Arms Export Controls, Subsidies and the WTO Exemption*

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Abstract

Owing to the WTO exemption that allows governments to subsidize arms exports, the arms trade is one of the few remaining areas of trade where we observe lump-sum and per unit transfers to exports. This paper examines the effect of arms controls, in the form of licensing delays, on the incentives to subsidize arms exports and conversely the effect of the WTO arms trade exemption on the incentives to break arms control agreements. Our main result is that arms controls and free trade commitments re-enforce each other. Licensing delays reduce the incentive to subsidise and free trade without subsidies reduces the benefits of a unilateral abrogation of arms controls. Transparency actually worsens the Nash inefficiencies at play in that incomplete information leads to lower subsidies and lower arms exports.

Keywords: arms export controls, export subsidies, World Trade Organisation.

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1 Introduction

The arms trade is an activity where foreign policy concerns such as security, human rights and international stability interact and often clash with economic concerns. One manifestation of this tension is the fact that among main weapon exporters arms export controls often exist side-by-side with export subsidization. In the case of the UK, for example, arms export subsidies in the form of cheap loans and credit insurance guarantees for exporters constitute almost one third of the total volume of subsidies provided by the Exports Credit Guarantee Department which amounts to £9 billion (at 1995 prices) or almost 5% of the value of total exports (see Martin, 1999 and Martin, 2001).

However, the relevance of arms export subsidies becomes much higher if we follow the definition of subsidy agreed by the World Trade Organization members (WTO) in the *Agreement on Subsidies and Countervailing Measures*[1] (ASCM, article 1.1). According to this criteria, an export subsidy to a firm would include not only direct transfers of funds (e.g. grants, loans, and equity infusions) and potential direct transfers of funds or liabilities (e.g. loan guaranties) but also, indirect subsidies channeled through purchases of goods by the government, among others. Following this definition, military aid to importers, marketing advice to national champions, subsidized export credit guaranties[2] and a portion of national defence procurement would all enter into the 'export subsidy' category.

Despite the fact that arms trade constitutes the first source of 'legal' trade in the world, the WTO has given an exemption to arms exports subsidies. Therefore, the categories of prohibited or actionable subsidies in the ASCM do not apply to arms exports. This exemption is recorded in the General Agreement on Tariffs and Trade (GATT):

"...nothing in this Agreement shall be construed...to prevent any contracting party

[1] For detailed information on the WTO agreements see http://www.wto.org/

[2] For estimates of subsidies to arms exports through the use of export credit guarantees see Bagci et al. (2003).

from taking any action which it considers necessary for the protection of its essential security interests

(i) relating to fissionable materials or the materials from which they are derived;

(ii) relating to the traffic in arms, ammunition and implements of war and to such traffic in other goods and materials as is carried on directly or indirectly for the purpose of supplying a military establishment;

(iii) taken in time of war or other emergency in international relations;..." (Article XXI, GATT, Security Exceptions).

Earlier work by the authors analyzed the regulation of arms exports and its relationship with procurement (Levine and Smith, 2000; Levine, Mouzakis and Smith, 2000; Garcia-Alonso, 1999). In those papers, it was assumed that regulation took the form of direct controls through the use of export licenses, embargoes, etc. and there was no uncertainty facing the government. Garcia-Alonso (2000) introduces a combination of indirect controls (R&D subsidies) and direct controls (export controls) to regulate arms trade. The objective of this paper is to analyze the impact of the WTO exemption, which allows governments to subsidize arms exports. Also, we analyze the additional impact of informational asymmetries between governments and the weapon producers. In our analysis we introduce both national defence procurement and price export subsidies as tools that governments use to regulate the arms export market. In doing so, we attempt to reflect the variety of export subsidy tools which can still be used by weapon exporters 'thanks' to the WTO exception.

Defence procurement by government has a number of distinctive characteristics. In a recent survey, Rogerson (1994) lists these as the importance of R&D, uncertainty, economies of scale and the role of governments as the sole purchasers. Large R&D and other fixed costs mean that suppliers need to sell on the international market in order to be commercially viable. The resulting arms trade, where security concerns compete with economic concerns, is a further distinctive feature of the defence procurement process.

Uncertainty facing the procuring government can involve both demand and cost conditions. This is reflected in the recent theoretical literature, which studies asymmetric information and incentive contracts that force firms to reveal their private information (Laffont and Tirole, 1993). The seminal work of Brander and Spencer (1985) launched the strategic trade literature with the insight that strategic trade policies can exacerbate the Prisoner's Dilemma problem facing oligopolistic firms; i.e., the Nash equilibrium quantity sold by each firm is higher than the quantity they would each sell if they could form a cartel and multilateral government rent-seeking subsidies make this problem even worse for the firms. A recent trade literature studies the impact of asymmetric information on optimal strategic trade policies. Maggi (1999) analyses how asymmetric information affects strategic trade policies in a third market model

Our paper introduces direct government transfers to the firm, payments for national procurement, as a policy tool. In this respect our model is closer to Brainard and Martimort (1997). In their paper, price export subsidies and direct transfers are combined to create a revelation mechanism that forces firms to truthfully reveal their type when policymakers are incompletely informed. Due to the restriction on export subsidization imposed by the WTO in most industries, this model structure applies best to the existing regulatory framework in the exception – the arms industry. The direct transfers alluded to by Brainard and Martimort (1997) become the price paid for defence procurement by the government. However, if such model is to be applied to the arms trade, the security concerns which affect this unique industry and the export controls that exporter governments put in place must also be considered.

