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Reciprocal dumping by locally regulated monopolists

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Abstract: This paper develops an international-trade game with two locally regulated producers. They may freely export but have to sell in their local market at a price equal to their marginal cost. We consider a setting where local production is decided after exports. The rationale for this sequentiality in decision making is in the fact that exports are often set by contract long before expedition takes actually place. In the parlance of game theory, the game is played with a closed-loop information structure. We characterize sufficient conditions for existence and uniqueness of the subgame perfect Nash equilibrium in two scenarios, namely, without and with local regulation. In an asymmetric game with local regulation, we derive conditions under which dumping and cross-hauling take place. In the symmetric version of this game, we show that reciprocal dumping always occurs and that autarky Pareto-dominates this equilibrium. These elements are counter-telling the traditional viewpoint that price-making behavior is a necessary condition for dumping in a deterministic framework. Our model and results are of special interest in a context where locally regulated firms are playing a significant role in international trade.

Keywords: International trade, reciprocal dumping, two-stage game, Cournot, regulation

Résumé : Dans cet article, nous analysons un jeu de commerce international où les producteurs peuvent librement exporter, mais sont soumis à une tarification au coût marginal quant à leur marché local. Nous développons un jeu à deux étages, résolu par induction à rebours, de manière à obtenir un équilibre de Nash parfait en sous-jeu. Une telle séquentialité peut s'expliquer par le fait que la plupart des exportations sont contractées en amont de la production. Nous caractérisons des conditions suffisantes d'existence et d'unicité de l'équilibre avec et sans régulation. Dans le cas assymétrique avec régulation, nous définissons des conditions nécessaires pour que le producteur du marché ayant un prix élevé pratique la vente à perte. Dans le cas symmétrique, les deux joueurs vendent "réciproquement" à perte, si l'on considère le prix de revient net du coût de transport des exportations. Ces éléments contredisent le paradigme qui veut que les producteurs doivent être "faiseur" de prix pour pratiquer la vente à perte dans un cadre déterministe. Cette étude revêt un interêt particulier dans un contexte où les entreprises localement régulées jouent un rôle de premier plan en commerce international.

Mots clés : Commerce international, vente à perte réciproque, jeux à deux niveaux, Cournot, régulation

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1 Introduction

State-owned firms[1] have been playing a growing role in international trade. To illustrate, in 2011 these companies accounted for approximately 19% of the total value of global cross-border trade in goods and services, and their revenue share in the Fortune Global 500 increased from 6% in 2000 to 20% in 2011 (Przemyslaw and Katernya (2015)). These appreciable numbers may raise some concerns that these firms would receive preferential treatment from their home government, and the distortions that this treatment could create in the world market. An interesting question is how these regulated firms behave in an open economy where they could anticipate regulatory outcomes? The issue of interest here stems from the fact that the regulator's playground is generally local, while the firm's expertise is in the market, which is international. By being incomplete, regulation leaves the firm open to acting strategically, with the result that the regulator's rule may end up producing a different effect than the one sought.

We consider a setup with two domestic regulated monopolies producing at a non-decreasing marginal cost, and where each monopolist can freely export to the other country. The paper does two things. First, we adapt Brander and Krugman (1983) to a two-stage game, where in the first stage, each firm decides on its exports, and in the second, on its local production. We provide sufficient conditions for existence and uniqueness of the equilibrium in a fully asymmetric case. In a symmetric setting, we compare the two-stage model to Brander and Krugman (1983), which amounts to comparing closed-loop and open-loop equilibria. In the closed-loop case, a firm can assess its and the rival's local productions before it makes its export decision for the local market. In the open-loop case, the firm makes its output decisions without any observation about the rival's actions (Fudenberg and Tirole (1991)). We show that the change in information structure tends to increase the reciprocal dumping effect. This is mainly due to the competitive effect of the closed-loop information structure, which is relatively standard in the literature (see, e.g., Haurie et al. (2012) for a description of this effect). Second, we modify the model by assuming that the local monopolies are regulated. This is done by enforcing marginal-cost pricing for each producer in its home country. Hence, each firm decides on its output under a given regulatory constraint. This setup corresponds to the notion of a state trading enterprise (STE), as defined in Article XVII of GATT 1994.[2] In an asymmetric case, we characterize the conditions–in terms of transport cost and local supply elasticity–to be met for a cross-hauling and dumping equilibrium. In a symmetric case we show that reciprocal dumping occurs if the production cost function is strictly convex. Finally, we proceed to a welfare analysis, and show that the trade equilibrium between locally regulated symmetric monopolies is strictly Pareto-dominated by autarky. However, each player has a unilateral incentive to deviate from autarky, provided that the elasticity of demand is low enough.

Reciprocal dumping–defined as a two way intra-industry trade where both producers are willing to sell at a free-on-board (FOB) foreign price lower than their home price–was first demonstrated in Brander (1981) in a symmetric two-player framework, with constant marginal cost and linear inverse demand. For the producers to equalize their marginal revenue in the two markets, they sell in both, which causes the cross-hauling of goods. Since by construction, the two prices are equal in the two markets, the FOB foreign price for each player is necessarily lower than the home price, and cross-hauling is thus equivalent to reciprocal dumping. Brander and Krugman (1983) generalized the model to any type of inverse demand function and demonstrated that the global welfare is U-shaped with respect to the transport costs. Weinstein (1991) introduced some asymmetry by assuming different numbers of players between in two markets. Yomogida (2008) extended Weinstein (1991) by introducing asymmetry in production cost.

The reciprocal dumping result in our regulated framework stand in sharp contrast to the traditional view that, for dumping to occur in a deterministic framework, it is necessary that (i) producers be price-makers and (ii) markets be segmented (Krugman and Obstfeld (2008)). This result is due to the anticipation that

[1]OECD definition: *"Any corporate entity recognized by national law as an enterprise, and in which the state exercises ownership, should be considered as an SOE. This includes joint stock companies, limited liability companies and partnerships limited by shares. Moreover statutory corporations, with their legal personality established through specific legislation, should be considered as SOEs if their purpose and activities, or parts of their activities, are of a largely economic nature."*

[2]The formal definition is as follows: *"Governmental and non-governmental enterprises, including marketing boards, which have been granted exclusive or special rights or privileges, including statutory or constitutional powers, in the exercise of which they influence through their purchases or sales the level or direction of imports or exports."*

by increasing exports, production also increases, which raises the marginal cost and thus, the price. Each firm is willing to lose a bit in the foreign market on the expectation of gaining a lot locally.[3]

Our assumption that exports are set before local production is motivated by the following: (i) exports need time to reach foreign markets; (ii) exports are usually managed by longer-term contract than local supplies; (iii) as it induces costly transport, firms tend to make more careful decisions about their exports than they do about local supply, and (iv) in the marginal-cost-pricing case, the local supply is naturally at the same information level as the demand. Such sequentiality is also in Eden (2007), who analyzes a partial equilibrium in perfect competition, with uncertainty on the demand side. He interprets this sequentiality as a "delivery to trade" case such as for food to a supermarket. Assuming a quadratic increasing cost function, he found that trade increases welfare, with dumping occurring, but no cross-hauling.

