SECURITY AND PRICE ARBITRAGE

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Abstract

We examine the effect of international price arbitrage on the willingness to set unilateral export controls. The restriction on the quality of exports of security sensitive products limits the outside option of domestic customers: if the product available on the international market is of low quality the firm can charge a high price to domestic customers for its latest technology. This effect leads the government to be less willing to introduce export controls on security sensitive products.

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1 INTRODUCTION

The development of dual use technologies has made it difficult to give a clear answer to which products are 'security sensitive', i.e., which products have potential military applications. It is particularly interesting to observe how the evolution of information technologies and computer capacity has provoked a change in the perception of national security among the most developed countries. This change in perception is specially evident in the US. The increasing dependency that this country has on information networks makes it the 'most vulnerable objective in the World[1]' to eventual attacks with 'viruses' or 'logic bombs' from a foreign enemy. The Presidential Commission for the Protection of Essential Infrastructures (DARPA) has been created to design defensive mechanisms in the event of 'Information Warfare'. Besides, the Bureau of Export Administration (BXA) implements several export controls in order to avoid state of art technologies becoming a threat to US national security when exported to other countries. The National Defense Authorization Act on High Performance Computers[2] controls and restricts the exports of powerful computers to Tier 3 countries. This is a group of 50 countries among which are Russia, China and Israel. Some of these countries are also producers of high tech computers though US computers have a higher quality. Export controls also apply to computer related products like software and cryptographic equipment.

There is a debate over the use of export controls as a method to preserve national security (Becker (1998)). Defence producers are already well known for lobbying governments (see e.g. Lichtenberg (1989)). The extension of export controls to dual use goods has further stimulated the involvement of different interest groups trying to influence governments in their policy making. Firms lobby governments to obtain export licences[3], defence authorities want to see national security preserved and consumers can also be affected by the effect that export controls on dual use products may have on the

[1] This is the opinion of people like John McConnell, former director of the National Security Department, and William Studeman, former subdirector of the CIA.

[2] High Performance Computers (HPC) are those of speeds above 2000 theoretical operations per second (MTOPS). The most recent regulations on the exports of HPC have been implemented in February of 1998 (Federal Register, Vol. 63, No. 22. Tuesday, February 3, 1998. Rules and Regulations).

[3] The political economy of trade literature discusses in detail this kind of lobbying although not in the context of dual-use goods export controls (see e.g. Bhagwati (1982)).

domestic market.

The purpose of this paper is to examine the effect of quality restrictions on the domestic and foreign producers' profits and on the welfare of the country that sets export controls with and without international price arbitrage.

This work is related to a large number of papers about 'strategic' trade policy in which governments use various trade tools (e.g. tariffs, quotas or subsidies) in order to affect the rivalry between foreign and domestic firms[4]. The present paper introduces two main innovations. Firstly, because of the security concern of the governments, we focus on a new policy tool, namely restrictions on the quality of exported goods. Secondly, in order to reflect the 'free-flowing' nature of the international markets, we consider the effect of international price arbitrage on the quality restriction. The security concern of exporters of weapons has been analyzed in the Arms Trade literature[5].

There are very few papers that analyze trade policies in the presence of price arbitrage. Donnenfeld (1988) examines the effect of commercial policy on the composition and quality of imports which are supplied by a multiproduct foreign monopolist that sells goods of variable quality to a population of buyers which differ in their willingness to pay for quality. In his paper the foreign monopolist uses product differentiation as a device to discriminate among domestic consumers whose preferences differ. He examines the implications for trade policy of this type of discrimination. Restricting the quantity of imports is shown to have a positive effect on the welfare of consumers.

Markusen and Venables (1988) compare the effect of trade and industrial policies in segmented with non segmented markets. They use a model in which firms located in two different countries compete in quantities under the existence of transport costs between the two countries. In the segmented market situation, firms decide the domestic and foreign quantities, taking as given the quantity that the foreign competitor sells in the domestic and foreign country individually. In the non segmented market situation, however, firms decide the aggregate quantity, taking as given the aggregate quantity that the competitor sells in both markets. The paper concludes that the effect of policy is greater when markets are segmented than when they are not segmented.

[4] See e.g. Brander and Spencer (1983) and (1985). For a review of this literature see Helpman, Elhanan and Krugman (1987) and (1989).