In the case of the US, the world's leading arms exporter, the Office of Defense Trade Controls (DTC), in accordance with sections 38-40 of the Arms Export Control Act (AECA) (22 U.S.C. 2778-80) and the International Traffic in Arms Regulations (ITAR)(22 C.F.R. Parts 120-130), controls the export of defense articles and services by taking final action on license applications and other requests for approval for defense trade exports and re-transfers[3]. Even if a license is awarded in the end, the administrative compliance of these regulations imposes not only a delay in the receipt of export revenues but also a delay in the security costs involved in arms exports. This aspect of arms trade is reflected in our paper.

Administrative delays in the concession of import licenses have been recently analyzed in Regibeau and Rochet (2001). They consider the case in which an importing country may impose a delay on the foreign firm in obtaining approval for sale of a particular product, as opposed to the domestic firm. Administrative delays are presented as non-tariff barriers to trade. In our case, the administrative delay has a very different flavour; it applies to exporters and its main objective is to increase national security.

In this paper we show that arms controls and free trade commitments re-enforce each other. Licensing delays reduce the incentive to subsidise and free trade without subsidies reduces the benefits of a unilateral abrogation of arms controls. Furthermore, we show that transparency actually worsens the Nash inefficiencies at play in that incomplete information leads to lower subsidies and lower arms exports.

The rest of the paper is organized as follows. Section 2 presents an arms trade model in which government or regulator procures a defence good from a sole national supplier who also sells in a world market. Weapon exporters compete in a Cournot fashion in the exports market. Governments regulate arms trade using a combination of policy tools: first they pay for national procurement, second they subsidize/tax the exports price, third they set controls on arms exports in the form of administrative delays, which affect both exports revenue and security. Section 3 considers a complete information structure, where the regulator knows the cost function of the firm and demand conditions and can therefore anticipate the firm's choice of exports. In section 4 we then contrast this benchmark case with the incomplete information set-up where the exporting firms possess private information regarding their cost structure. Section 5 concludes the paper.

[3] For up to date information on defence export controls in the US check: http://www.pmdtc.org/

2 The Model

In each of n countries, a government or regulator procures a defence good from a sole national supplier who also sells in a world market. Label countries $i = 1, ..., n$ and refer to variables in country i with a subscript i. To ease the notational burden, we omit the subscript in country 1. In that country, output is $y = g + x$ units where g is purchased by the government at a price p and x is exported. g is held fixed in the analysis. In the international market for arms, the price is $P(X)$, where X is world output. Total costs, consisting of fixed and variable costs, given by

$$C(y) = F + \beta y \tag{1}$$

where F are fixed costs and β denotes marginal costs.

Since g is fixed, the payment pg is in effect a *lump-sum* transfer from the government to the firm. In addition we allow the government two additional instruments: a per-unit *export subsidy* s (or tax if $s < 0$) paid (as with the lump-sum transfer) when production is completed, and a *licensing delay* τ. The latter is the form that the export regime takes and reduces the current value of \$1 of arms revenue to the exporting firm to $\$\frac{1}{(1+r)^{\tau}} = \$\delta$, say, where r is the rate of discount. Then assuming that the exported military good paid for at the time of delivery, the single-period expected payoff for the firm is

$$U = pg + x(\delta P(X) + s) - C(y) \tag{2}$$

Given the level of procurement, g, in a Cournot-Nash equilibrium firms then choose output to be exported given the aggregate output of all competitors in the international market.

Total world exports give rise to a security externality modelled as follows. Let the current value of security of producer country 1 associated with procurement g and world exports X with delay τ be $S(g, \delta X)$; $S_1 > 0$, $S_2 < 0$. The property $S_2 < 0$ captures the existence of negative security externality as a result of aggregate arms exports to the world market, from the viewpoint of each producer. Although it is reasonable to suppose that arms exports can satisfy legitimate security concerns of importing countries, arms races can take exports to a level where regional stability is threatened.

Then a utilitarian form of the social welfare of producer country 1 is

$$W = S(g, \delta X) - (1 + \lambda)(pg + sx) + U \tag{3}$$

where $(1 + \lambda)$ is the social cost of a unit of taxation.

Substituting for $pg + sx$ from (2), (3) can be written

$$W = S(g, \delta X) - (1 + \lambda)[C(y) - x\delta P(X)] - \lambda U \tag{4}$$

Given the level of procurement, g, and the multilateral arms control regime in place reflected in the value of $\delta \leq 1$, the regulator's choice variables are the procurement price p and the per-unit export subsidy, s. These instruments are chosen subject to a participation or individual rationality constraint $U \geq 0$.

Under *complete information* the regulator knows the cost function of the firm and demand conditions and can therefore anticipate the firm's choice of exports. We contrast this benchmark case with the following principal-agent problem. Given procurement g, the government chooses its price p and the export subsidy s but cannot observe marginal cost parameter β_i in country i. The distribution of the β_i however is public knowledge to all countries. In choosing a procurement price and subsidy the government now faces an adverse selection problem.

This problem is closest to the Brainard and Martimort (1997) case with a zero-profit participation constraint. They assume differentiated goods; here we have a homogeneous good, but also a security effect. We also allow for arms control in the form of a licensing delay and for regulators with different preferences over consumer surplus and firm profits. We now examine the complete and incomplete information problems in turn.