To keep the model parsimonious, we consider regulation in its simplest form – marginal-cost pricing – which confers the advantage of straightforwardly maximizing social welfare in a closed economy (without externalities). This setup could be extended to cases where a monopolist sells its local production at a rate negotiated with its regulator.[4] We also assume that firms have perfect foresight of the regulated outcome. But, even in its simplest form, our approach covers a number of realistic cases. For example, local regulation is prominent in the agricultural sector, be it in terms of price (Sumner (1998)), or trade barrier (Philippidis et al. (2013)). Furthermore, 75% of STEs are within the agricultural sector (Pearce and Morrison (2002)). During the period 2012-2014, countries like Canada, China and Indonesia, which account among the world top exporters of agricultural products, provided most of their support policies in influencing the market price through output-linked payment (OECD (2015)). In electricity, the integration between regulated areas and power markets is a topical issue, for example between regions like Québec and the Northeastern US power markets, NYISO and ISONE. In Québec, the national producer, Hydro-Québec, has to supply local demand at a regulated price, based on its marginal cost, but is free to contract outside of the province at a negotiated rate. On the one hand, the determination of the local price is largely regulated, even in liberalized power markets. For example, the Northeastern U.S. markets have put in place mitigation rules that promotes competitive bidding in presence of dominant positions, the outcome being that observed prices are close to estimated marginal costs (see the state of the market reports, e.g. PJM (2016), ISONE (2016) and Patton et al. (2016)). On the other hand, cross-border trades generally occur ex-ante of market settlement (see, e.g., Gebhardt and Höffler (2013) for a description of such timing) and are not regulated or, at best, subject to a light regulatory regime (Spees and Pfeifenberger (2012)). This lack of regulation might be the cause of very puzzling strategies in interconnectors, such as counter-directional arbitrage in the case of the IFA interconnector between England and France (Bunn and Zachmann (2010)). In a non-strategic price-taking framework, Antweiler (2016) show that dumping may occur as an insurance against stochastic and correlated demands between Canadian provinces and the U.S. states. This effect compounds with the structural comparative advantage between the two countries to explain the observed two-way trading pattern. Generally, market integration is promoted through a harmonization of local market rules, but few research effort has been made on inter-jurisdictional trading rules.[5] Our study shows that harmonized local regulations may not be sufficient to ensure efficiency.

[3]Another strand of the literature is dedicated to analyzing dumping in a competitive general equilibrium framework. As we focus our attention on strategic partial equilibrium models, this strand is not directly related to what we are doing in this paper. We refer the interested reader to the recent literature review in Blonigen and Prusa (2016), and to the seminal papers by Ethier (1982) and Dixit (1989).

[4]The marginal cost function would then be equivalent to a supply function, and the negotiation terms would be about the component of the marginal cost, e.g., labor and capital costs.

[5]The importance of market design in power markets is covered in Wilson (2002). However, such market architecture is designed locally, it is difficult to design efficient trading rules between markets managed by different operators. More specifically, in the case where a bundle of markets is coordinated by a meta-entity such as NERC in the case of the Northeastern US and ENTSO-E in the case of the Western Europe, trading rules had been put in place but their efficiency had been put in question, see for example Oggioni et al. (2012). In the case of inter-jurisdictional trades (i.e., where the markets are not coordinated), little regulation has been implemented; see for example Spees and Pfeifenberger (2012) for an overview of the problem. The reason for such non-regulation may be the difficulty of sharing costs in case of public investment in interconnection lines (Hogan (2011)) or that regulation may lower incentives for private investors (Joskow and Tirole (2005), Brunekreeft and Newberry (2006), Turvey (2006) and van Koten (2012)).

The interweaving between strategic behavior, local regulation, trading policy and free trade has been extensively looked at in the literature.[6] Notably, Staiger and Sykes (2011) state that many globally traded commodities are subject to local regulation of some forms. The authors highlight the idea that the WTO's rules against non-discrimination are efficient, but that its legal body omits rules to correct biases caused by local regulation. However, to the best of our knowledge, the normative literature on trading games has never considered that firms may anticipate the effect of regulation on each local market outcome. Indeed, this literature generally analyzes trade-policy design as a two-stage game, where regulators act as leaders, and strategic producers act as followers by taking policy as given. This is implicitly equivalent to assuming that firms are myopic with respect to regulation. But, it is our belief that one of the main task of a firm is to assess such an impact. Furthermore, firms can themselves impact the terms of trade through lobbying, which signals some anticipation of the regulation's expected outcome. While our paper is not normative (in the sense that it outlines a problem rather than providing a specific solution), our framework naturally applies to this type of issue. Indeed, as stated in Bulow et al. (1985), "A firm's actions in one market can change competitors' strategies in a second market by affecting its own marginal costs in that other market". More generally, a firm's action in one market can affect the whole structure of trade, and thus, the optimal trade policy.

The rest of the paper is organized as follows: In Section 2, we introduce the model. Sections 3 and 4 characterize the equilibrium strategies and outcomes in the game without and with regulation, respectively. Section 5 briefly concludes.

2 Model

Consider two countries and suppose that their (partial) economy is based on a single homogeneous good consumed in quantity $Z_i, i = 1, 2$. The demand in country $i = 1, 2$ is supplied by local production y_i, and by imports x_j from market j. Markets are segmented, which means that consumers in market i cannot directly buy in market j. Transport of the good is costly, with the cost being of the "iceberg" type, that is, a portion $1 - g$, $g \in [0, 1]$, is lost during the transportation process. This is interpretable as good x_j also being the numeraire for the transport payment, i.e. the transport being paid in real value (Samuelson (1954)). Note that g is the same in both directions. Consequently, the consumption is given by

$$Z_i = y_i + gx_j, \qquad i, j = 1, 2, i \neq j. \tag{1}$$

Each country has one producer (a local monopoly, also indexed by i) who decides on the quantity to put on the local market, that is, y_i, and the quantity to be exported, denoted by x_i. Player i's total production is given by

$$Q_i = y_i + x_i, \qquad i, j = 1, 2, i \neq j. \tag{2}$$

Remark 1 *In Brander and Krugman (1983), the iceberg transportation cost is included in the production cost and is given by $1/g$ times a constant marginal cost c. We cannot do the same here with a general cost function. To keep the transportation cost independent from the production cost, we measure it, as in Samuelson (1954) and Brander (1981), by $(1 - g)\,x_j$.*

Denote by $\mathbf{y} = (y_1, y_2) \in (Y_1, Y_2) \subseteq \mathbb{R}^2_+$ the vector of locally sold quantities and by $\mathbf{x} = (x_1, x_2) \in (X_1, X_2) \subseteq \mathbb{R}^2_+$ the vector of exports. Let $C_i(y_i + x_i)$ be the production cost function of player i, and $P_i(Z_i)$ the inverse demand function in market i. We make the following (standard) assumptions:

A1. The cost function $C_i(Q_i)$ is non-negative and convex non-decreasing ($C_i' \geq 0$, $C_i'' \geq 0$) in both y_i and x_i.
A2. The inverse demand function $P_i(Z_i)$ is continuous, smooth and decreasing ($P_i' < 0$).
A3. There exists $\bar{Z}_i < \infty$ such that $P_i(\bar{Z}_i) = 0$, and $0 \leq C_i'(0) < P_i(0) < \infty$.[7]

[6] We refer the interested reader to seminal papers such as Brander and Spencer (1985) and Eaton and Grossman (1986), or more recent ones such as Bagwell and Staiger (2012) and Davies (2013). For a recent survey, see Bagwell et al. (2015).

[7] We do not require that $P_i(Z_i) = 0$ for $Z_i > \bar{Z}_i$. This is hardly justifiable with an equilibrium *equality* constraint $Z_i = y_i + gx_j$.

Note that **A2** implies that y_i and x_j are only differentiated at the consumption stage by a share $(1-g)$ that is lost during the transport process of x_j. The Assumption **A3** defines the feasible strategy set as a compact set (and prevents the existence of a trivial equilibrium).

Remark 2 *The additivity in the arguments of the cost and the inverse demand function implies the following properties :*

$$C_i^{n\prime} = \frac{\partial^n C_i}{\partial y_i^n} = \frac{\partial^n C_i}{\partial y_i^m \partial x_j^{n-m}} = \frac{\partial^n C_i}{\partial x_j^{n-m} \partial y_i^n} = \frac{\partial^n C_i}{\partial x_j^n}, \tag{3}$$

$$g^n P_i^{n\prime} = g^n \frac{\partial^n P_i}{\partial y_i^n} = g^m \frac{\partial^n P_i}{\partial y_i^m \partial x_j^{n-m}} = g^m \frac{\partial^n P_i}{\partial x_j^{n-m} \partial y_i^m} = \frac{\partial^n P_i}{\partial x_j^n}, \tag{4}$$

where $F_i^{n\prime}$ is the n^{th} derivative of function F_i.

