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# Mandated countertrade as a strategic commitment

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## Abstract

Mandated countertrade is a policy to restrict unilateral imports. A country's government thereby in effect commits domestic firms not to purchase from a foreign trading partner unless there are reciprocal sales. We argue that the policy may be a rational response to fundamental contracting failures, our key assumption being that sellers are incompletely informed about buyers' valuations.

In line with observed practices, the analysis suggests that an optimal mandated countertrade policy will target high mark-up imports and low mark-up exports. Implications for global welfare are ambiguous and depend upon the extent of a double coincidence of wants.

*Key words:* Mandated countertrade; Trade policy; Asymmetric information

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## 1. Introduction

It is a remarkable fact that barter and other forms of countertrade<sup>1</sup> continue to play a significant role in the world economy.<sup>2</sup> While it is hard to

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<sup>1</sup> We do not distinguish between the various forms of countertrade. Offsets, barter, swaps, and buy-backs are some of the many variants of the same fundamental phenomenon. For the purposes of this paper, we will use the terms barter, reciprocal dealing, and countertrade interchangeably.

<sup>2</sup> It is interesting that barter has for so long been seen as an inferior mode of trade. As Jevons, 1875 pointed out, an important function of money is precisely that it facilitates trade in the absence of a "double coincidence of wants." Accordingly, a standard result in modern theories of money is that barter disappears completely in equilibrium.

obtain a precise estimate, we can be fairly sure that at least 10% of world trade involves a two-way flow of goods rather than a simple purchase of goods for money. Some sources such as OECD (1981, OECD, 1985) and UNCTAD (1984) define the practice quite narrowly, but the latter nevertheless estimates that it constitutes 15% of world trade. In a detailed country study of Switzerland, Bürgin (1986) concludes that 13% of its foreign trade takes this form, while the chairman of the American Countertrade Association claimed in a recent interview that countertrade accounts for around 20% of US exports (Fortune, 1992). Based on a variety of sources, including a complete database of publicized deals and a number of interviews, Hveem et al. (1989) put the number at 15–25% of world trade.<sup>3</sup>

*Mandated countertrade* occurs when unilateral purchases are restricted by a national government. Governments mandate countertrade for their domestic industries by limiting imports which are not accompanied by matching exports. Carter and Gagne (1988) reported that in 1984 countertrade was mandated in some form by 88 countries, and the current number probably runs into three figures. The most powerful policy instrument at a government's disposal is allocation of foreign exchange. The governments of Argentina and Zimbabwe have both required export sales as a condition for allocating currency for imports. Another effective policy is to grant import licenses for certain classes of products only if the purchases are reciprocated; variants of this policy have been used by e.g. Algeria, Argentina, Bolivia, Brazil, Columbia, Costa Rica, India, Indonesia, Korea, Libya, Mexico, Tanzania and Libya.<sup>4</sup> Finally, the policy of requiring counterpurchase for certain public sector imports has been used by Australia, Austria, Israel and Sweden (especially for weapons), among many others. Out of the total volume of countertrade, an informed estimate is that around half is mandated. Walsh (1985) states that most is mandated, but fewer than half of the deals registered by Hveem et al. (1989) involve government mandating.

The data clearly shows that countertrade is not a freak phenomenon. It is sizable and regular enough to demand an explanation. Nonetheless, formal theoretical models of countertrade are still in their infancy. In this paper we shall argue that countertrade could be due to fundamental contracting failures, a position which is shared by an increasing number of observers

<sup>3</sup> Bibliographies of works on countertrade are compiled by Debroy, 1987 and by Zurawicki and Suichmezian, 1991. Some general overviews are Alexandrides and Bowers, 1987 and Hammond, 1990. Information on recent deals can be found in the weekly *Countertrade Outlook* and in the monthly *Trade Finance*.

<sup>4</sup> Sources for this information are Walsh, 1985 and Carey and McLean, 1986. Liesch, 1991 is a recent book on mandated countertrade.

(see e.g. Hennart and Anderson, 1993; Mirus and Yeung, 1993). Specifically, we stress the role of incomplete information at the time of contracting.<sup>5</sup>

As is now well understood, informational asymmetry is one of the main obstacles to efficient trade. The fact that sellers do not usually know exactly the buyers' willingness to pay is taken to explain a number of trading practices. Examples from the literature on optimal selling mechanisms include second-degree price discrimination, bundling, and the form of auction procedures. It seems natural, therefore, to ask whether informational asymmetry can contribute to explain barter as well.

To address the question, we design a very simple model of two countries. In each country there is a domestic producer of some product which is not made in the other country. Due to sellers' market power and their incomplete information, prices are above marginal costs. Hence, there are unrealized gains from trade in both markets. Supposing that the two producers are buyers in each other's market, could barter be a way of exploiting their dual roles to increase trade?

