price of the domestic firm in the foreign currency. Foreign firms would not change their own prices, but fewer would enter in the market, so that the market share of the domestic firm would expand—in this case, a devaluation has also a direct beneficial effect, because it increases revenues of the domestic firm in domestic currency.[37] Summing up, the usual claim that devaluations give a strategic advantage to exporting firms is correct only for foreign markets whose structure is endogenous:

PROPOSITION 8. *Under price competition, (a) when the number of firms is exogenous, there is a strategic incentive to appreciate the domestic currency, but (b) when entry is free there is a strategic incentive for competitive devaluations.*

The bottom line is quite intuitive. Devaluations can be deleterious for exporting firms when they induce a war between international firms to reduce prices in foreign currency, and this happens when there are clear barriers to entry. However, when entry is free, international firms cannot undertake such a war and the domestic firm can unilaterally decrease its price in foreign currency, expanding its market share: Only in this case there is a strategic incentive toward competitive devaluations.

5. CONCLUSIONS

In this article, I adopted a simple model of endogenous market structures to show the general optimality of unilateral export promotion policies for firms active in foreign markets. The theoretical implications are particularly strong for markets with competition in prices: The opening up of such markets to free entry of foreign firms would change the optimal unilateral trade policy for the exporting countries from taxation to subsidization of the exports. This would create profits for the domestic firm without affecting welfare in the importing country, at least in my examples. My analysis of another interesting case, that of competition in quantities with homogenous goods, has shown that the optimal export subsidy is inversely proportional to the elasticity of foreign demand, just the opposite of the optimal policy within the neoclassical framework. Moreover, the optimal subsidy creates profits for the domestic country without affecting the equilibrium price in the importing country. Therefore, it improves the allocation of resources compared to the free trade outcome, a result that holds also when other countries can choose their subsidies as well. A possible policy implication is that banishing export subsidies, one of the principles of the WTO, may not be a good idea, at least for markets with endogenous entry at the global level. Moreover, protectionist tendencies (often emerging during crises) could be better directed toward this form of active policy (through export subsidies) rather than toward passive protectionism (import tariffs). The positive aspect of the former is that it does not restrict trade volumes, but it actually promotes them.[38]

[36] Of course, this is just the strategic incentive for the government: An appreciation would also have a negative direct effect on profits, reducing the markup of the domestic firm, and, finally, it will induce other effects for domestic welfare like a reduction in the price of imports.

[37] The positive direct and strategic effects of a devaluation should be compared with the costs in terms of a higher price of imports, which is beyond the scope of this discussion.

[38] The typical argument against foreign export subsidies is that subsidized foreign firms exert unfair competition against unsubsidized domestic firms. This sounds quite similar to the typical argument in favor of passive protectionism: Since more cost-efficient foreign firms exert unfair competition toward less cost-efficient domestic firms, we should adopt import tariffs. We believe that both arguments are flawed. In both cases, subsidized or more efficient foreign firms end up selling goods at lower prices with clear gains for the domestic consumers. The only difference is that in the

I have also applied my framework to show the general optimality of R&D subsidies and protection of domestic intellectual property rights to strengthen the incentives of the domestic firms to invest in R&D and lead the competition for international markets. Finally, I have shown that competitive devaluations represent the optimal unilateral policy to give short-run advantages to domestic firms engaged in competition in international markets with endogenous entry.

Other applications may concern the strategies of multinationals with superior technologies investing in foreign markets. As an immediate consequence of Proposition 2, these investments would not affect the equilibrium strategy of all the other firms, but only their equilibrium number. For instance, entry in the foreign market with a direct investment building a factory that produces at a lower cost would induce exit of other firms, whereas the acquisition of a local firm would not induce this effect, and would be preferred only if the fixed cost of the direct investment is high enough or the synergies from the merger are high enough. In both cases, the investment would be profitable for the multinational firm, without changing the strategies of the other firms and (under homogenous goods and Cournot competition or under my examples of Bertrand competition) without affecting welfare in the importing country.