The problem of choosing the quantities to be sold locally and to export is modeled as a two-stage non-cooperative game. In the first stage, each producer sets its export x_i anticipating the reaction of supply and demand in the two markets. In the second stage, each producer maximizes its profit with respect to y_i, taking (x_i, x_j) as given. Denote by $J_i(\mathbf{y}, \mathbf{x})$ the total profit of player i, and by $\Pi_i(y_1(\mathbf{x}), y_2(\mathbf{x}))$ the profit in the second stage. To obtain a subgame-perfect Nash equilibrium (SPNE), we solve the game in the reverse order.

Let $(y_1, y_2) = \mathbf{y} \in Y$ and $(x_1, x_2) = \mathbf{x} \in X$. Let $\Pi_i : Y_i \to \mathbb{R}$ be the second-stage profit function of player i, and $\hat{y}_i : X \to Y_i$ be the best reply mapping of player i such that

$$\hat{y}_i(\mathbf{x}) = \{\hat{y}_i \in Y_i \mid \Pi_i(\hat{y}_i, \mathbf{x}) \geq \Pi_i(y_i, \mathbf{x}) \ \forall y_i \in Y_i\}, \quad i, j = 1, 2, i \neq j. \tag{5}$$

Definition 1 *Let $J_i : Y \cap X_i \to \mathbb{R}$ be player i's profit function for the two-stage game. A point $\hat{\mathbf{x}} = (\hat{x}_1, \hat{x}_2)$ is a subgame-perfect Nash equilibrium if*

$$J_i(\hat{y}_i(\hat{\mathbf{x}}), \hat{y}_j(\hat{\mathbf{x}}), \hat{\mathbf{x}}) \geq J_i(\hat{y}_i(x_i, \hat{x}_j), \hat{y}_j(x_i, \hat{x}_j), x_i, \hat{x}_j), \ \forall x_i \in X_i, \ i, j = 1, 2, i \neq j. \tag{6}$$

We shall characterize and contrast the equilibrium strategies and outcomes in the two scenarios. In the first, we consider two unregulated local monopolies competing in quantity in both the local and foreign market.

Remark 3 *In Brander and Krugman (1983), each monopolist simultaneously chooses y_i and x_i in a one-stage game. This is similar to assuming a two-stage game with precommitment or an open-loop information structure (OLIS). In our case, the game is played in two stages, and the information structure is closed-loop (CLIS). This difference allows us to assess the impact of varying the information structure on the results.*

In the second scenario, we suppose that each local monopoly is regulated in its home market, i.e., the price is set by the regulator at the marginal cost. Here, we aim at analyzing the behavior and outcomes of locally regulated firms in an open economy.

Remark 4 *We need to analyze these two scenarios because, in the second one, we have modified two key elements with respect to Brander and Krugman (1983), i.e., the information structure and the market architecture. Hence, the first scenario's purposes is to control for the impact on the results of changing the information structure. We need not to control for the impact of the change in the market architecture as, in our case, it is trivial that a regulated local monopolist would not trade at all in the other market in an open-loop information structure. Indeed, marginal cost (which is equal to price) is always lower than marginal revenue in a symmetric case.*

3 Unregulated local monopoly

3.1 Existence and uniqueness in the general case

We start by considering the second-stage game. For any given $\mathbf{x}$, player i solves the following profit optimization problem:

$$\max_{y_i} \Pi_i(y_i, \mathbf{x}) = y_i P_i(y_i + g x_j) - C_i(y_i + x_i). \tag{7}$$

Assuming an interior solution, the first-order optimality conditions are

$$\frac{\partial \Pi_i}{\partial y_i} = y_i P_i' + P_i - C_i' = 0, \quad i = 1, 2. \tag{8}$$

Under Assumptions **A1**–**A3**, the implicit function theorem guarantees that $\hat{y}_i(\mathbf{x})$ is uniquely defined. Its derivatives with respect to x_k, $k = i, j$ are given by (see, e.g., Friedman (1977)):

$$\frac{\partial \hat{y}_i}{\partial x_k} = -\frac{\partial^2 \Pi_i / \partial y_i \partial x_k}{\partial^2 \Pi_i / \partial y_i^2}, \quad k = i, j. \tag{9}$$

Using the properties in (3)–(4), we get

$$\frac{\partial \hat{y}_i}{\partial x_i} = \frac{C_i''}{y_i P_i'' + 2P_i' - C_i''},$$
$$\frac{\partial \hat{y}_i}{\partial x_j} = \frac{-g\left(y_i P_i'' + P_i'\right)}{y_i P_i'' + 2P_i' - C_i''}.$$

As Π_i is independent of y_j, for the maximization problem in (7) to have a unique solution, it suffices to have Π_i strictly concave in y_i. Formally,

A4. $\partial^2 \Pi_i / \partial y_i^2 = y_i P_i''(Z_i) + 2P_i'(Z_i) - C_i''(y_i + x_i) < 0$ for any $y_i, Z_i \in [0, \bar{Z}_i]$ and any $x_i \in [0, \bar{Z}_j]$.

The above assumption and the convexity of the cost function imply that $\hat{y}_i$ is non increasing in x_i. To ensure that $\hat{y}_i(\mathbf{x})$ is decreasing in x_j, that is, y_i and x_j are strategic substitutes (Bulow et al. (1985)), we also make the following assumption (see Long and Soubeyran (2000)):

A5. $y_i P_i''(Z_i) + P_i'(Z_i) < 0$ for any $y_i, Z_i \in [0, \bar{Z}_i]$.

Assumption **A5** implies that $\hat{y}_i(\mathbf{x})$ is a contraction mapping in $\mathbf{x}$, that is,

$$\frac{\mathrm{d}\hat{y}_i}{\mathrm{d}\mathbf{x}} = \frac{\partial \hat{y}_i}{\partial x_i} + \frac{\partial \hat{y}_i}{\partial x_j} \in (-1, 0).$$

For later use, we introduce the following function that make it possible to separate the transport cost effect from the rest:

$$r_i(\mathbf{x}) = \frac{1}{g}\frac{\partial \hat{y}_i}{\partial x_j} = \frac{-y_i P_i'' - P_i'}{y_i P_i'' + 2P_i' - C_i''} \in (-1, 0). \tag{10}$$

This function is directly interpretable as the first derivative of the "gross" reaction function $\hat{y}_i(x_j)$, i.e., the reaction function non-netted of the transport costs.

Now, we turn to the first stage. Each producer chooses the exports that maximize the overall profit given by

$$J_i(\hat{y}_i(\mathbf{x}), \mathbf{x}) = x_i \; P_j\left(\hat{y}_j(\mathbf{x}) + x_i\right) + \hat{y}_i(\mathbf{x}) \; P_i\left(\hat{y}_i(\mathbf{x}) + g x_j\right) - C_i\left(\hat{y}_i(\mathbf{x}) + x_i\right), \tag{11}$$

$i, j = 1, 2$, and $i \neq j$, where

$$\hat{y}_i(\mathbf{x}) \; P_i\left(\hat{y}_i(\mathbf{x}) + g x_j\right) - C_i\left(\hat{y}_i(\mathbf{x}) + x_i\right),$$

is the profit in the second stage. The first-order conditions are

$$\frac{\partial J_i}{\partial x_i} = \hat{y}_i \frac{\partial P_i}{\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i} + \frac{\partial \hat{y}_i}{\partial x_i} P_i + g x_i \left(\frac{\partial P_j}{\partial \hat{y}_j}\frac{\partial \hat{y}_j}{\partial x_i} + \frac{\partial P_j}{\partial x_i}\right) + g P_j - \frac{\partial C_i}{\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i} - \frac{\partial C_i}{\partial x_i} = 0, \tag{12a}$$

$i, j = 1, 2$, and $i \neq j$. Using (4) and (10), the above equations can be rewritten as

$$\frac{\partial J_i}{\partial x_i} = \frac{\partial \hat{y}_i}{\partial x_i}\left[\hat{y}_i P_i' + P_i - C_i'\right] + g\left[x_i g P_j'\left(1 + r_j\right) + P_j\right] - C_i' = 0, \tag{12b}$$