3 Arms Exports under Complete Information

3.1 First-Best Choice of Arms Exports

As a bench-mark we first calculate *first-best* (FB), the choice of arms exports and rent for each country that would be chosen by a utilitarian world social planner. The mythical social planner has direct control over arms exports is constrained only by the firms' participation constraints and has no need for licensing delay. We therefore set $\delta = 1$. Total arms exports are chosen to maximize $\sum_{i=1}^{n} W_i$ where W_i is the social welfare of the *ith* country. In this section, we first study *symmetric equilibria*. Then for the first-best, putting $x_i = x$, this amounts to maximizing

$$W = S(g, nx) - (1+\lambda)[C(g+x) - xP(nx)] - \lambda U \tag{5}$$

with respect to x and U subject to the individual rationality condition (IR), $U \geq 0$. Clearly the latter binds, $U = 0$ and $x = x^{FB}$ is given by the first order condition:

$$n\frac{\partial S}{\partial X} - (1+\lambda)(\beta - P(nx) - nxP'(nx)) = 0 \tag{6}$$

From this point onwards we restrict ourselves to the following linear functional forms for the functions $S(\cdot)$ and $P(\cdot)$:

$$\begin{aligned} S(g, X) &= G(g) - \gamma X\,;\; G' > 0 & (7)\\ P(X) &= a - bX\,; \quad X \in [0, a/b] & \\ &= 0\,; \quad X > a/b & (8) \end{aligned}$$

Assuming these functional forms and (1) for $C(y)$, the social welfare function (5) becomes

$$\begin{aligned} W &= G(g) - \gamma(x + x_{-1}) \\ &- (1+\lambda)[F + \beta(g+x) - x(a - b(x + x_{-1}))] - \lambda U \qquad (9) \end{aligned}$$

where total arms exports $X = x + x_{-1} = x_i + x_{-i}$.[4] Then the first order condition

[4]Thus we use the standard notation: $x_{-i} = x_1 + x_2 + \cdot\cdot\, x_{i-1} + x_{i+1} + \cdot\cdot\, x_n$

(6) yields the first-best choice of exports for each of the n identical countries:

$$x^{FB} = \frac{1}{2bn}\left[a - \beta - \frac{n\gamma}{1+\lambda}\right] \quad (10)$$

3.2 The Constrained Non-Cooperative Equilibrium

Now consider the independent design of an arms export subsidy and procurement programme when a licensing delay regime is in force. The following *timing* of the game is now crucial:

1. Each government commits itself to a given arms export licensing delay, possibly within a multilateral agreement, implying a discount factor $\delta = \frac{1}{(1+r)^{\tau}}$.
2. Constrained by the commitment at stage 1, in a non-cooperative equilibrium of the rest of the game, each government now independently chooses the procurement price and subsidy (p and s for country 1).
3. Firms choose whether or not to participate.
4. Firms choose output.
5. Firms export with a delay τ and receive the current value of δ dollars for each dollar of arms export revenue.

The appropriate equilibrium concept for this dynamic game with complete information is a *subgame perfect equilibrium*, found by backward induction. Starting at *stage 4*, given p and s decided previously, given g which we take as exogenous, and given the output of all other firms x_{-1}, the firm in country 1 maximizes, with respect to x, profits given by (2). Substituting our chosen functional forms this becomes

$$U = U(x) = pg + x[\delta a - \beta + s - \delta b(x + x_{-1})] - F - \beta g \quad (11)$$

The first order condition for this optimization problem is

$$x = \frac{1}{2\delta b}\left[\delta a - \beta + s - \delta b x_{-1}\right] \quad (12)$$

For country i the corresponding reaction function is

$$x_i = \frac{1}{2\delta b}\left[\delta a - \beta_i + s_i - \delta b x_{-i}\right] \quad (13)$$

Hence we have

$$x_{-1} = \sum_{i=2}^{n} x_i = \frac{1}{2\delta b}\left[(n-1)\delta a - \beta_{-1} + s_{-1} - \delta b \sum_{i=2}^{n} x_{-i}\right] \tag{14}$$

Now note that $\sum_{i=2}^{n} x_{-i} = \sum_{i=2}^{n}(X - x_i) = (n-1)X - x_{-1} = (n-1)x + (n-2)x_{-1}$. In addition, since the countries are identical in structure, we have that $\beta_{-1} = (n-1)\beta$ and $g_{-1} = (n-1)g$. Hence (14) becomes

$$x_{-1} = \frac{1}{n\delta b}\left[(n-1)(\delta a - \beta - \delta b x) + s_{-1}\right] \tag{15}$$

Using (12) and (15) we can solve for the *Nash equilibrium of stage 3* of the game to obtain:

$$x = \frac{(\delta a - \beta) + ns - s_{-1}}{\delta b(n+1)} = x^{NS} + \frac{ns - s_{-1}}{\delta b(n+1)} \tag{16}$$

In (16) x^{NS} is the *no-subsidies* constrained non-cooperative equilibrium. The last term is the perturbation to the non-cooperative equilibrium brought about by subsidies. Notice that in a symmetric equilibrium, $s_{-1} = (n-1)s$ and this last term becomes $s/(\delta b(n+1))$ which is positive if the subsidy is positive.