Our first result demonstrates that voluntary (non-mandated) countertrade cannot increase the efficiency of trade. The reason is that if firm  $i$  has a low valuation of firm  $j$ 's product, it rejects barter. Therefore, willingness to barter becomes a signal of a high valuation; in fact only a buyer that would have been willing to purchase in the first place accepts a countertrade agreement! This result serves as a useful benchmark for the examination of government trade policies. The paper's main contribution is to show that mandated countertrade may raise domestic welfare. The intuition goes roughly as follows. Suppose each government cares about the expected surplus of the domestic firm. If country  $i$  mandates countertrade, the foreign firm (firm  $j$ ) knows it cannot make a unilateral sale to firm  $i$ . Firm  $j$  is therefore willing to accept barter even if its valuation of firm  $i$ 's product is fairly low (but above its own marginal costs). Hence, even though the domestic firm is prevented from buying, it gets some compensation: essentially, it can choose freely between selling and bartering, depending on its own valuation. From the vantage point of the government, mandating

<sup>5</sup> The role of pre-contractual asymmetric information is also emphasized by Caves and Marin, 1992, who argue that barter could be a form of second-degree price discrimination. In contrast, Chan and Hoy, 1991 and Choi and Maldoom, 1992 emphasize *post-contractual* asymmetric information and the associated difficulty of ensuring correct levels of performance (i.e. moral hazard). Williamson, 1983, Williamson, 1984, Hennart, 1989, and Marin and Schnitzer, 1995, argue that countertrade could be caused by imperfect contract enforcement, the basic idea being that the tying of trades introduces new ways of penalizing non-performance. Finally, Amann and Marin, 1994 claim that countertrade can substitute for missing forwards markets. Neither of these papers studies mandated countertrade.

countertrade is rational whenever the gains from barter outweigh the loss of unilateral imports.

We develop a number of comparative static results. In particular we find that mandated countertrade occurs in equilibrium whenever there is a sufficiently high probability that both firms prefer barter to not trading; in other words, there is a high likelihood of a double coincidence of wants. This result fits the evidence that mandated countertrade is often associated with economies of scale and 'surplus commodities' (see e.g. Outters–Jaeger, 1979; Banks, 1985). Also, asymmetries matter. A low domestic and a high foreign mark-up invite intervention, a result which is consistent with the observations that (i) the export products eligible for countertrade deals are frequently 'non-traditional exports', which do not contribute much to current earnings,<sup>6</sup> and (ii) the import restrictions are typically put on high mark-up items such as weapons, oil, and luxuries (see Walsh, 1985; Carey and McLean, 1986).

Many writers, notably Caves (1974), have remarked on the similarity between international countertrade and reciprocal dealing between domestic firms. Our theory contrasts with much of the literature in that it applies rather specifically to international barter: the mandating of countertrade relies on a credible (non-renegotiable) commitment, and credibility is here ensured by an authority outside the firms (the government).<sup>7</sup> Also, it is rational for the authority to interfere partly because it neglects the welfare of one party (the foreign firm), which seems less likely in a domestic setting.

The paper is outlined as follows. Section 2 introduces the analytical framework. Section 3 presents some preliminary results, in particular that (under our assumptions) non-mandated countertrade is not a viable way of creating trade. Equilibrium trade policies are derived in Section 4. Section 5 concludes.

## 2. The framework

There are two markets. Each market is served by a single seller.<sup>8</sup> The

<sup>6</sup> The common objection to this view, that low saleability implies an equally low barter value, is thus shown to be incorrect once we leave the world of perfect competition. Drawing a distinction between market value (the profit maximizing price) and profitability, we see that low profit exports can be turned into valuable items of barter, even when the barter transaction is carried out according to market prices.

<sup>7</sup> Of course, there are other mechanisms which may support a credible commitment, notably reputation. Stocking and Mueller, 1957 argues that reciprocal dealing for many years was part of the company policy of DuPont, the large American conglomerate. Possibly DuPont's headquarters were able to play the same role as governments do in our model. For further references to work on domestic reciprocity, consult Ellingsen, 1991.

<sup>8</sup> The assumption of a single seller is inessential to our main results.

sellers are located in separate countries, 1 and 2, and operate under the laws of their respective governments. The seller located in country  $i$  is referred to as firm  $i$ .

The seller in market 1 is also one of a number of *ex ante* identical buyers in market 2, and vice versa. (Alternatively, we can think of sellers and buyers as separate firms, but where the seller in market  $i$  is located in the same country as one of the buyers in market  $j$ .) Each buyer in a market wants exactly one unit of the relevant product. Importantly, each buyer's valuation is private information (it is known to the buyer but not to the seller).

A seller is assumed to have all the bargaining power and thus sets a monopoly price. As is well known, monopoly pricing under incomplete information normally entails an efficiency loss, as the seller will be committed to a price which is higher than the marginal cost and thus typically higher than the lowest possible buyer valuation. This inefficiency is an important ingredient in the present model.