$i, j = 1, 2$, and $i \neq j$. By (8), the first term in brackets is zero, and consequently the above equations become

$$\frac{\partial J_i}{\partial x_i} = g\left[x_i g P_j'\left(1 + r_j\right) + P_j\right] - C_i' = 0, \quad i, j = 1, 2, i \neq j.$$

We observe that the exports by one firm are not directly competing with the exports of the other firm, but rather compete indirectly through the (direct) impact on local production in both markets. The slope of the exports' reaction function with respect to imports is given by

$$\frac{\mathrm{d}\hat{x}_i}{\mathrm{d}x_j} = \frac{\partial \hat{x}_i}{\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_j} + \frac{\partial \hat{x}_i}{\partial \hat{y}_j}\frac{\partial \hat{y}_j}{\partial x_j}.$$

If local production is a strategic substitute to both imports and exports, that is, $\partial \hat{x}_i/\partial \hat{y}_i$ and $\partial \hat{x}_i/\partial \hat{y}_j$ are negative, then exports and imports would be strategic complements. Hence, to ensure the stability of a unique equilibrium, a contraction property of the reaction function $\hat{x}_i(x_j)$ is needed (along with quasi-concavity of the objective function with respect to x_i) (Friedman (1977)), that is,[8]

$$\frac{\partial^2 J_i}{\partial x_i^2} < 0 \quad \text{and} \quad \frac{\partial^2 J_i}{\partial x_i^2} - \left|\frac{\partial^2 J_i}{\partial x_i \partial x_j}\right| < 0.$$

Proposition 1 *Under Assumptions **A1**–**A5**, a unique subgame-perfect Nash equilibrium exists if*

$$\begin{aligned}\frac{\partial^2 J_i}{\partial x_i^2} =& \left(\frac{\partial \hat{y}_i}{\partial x_i}\right)^2 (\hat{y}_i P_i'' + 2P_i') - C_i''\left(1 + \frac{\partial \hat{y}_i}{\partial x_i}\right)^2 \\ &+ g^2\left(1+r_j\right)\left(x_i P_j'' g\left(1+r_j\right) + 2P_j'\right) + g x_i P_j' \frac{\partial^2 \hat{y}_j}{\partial x_i^2} < 0,\end{aligned} \tag{13}$$

and

$$\begin{aligned}&\frac{\partial \hat{y}_i}{\partial x_i}\left(y_i P_i'' + P_i'\right)\left(g(1+r_i) + \frac{\partial \hat{y}_i}{\partial x_i}\right) - C_i''\left(1 + \frac{\partial \hat{y}_i}{\partial x_i}\right)\left(1 + \frac{\partial \hat{y}_i}{\partial x_i} + g r_i\right) \\ &+ g\left(x_i P_j'' g\left(1+r_j\right) + P_j'\right)\left(g(1+r_j) + \frac{\partial \hat{y}_j}{\partial x_j}\right) \\ &+ P_i' \frac{\partial \hat{y}_i}{\partial x_i}\left(g r_i + \frac{\partial \hat{y}_i}{\partial x_i}\right) + P_j' g\left(g(1+r_j) + x_i\left(\frac{\partial^2 \hat{y}_i}{\partial x_i^2} + \frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j}\right)\right) < 0\end{aligned} \tag{14}$$

for any x_i, Z_i in $[0, \bar{Z}_i]$ and x_j, Z_j in $[0, \bar{Z}_j]$.

Proof. See Appendix A. □

Without specifying functional forms, it is hard to say much about the above conditions. Still, we can observe that all terms in the right-hand side of (13) are negative with the exception of the last one $\left(g x_i P_j' \frac{\partial^2 \hat{y}_j}{\partial x_i^2}\right)$, which we cannot sign. However, it is sufficient (not necessary) to have $\frac{\partial^2 \hat{y}_j}{\partial x_i^2} \geq 0$ for (13) to hold true. The contraction condition (14), which ensures uniqueness, is more difficult to satisfy. Indeed, on top of the second derivative terms $\frac{\partial^2 \hat{y}_i}{\partial x_i^2}, \frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j}$ that cannot be signed, the first and third terms have opposite signs.

3.2 The symmetric case

As we are interested in comparing our results to the ones in Brander and Krugman (1983), we adopt their same assumptions, that is, that the two countries are symmetric and the marginal production cost is constant, denoted by c. As alluded to before, the only remaining difference between the model in Brander and Krugman (1983) and ours is then the information structure; open loop in Brander and Krugman (1983) and closed loop in our case. Here, each local producer internalizes the impact of its export strategy on its and on the other player's local supply.

[8]This property is stronger than the usual stability property

$$\frac{\partial^2 J_1}{\partial x_1^2}\frac{\partial^2 J_2}{\partial x_2^2} - \frac{\partial^2 J_1}{\partial x_1 \partial x_2}\frac{\partial^2 J_2}{\partial x_2 \partial x_1} > 0.$$

However, in a two-stage asymmetric game with non parametric functional forms, it becomes very difficult to have a decomposition with respect to the original functions.

Let $Z = y + gx$ be the total demand in the local market, and $\sigma = gx/Z$ be the share of imports. Denote by $\epsilon = -P/ZP'$ the price elasticity. The first-order condition for local production (8) can be then rewritten as

$$P = \frac{c\epsilon}{\epsilon + \sigma - 1}, \tag{15a}$$

which is the same as in Brander and Krugman (1983). For the foreign producer, using in (8) the fact that in any subgame-perfect equilibrium, $yP' + P - c = 0$, we can restate (12b) as follows:

$$g\left(xP'g\left(1 + r\right) + P\right) - c = 0,$$

which in terms of σ and ϵ leads to the following price equation:

$$P = \frac{c\epsilon}{g\left(\epsilon - \sigma\left(1 + r\right)\right)}. \tag{15b}$$

We note that the corresponding expression to (15b) in Brander and Krugman (1983) is

$$P^B = \frac{c\epsilon^B}{g(\epsilon^B - \sigma^B)}, \tag{16}$$

where the superscript B stands for Brander and Krugman (1983). The above equation shows that the impact of σ on the price is reduced by $(1+r) < 1$ in a closed-loop information structure equilibrium. Equating (15a) and (15b), we obtain the (almost) closed-form equilibrium price P and export market share σ, that is,

$$\sigma = \frac{\epsilon(g-1)+1}{1+g(1+r)}, \quad P = \frac{c\epsilon\left(1 + g\left(1+r\right)\right)}{g\left(\epsilon + \left(\epsilon - 1\right)\left(1 + r\right)\right)}. \tag{17}$$

The corresponding expressions in Brander and Krugman (1983) are

$$\sigma^B = \frac{\epsilon^B(g-1)+1}{1+g}, \quad P^B = \frac{c\epsilon^B(1+g)}{g(2\epsilon^B - 1)}. \tag{18}$$

Comparing the two equilibria, we obtain the following: (i) the share of imports is larger in a closed-loop than in an open-loop equilibrium, that is, $\sigma > \sigma^B$; and (ii) the result for the prices goes in the opposite direction, i.e., $P < P^B$, for $\epsilon < \frac{1}{1-g}$.[9] The conclusion here is that a CLIS equilibrium leads to more trading, and, consequently, more reciprocal dumping occurs if the transport cost is sufficiently low. This increasing volume is accompanied by a price reduction. This result goes in the general direction stating that a CLIS hardens competition with respect to OLIS.[10]

We now turn to the impact of changing the information structure on welfare. Recall that y is the local production, and x is the imports. By symmetry, the total welfare of both countries is given by

$$W = 2\left(U(Z) - c(\hat{y} + x)\right). \tag{19}$$

Differentiating W with respect to the transport cost parameter g, we get

$$\frac{\mathrm{d}W}{\mathrm{d}g} = 2\left(p\frac{\mathrm{d}Z}{\mathrm{d}g} - c\left(\frac{\mathrm{d}\hat{y}}{\mathrm{d}g} + \frac{\mathrm{d}x}{\mathrm{d}g}\right)\right). \tag{20}$$

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[9]Note that for the equilibrium to be interior in both OLIS and CLIS, we must have both ϵ and ϵ^B strictly lower than $\frac{1}{1-g}$.