Further theoretical research could extend these results. On one side, one could study more complex models of interaction between firms and governments and introduce this setup in a standard two-country framework of international trade. Moreover, it would be interesting to extend the model of strategic trade policy for the domestic market in presence of free entry.[39] On the other side, one could analyze the strategic effects of devaluations on both foreign and domestic markets. Finally, the welfare and equilibrium analysis could be extended to more general frameworks.

APPENDIX

Proof of Proposition 1. Let us totally differentiate the systems (6) and (7) under the stability assumption

$$\Delta \equiv \Pi_{11}^H \Pi_{11} + (n-2)\Pi_{12}\Pi_{11}^H h'(x) - (n-1)\Pi_{12}\Pi_{12}^H h'(x)h'(z) > 0$$

and

$$\Pi_{11}^H + \Pi_{11} + (n-2)\Pi_{12}h'(x) < 0,$$

where $\Delta > 0$ is the determinant of the equilibrium system. Moreover, let us assume

$$\Pi_{11} + (n-2)\Pi_{12}h'(x) < 0,$$

which always holds under strategic substitutability, and under strategic complementarity if the number of firms is small enough. The equilibrium strategies $x = x(s)$ and $z = z(s)$ are two functions of the domestic policy s with

$$\frac{dx(s)}{ds} = \frac{\Pi_{12}\Pi_{13}^H h'(z)}{\Delta} \gtreqless 0 \text{ if } \Pi_{12}\Pi_{13}^H \gtreqless 0,$$
$$\frac{dz(s)}{ds} = -\frac{[\Pi_{11} + (n-2)\Pi_{12}h'(x)]\,\Pi_{13}^H}{\Delta} \gtreqless 0 \text{ if } \Pi_{13}^H \gtreqless 0.$$

former case foreign governments are paying for those gains, and in the latter case foreign workers are receiving lower wages to provide those gains: Ultimately the costs are abroad and the gains are at home. Therefore, adopting import tariffs or forbidding export subsidies simply reduces consumer welfare to protect domestic profits.

[39] See Etro (2009) for a preliminary investigation of these topics.

In the initial stage the government will choose the policy to maximize welfare. Using the envelope theorem and the previous results, we obtain the strategic incentive to export promotion as

$$SI = \frac{(n-1)h'(x)h'(z)\Pi_2^H \Pi_{12}\Pi_{13}^H}{\Delta},$$

whose sign proves the proposition. ■

Proof of Proposition 2. In order to verify the comparative statics of the systems (6)–(9) with respect to s, let us use the definitions $\beta = (n-2)h(x) + h(z)$ and $\beta_H \equiv (n-1)h(x)$ to rewrite it in terms of the three unknown variables x, z, and β_H:

$$\Pi_1[x, h(z) - h(x) + \beta_H, 0] = 0,$$
$$\Pi_1^H[z, \beta_H, s] = 0,$$
$$\Pi[x, h(z) - h(x) + \beta_H, 0] = F.$$

The second equation provides an implicit relationship $z = z(\beta_H, s)$ with $\partial z/\partial \beta_H = -\Pi_{12}^H/\Pi_{11}^H$ and $\partial z/\partial s = -\Pi_{13}^H/\Pi_{11}^H > 0$. Substituting this expression we obtain a system of two equations in two unknowns, x and β_H

$$\Pi_1[x, h(z(\beta_H, s)) - h(x) + \beta_H, 0] = 0,$$
$$\Pi[x, h(z(\beta_H, s)) - h(x) + \beta_H, 0] = F.$$

Totally differentiating the system, it follows that $x = x(s)$, $\beta_H = \beta_H(s)$, and $z = z(\beta_H(s), s)$ are the equilibrium functions with the following comparative statics:

$$\frac{dx}{ds} = 0$$
$$\frac{d\beta_H}{ds} = \frac{h'(z)\Pi_{13}^H}{\Pi_{11}^H - h'(z)\Pi_{12}^H} \lesseqgtr 0 \text{ iff } \Pi_{13}^H \gtreqless 0,$$
$$\frac{dz}{ds} = -\frac{\Pi_{13}^H}{\left[\Pi_{11}^H - h'(z)\Pi_{12}^H\right]} \gtreqless 0 \text{ iff } \Pi_{13}^H \gtreqless 0.$$