We assume that any buyer can always purchase (anonymously if necessary) at the going market prices. Apart from trading through the market, firms 1 and 2 have an additional option. Since there is a bilateral externality between them, they may try to tie their deals in the two markets. Thus, as an alternative to market transaction the two firms are allowed to barter. For barter to be an interesting option, reselling cannot occur without cost. (With costless reselling, a firm can barter and resell at the monopoly price to another buyer.) For simplicity, we make the stronger assumption that reselling is impossible.<sup>9</sup>

The main focus of the paper is on government mandated countertrade: Each government decides as a matter of long-term policy whether or not to allow unilateral imports. If the government in country  $i$  mandates countertrade, it is forbidden for firm  $i$  to purchase on market  $j$ . Thus, in this case firm  $i$  can get hold of firm  $j$ 's product only through barter.

The timing of events is the following. At  $t = 1$ , cost conditions are observed by all parties and governments decide on their policies. At  $t = 2$ , firms set their market prices. At  $t = 3$ , buyers learn their valuations. Finally, at  $t = 4$ , trade takes place in accordance with the possible countertrade mandates and the pre-existing prices.

What happens at stage 4 when the two firms meet? Clearly, the most efficient trade would come about if they could both agree to sell at marginal cost. However, under a free trade regime this does not seem reasonable. A

<sup>9</sup> Although this is exogenous, it will become clear that by extending the analysis slightly, it is possible to derive prohibitions on reselling as a property of bilateral trading contracts. Moreover, since many bilateral trading agreements severely restrict reselling (see Walsh, 1985; Carey and McLean, 1986), we feel justified in adopting the assumption here.

firm whose valuation of the other’s product is low may then earn less from the transaction than if it treats the other as a standard customer at posted prices. For realism, we therefore take it as given that each firm must consent to any bilateral trade agreement. Only firms whose position is thereby improved, relative to trade at market prices, agree to countertrade.

A major modeling decision is what class of countertrade arrangements to consider. We believe we have chosen the simplest possible bargaining model that incorporates the participation constraint alluded to above. Here, either both parties agree to tied trading (barter) or – if one of them rejects it – revert to ordinary market interaction at posted prices (Table 1).

This specification may seem unduly restrictive, but (as we will argue below) allowing for richer trading mechanisms does not substantially affect our results.

We are now ready to introduce our notation and formal assumptions. To avoid unnecessary duplication of expressions, we often state conditions only for firm  $i$ . When nothing else is said, the condition then applies for  $i = 1, 2$ , and subscript  $j$  reads  $j \neq i$ . Firm  $i$ ’s unit variable costs are constant, commonly known, and denoted  $c_i$ . Firm  $i$ ’s valuation of  $j$ ’s product is denoted  $v_i$  and is, as previously mentioned, information private to firm  $i$ . (We shall sometimes refer to  $v_i$  as firm  $i$ ’s *type*.) The distribution of valuations is common knowledge, and described by an integrable density function  $f_i(v)$ , with support  $V_i = [a_i, b_i]$ . Suppose firm  $i$  sets the price  $p$ . Firm  $j$ ’s demand for  $i$ ’s product is then the probability that  $v_j$  exceeds  $p$ , i.e.

$$D_j(p) = \int_p^{b_j} f_j(s) ds.$$

Firm  $i$ ’s expected profit from selling to firm  $j$  at a price of  $p$  is  $\pi_i = D_j(p)(p - c_i)$ , and it is assumed that there is a unique profit maximizing price

$$p_i(c_i) = \arg \max_p D_j(p)(p - c_i).$$

Since the buyers in each market are ex ante identical and the unit variable

Table 1  
The market game

Firm 1	Firm 2	
	Accept	Reject
Accept	Barter	Market transaction
Reject	Market transaction	Market transaction

costs are constant; seller  $i$  optimally offers the price  $p_i$  to the market.<sup>10</sup> The maximum expected profit is denoted as  $\pi_i^* = \pi_i(p_i(c_i), c_i)$ .

As indicated in Table 1, in the market game firm  $i$  can take one of two possible actions. A pure strategy for firm  $i$  is thus a one-to-one mapping from the set of types,  $V_i$ , into the set of actions, {Accept, Reject}.

Governments decide trade policies. Government  $i$ 's policy is denoted  $T_i \in \{F_i, M_i\}$ , where  $F_i$  means that country  $i$  pursues a free trade policy, and  $M_i$  indicates mandated countertrade. In the latter case, country  $i$  prohibits unilateral imports; all imports must be tied to exports of similar value. Mandating countertrade entails a direct cost  $g_i \geq 0$ , capturing added administrative costs as well as any punishments imposed by the international community. Apart from  $g_i$ , the government only cares about the total expected surplus of the domestic firm. (In addition to the expected profit,  $\pi_i$ , the government thus also considers the potential gain from buying,  $v_i - p_j$ , and from barter,  $v_i - c_i$ .) Government  $i$ 's payoff function (expected utility) is denoted  $G_i(T_i, T_j)$ , and will be given a precise formulation in Section 4.1. Global welfare is defined as the sum of the two governments' payoffs.