[10]From (18), we see that for an interior equilibrium to exist, we must have $\epsilon^B \in \left(\frac{1}{2}, \frac{1}{1-g}\right)$, and σ^B attains it maximum when $\epsilon = 1/2$. In our case, an interior solution requires that σ and P in (15a) and (15b) be strictly positive, which yields

$$\frac{1+r}{2+r} < \epsilon < \frac{1}{1-g},$$

that is, $\epsilon \in \left(\frac{1+r}{2+r}, \frac{1}{1-g}\right)$. Clearly the interval $\left(\frac{1+r}{2+r}, \frac{1}{1-g}\right)$ is larger $\left(\frac{1}{2}, \frac{1}{1-g}\right)$, which means that the existence of an interior equilibrium in CLIS is obtained for a larger interval of parameter values than for its OLIS counterpart.

Notice that here, unlike in Brander and Krugman (1983), $\hat{y}$ is an implicit function of x because of the sequential decisions. Hence,

$$\frac{\mathrm{d}Z}{\mathrm{d}g} = \frac{\mathrm{d}\hat{y}}{\mathrm{d}g} + g\frac{\mathrm{d}x}{\mathrm{d}g} + x = x + \frac{\mathrm{d}x}{\mathrm{d}g}\left(g + \frac{\mathrm{d}\hat{y}}{\mathrm{d}x}\right).$$

From (15b), we see that for $p = c/g$, we get $x = 0$. This prohibitive price is the same as in Brander and Krugman (1983). At this specific point, we have

$$\left.\frac{\mathrm{d}W}{\mathrm{d}g}\right|_{p=c/g} = 2(p-c)\frac{\mathrm{d}\hat{y}}{\mathrm{d}x}\frac{\mathrm{d}x}{\mathrm{d}g} < 0. \tag{21}$$

Negativity follows from $\mathrm{d}x/\mathrm{d}g > 0$ and $\mathrm{d}\hat{y}/\mathrm{d}x < 0$. Therefore, when the transport cost is prohibitively high, reducing it (that is, increasing g) decreases the total welfare. On the other hand, if $g = 1$, it is apparent that, using the contraction property of $\hat{y}(\mathbf{x})$ derived from Assumption **A5**, (20) is positive. Hence, modifying the information structure from an open-loop simultaneous decision to a closed-loop sequential decision does not qualitatively change the results from Brander and Krugman (1983), that is, the shape of welfare as a function of transport cost is the same. However, in terms of surplus distribution, the CLIS is more favorable to consumers than is the OLIS. For the total surplus, the effect is unclear, as the outcome is closer to perfect competition in the CLIS, but the augmented volume of trade implies more waste in transport costs. Nevertheless, as g tends to 1, the former effect naturally dominates the latter one, which results in an increase of wealth.

Remark 5 *All these results analytically hold for any cost function with $C''(.) \geq 0$. Having $C''(.) > 0$ only implies that $1 + r$ is greater than when $C''(.) = 0$.*

4 Regulated local monopoly

We suppose that the supply is locally subject to marginal-cost pricing; clearly, such regulation maximizes welfare in a closed-economy. In an open economy, this is not true in general, as local regulation biases the signal to suppliers. To better see the sources of incentive, we first keep the players' labels, and next drop them when we assume symmetry.

4.1 The general case

Let us start by stating the following:

Remark 6 *Under marginal-cost pricing, the local production reaction function has the following properties:*

$$\begin{aligned}\partial\hat{y}_i/\partial x_i &= C_i''/(P_i' - C_i'') \in [-1, 0],\\ \partial\hat{y}_i/\partial x_j &= -gP_i'/(P_i' - C_i'') \in [-1, 0].\end{aligned}$$

The local production function is a contraction mapping in $\mathbf{x}$ if and only if $g < 1$. Denote by s_i the derivative of the reaction function $\hat{y}_i$ with respect to x_j netted from the transport cost, that is, $s_i = \partial\hat{y}_i/g\partial x_j$. Consequently, we have $\partial\hat{y}_i/\partial x_i = -(1 + s_i)$.

Using the marginal-cost-pricing rule $P_i = C_i'$, the first-order optimality condition of the producer in the first stage (8) can be rewritten for an exporter j as[11]

$$-\hat{y}_j P_j'(1+s_j) + g\left[x_j P_i' g\,(1+s_i) + P_i\right] - C_j' = 0. \tag{22}$$

Observe in (22) the additional positive term $\left(-\hat{y}_j P_j'(1+s_j)\right)$ compared to the unregulated case. The price being locally regulated, the first term adds a local incentive to increase exports. Consequently, a regulated monopolist tends to overexport in order to raise the local price. However, if the marginal cost is constant for one producer, e.g., $C_i'' = 0$, then $s_i = -1$. As we can see in (22), the first-order condition becomes constant in this case, and x_j would be settled such that $C_j' = gP_i$. If both marginal production costs are constants and $C_j'/g < C_i'$, then we have a corner solution characterized by $y_i, x_i = 0$. If $C_j'/g = C_i'$, we have infinitely many equilibria. If $C_j'/g > C_i' \geq C_j'$ no trade would occur, another corner solution. To permit interior solution, we assume further diseconomies of scale, that is,

A6. $C_i''(y_i + x_i) > 0$ for any y_i, x_i, $i = 1, 2$.

This assumption implies that $s_i > -1$. In this case, as g gets closer to 1, a producer is willing to dump in the foreign market, at a CIF (cost insurance freight) price below its marginal cost . This corresponds to a stronger definition of dumping than in the related literature (Brander (1981), Brander and Krugman (1983), Weinstein (1991), Yomogida (2008)), where dumping is given in terms of FOB price. Indeed, in our case, the selling price, *including transportation cost*, is lower than the marginal cost of production.

Proposition 2 *Assume **A1-A6** hold and that price is settled at the local supplier's marginal cost. Assume an equilibrium exists. Then, supplier j will sell at a CIF price below its marginal cost, i.e., $C_j' > P_i$ and $x_j > 0$ if*

$$g > \tilde{g} = 1 + \frac{s_j}{\gamma_j}\frac{P_j}{P_i}, \tag{23}$$

where

$$\gamma_i = \frac{C_i'}{\hat{y}_i C_i''} > 0. \tag{24}$$

The interval $(\tilde{g}, 1)$ is always non-empty, such that there always exist values of g for that equilibrium to exist. In this case, cross-hauling occurs, along with unilateral dumping.

Proof. Assume without loss of generality that $C_1' = P_1 < P_2 = C_2'$ and $x_2 > 0$. From (22), and using the inequality $P_1 < P_2$, we obtain

$$C_1' < C_2' < gC_1' - \hat{y}_2 P_2'(1+s_2),$$

and we get the desired result that such equilibrium exists if

$$g > 1 + \frac{\hat{y}_2 P_2'(1+s_2)}{C_1'}.$$

As the second member of the RHS is negative, this threshold is strictly lower than 1, and the interval is non-empty. It is trivial that if $P_2 > P_1$, then $x_1 > 0$. As we are in a marginal-cost-pricing setup, $P_i = C_i'$ for any x_i and x_j. In particular, for that equality to remain true for any variation of x_i, it must be the case that

$$\frac{\partial P_i(y_i(\mathbf{x}), x_j)}{\partial x_i} = \frac{\partial C_i'(y_i(\mathbf{x}), x_i)}{\partial x_i} \iff \frac{\partial P_i}{\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i} = \frac{\partial C_i'}{\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i} + \frac{\partial C_i'}{\partial x_i} \iff P_i'(1+s_i) = C_i'' s_i,$$