[5] E.g. Levine et al. (1994), Levine and Smith (1995), García-Alonso(1999) and García-Alonso (2000).

An increasingly globalized economy suggests that markets are now more integrated than before and, therefore, cross country prices for the same commodity should be lower. Goolsbee (2001) states that computer goods are the single largest category of retail goods sold on-line. This study also suggests that on-line (remote) and off-line sales of computer related products are already unlikely to be truly separate markets. Although Goolsbee (2001) focuses on the US market, his study seems a good indicator of why globalization may work harder in the computer industry. Lower transport costs and an increase in the flow of information through on-line buying should accelerate such international market integration.

Our paper analyzes the effect of price arbitrage on the decision of governments to impose quality restrictions on exports of security sensitive products. We consider two firms located in different countries which produce a good with an exogenously given quality. One of the firms is restricted by the domestic government to sell a lower quality in the foreign market. We compare the effect of a restriction on the quality exported in the case in which the non restricted firm can set two different prices in the home and foreign market (i.e. no price arbitrage) with the case in which it must sell its product at the same price in both markets (i.e. perfect price arbitrage).

It is shown that, under perfect price arbitrage, a looser restriction on the quality of the security sensitive good exported has a negative effect on the domestic profits of the restricted firm and a positive effect on consumer welfare. We also prove that the introduction of restrictions on quality becomes more difficult with perfect price arbitrage.

The rest of the paper is organized as follows. Section 2 presents the model and compares the results with and without perfect price arbitrage between the two countries. Finally, section 3 presents the main conclusions of the paper.

2 THE MODEL

Consider two firms located in different countries, A and B. Firms produce a good with quality q_A and q_B respectively. Both firms sell their product in the home and the foreign market.

Consumers buy either one or zero units of the good. Their willingness to pay is increasing in the quality of the product, but, they perceive the goods produced by the two firms as imperfect substitutes. This is modeled by

assuming that consumers are 'located' at different distances from the firms. This, together with the existence of transportation costs, different for each consumer, allows a firm with a lower quality product to have a positive share in the market. More precisely, consumers in both countries are uniformly distributed along the 0-1 line according to their preference for the two firms' products (firm and consumers in country A will be usually referred to as *domestic* firm and consumers). Firms A and B are located at '0' and '1' on the line respectively. The utility function of a domestic consumer i that buys from firm j has the following form:

$$U_{ij}\left[q_j, P_j\right] = R + q_j - \lambda d_{ij} - P_j, \tag{1}$$

where U_{ij} is the utility that consumer i gets from buying good j, $j = A, B$; d_{ij} is the distance between consumer i and firm j, λ is a positive parameter and q_j and P_j are the quality and price that firm j offers. R is a positive constant which we assume to be high enough for the participation constraint of consumers to be fulfilled. Foreign consumers have the same utility function. This framework constitutes a simple way of modelling vertical differentiation together with horizontal differentiation and was first used by Economides (1989). Also, as in Economides (1989), quality is normalized so that the increase of one unit in its level pushes up the utility for the product by one unit. One could think of it as the speed of a computer.

The government in country A restricts the quality that the domestic firm, firm A, can export; it only allows the firm to export a proportion of the quality available in the domestic market, we denote this proportion γ. Therefore, we will have that the domestic firm offers a quality q_A in its domestic market and a quality q_A^* in its foreign market such that:

$$q_A^* = \gamma q_A, \qquad \gamma \in [0, 1]\,. \tag{2}$$

The government in country B does not restrict quality, hence, the foreign firm, firm B, sells the same quality at home and abroad since the willingness to pay for consumption is increasing in quality, we denote this quality q_B.

In this paper, we will restrict ourselves to cases when the restricted quality, γq_A, is equal of bigger than the other firm's quality, q_B. This reflects the idea that set export controls are quality leaders that do not want the state-of-the-art technology to be transferred to other countries.

The domestic firm sets a price P_A in its domestic market and a price P_A^* in its foreign market and the foreign firm sets prices P_B^* and P_B its home and

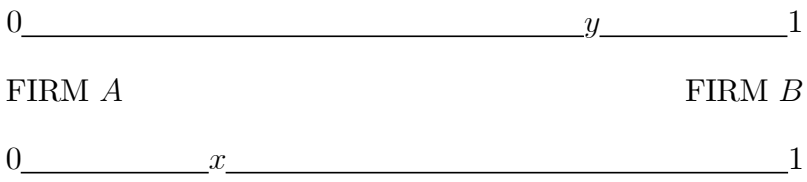
foreign market respectively.