The main objective of the paper is to derive non-cooperative policy equilibria. We focus on pure strategy subgame perfect equilibria in the analysis which follows. In other words, for any policy profile, the governments expect firms to play a (Bayesian) Nash equilibrium in the market game. As it turns out, it is straightforward to characterize the market game equilibria when at least one government intervenes. The analysis is more subtle under the free trade regime.

### 3. The free trade regime

Suppose that the market game depicted in Table 1 is played by firms which are unrestricted by government intervention, the policy profile  $(F_1, F_2)$ . It is easy to see that a firm's decision has an impact on the outcome only in the case where the other firm accepts barter.<sup>11</sup> Hence, firm  $i$  agrees to barter only if the gain from trade is at least as large as the expected gain

<sup>10</sup> It is well known from the literature on optimal selling mechanisms that, under risk neutrality, an optimal strategy for a seller facing a privately informed buyer is to commit to a fixed price (e.g. Riley and Zeckhauser, 1983).

<sup>11</sup> Thus, both will choose as if the other had already accepted barter, and their beliefs as to whether the other will accept it do not come directly into play. The practical relevance of this observation is, as already indicated, that the simultaneous moves assumption is innocuous. (Excluding weakly dominated strategies, any pure-strategy equilibrium of this particular normal form game is also a sequential equilibrium of any extensive form of the game.) We might as well have assumed that a firm which wants to countertrade takes the initiative by moving first.

from market transaction given that the other firm is willing to barter. To express this condition formally, let  $\Phi_j = \Pr[v_j \geq p_i | A_j]$  be the probability that firm  $j$ , having agreed to barter, values its purchase from firm  $i$  above market price. The necessary condition for firm  $i$  to accept barter can then be written as

$$v_i - c_i \geq (p_i - c_i)\Phi_j + \max\{0, v_i - p_j\}, \tag{1}$$

where the left-hand side is the gain from barter and the right-hand side is the expected cost of giving up the market transaction.

A direct consequence of this condition is that if firm  $i$  accepts barter when its valuation is  $\tilde{v}_i$ , then it is rational to accept barter for all  $v_i \geq \tilde{v}_i$ . In seeking the equilibria, we may thus confine attention to the subset of pure strategies which are summarized by such critical values; all types below the critical value rejecting and all types above accepting barter. Formally, let  $\underline{v}_i$  be the lowest valuation such that firm  $i$  accepts barter. A Bayesian Nash equilibrium of the market game is then completely described as a pair  $(\underline{v}_1^*, \underline{v}_2^*)$  such that  $\underline{v}_1^*$  is a best reply to  $\underline{v}_2^*$  and vice versa.

The probability that firm  $i$  will accept barter is clearly  $D_i(\underline{v}_i)$ . Note that we can write  $\Phi_j(p_i, \underline{v}_j) = \Pr[v_j \geq p_i | v_j \geq \underline{v}_j]$ . Since the probability cannot exceed one, we have

$$\Phi_j(p_i, \underline{v}_j) = \min\left\{1, \frac{D_j(p_i)}{D_j(\underline{v}_j)}\right\}.$$

Firm  $i$ 's best reply mapping,  $R(\cdot)$ , assigns one or more critical values  $\underline{v}_i$  for each  $\underline{v}_j$ . Using Eq. (1), we have

$$R_i(\underline{v}_j) - c_i = (p_i - c_i)\Phi_j(p_i, \underline{v}_j) + \max\{0, R_i(\underline{v}_j) - p_j\}, \tag{2}$$

or, equivalently,

$$R_i(\underline{v}_j) = \begin{cases} (p_i - c_i)\Phi_j(p_i, \underline{v}_j) + c_i & \text{if } (p_i - c_i)\Phi_j(p_i, \underline{v}_j) + c_i < p_j, \\ [p_j, b_j] & \text{if } (p_i - c_i)\Phi_j(p_i, \underline{v}_j) + c_i = p_j. \end{cases} \tag{3}$$

(To see the equivalence, note from Eq. (2) that a change in regime occurs at the point  $\underline{v}_i = p_j$ , and that for parameter configurations other than those considered in Eq. (3) firm  $i$  should always reject barter.) In the range where  $\underline{v}_i \leq p_j$  and  $\underline{v}_j \leq p_i$ , we can insert for  $\Phi_j$  to get

$$R_i(\underline{v}_j) = \frac{(p_i - c_i)D_j(p_i)}{D_j(\underline{v}_j)} + c_i. \tag{4}$$

We are now ready to prove our first result, which says that non-mandated countertrade does not create trade.

*Proposition 1. (i) If market prices are identical, i.e.  $p_1=p_2=p$ , there is a continuum of equilibria, given by all pairs  $\{v_1, v_2\} \in [p, \infty) \times [p, \infty)$ . (ii) There are no other equilibria.*

The proof is contained in the appendix. Proposition 1 says that the opportunity of barter does not increase trade. Both firms agree to barter only if they would have bought in the marketplace, and then only if market values (prices) are exactly identical. Hence if the firms must bear any administrative costs of arranging barter, we may rule it out altogether.