[11] The sufficient conditions for existence and uniqueness are very similar to the unregulated case. They are achieved by adding

$$\frac{\partial^2 \hat{y}_i}{\partial x_i^2}\hat{y}_i P_i' \quad \text{and} \quad \left(\frac{\partial \hat{y}_i}{\partial x_i}\right)^2 \left(P_i' + \hat{y}_i P_i''\right) < 0$$

to conditions (13). The first term sign is undefined. Similarly for (14), we add

$$\left(\frac{\partial^2 \hat{y}_i}{\partial x_i^2} + \frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j}\right)\hat{y}_i P_i', \quad \left(\left(\frac{\partial \hat{y}_i}{\partial x_i}\right)^2 + \frac{\partial \hat{y}_i}{\partial x_i}\frac{\partial \hat{y}_i}{\partial x_j}\right)\left(P_i' + \hat{y}_i P_i''\right) < 0, \text{and} \quad g\frac{\partial \hat{y}_i}{\partial x_i}\frac{\partial \hat{y}_i}{\partial x_j}\hat{y}_i P_i'' > 0,$$

where the first term is unsigned. Thus, we refrain from providing the detailed characterization of the equilibrium in this case, as it does not provide much additional insight.

for any i. Let $\gamma_i = C_i'/\hat{y}_i C_i''$. We end up with

$$g > 1 + \frac{s_2}{\gamma_2}\frac{P_2}{P_1},$$

which is the desired result. □

This proposition shows that a strong dumping equilibrium may exist for relatively low transport costs, i.e., $g \in (\tilde{g}, 1)$. The lower the transport cost, the less money will be lost by players in exercising their dumping strategy. To interpret the RHS of Equation (23), note first that the parameter γ_j corresponds to the local production's price elasticity, and hence, that the lower is this elasticity, the higher is the producer willingness to dump overseas. Indeed, by dumping overseas, it increases its production, and hence, raises its marginal cost, which ultimately raises the local price. The parameter s_j–which is the reaction of local supply to imports–is also interpretable in our marginal-cost-pricing setup as the relative curvature of the inverse demand function compared to the curvature of marginal cost function at equilibrium (see Remark 6). Hence, the higher is the quantity sensitivity of price compared to that of marginal cost, the more dumping will take place. Indeed, an increase in exports is equivalent to a reduction in local sales, and hence, to an increase in the willingness to pay. For the local producer, increasing exports decreases the total production, as local production is a contraction of exports. Consequently, the price, settled at the marginal cost, decreases, but less so than does the raise of the demand-side willingness to pay. As an exporter, a producer is an unregulated Cournot player, so the foreign competitor does not wish to increase its exports very much in reaction, because a marginal volume's growth would decrease the price more significantly. Hence, the higher is s_j (in absolute terms), the less foreign competitor would impede the dumping strategy of the local producer. Thus, the ratio s_j/γ_j is interpretable as an index of individual efficiency for the dumping strategy in an open economy.

Dumping also becomes more efficient the greater is the price difference between the two markets. This may seem counterintuitive, as losses from exports are higher in this case, but the intuition is as follows. In a context where the gap between the two prices is sizeable, a producer in a high-price area sells much more locally than to other markets (and accordingly, the local supply elasticity is low). Therefore, the sum of local gains is much greater than the foreign losses, such that the latter has a relatively low impact on the total profit. Hence, the higher is the price differential, the more exports would be made to raise the local price rather than equating foreign marginal revenue and local marginal cost of production.

Contrary to Brander and Krugman (1983), where dumping was caused by the perception of a segmented market by each oligopolist, here, dumping is a way to increase local price, and accordingly, a local producer is always willing to sell below its marginal cost to export. The loss on the foreign market is compensated by the rise in local profits. Hence, because of local regulation, the dumping definition is reinforced to include selling below marginal cost.[12] To sum up, trying to decrease the unit transport cost in a regulated monopoly setting may perversely have the effect of favoring dumping in this strong sense. Of course, dumping is not in itself reprehensible, as long as it does not decrease wealth. However, this result is useful in explaining the welfare result of Proposition 3.

4.2 The symmetric case

We now turn to the symmetric case and again use σ for the share of imports in a country and ϵ for the price elasticity of demand. As price is equal to marginal cost, we obtain

$$\sigma = \frac{\epsilon(g-1) + 1 + s}{(1+g)(1+s)}. \tag{25}$$

As explained earlier, if the marginal cost is constant, i.e., $C'' = 0$, then $s = -1$ and the above equation is undefined. However, looking at the limit $s \to -1_+$, we see that $\sigma \to -\infty$. So no trade would occur in this situation. The intuition is simple. There is no point in exporting if it does not raise the local market price, set at a constant marginal cost.

[12] Remark that with constant marginal cost, the elasticity of local supply tends to infinity, such that $\tilde{g}$ is always equal to one. The producer has no incentive to dump if it cannot increase the local price.

Assumption **A6** implies $s \in (-1, 0)$, and therefore, there is trade for as long as $\epsilon < (1+s)/(1-g)$. This threshold is lower than in the non-regulated monopoly case, where we had $\epsilon < 1/(1-g)$, such that reciprocal dumping occurs in fewer situations in the local-regulation case. But, contrary to the unregulated case, there is no lower bound on ϵ below which no equilibrium is defined.[13] Also, reciprocal dumping occurs for any g, provided ϵ is low enough. The intuition is the following: even if an infinitesimal unit of export makes it to the foreign market, it serves the purpose of increasing the local price by increasing the producer's marginal cost. This effect is interesting for the supplier only if the demand is relatively inelastic.

In Krugman and Obstfeld (2008), the authors give these as necessary conditions for dumping: (i) the industry must be imperfectly competitive, so that firms are price-makers, and (ii) the markets must be segmented. We just demonstrated that reciprocal dumping occurs in a case where the price is set by regulation to marginal cost . Despite the fact that producers anticipate the realization of the prices, they cannot mark up their marginal cost in the usual sense (e.g., as the Lerner index measures it).

Furthermore, in this case, reciprocal dumping is necessarily equivalent to a welfare loss for any $g < 1$. Indeed, differentiating (19) with respect to $\mathbf{x}$, recalling that $\mathrm{d}Z/\mathrm{d}\mathbf{x} = \mathrm{d}\hat{y}/\mathrm{d}\mathbf{x} + g$ and assuming $p = C'$, we end up having[14]

$$\frac{\mathrm{d}W}{\mathrm{d}x} = 2C'(g-1) < 0 \quad \forall g < 1. \tag{26}$$

The intuition is simple, and it is worth recalling how the impact of international trade can be decomposed in a game context: (i) it increases wealth because of a better allocation of resources (the so-called comparative advantage); (ii) it increases wealth because it increases the level of competition; and (iii) it decreases wealth because some local supply is replaced with more costly foreign supply because of the transport cost. By symmetry, (i) is canceled, and because markets are locally regulated, (ii) is also canceled and we remain with the negative effect.

But the trade equilibrium's main effect is to transfer wealth from consumers to producers. Indeed, the main objective for each monopolist is to increase its production in order to increase its marginal cost, and thus the price. Figure 1 shows an example of wealth transfer and losses where $Z = y + gx$ is local consumption and $Q = y + x$ is the monopolist total production. The superscript A stands for the autarky value, and T for the trade equilibrium.

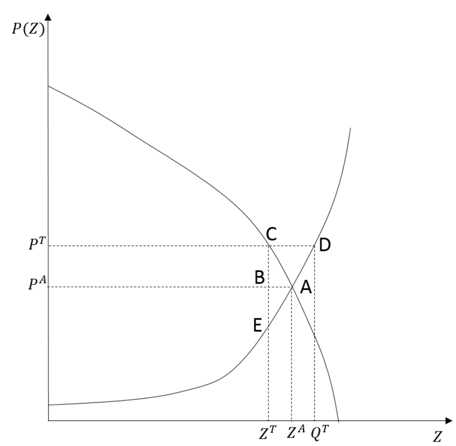

Figure 1: Regulated subgame equilibrium

In this example, we can see that going from autarky to an open economy amounts to transferring wealth from consumers to the regulated monopolist (zone P^ABCP^T) and to a loss of efficiency (zones ACE and

[13] This makes sense as, in a decreasing-return market with a low demand elasticity, regulation would be considered to protect consumers from harmful abuses of dominant position.