Proceeding to *stage 3* of the game, the outside option of the firm to choose not to participate imposes the participation constraint $U \geq 0$. At *stage 2*, in a Nash equilibrium of this stage of the game, the regulator in country 1 chooses s and p so as to maximize its social welfare given by (5), given the choice of subsidies by the other regulators, s_{-1}, and given the participation constraint. The latter must bind, and the regulator chooses the price of the procured good, p at its minimum value to ensure this. Hence putting $U = 0$ in (5), and using our assumed functional forms, we can write the social welfare function in country 1 as

$$W = G(g) - \delta\gamma X - (1+\lambda)([(\beta - (\delta a - \delta b X)]x - \beta g) \tag{17}$$

where we note that a licensing delay also affects the security. The optimal subsidy for country 1, given s_{-1}, must now satisfy the first-order condition:

$$\frac{\partial W}{\partial s} = -(\delta\gamma + (1+\lambda)x\delta b)\frac{\partial X}{\partial s} - (1+\lambda)[\beta - \delta(a - bX)]\frac{\partial x}{\partial s} = 0 \tag{18}$$

To complete the solution we first note from (16) that

$$\frac{\partial x}{\partial s} = \frac{n}{\delta b(n+1)} \tag{19}$$

and from (15) that

$$X = x + x_{-1} = \frac{bx + (n-1)(\delta a - \beta) + s_{-1}}{n\delta b} \tag{20}$$

Hence

$$\frac{\partial X}{\partial s} = \frac{1}{n}\frac{\partial x}{\partial s} = \frac{1}{b(n+1)} > 0 \tag{21}$$

Bringing together (18), (19) and (21) we arrive at the equilibrium level of exports *with subsidies* constrained by the arms export regime in the form of a licensing delay:

$$x^S = \frac{n(\delta a - \beta) - \frac{\delta\gamma}{(1+\lambda)}}{\delta b(1+n^2)} \tag{22}$$

Comparing (22) and (16), some algebra leads us to the following proposition:

Proposition 1

(i) Arms exports are higher under a subsidies programme ($x^S > x^{NS}$) iff $\gamma < \bar{\gamma}$ where

$$\bar{\gamma} = \frac{(n-1)(\delta a - \beta)(1+\lambda)}{\delta(n+1)} \tag{23}$$

(ii) At the threshold value of the security parameter $\gamma \geq \bar{\gamma}$, subsidies disappear and give way to a tax on exports.

(iii) Since from (i) $\bar{\gamma}$ is a increasing function of δ, the effect of strengthening export controls (reducing δ) is to lower the threshold $\bar{\gamma}$ and therefore discourage subsidies as well as arms exports.

To understand these results let us first imagine countries in the no subsidy state ($s = s_{-1} = 0$). A single country acting unilaterally can improve its situation by acting as a Stackelberg Leader both with respect to its own firm and the other countries. Introducing a subsidy will result in higher exports by its own firm and, in the absence or retaliation by other countries, lower exports by its rivals, and therefore higher market share. By choosing a subsidy at *stage 2* of the game on its reaction function at that stage, the country unambiguously benefits. However this outcome is not an equilibrium. When other countries act is a similar fashion setting subsidies simultaneously, the Nash equilibrium of *stage 2* is an example of a 'Prisoners' Dilemma': all countries subsidize, providing that the security parameter γ is below the threshold given in (23), market shares are equal and all countries export more taking the equilibrium further away from the first-best. From (16) the equilibrium subsidy is then given by

$$s = (n+1)\delta b(x^S - x^{NS}) \tag{24}$$

Thus relaxing arms controls (i.e., reducing δ) encourages a higher subsidy and more arms exports. The intuition behind this result is as follows. Under complete information governments pay a procurement price that just satisfies the firm's participation (or IR) constraint. As exports rise average costs fall and this threshold procurement price also falls. The welfare 'return' on subsidies, which must be financed out of distortionary taxes, arises from this reduction in the procurement price. As export controls are relaxed this welfare return from a subsidy increases, thus increasing its optimal value in equilibrium.

If countries cooperate then the first-best can be supported by the negative subsidy (i.e,. a tax):

$$s = (n+1)\delta b(x^{FB} - x^{NS}) \tag{25}$$

In the absence of cooperation if $\gamma > \bar{\gamma}$ then the security threat is such that subsidies give way to taxes. From (23) the threshold $\bar{\gamma}$ is a decreasing function of δ resulting in (ii) of the proposition.

3.3 The Two-Country Case

In the next section of the paper, we assume incomplete information and we introduce asymmetries between countries so that parameters δ_i, λ_i, β_i, F_i, β_i, g_i and α_i, $i = h, f$ are country-specific. Then, to ease the exposition, we restrict ourselves to two countries, say 'home' (h) and 'foreign' (f). We will compare the incomplete information outcome with that under the benchmark of complete information which, following a similar analysis to that above, has a subgame perfect equilibrium in exports, (x_h, x_f) given by

$$\begin{aligned} 3x_h + 2x_f &= -\frac{\gamma_h}{b(1+\lambda_h)} + \frac{2(\delta_h a - \beta_h)}{\delta_h b} \\ 3x_f + 2x_h &= -\frac{\gamma_f}{b(1+\lambda_f)} + \frac{2(\delta_f a - \beta_f)}{\delta_f b} \end{aligned} \tag{26}$$

which reduces to (22) if $n = 2$ and parameters are equal in the two countries. The subsidies that support (26) are given by

$$4\delta_f s_h + \delta_h s_f = -\frac{3\gamma_h \delta_h \delta_f}{1+\lambda_h} + a\delta_h\delta_f - 2\beta_h\delta_f + \beta_f\delta_h \tag{27}$$

$$4\delta_h s_f + \delta_f s_h = -\frac{3\gamma_f \delta_f \delta_h}{1+\lambda_f} + a\delta_f\delta_h - 2\beta_f\delta_h + \beta_h\delta_f \tag{28}$$

An important consideration for arms control regimes is their stability given that a single country can benefit from unilaterally relaxing or abandoning its arms control. That is, the h-country can benefit from increasing δ_h. Using (9), for the h-country we can write the welfare as

$$W_h = G(g_h) - \gamma(\delta_h x_h + \delta_f x_f) - (1+\lambda_h)[C(x_h + g_h) - \delta_h(a - b(x_h + x_f))x_h] - \lambda U_h \tag{29}$$

In a Cournot-Nash equilibrium, (29) is maximized with respect to x_h, given x_f.