The intuition behind Proposition 1 is that because a firm with a low valuation has no incentive to barter, its willingness to barter indicates a high valuation. Since each firm influences the outcome only when the other accepts barter, they both act as if they face a high valuation buyer, and are consequently unwilling to barter. We emphasize that the reason why no trade is created is the attractiveness of trading in the market place.<sup>12</sup> To induce barter, trade policies need to make the market place less attractive.

#### 4. Equilibrium trade policies

Having shown that barter does not affect payoffs under the free trade regime, we now study the costs and benefits of mandating countertrade. To simplify the analysis, assume from now on that market prices are identical, i.e.  $p_j=p_i=p$ .<sup>13</sup> There are four possible policy regimes, and to find the equilibrium regime we first need to define the governments' utilities precisely.

##### 4.1. Governments' payoffs

Recall that the government does not know the valuations of either firm, and cares about the domestic firm's *expected* total benefit. Consider first the free trade regime  $(F_i, F_j)$ . By Proposition 1, firm  $i$ 's benefit under the free trade regime is unaffected by the barter option. Hence, the government's expected utility is

<sup>12</sup> A similar 'no trade creation' result appears to hold for any bargaining mechanism, as long as interim individual rationality is imposed and the initial prices are profit maximizing (and hence interim efficient for each party). This result is akin to those of the Maskin and Tirole (1992) analysis of common value mechanism design by an informed principal where interim efficiency implies renegotiation proofness.

<sup>13</sup> Our reason for doing this is to avoid the complications of monetary transfers. If prices are different, a straight barter may be an unconvincing alternative; instead there should be an additional cash payment.

$$G_i(F_i, F_j) = \int_p^{b_i} (v - p) f_i(v) dv + \pi_i^*, \tag{5}$$

i.e. the sum of expected ‘consumer surplus’ and expected profits.

Consider next the regime  $(M_i, F_j)$ , in which there is one-sided intervention by government  $i$ . Firm  $j$  is then unable to sell to firm  $i$  and hence firm  $j$  barter whenever  $v_j > c_j$ , i.e.

$$\underline{v}_j^*(M_i, F_j) = c_j. \tag{6}$$

Firm  $i$  cannot buy, so its best response to  $\underline{v}_j = c_j$  is unique and given by Eq. (4),

$$\underline{v}_i^*(M_i, F_j) = \frac{\pi_i^*}{D_j(c_j)} + c_i. \tag{7}$$

Importantly, mandating makes the market option less attractive for the foreign as well as the domestic firm, and hence there is scope for barter. (As  $D_j(c_j) < D_j(p)$ , it is easily seen that both  $\underline{v}_i^*$  and  $\underline{v}_j^*$  are smaller than  $p$ .) Government  $i$ ’s expected utility now contains three terms; the expected benefit from barter, the expected profit from selling, and the direct costs of mandating:

$$\begin{aligned} G_i(M_i, F_j) &= D_j(c_j) \int_{\underline{v}_j^*(M_i, F_j)}^{b_i} (v - c_i) f_i(v) dv + [1 - D_i(\underline{v}_i^*(M_i, F_j))] \pi_i^* - g_i \\ &= D_j(c_j) \int_{\underline{v}_j^*(M_i, F_j)}^{b_i} [v - \underline{v}_i^*(M_i, F_j)] f_i(v) dv + \pi_i^* - g_i. \end{aligned} \tag{8}$$

The second expression decomposes firm  $i$ ’s expected benefit into the value of the barter option and the expected gain from market interaction.<sup>14</sup>

Suppose instead that country  $j$  unilaterally intervenes. Then it is firm  $i$  that can’t sell. Government  $i$ ’s payoff is therefore the sum of the expected gain from barter and the expected gain from unilateral purchases,

<sup>14</sup> Note that we ignore the case where firm  $i$  accepts and firm  $j$  rejects barter, as in this case firm  $j$  will not buy.

$$\begin{aligned}
 G_i(F_i, M_j) &= D_j(\underline{v}_j^*(F_i, M_j)) \int_{c_i}^{b_i} (v - c_i) f_i(v) \, dv \\
 &+ [1 - D_j(\underline{v}_j^*(F_i, M_j))] \int_p^{b_i} (v - p) f_i(v) \, dv. \tag{9}
 \end{aligned}$$

Finally, if both governments intervene, barter represents the only trading opportunity. Firm  $i$  thus agrees to barter whenever its valuation exceeds its cost, i.e.  $\underline{v}_i^*(M_i, M_j) = c_i$ . Government  $i$ 's expected utility is

$$G_i(M_i, M_j) = D_j(c_j) \int_{c_i}^{b_i} (v - c_i) f_i(v) \, dv - g_i. \tag{10}$$

Having computed the governments' utilities, we are now in a position to characterize equilibria and social optima. Our basic question is, what characteristics of imports and exports invite mandated countertrade?

#### 4.2. What and when to barter?

The examples cited in the introduction suggest that countertrade policies display regularities with respect to import as well as export characteristics.