[14] As we are in a symmetric case,

$$\mathbf{x} = \begin{bmatrix} x \\ x \end{bmatrix}, \text{ hence } \mathrm{d}\hat{y}/\mathrm{d}\mathbf{x} = \mathbf{1}^T \nabla_x \hat{y}(\mathbf{x}) = \frac{\partial \hat{y}_i}{\partial x_i} + \frac{\partial \hat{y}_i}{\partial x_j}, \ \forall i \text{ and } j \neq i.$$

Z^AADQ^T). This strategy is realized at a high cost, as only part of g is sold at a price below the marginal cost, whereas the rest is wasted. Consequently, the trade equilibrium is highly inefficient. The following proposition shows that, if $g < 1$, then the trade equilibrium always results in a loss of wealth for both consumers and producers, compared to the autarky case.

Proposition 3 *Assume* ***A1*****–*****A6*** *hold and that price is settled at the local supplier's marginal cost; then a trade equilibrium is strictly Pareto-dominated by autarky for any $g < 1$.*

Proof. To show that non-strategic consumers' surplus decreases in $\mathbf{x}$, it is necessary and sufficient to show that price increases in $\mathbf{x}$. As price always equates marginal cost, which in turns increases the total production, it is sufficient to show that total production increases in $\mathbf{x}$. Denote by $Q(\mathbf{x}) = x + \hat{y}(\mathbf{x})$ the total production of a producer and recall that $\mathrm{d}\hat{y}/\mathrm{d}\mathbf{x} \geq -1$ for $g \leq 1$ with equality if and only if $g = 1$. Since

$$\frac{\mathrm{d}Q(\mathbf{x})}{\mathrm{d}\mathbf{x}} = 1 + \frac{\mathrm{d}\hat{y}(\mathbf{x})}{\mathrm{d}\mathbf{x}},$$

consumers' welfare decreases if and only if $g < 1$.

For the producers, differentiate the profit function with respect to $\mathbf{x}$ to get

$$\begin{aligned} \frac{\mathrm{d}J}{\mathrm{d}\mathbf{x}} &= \frac{\mathrm{d}\hat{y}}{\mathrm{d}\mathbf{x}}(P - C') + ZP'\left(\frac{\mathrm{d}\hat{y}}{\mathrm{d}\mathbf{x}} + g\right) + gP - C', \\ &= ZP'\left(\frac{\mathrm{d}\hat{y}}{\mathrm{d}\mathbf{x}} + g\right) + P(g-1). \end{aligned}$$

Further, using

$$\frac{\mathrm{d}\hat{y}}{\mathrm{d}\mathbf{x}} + g = \frac{-gP' + C''}{P' - C''} + g = (g-1)(1+s) < 0,$$

we end up with

$$\frac{\mathrm{d}J}{\mathrm{d}\mathbf{x}} = (g-1)\left[Z(\mathbf{x})P'(Z(\mathbf{x}))\left(1 + s(\mathbf{x})\right) + P(Z(\mathbf{x}))\right].$$

To compare profits in the trade equilibrium with profits in autarky, we integrate this function by part over $\mathbf{x}$, to obtain

$$(g-1)\left(\left[Z(\xi)P(Z(\xi))\right]_0^{\mathbf{x}} + \int_0^{\mathbf{x}} f(\xi)\mathrm{d}\xi\right), \tag{27}$$

where

$$f(\xi) = P(Z(\xi))\left[1 - Z'(\xi)\right] + s(\xi)P'(Z(\xi))Z(\xi).$$

As $f(\mathbf{x}) \geq 0$ for $\mathbf{x} \geq 0$, we have $\int_0^{\mathbf{x}} f(\xi)\mathrm{d}\xi \geq 0$. For the primitive part of the equation, we demonstrated that price in a trade equilibrium is higher than in autarky, which implies that $Z(\mathbf{x}) < Z(0)$. On the other hand, the revenue is maximized for the monopolistic outcomes $\bar{Z}$, $\bar{C}'$ and $\bar{P}$. It suffices now to show that $Z(\mathbf{x}) > \bar{Z}$. By definition of marginal-cost pricing, we have, for any $\mathbf{x}$,

$$ZP' + P - C' < yP' + P - C' < 0 = \bar{Z}\bar{P}' + \bar{P} - \bar{C}',$$

which implies that $Z(\mathbf{x}) > \bar{Z}$ by Assumption **A4**. So the primitive is positive. Since $g < 1$, the profit in trade equilibrium is lower than in autarky. If $g = 1$, then (27) is zero. □

This proposition shows that autarky strictly dominates the equilibrium from an ordinal point of view, that is, no one takes advantage of trade at equilibrium. The explanation of this effect is as follows. In the unregulated case, consumers benefit from trade thanks to an increase in competition, and hence, to a price reduction. In this regulated case, trade is not reducing price, and consumers are losing. The intuition is simple: the price is already at the marginal cost, and there is no (positive) mark-up to reduce. Furthermore, as shown in Proposition 2, a significant share of the imports consists in dumping, which causes an important dead-weight loss for the economy. As g increases, the losses due to import cost decrease, but a larger share of exports occurs due to the players' willingness to dump. In a symmetric case, the two players have an equal ability to resist the other's strategy. The individually positive effect of raising local profits is thus canceled. What remains is the dead-weight losses of transport costs.

5 Conclusion

By transforming the one-stage model in Brander and Krugman (1983), we modified the information structure from open-loop to closed-loop. We proved that changing the information structure increases the share of exports in the total supply, resulting in a more competitive equilibrium. Modifying the subgame to take account for marginal cost pricing, two asymmetric players may cross-haul their product when the costly producer's local supply function is inelastic. In such a case, this producer dumps its product at a CIF price below its marginal cost, thus reinforcing the definition of dumping. In a symmetric case, the two players are systematically willing to dump their product at below marginal cost. These two elements contradict the traditional assertion that price-making behavior is a necessary condition for dumping in a deterministic framework. Furthermore, this equilibrium is strictly Pareto-dominated by the autarky situation. This game belongs to the class of prisoner's dilemma: both producers lose by moving from autarky to free trade, but each would unilaterally deviate from the autarky situation. In other words, each producer would hope to increase its profit by capturing some of the consumers' rent, but, given that it does not anticipate the market externalities, its profit decreases.

In certain sectors, e.g., natural resources, local regulation is unavoidable, to mitigate market power or to ensure output quality. Furthermore, the emerging economies, e.g., BRICS countries, where the state plays an important role in the economy, are gaining importance in international trade. Consequently, the role of local regulation is now, more than ever, a key feature in the world economy. However, the expertise of local regulators cannot account for the increasing role played by regulated firms at the international level. Recognizing that firms might anticipate such regulation may change the perspective on international trade. In this context, opening the economy via free trade could be seen as an opportunity for concentrated firms to manipulate regulated markets, in order to increase their short-term profit. In other words, opening the markets is equivalent to widening the playground of firms, giving them more opportunity to abuse an initially constrained dominant position. Hence, by opening up the markets, free trade may cause the counter-productive outcome of increasing inefficiencies. In that respect, it seems important for the WTO to set some trade rules, not only to ensure free entry, but also to overcome the potential for enterprises to abuse their dominant position at a global level.

This study could be extended in different directions. First, it would be useful to test anti-dumping trading policies along a closed-loop information structure, where firms could anticipate the outcome of local regulation. Second, some gaps in the international economics literature could be filled by replacing the lower-level partial equilibrium of this paper with a general equilibrium, in the spirit of Neary (2015). This could be done at least numerically thanks to advances in computing equilibria in games exhibiting equilibrium constraints (Luo et al. (1996), Pang (2010)).