Now write (29) as $W_h = F(\delta_h, x_h, x_f)$. Then partially differentiating with respect to δ_h we have that

$$\frac{\partial W_h}{\partial \delta_h} = \frac{\partial F}{\partial \delta_h} + \frac{\partial F}{\partial x_h}\frac{\partial x_h}{\partial \delta_h} + \frac{\partial F}{\partial x_f}\frac{\partial x_f}{\partial \delta_h} \tag{30}$$

(30) provides a measure of the incentive of the h-country to relax its arms control policy by allowing the licensing delay to decrease (i.e., increasing δ_h).

The demand and cost structure chosen for the model (linear demand functions and constant marginal cost) has the property that in asymmetric equilibrium with $x_h = x_f = x$, say, the revenue $Px = (a - 2bx)x$ is decreasing for $x > \frac{a}{4b}$. These assumptions are chosen for reasons of analytical tractability, but have the disadvantage that the price is driven to zero as output increases. A more empirically plausible demand function would take a constant elasticity form $x = AP^{-\epsilon}$ with an elasticity $\epsilon > 1$ in which case the revenue is an increasing function of x. Rather than introduce this less tractable form, we confine ourselves to levels of output $x < \frac{a}{4b}$. Maximum equilibrium output is reached in the subsidy regime where there are no security concerns ($\gamma = 0$). Then from (22) with n=2, the maximum output in a symmetric equilibrium is $x^{max} = \frac{2(a-\beta)}{5b}$. Hence we must restrict parameters to those satisfying $\frac{2(a-\beta)}{5b} < \frac{a}{4b}$ or in other words $a < \frac{8\beta}{3}$. The following propositions requires that we strengthen this condition to:

$$a < \min\left[\frac{8\beta}{3}, \frac{4\beta}{3\delta}\right] \tag{31}$$

We can now prove the proposition:

Proposition 2

For small deviations in δ_i about a symmetrical equilibrium with $\delta_h = \delta_f$, if condition (31) holds and $\gamma < \bar{\gamma}$ then:

(i) $\frac{\partial W_i}{\partial \delta_i} > 0\,;\, i = h, j$**.**

(ii) $\left(\frac{\partial W_h}{\partial \delta_h}\right)^S > \left(\frac{\partial W_h}{\partial \delta_h}\right)^{NS}$ **and therefore the ability to subsidise exports has the effect of destabilising the arms control regime.**

Proof. See Appendix.

The intuition behind this result is similar to the previous proposition. The welfare gain from relaxing arms controls arises from the increased revenue (assuming condition (31) holds) in current value terms, from exports. This may be welfare-enhancing because it reduces the procurement price required to satisfy the firm's participation constraint, a benefit which must be weighed against the negative security effect from increased exports. If (31) holds, the former outweighs the latter. In a trade regime that allows subsidies, revenue from exports rises more than the negative security effect. The benefit of a unilateral abrogation of the arms control regime correspondingly rises, making the regime less stable.

4 Arms Exports under Incomplete Information

We now assume that the governments cannot observe the marginal cost parameter β_i in country $i = h, f$, which constitute asymmetric information only known to the firm in question. The distribution of the β_i however is public knowledge. We confine ourselves to a multilateral agreement with equal licensing delays; i.e., $\delta_h = \delta_f = \delta$. In choosing a procurement price and subsidy, the government now faces an adverse selection problem. The sequencing of events is now:

1. Each government commits itself to a given arms export licensing delay implying a discount factor $\delta = \dfrac{1}{(1+r)^{\tau}}$.
2. Each government $i = h, f$ independently designs a *revelation mechanism* consisting of mappings $p_i = p_i(\beta_i)$ (implying a lump-sum $p_i g_i$) and a subsidy $s_i = s_i(\beta_i)$ to induce truthful reporting and participation.
3. Firms choose whether or not to participate.
4. Firms report $\beta_i = \hat{\beta}_i$ and receives $p_i = p_i(\hat{\beta}_i)$ and $s_i = s_i(\hat{\beta}_i)$.
5. Given p_i and s_i, firms choose output including exports x_i ; $i = h, f$.
6. Firms export with a delay τ and receive the current value δ\$ for each \$ of arms export revenue.

The appropriate equilibrium concept is now a *Perfect Bayesian Equilibrium (PBE)*. To solve for the PBE, we first solve for the Cournot-Nash equilibrium of stage 5:

Stage 5. The Cournot-Nash Equilibrium

Proceeding as for the complete information game between symmetric economies above, with subsidies and procurement prices set in both countries, each firm $i = h, f$ maximizes U_i with respect to x_i taking the output of its foreign rival as given. This leads to the Cournot-Nash equilibrium:

$$
\begin{aligned}
x_h &= \frac{\delta a - 2\beta_h + \beta_f + 2s_h - s_f}{3\delta b} = x_h(\beta_h, \beta_f) && (32)\\
x_f &= \frac{\delta a - 2\beta_f + \beta_h + 2s_f - s_h}{3\delta b} = x_f(\beta_h, \beta_f) && (33)\\
P &= \frac{a + \beta_h + \beta_f - s_h - s_f}{3} = P(\beta_h, \beta_f) && (34)\\
U_i &= (p_i - \beta_i)g_i + \delta b x_i^2 - F_i = U_i(\beta_h, \beta_f)\,;\, i = h, f && (35)
\end{aligned}
$$