We first ask: under what conditions will a country unilaterally mandate countertrade in our model? Subtract Eq. (8) from Eq. (5) and simplify to obtain

$$\begin{aligned}
 G_i(M_i, F_j) - G_i(F_i, F_j) &= D_j(c_j) \int_{\underline{v}_i^*(M_i, F_j)}^{b_i} [v - \underline{v}_i^*(M_i, F_j)] f_i(v) \, dv - g_i \\
 &- \int_p^{b_i} (v - p) f_i(v) \, dv. \tag{11}
 \end{aligned}$$

Neglecting  $g_i$ , the difference is simply the option value of being able to barter, less the lost consumer surplus from being committed not to buy unilaterally. This expression would have been zero if  $D_j(c_j)=1$  and  $\underline{v}_i^*(M_i, F_j) = p$ . However, it follows from Eq. (7) that  $\underline{v}_i^*(M_i, F_j) < p$ . Hence, we know that there are circumstances in which it pays to mandate countertrade, as well as circumstances in which it does not, or, more precisely:

*Proposition 2.* Suppose  $g^i=0$ . Then there exists a number  $\delta_i \in (0,1)$  such that, *ceteris paribus*, it is optimal for country  $i$  to mandate countertrade unilaterally if and only if  $D_j(c_j) \geq \delta_i$ .

*Corollary 1.* For any non-negative  $g_1$  and  $g_2$ , there exist pairs  $(\kappa_1, \kappa_2)$  with  $\kappa_1 > 0$ ,  $\kappa_2 > 0$  such that if  $D_1(c_1) < \kappa_1$  and  $D_2(c_2) < \kappa_2$ , free trade is a policy equilibrium.

Noting that  $v_i$  is monotonically decreasing in  $D_j(c_j)$ , the proof of Proposition 2 is immediate from inspection of Eq. (11). By continuity, it also holds for small costs  $g_i$ . The intuition behind Proposition 2 is straightforward. If  $D_j(c_j)$  is large, it is likely that firm  $j$  accepts barter, and country  $i$  has the best of both worlds: it runs little risk that firm  $j$  rejects barter, while retaining the opportunity for the domestic firm to reject barter (which is preferable if  $v_i$  turns out to be low). On the other hand, if it is unlikely that firm  $j$  accepts barter, mandating simply means throwing away consumers' surplus without any offsetting gain. Corollary 1 underscores the importance of a double coincidence of wants: if  $D_1(c_1)$  and  $D_2(c_2)$  are both sufficiently small, free trade is an equilibrium. (Unfortunately, equally simple conditions for the uniqueness of free trade as an equilibrium cannot be given.)

Proposition 2 highlights the kind of imports which invite restrictions. For example it is tempting for country  $i$  to mandate countertrade of imports with high (and sunk) development costs and low variable production costs, the latter being the relevant marginal cost of firm  $j$ . The gain from mandating is also affected by the costs and revenues of exports: to see this, keep  $D_j(c_j)$  fixed, and recall that the gain from mandating is decreasing in  $v_i^*(M_i, F_j)$ . From Eq. (7), it is readily checked that  $v_i^*(M_i, F_j)$  is increasing in the profit from selling,  $\pi_i^*$ . Intuitively, the option to barter rather than sell is more valuable when the profit from selling is low. Finally, keeping the profit from selling constant, the gain from barter is decreasing ( $v_i^*$  is increasing) in the marginal cost,  $c_j$ . Here, the explanation is that the barter option is more valuable when the marginal cost is low, as in this case firm  $i$  gives up less in the transaction. The above comparative statics can thus be summarized:

*Proposition 3.* *Ceteris paribus*, the gain to country  $i$  from mandating countertrade is increasing in  $D_j(c_j)$  and decreasing in  $c_i$  and  $\pi_i^*$ .

Note that the three forces are not independent. The profit  $\pi_i$  depends on the firm's own marginal cost,  $c_i$ , as well as on the demand  $D_j(\cdot)$ . In particular, the marginal cost of the domestic firm affects the gains from mandating in two opposing ways: the direct effect of a higher marginal cost works against mandating, but the effect through the profit from selling works in favor.

So far, we have only considered unilateral deviations from free trade. What about policy equilibria? As it turns out, there are circumstances under which both countries mandate countertrade.

*Proposition 4. Suppose  $g_1 = g_2 = 0$  and that  $D_1(c_1) = D_2(c_2) = 1$ . Then  $(M_1, M_2)$  is the unique policy equilibrium.*

We have already shown that  $M_i$  is a strict best reply to  $F_j$  under these conditions (Proposition 2). That  $M_i$  is also a strict best reply to  $M_j$  can be seen directly by comparing Eq. (9) and Eq. (10). The reason is obvious. Being unable to sell, it is strictly better to be able purchase at an implicit price equal to the firm's own marginal cost,  $c_i$ , than at the price  $p > c_i$ . In the situation described here, bilateral mandating is also socially optimal; trade is always efficient, and it always occurs. Note that Proposition 4 is not a knife edge result, as each government's utility is continuous in  $g$ ,  $D_i$  and  $D_j$ .