In equilibrium, it must be the case that domestic consumers in country A are not better off by buying the lower quality good that the home firm sells in the foreign market. In other words, we must have that $U_{iA}[q_A, P_A] \geq U_{iA}[q_A^*, P_A^*]$. For this to be the case, the following arbitrage condition must hold:

$$q_A(1-\gamma) \geq P_A - P_A^*. \tag{3}$$

There is a distance from firm A, denoted y, at which a consumer in country A is indifferent between buying from the domestic or the foreign firm. Correspondingly, the consumer from country B which is at a distance x from firm A is indifferent between buying from either of the two firms. Therefore, a proportion y of consumers in country A buy from the domestic firm, firm A, and proportion $(1-y)$ of the consumers of country A import from firm B. Also, we have that a proportion x of consumers of country B import from firm A and a proportion $(1-x)$ of country B's consumers buy from their domestic firm, firm B (see Figure 1).

Figure 1: The security sensitive market



Note that we assume that there is a unilateral concern about security, only government A may set a restriction on the exported quality. This is an attempt to reflect the different levels of concern about security across countries. Security, $S[\gamma]$, is expressed as a decreasing function of the proportion of quality exported, $S'[\gamma] < 0$. Note also that $(1-\gamma) = \dfrac{q_A - \gamma q_A}{q_A}$ can be interpreted as the rate of restriction on the exported quality. As in García-Alonso (2000), security is not a function of quantity but of quality, this corresponds with the characteristics of the export control rules on high-tech dual use products (see García-Alonso and Hartley (2000) and Becker (1998) for a discussion). However, here we also assume that security depends on the *domestic* rate of restriction on exported quality. This attempts to capture the fact that those countries most concerned about the security

repercussions of exporting high-tech dual use goods, specially information technology, are also those more technologically advanced, and therefore, we would expect the quality produced by security unconcerned countries to be lower.

Overall, the model is presented as a two stage game. In the first stage, government A commits to a quality restriction, in the second stage firms compete in prices, the game is solved backwards both for the no price arbitrage and price arbitrage case.

2.1 No Price Arbitrage

We start by assuming that firm B can discriminate between the home and foreign consumers and therefore set different domestic and export prices. We will use this as a benchmark for comparison with the case when there is perfect price arbitrage between the two countries.

2.1.1 Firms' problem

In order to solve the maximization problem of the firms, we first derive the domestic and foreign demand of each of the two firms. These are given by the locations of the indifferent domestic and foreign consumers: y and x. Using equation (1), we obtain the following firm A's export demand:

$$x = \frac{\gamma q_A - q_B + P_B^* - P_A^*}{2\lambda} + \frac{1}{2}. \tag{4}$$

Similarly, we obtain firm A's domestic demand:

$$y = \frac{q_A - q_B + P_B - P_A}{2\lambda} + \frac{1}{2}. \tag{5}$$

Since firm A sells goods with different qualities in the domestic and foreign market, it has two decision variables in the maximization problem which are domestic and exports price, for simplicity, we assume zero production costs:

$$\underset{\{P_A, P_A^*\}}{Max}\ \alpha\pi_A + \pi_A^* = \alpha y P_A + x P_A^*, \tag{6}$$

where, π_A are the profits that firm A obtains in the domestic market, π_A^* are the profits it obtains in the export market and α is the relative size of

the market in country A with respect to the market in country B. We can think of it as the density of consumers along the line in country A.

Substituting x and y (equations (4) and (5)) into the profit function of firm A (equation (6)) we can derive the first order conditions for its maximization problem:

$$P_A = \frac{q_A - q_B}{2} + \frac{P_B}{2} + \frac{\lambda}{2}, \tag{7}$$

$$P_A^* = \frac{\gamma q_A - q_B}{2} + \frac{P_B^*}{2} + \frac{\lambda}{2}. \tag{8}$$

These are the reaction functions of the domestic and export price of firm A with respect to the export and domestic price of firm B. They are both upward sloping.

In the absence of price arbitrage, firm B can also discriminate between the home and the foreign market even though it sells the good with the same quality in both markets. The maximization problem is:

$$\underset{\left\{P_B^*, P_B\right\}}{Max}\ \pi_B^* + \alpha\pi_B = P_B^*(1-x) + P_B\alpha(1-y),$$

where, π_B^* are the profits that firm B obtains in the domestic market and π_B are the profits it obtains in the export market.