Stage 4: Truthful Reporting

Given the mechanism $p_i = p_i(\beta_i)$ and $s_i = s_i(\beta_i)$, if firm h reports $\hat{\beta}_h$ and firm f reports truthfully (which happens in equilibrium), then firm h produces

$$
\hat{x}_h = \frac{\delta a - 2\beta_h + \beta_f + 2s_h(\hat{\beta}_h) - s_f(\beta_h)}{3\delta b} = \hat{x}_h(\hat{\beta}_h, \beta_h\ \beta_f) \tag{36}
$$

say, and receives rent

$$
\hat{U}_h = (p_h(\hat{\beta}_h) - \beta_h)g_h + \delta b \hat{x}_h^2 - F_h = \hat{U}_h(\hat{\beta}_h, \beta_h\ \beta_f) \tag{37}
$$

which depends on both β_h and β_f. The home firm knows its own efficiency parameter β_h but does not observe β_f. Let $f(\beta_f \mid \beta_h)$ be the conditional density function on the interval $\beta_f \in [\underline{\beta}_f, \overline{\beta}_f]$ which is known to all players in the game. Then at stage 4 before revelation, firm h will choose its report $\hat{\beta}_h$ to maximize expected rent over the distribution of β_f given by

$$
E_{\beta_f}(\hat{U}_h) = \int_{\underline{\beta}_f}^{\overline{\beta}_f} \hat{U}_h(\hat{\beta}_h, \beta_h\ \beta_f) f(\beta_f \mid \beta_h) d\beta_f \tag{38}
$$

Truthful reporting (i.e., incentive compatibility) then requires

$$
\left[\frac{\partial E_{\beta_f}(\hat{U}_h)}{\partial \hat{\beta}_h}\right]_{\hat{\beta}_h = \beta_h} = 0 \tag{39}
$$

To proceed further we need to restrict the density function. We assume a uniform distribution and two extreme cases: β_h and β_f either perfectly correlated or completely independent. For the case of perfectly correlated shocks β_i ($\beta_h = \beta_f = \beta$), say, $f(\beta_f \mid \beta_h) = 1$ if $\beta_f = \beta_h$, and zero otherwise. Then

$$
E_{\beta_f}(\hat{U}_h) = \hat{U}_h(\hat{\beta}, \beta, \beta) = \left(p_h(\hat{\beta}) - \beta\right) g_h + \delta b \hat{x}_h^2 - F_h \tag{40}
$$

For the case of independently distributed β_i, $f(\beta_f \mid \beta_h) = f(\beta_f)f(\beta_h)$ and expected profits for the home firm after reporting $\hat{\beta}_h$ are given by

$$\begin{aligned} E_{\beta_f}(\hat{U}_h) &= \frac{\delta b}{(\overline{\beta}_f - \underline{\beta}_f)} \int_{\underline{\beta}_f}^{\overline{\beta}_f} \hat{U}_h(\hat{\beta}_h, \beta_h, \beta_f) d\beta_f \\ &= (p_h(\hat{\beta}_h) - \beta_h) g_h + \frac{1}{(\overline{\beta}_f - \underline{\beta}_f)} \int_{\underline{\beta}_f}^{\overline{\beta}_f} \hat{x}_h^2 d\beta_f - F_h \end{aligned} \tag{41}$$

Now consider the incentive compatibility constraint (39) for these two cases. For $\beta_h = \beta_f = \beta$, from (40) we have

$$\left[\frac{dp_h(\hat{\beta})}{d\hat{\beta}} g_h + 2\delta b \hat{x}_h \frac{\partial \hat{x}_h}{\partial \hat{\beta}} \right]_{\hat{\beta}=\beta} = 0 \tag{42}$$

But from (36) we have that $\frac{\partial \hat{x}_h}{\partial \hat{\beta}} = \frac{2}{3\delta b} \frac{ds_h(\hat{\beta})}{d\hat{\beta}}$. Hence (42) becomes

$$\frac{dp_h(\beta)}{d\beta} g_h + \frac{4}{3} x_h \frac{ds_h(\beta)}{d\beta} = 0 \tag{43}$$

With truthful reporting, $\hat{U}_h(\hat{\beta}, \beta, \beta) = U_h(\beta, \beta)$, given by (32). If $\beta_h = \beta_f = \beta$, the latter is a function of only β and we can differentiate to obtain

$$\frac{dU_h}{d\beta} = \frac{dp_h}{d\beta} g_h + 2\delta b x_h \frac{dx_h}{d\beta} = \frac{dp_h}{d\beta} g_h + \frac{2}{3} x_h \left(-1 + 2\frac{ds_h}{d\beta} - \frac{ds_f}{d\beta} \right) \tag{44}$$

using (32). Combining (43) and (44) we arrive at the final form of the incentive compatibility constraint for the home country when $\beta_h = \beta_f$:

$$\mathbf{IC_h}(\beta_h = \beta_f = \beta): \quad \frac{dU_h}{d\beta} = -\frac{2}{3} x_h \left(1 + \frac{ds_f}{d\beta} \right) \tag{45}$$