Beyond Corollary 1 and Proposition 4 it is hard to give general characterizations of policy equilibria. Do the comparative static results concerning unilateral mandating (Proposition 3) have any relevance (can unilateral mandating occur at all), and if so what is the magnitude of the various effects? Under what conditions is free trade the unique equilibrium? To dig a bit deeper, we shall look at two specific examples.

*Example 1: asymmetric characteristics*

We first address the question of asymmetric industry characteristics. Let  $c_1 = 0$  and  $c_2 = 2$ , let  $v_1$  be uniformly distributed on  $[0, 4]$  and let  $v_2$  be uniformly distributed on  $[0, 6]$ . Finally, let  $g_1 = g_2 = g$ . These are all the exogenous variables.

The profit maximizing prices are here  $p_1 = p_2 = 3$ , so market values are identical.<sup>15</sup> Profits are different, though, with  $\pi_1^* = 3/2$  and  $\pi_2^* = 1/4$ . Notice also that  $D_1(c_1) = 1$  while  $D_2(c_2) = 2/3$ . Hence, if country 2 mandates countertrade, firm 1 always agrees to barter, but if country 1 mandates countertrade, firm 2 agrees only with probability  $2/3$ . Use Eq. (7) to compute  $\underline{v}_1^*(M_1, F_2) = \underline{v}_2^*(F_1, M_2) = 9/4$ .<sup>16</sup> Manipulating Eq. (5) and Eqs. (8–10), we can compute the governments' payoffs as functions of  $g$  in each of the four regimes. The resulting policy game is illustrated in Table 2, with country 1's payoff listed first. From the payoff matrix we can easily find the equilibrium for each value of  $g$ . By adding together the payoffs, we can also make a welfare ranking of the policies (Table 3).

<sup>15</sup> To construct uniform examples with identical market prices, simply apply the formula  $p_i = (c_i + b_i)/2$ .

<sup>16</sup> The equality between  $\underline{v}_1^*(M_1, F_2)$  and  $\underline{v}_2^*(F_1, M_2)$  is not a pure coincidence. It extends to any pair of uniform distributions of valuations yielding identical prices.

Table 2  
Policy game I

	$F_2$	$M_2$
$F_1$	$\frac{13}{8}, 1$	$\frac{83}{64}, \frac{91}{64} - g$
$M_1$	$\frac{337}{192} - g, \frac{193}{192}$	$\frac{4}{3} - g, \frac{4}{3} - g$

For administrative costs  $g$  below  $7/192$ , both countries mandate countertrade. If  $g$  is in the interval  $7/192, 81/192$ , i.e. between 1.2% and 14% of the market value, only country 2 mandates countertrade. Finally, if  $g$  exceeds  $81/192$ , both countries pursue free trade. Only in this last case do the equilibrium policies coincide with the socially optimal policies.

The example illustrates clearly the role of asymmetries between the two countries. Country 2 has a lot more to gain by intervention than does country 1, and hence is the only country to perform a unilateral intervention. Note that the industry of the intervening country has a considerably lower mark-up than the free trade country. Indeed, this relationship between the mark-ups extends to all situations with uniform distributions of valuations and asymmetric firm characteristics: the firm with the highest mark-up is also less likely to reject barter at marginal cost. Thus the firm with the lowest mark-up has more to gain by mandating countertrade. As we argued in the introduction, some of the factual observations square well with this result.

From the perspective of international regulation of trade policies, the example does not point to an entirely clear-cut conclusion. While mandating of countertrade by country 2 always imposes a negative externality on country 1, there are instances in which the equilibrium is preferable to free trade, and in others the reverse is true.

Table 3  
Equilibria and social optima of policy game I

$g$	Policies	
	Nash equilibrium	Social optimum
$\left[0, \frac{7}{192}\right]$	$(M_1, M_2)$	$(M_1, F_2)$
$\left[\frac{7}{192}, \frac{26}{192}\right]$	$(F_1, M_2)$	$(M_1, F_2)$
$\left[\frac{26}{192}, \frac{81}{192}\right]$	$(F_1, M_2)$	$(F_1, F_2)$
$\left[\frac{81}{192}, \infty\right]$	$(F_1, F_2)$	$(F_1, F_2)$

Table 4  
Policy game II

	$F_2$	$M_2$
$F_1$	$\frac{3(1-c)^2}{8}, \frac{3(1-c)^2}{8}$	$\frac{(1-c)^2(13-9c)}{32}, \frac{(1-c)^2(17-9c)}{32}$
$M_1$	$\frac{(1-c)^2(17-9c)}{32}, \frac{(1-c)^2(13-9c)}{32}$	$\frac{(1-c)^3}{2}, \frac{(1-c)^3}{2}$

*Example 2: double coincidence of wants*

The previous example highlighted the role of asymmetries between the two industries, but kept technology and demand fixed. Our intuition says that mandating countertrade is only profitable if there is a sufficient double coincidence of wants, and so we would like to vary  $D_i(c_i)$ . We shall confirm the intuition in another simple example, this time with symmetric industries. Let  $g=0$ . Both firms have marginal cost  $c$  and their valuations are drawn from a uniform distribution on the interval  $[0,1]$ . The probability of a double coincidence of wants is hence  $(1-c)^2$ .