Appendix

A Proof of proposition 1

Proof. The second-order condition of (11) yields

$$\begin{aligned}\frac{\partial^2 J_i}{\partial x_i^2} =&\hat{y}_i\left[\frac{\partial^2 P_i}{\partial^2 \hat{y}_i}\left(\frac{\partial \hat{y}_i}{\partial x_i}\right)^2+\frac{\partial P_i}{\partial \hat{y}_i}\frac{\partial^2 \hat{y}_i}{\partial x_i^2}\right]+2\frac{\partial P_i}{\partial \hat{y}_i}\left(\frac{\partial \hat{y}_i}{\partial x_i}\right)^2+\frac{\partial^2 \hat{y}_i}{\partial x_i^2}P_i\\ &+x_i g\left[\frac{\partial^2 P_j}{\partial^2 \hat{y}_j}\left(\frac{\partial \hat{y}_j}{\partial x_i}\right)^2+\frac{\partial^2 P_j}{\partial \hat{y}_j\partial x_i}\frac{\partial \hat{y}_j}{\partial x_i}+\frac{\partial P_j}{\partial \hat{y}_j}\frac{\partial^2 \hat{y}_j}{\partial x_i^2}+\frac{\partial^2 P_j}{\partial x_i^2}+\frac{\partial^2 P_j}{\partial x_i\partial \hat{y}_j}\frac{\partial \hat{y}_j}{\partial x_i}\right]\\ &+2g\left[\frac{\partial P_j}{\partial \hat{y}_j}\frac{\partial \hat{y}_j}{\partial x_i}+\frac{\partial P_j}{\partial x_i}\right]\\ &-\frac{\partial^2 C_i}{\partial^2 \hat{y}_i}\left(\frac{\partial \hat{y}_i}{\partial x_i}\right)^2-\frac{\partial^2 C_i}{\partial \hat{y}_i\partial x_i}\frac{\partial \hat{y}_i}{\partial x_i}-\frac{\partial C_i}{\partial \hat{y}_i}\frac{\partial^2 \hat{y}_i}{\partial x_i^2}-\frac{\partial^2 C_i}{\partial x_i^2}-\frac{\partial^2 C_i}{\partial x_i\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i}<0,\end{aligned} \tag{28a}$$

which gives, in rearranged form,

$$\begin{aligned}\frac{\partial^2 J_i}{\partial x_i^2} =&\frac{\partial^2 \hat{y}_i}{\partial x_i^2}\left[\hat{y}_i P_i' + P_i - C_i'\right] + \left(\frac{\partial \hat{y}_i}{\partial x_i}\right)^2 \left[\hat{y}_i P_i'' + 2P_i'\right] - C_i''\left(1+\frac{\partial \hat{y}_i}{\partial x_i}\right)^2 \\ &+ g^2\left(1+r_j\right)\left[x_i P_j'' g\left(1+r_j\right) + 2P_j'\right] + g x_i P_j' \frac{\partial^2 \hat{y}_j}{\partial x_i^2} < 0.\end{aligned} \tag{28b}$$

The first term is canceled since $\hat{y}_i P_i' + P_i - C_i' = 0$ for any $\mathbf{x}$. Hence, notwithstanding the sign of the higher order term $\partial^2 \hat{y}_j/\partial x_i^2$, we can see that assuming $\partial \hat{y}_j/\partial x_i < 0$ is largely sufficient to ensure concavity.[15]

As stated previously, strict concavity of the objective function with respect to the control variable (Equation (28a)) is not sufficient to obtain uniqueness of the Nash equilibrium. On top of this, a sufficient condition for uniqueness is for the reaction function $x_i = \hat{x}_i(x_j)$, defined such that

$$\frac{\partial J_i}{\partial x_i}\left(\hat{y}_i(\hat{x}_i(x_j), x_j), \hat{x}_i(x_j), x_j\right) = 0,$$

to be a contraction, that is,

$$\left|\frac{\mathrm{d}\hat{x}_i}{\mathrm{d}x_j}\right| = \left|\frac{\frac{\partial^2 J_i}{\partial x_i \partial x_j}\left(\hat{y}_i(\hat{x}_i(x_j), x_j), \hat{x}_i(x_j), x_j\right)}{\frac{\partial^2 J_i}{\partial x_i^2}\left(\hat{y}_i(\hat{x}_i(x_j), x_j), \hat{x}_i(x_j), x_j\right)}\right| < 1, \quad i = 1, 2.$$

Deriving (12a) with respect to x_j, we obtain

$$\begin{aligned}\frac{\partial^2 J_i}{\partial x_i \partial x_j} =&\hat{y}_i\left[\frac{\partial^2 P_i}{\partial^2 \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i}\frac{\partial \hat{y}_i}{\partial x_j} + \frac{\partial^2 P_i}{\partial \hat{y}_i \partial x_j}\frac{\partial \hat{y}_i}{\partial x_i} + \frac{\partial P_i}{\partial \hat{y}_i}\frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j}\right] + \frac{\partial \hat{y}_i}{\partial x_j}\frac{\partial P_i}{\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i} \\ &+ \frac{\partial \hat{y}_i}{\partial x_i}\left[\frac{\partial P_i}{\partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_j} + \frac{\partial P_i}{\partial x_j}\right] + \frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j}P_i \\ &+ g x_i\left[\frac{\partial^2 P_j}{\partial^2 \hat{y}_j}\frac{\partial \hat{y}_j}{\partial x_i}\frac{\partial \hat{y}_j}{\partial x_j} + \frac{\partial P_j}{\partial \hat{y}_j}\frac{\partial^2 \hat{y}_j}{\partial x_i \partial x_j} + \frac{\partial^2 P_j}{\partial x_i \partial \hat{y}_j}\frac{\partial \hat{y}_j}{\partial x_j}\right] + g\frac{\partial P_j}{\partial \hat{y}_j}\frac{\partial \hat{y}_j}{\partial x_j} \\ &- \frac{\partial^2 C_i}{\partial^2 \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_i}\frac{\partial \hat{y}_i}{\partial x_j} - \frac{\partial C_i}{\partial \hat{y}_i}\frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j} - \frac{\partial^2 C_i}{\partial x_i \partial \hat{y}_i}\frac{\partial \hat{y}_i}{\partial x_j},\end{aligned} \tag{29a}$$

which, in a simpler, rearranged form, gives

$$\begin{aligned}\frac{\partial^2 J_i}{\partial x_i \partial x_j} =&\frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j}\left[\hat{y}_i P_i' + P_i - C_i'\right] + g\frac{\partial \hat{y}_i}{\partial x_i}\left[\left(1+r_i\right)\left(\hat{y}_i P_i'' + P_i'\right) + r_i P_i'\right] \\ &- g r_i C_i''\left(1+\frac{\partial \hat{y}_i}{\partial x_i}\right) + g\frac{\partial \hat{y}_j}{\partial x_j}\left[x_i P_j'' g\left(1+r_j\right) + P_j'\right] + g x_i P_j' \frac{\partial^2 \hat{y}_j}{\partial x_i \partial x_j}.\end{aligned} \tag{29b}$$

As previously, Assumption **A4** implies that the first term is null. All other terms but the higher-order term are positive. It is thus likely that (29b) is positive. For the upper bound, that is $-\partial^2 J_i/\partial x_i^2 > \partial^2 J_i/\partial x_i \partial x_j$ for every $x_i,\ x_j$, and canceling the null term, we get

$$\begin{aligned}&\frac{\partial \hat{y}_i}{\partial x_i}\left[y_i P_i'' + P_i'\right]\left(g(1+r_i) + \frac{\partial \hat{y}_i}{\partial x_i}\right) + P_i'\frac{\partial \hat{y}_i}{\partial x_i}\left(g r_i + \frac{\partial \hat{y}_i}{\partial x_i}\right) - C_i''\left(1+\frac{\partial \hat{y}_i}{\partial x_i}\right)\left(1+\frac{\partial \hat{y}_i}{\partial x_i} + g r_i\right) \\ &+ g\left[x_i P_j'' g\left(1+r_j\right) + P_j'\right]\left(g(1+r_j) + \frac{\partial \hat{y}_j}{\partial x_j}\right) + P_j' g\left(g(1+r_j) + x_i\left(\frac{\partial^2 \hat{y}_i}{\partial x_i^2} + \frac{\partial^2 \hat{y}_i}{\partial x_i \partial x_j}\right)\right) < 0.\end{aligned} \tag{30}$$

□

[15] Indeed, because x_i and y_j are a homogeneous commodity, $y_i P_i'' + P_i' < 0$ for any y_i $i = 1, 2$ implies that $x_i P_j'' + P_j' < 0$ for any x_i $i = 1, 2$.

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