For β_i independent, (43) and (44) are replaced with

$$\frac{dp_h}{d\beta_h} g_h + \frac{4}{3} E_{\beta_f}(x_h) \frac{ds_h}{d\beta_h} = 0 \tag{46}$$

$$\frac{dE_{\beta_f}(U_h)}{d\beta_h} = \frac{dp_h}{d\beta_h} g_h + 2\delta b E_{\beta_f} \left(x_h \frac{\partial x_h}{\partial \beta_h} \right) = \frac{dp_h}{d\beta_h} g_h + \frac{4}{3} E_{\beta_f}(x_h) \left(-1 + \frac{ds_h}{d\beta_h} \right) \tag{47}$$

and hence from (46) and (47)the final form of the incentive compatibility constraint for the home country when β_h and β_f are independent is:

$$\mathbf{IC_h}(\beta_h,\, \beta_f \,\text{independent}): \quad \frac{dE_{\beta_f}(U_h)}{d\beta_h} = -\frac{4}{3} x_h \tag{48}$$

Stage 2. Mechanism Design

Given β_h and β_f, the social welfare function of the form (4) for the home country is

$$W(\beta_h, \beta_f) = S(g_h, \delta X) - (1+\lambda_h)[F_h - x_h(\beta_h, \beta_f)(\beta_h - \delta P(X))] - \lambda_h U_h(\beta_h, \beta_f) \quad (49)$$

The home policymaker then designs a mechanism to maximise

$$E_{(\beta_h,\beta_f)}(W_h(\beta_h, \beta_f)) = \int_{\underline{\beta}_h}^{\overline{\beta}_h} \left[\int_{\underline{\beta}_h}^{\overline{\beta}_h} W_h(\beta_f, \beta_f) f(\beta_f \mid \beta_h) d\beta_f \right] f(\beta_h) d\beta_h \quad (50)$$

subject to the IC_h and the participation constraint:

$$E_{\beta_f}(U_h(\beta_h, \beta_f)) \geq 0 \quad \text{for all } \beta_h \quad (51)$$

First consider $\beta_h = \beta_f = \beta$. Then the mechanism maximizes

$$E_\beta(W_h(\beta, \beta)) = \int_{\underline{\beta}}^{\overline{\beta}} W_h(\beta, \beta) f(\beta) d\beta \quad (52)$$

subject to the IC_h constraint, (48), and the participation constraint, which now becomes $U_h(\beta, \beta)) \geq 0$ for all β. This optimization problem is carried out using Pontryagin's maximum principle. Define the Hamiltonian

$$H_h(\beta) = W_h(\beta, \beta) f(\beta) - \frac{2}{3}\mu_h(\beta) x_h(\beta, \beta) \left(1 + \frac{ds_f(\beta)}{d\beta}\right) \quad (53)$$

Let the control variables be s_h and U_h. Then writing H_h as a function of these control variable, the first-order conditions for a maximum are:

$$\frac{\partial H_h}{\partial s_h} = 0 \quad (54)$$

$$\frac{\partial H_h}{\partial U_h} = -\dot{\mu_h} \quad (55)$$

and the transversality condition $\mu(\underline{\beta}) = 0$. Some manipulation then leads to

$$3x_h + 2x_f = -\frac{\gamma_h}{b(1+\lambda_h)} + \frac{2(\delta a - \beta_h)}{\delta b} - \frac{4\mu_h(\beta)(1+\dot{s}_f)}{3\delta b f(\beta)(1+\lambda_h)} \quad (56)$$

$$\dot{\mu_h} = \lambda_h f(\beta) \quad (57)$$

Assuming a uniform distribution, integrating (56) and imposing the transversality condition gives

$$\mu_h = \lambda_h \int_{\underline{\beta}}^{\beta} f(\tilde{\beta}) d\tilde{\beta} = \lambda_h \frac{(\beta - \underline{\beta})}{(\overline{\beta} - \underline{\beta})} \quad (58)$$

Hence from (56) and (58) we arrive at

$$3x_h + 2x_f = -\frac{\gamma_h}{b(1+\lambda_h)} + \frac{2(\delta a - \beta)}{\delta b} - \frac{4\lambda_h(\beta - \underline{\beta})(1+\dot{s}_f)}{3\delta b(1+\lambda_h)} \tag{59}$$

Similarly for the f country

$$3x_f + 2x_h = -\frac{\gamma_f}{b(1+\lambda_f)} + \frac{2(\delta a - \beta)}{\delta b} - \frac{4\lambda_f(\beta - \underline{\beta})(1+\dot{s}_h)}{3\delta b(1+\lambda_f)} \tag{60}$$

Substituting for x_h and x_f from the Nash equilibrium at stage 3 we arrive at the following differential equations for the subsidies in the two countries:

$$4s_h + s_f = -\frac{3\gamma_h\delta}{1+\lambda_h} + \delta a - \beta - 4\lambda_h(\beta - \underline{\beta})(1+\dot{s}_f) \tag{61}$$

$$4s_f + s_h = -\frac{3\gamma_f\delta}{1+\lambda_f} + \delta a - \beta - 4\lambda_f(\beta - \underline{\beta})(1+\dot{s}_h) \tag{62}$$

We look for solutions to these two differential equations of the form

$$s_i = s_h^{CI} - \theta_i(\beta - \underline{\beta})\ ,\ i = h, f \tag{63}$$

where s_i^{CI} are the subsidies under complete information found by solving (27). Confining ourselves to the symmetrical case $\lambda_h = \lambda_f = \lambda$ etc, substituting (63) into (61) gives[5]

$$\theta_h = \theta_f = \frac{16\lambda}{5(5+9\lambda)} > 0 \tag{64}$$

Thus from (63) and (64) we see that $s_i < s_i^{CI}$ and θ_i is a decreasing function of α_i. We summarise our results as follows:

Proposition 3

For the symmetrical case where all parameters such as γ_i are the same in the two countries, the presence of asymmetric information leads to lower subsidies, lower exports and a lower security threshold $\bar{\gamma}$ at which subsidies cease compared with the complete information case.