Prices are found to be  $p_1=p_2=(1+c)/2$ . In the case of a unilateral mandate by country  $i$  we have  $v_i(M_i, F_j) = (1+3c)/4$ . The payoff matrix for the two governments is then readily computed from Eq. (5), Eq. (8), Eq. (9) and Eq. (10), and is given in Table 4. Clearly the governments' best responses in this policy game depend on the marginal cost,  $c$ . Note also that due to the symmetry of the game, there is an even number of asymmetric equilibria (zero or two). Equilibria and social optima are readily derived, and are reported in Table 5.

We already knew from Proposition 4 that a bilateral mandate would be the unique equilibrium for low  $c$ . More surprisingly, perhaps, it remains the

Table 5  
Equilibria and social optima of policy game II

$c$	Policies	
	Nash equilibrium	Social optimum
$\left[0, \frac{9}{63}\right]$	$(M_i, M_j)$	$(M_i, M_j)$
$\left[\frac{9}{63}, \frac{21}{63}\right]$	$(M_i, M_j)$	$(M_i, F_j)$
$\left[\frac{21}{63}, \frac{27}{63}\right]$	$(M_i, M_j)$	$(F_i, F_j)$
$\left[\frac{27}{63}, \frac{35}{63}\right]$	$(M_i, F_j)$	$(F_i, F_j)$
$\left[\frac{35}{63}, 1\right]$	$(F_i, F_j)$	$(F_i, F_j)$

equilibrium policy as long as the probability of a double coincidence of wants exceeds  $(4/7)^2 \approx 32.7\%$ . On the other hand, a bilateral mandate is not always an equilibrium. In this example at least, free trade is the unique equilibrium whenever there is a sufficiently low probability of a double coincidence of wants. Possibly, one can build on this result to make predictions about the impact of business cycles on trade policies. Consider a recession. Producers with large stockpiles, or other kinds of excess capacity, also have a low opportunity cost. If their valuation of imports does not fall proportionally, the case for mandating countertrade is made more powerful by the recession.

As in our previous example, there is a tendency towards excessive intervention. Whether that tendency generalizes to all distributions, we do not know. Our conjecture is that there are distributions such that the consumers' surplus is very large relative to the seller's profit, for which there may be too little mandating in equilibrium.<sup>17</sup>

## 5. Conclusion

We have shown that mandated countertrade may increase the surplus of domestic firms. This could explain why the practice is not limited to underdeveloped countries, tightly regulated economies, or to undemocratic regimes. In our view, the model's most interesting prediction is that countertrade is mandated in order to purchase high mark-up imports in return for low mark-up exports. This implication seems broadly consistent with stylized facts. It can be made subject to rigorous testing, and it does not seem to be implied by any other theory in the literature.

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<sup>17</sup> At any rate, we would like to play down the welfare implications. The model completely neglects the possibility of *trade diversion* from competitors, which is a main concern of those who oppose countertrade (see Roessler, 1985; Walsh, 1985).

## Appendix 1

### Proof of Proposition 1

1. Choose any pair  $\underline{v}_i, \underline{v}_j$  such that  $\underline{v}_i \geq p_j$  and  $\underline{v}_j \geq p_i$ . It follows that  $\Phi_i = \Phi_j = 1$ , and it is immediate from Eq. (2) that the pair constitutes an equilibrium if and only if  $p_i = p_j$ .

2. The proof is by contradiction. Suppose that there was an equilibrium pair with  $\underline{v}_j < p_i$ . Then  $\Phi_j = D_j(p_i)/D_j(\underline{v}_j) < 1$  and Eq. (4) implies that

$$(\underline{v}_i - c_i)D_j(\underline{v}_j) = (p_i - c_i)D_j(p_i). \quad (12)$$

Since  $D_j(\underline{v}_j) > D_j(p_i)$ , we have  $\underline{v}_i < p_i$ . Next, recall that  $p_i$  is the unique maximizer of  $(p_i - c_i)D_j(p_i)$ . Since both  $\underline{v}_i$  and  $\underline{v}_j$  are smaller than  $p_i$ , we see from Eq. (12) that  $\underline{v}_i > \underline{v}_j$ .

There are two main cases to consider. Suppose first that  $\underline{v}_i < p_j$ , and note that this would be implied by  $p_i \leq p_j$ . It follows that  $\Phi_i < 1$  and we can perform the same steps as above to conclude that  $\underline{v}_i < \underline{v}_j$ , a contradiction. If  $\underline{v}_i \geq p_j$ , then  $\Phi_i = 1$ , and Eq. (2) reduces to  $p_i = p_j$ . But as we have seen,  $p_i = p_j$  implies  $\underline{v}_i < p_j$ , another contradiction.  $\square$

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