This implies that the policy s does not affect the strategy of the foreign firms x. Moreover, since $\beta_H \equiv (n-1)h(x)$ we have $n = 1 + \beta_H/h(x)$ and

$$\frac{dn}{ds} = \frac{d\beta_H}{ds} h(x)^{-1} \lesseqgtr 0 \text{ iff } \Pi_{13}^H \gtreqless 0,$$

which concludes the proof. ■

Optimal export subsidy under price competition. We solve for the optimal trade policy in a model of price competition with a demand function a la Dixit and Stiglitz (1977). In order to re-express the model presented in the text in terms of the variables of our general framework, let us set $x_i \equiv 1/p_i$ and $h(x_i) = x_i^{\frac{\theta}{1-\theta}}$ so that, in the presence of a specific subsidy, we have

(A.1) $$\Pi(x_i, \beta_i, s_i) = \frac{x_i^{\frac{\theta}{1-\theta}} - (c - s_i)x_i^{\frac{1}{1-\theta}}}{(1+\alpha)\left[h(x_i) + \beta_i\right]} Y.$$

It follows that $\Pi_{12} > 0$ at the optimal point satisfying $\Pi_1 = 0$, which implies strategic complementarity, and $\Pi_{13} > 0$.

Let us solve for the optimal export subsidy under price competition and free entry. The price of the foreign firms p and of the domestic firm p_H and the number of firms n solve a system of the equilibrium conditions

$$\left[p_H - \frac{c-s}{\theta}\right]\left[(n-1)p^{-\frac{\theta}{1-\theta}} + p_H^{-\frac{\theta}{1-\theta}}\right] = \left[p_H^{\frac{1}{1-\theta}} - (c-s)p_H^{-\frac{\theta}{1-\theta}}\right] \tag{A.2}$$

$$\left[p - \frac{c}{\theta}\right]\left[(n-1)p^{-\frac{\theta}{1-\theta}} + p_H^{-\frac{\theta}{1-\theta}}\right] = \left[p^{\frac{1}{1-\theta}} - cp^{-\frac{\theta}{1-\theta}}\right] \tag{A.3}$$

and the free entry condition

$$\frac{Y\left(p^{-\frac{\theta}{1-\theta}} - cp^{-\frac{1}{1-\theta}}\right)}{(1+\alpha)\left[(n-1)p^{-\frac{\theta}{1-\theta}} + p_H^{-\frac{\theta}{1-\theta}}\right]} = F. \tag{A.4}$$

From (A.3) and (A.4) one can derive the price of the international firms as

$$p = \frac{cY}{\theta[Y - F(1+\alpha)]},$$

which is independent of s. The optimal subsidy maximizes

$$W(s) = \frac{p_H^{-\frac{1}{1-\theta}}(p_H - c)}{\left[(n-1)p^{-\frac{\theta}{1-\theta}} + p_H^{-\frac{\theta}{1-\theta}}\right]} - F = \frac{p_H^{-\frac{1}{1-\theta}}(p_H - c)F(1+\alpha)}{\left(p^{-\frac{\theta}{1-\theta}} - cp^{-\frac{1}{1-\theta}}\right)Y} - F,$$

where we used (A.4) in the second line. It is immediate to verify that the optimal subsidy must satisfy the first-order condition

$$p_H = \frac{c}{\theta}.$$

Substituting for p_H in the equilibrium condition (A.2), one obtains the optimal subsidy

$$s_H^* = \frac{c(1-\theta)}{\theta\left\{\left[\frac{Y - F(1+\alpha)}{Y}\right]^{\frac{\theta}{1-\theta}}\left[\frac{Y(1-\theta)}{F(1+\alpha)} + \theta\right] - 1\right\}} > 0, \tag{A.5}$$

which is increasing in F/Y, the ratio between the fixed costs of production and the size of the market demand.

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