[5] Note (64) agrees with equation (24) of Brainard and Martimort (1997).

For completely independent β_i the analysis goes through in a similar fashion arriving at static equations for the subsidies

$$\begin{aligned}
4s_h + E_{\beta_f}(s_f(\beta_f)) &= -\frac{3\gamma_h\delta}{1+\lambda_h} + \delta a - 2\beta_h + E_{\beta_f}(\beta_f) \\
&- 8\lambda_h(\beta_h - \underline{\beta}_h) \qquad (65) \\
4s_f + E_{\beta_h}(s_h(\beta_h)) &= -\frac{3\gamma_f\delta}{1+\lambda_f} + \delta a - 2\beta_f + E_{\beta_h}(\beta_h) \\
&- 8\lambda_f(\beta_f - \underline{\beta}_f) \qquad (66)
\end{aligned}$$

Taking expectations, this gives us two equations in $E_{\beta_h}(s_h(\beta_h)$ and $E_{\beta_f}(s_f(\beta_f))$ in terms of $E_{(\beta_h,\beta_f)}(s_h^{CI})$ and $E_{(\beta_h,\beta_f)}(s_h^{CI})$, found by taking expectations of (27), and $E_{\beta_h}(\beta_h)$ and $E_{\beta_f}(\beta_f)$. Proceeding as before the solution is given by

$$E_{\beta_i}(s_i) = E_{(\beta_h,\beta_f)}(s_h^{CI}) - \phi_i(E_{\beta_i}(\beta_i) - \underline{\beta}_i)\ ,\ i = h, f \qquad (67)$$

where for the symmetrical case (other than the β_i) we have

$$\phi_i = \frac{8}{5}\lambda > \theta_i \qquad (68)$$

Thus the proposition:

Proposition 4

Asymmetric information reduces subsidies more on average (i.e., across all realisations of the β_i parameters) when the parameters β_i are independently distributed.

The intuition behind propositions 3 and 4 is as follows. Asymmetric information reduces the incentive to subsidize because part of this transfer is absorbed as rent by the more efficient firm in order to induce truthful reporting of their private information. This 'screening effect' reduces subsidies and exports in equilibrium, so less transparency in workings of the arms producers is actually a good thing. If the unobserved efficiency parameters in the two countries are independently distributed rather than equal, then the screening costs rise and the downward effect on subsidies is strengthened further.

5 Conclusions

This paper applies the tools of the strategic trade literature to the international trade in arms. Owing to the WTO exemption this is probably the only area of trade where we observe lump-sum and per unit transfers to exports. We have examined the effect of arms controls, in the form of licensing delays, on the incentives to subsidize arms exports and conversely the effect of the WTO arms trade exemption on the incentives to break arms control agreements. Our main result is that arms controls and free trade commitments re-enforce each other. Licensing delays reduce the incentive to subsidize and free trade without subsidies reduces the benefits of a unilateral abrogation of arms controls. Transparency actually worsens the Nash inefficiencies at play in that incomplete information leads to lower subsidies and lower arms exports. If and when the defence industry becomes more transparent, then the abolition of the WTO exemption becomes more urgent.

In our paper, the impact of transparency on security is determined by the type of information asymmetry introduced. We assume that the government is uncertain about a cost parameter. Other types of asymmetry could be considered, one of them being the actual quality or quantity of weapons being exported by either the domestic firm or its competitors, this type of asymmetry is likely to have a very different impact on security, this topic is the purpose of further research

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A Proof of Proposition 2

From (29) we have that

$$
\begin{aligned}
\frac{\partial W_h}{\partial \delta_h} &= -\gamma_h + (1+\lambda_h)Px_h \\
&- [\gamma_h\delta_h + (1+\lambda_h)(\beta_h - \delta_h(P - bx_h)] \frac{\partial x_h}{\partial \delta_h} \\
&- [\gamma_h\delta_f + (1+\lambda_h)\delta_h b x_h] \frac{\partial x_f}{\partial \delta_h} \qquad \text{(A.1)}
\end{aligned}
$$

In a symmetric equilibrium, putting $\delta_h = \delta_f = \delta$ etc, for the subsidy and no-subsidy cases we have:

$$
\begin{aligned}
x^S &= \frac{1}{5}\left[-\frac{\gamma}{b(1+\lambda)} + \frac{2(\delta a - \beta}{\delta b}\right] \qquad \text{(A.2)} \\
x^{NS} &= \frac{\delta a - \beta}{3\delta b} \qquad \text{(A.3)} \\
\frac{\partial x_h^S}{\partial \delta_h} &= \frac{6\beta}{5\delta^2 b} \qquad \text{(A.4)} \\
\frac{\partial x_f^S}{\partial \delta_h} &= -\frac{4\beta}{5\delta^2 b} \qquad \text{(A.5)} \\
\frac{\partial x_h^{NS}}{\partial \delta_h} &= \frac{2\beta}{3\delta^2 b} \qquad \text{(A.6)} \\
\frac{\partial x_f^{NS}}{\partial \delta_h} &= -\frac{\beta}{3\delta^2 b} \qquad \text{(A.7)} \\
P^S &= a - 2bx^S \qquad \text{(A.8)} \\
P^{NS} &= a - 2bx^{NS} \qquad \text{(A.9)}
\end{aligned}
$$

Substituting (A.2) to (A.9) into (A.1) a little algebra proves results (i) and (ii) in proposition 2.