Substituting the x and y into the profit function of firm B and differentiating we get the following first order conditions:

$$P_B = \frac{1}{2}(\lambda - q_A + q_B + P_A), \tag{9}$$

$$P_B^* = \frac{1}{2}(\lambda - \gamma q_A + q_B + P_A^*). \tag{10}$$

Introducing equations (7) and (8) in the above expressions we obtain the equilibrium domestic and export price of firm B in the absence of price arbitrage:

$$P_{Bna}^* = \lambda - \frac{\gamma q_A - q_B}{3}. \tag{11}$$

$$P_{Bna} = \lambda - \frac{q_A - q_B}{3}. \tag{12}$$

Introducing equation (12) into equation (7) we get the domestic price of firm A:

$$P_{Ana} = \lambda + \frac{q_A - q_B}{3}, \tag{13}$$

and introducing equation (11) into equation (8) we get the exports price of firm A:

$$P^*_{Ana} = \lambda + \frac{\gamma q_A - q_B}{3}. \tag{14}$$

Finally, we derive the foreign and domestic demand for firm A:

$$x_{na} = \frac{\gamma q_A - q_B + P^*_{Bna} - P^*_{Ana}}{2\lambda} + \frac{1}{2} = \frac{\gamma q_A - q_B}{6\lambda} + \frac{1}{2}. \tag{15}$$

$$y_{na} = \frac{q_A - q_B + P_{Bna} - P_{Ana}}{2\lambda} + \frac{1}{2} = \frac{q_A - q_B}{6\lambda} + \frac{1}{2}. \tag{16}$$

The following remark summarizes the main properties of prices and demand.

Remark 1 *In the absence of price arbitrage between countries, an increase in the proportion of quality exported, γ, has a positive effect on the home firm export price, P^*_{Ana}, and the exports demand for the domestic firm, x_{na}, and a negative effect on the competitor's domestic price, P^*_{Bna}.*

However, a variation in the proportion of quality exported does not affect the domestic price, P_{Ana}, or domestic demand of the restricted firm. Neither does it affect the exports price of the non-restricted firm, P_{Bna}. Let us also note that the relative size of markets does not have any influence on the equilibrium prices and market shares.

2.1.2 Country A's problem

The government of country A sets the proportion of quality which the domestic firm is allowed to export. The optimal proportion is the one that maximizes welfare. Welfare in country A is a function of the domestic firm's profits, domestic consumer surplus, CS, and security, $S[\gamma]$, $S'[\gamma] < 0$, $S''[\gamma] < 0$:

$$W = \alpha\pi_A + \pi^*_A + \alpha CS + S[\gamma]. \tag{17}$$

The consumer surplus in country A has the following form:

$$CS = \int_0^y U_{iA} \partial d_{iA} + \int_0^{1-y} U_{iB} \partial d_{iB}. \tag{18}$$

The first element in the RHS of the above expression is the consumer surplus of consumers who buy from the home firm and the second element is the consumer surplus of the consumers who buy from firm B.

The first order condition of the maximization problem of the government is:

$$\frac{\partial W}{\partial \gamma} = \alpha \frac{\partial \pi_A}{\partial \gamma} + \frac{\partial \pi_A^*}{\partial \gamma} + \alpha \frac{\partial CS}{\partial \gamma} + S'[\gamma] = 0. \tag{19}$$

Using the equilibrium prices and quantities derived previously, we analyze the effect of a variation in γ on the different elements of the welfare function separately. In the absence of price arbitrage, the profits that the domestic firm obtains in the domestic market do not depend on the proportion of quality exported since neither the domestic demand nor the domestic price depend on it. Also, consumer surplus is not affected by a variation in γ because the prices at which domestic consumers buy from the domestic or the foreign firm are not affected by it.

However, an increase in the proportion of quality exported has a positive effect on the export profits of the domestic firm:

$$\frac{\partial \pi_A^*}{\partial \gamma} = \frac{\partial x_{na}}{\partial \gamma} P_{Ana}^* + \frac{dP_{Ana}^*}{d\gamma} x_{na} = \frac{q_A}{3\lambda} \left(\lambda + \frac{\gamma q_A - q_B}{3} \right). \tag{20}$$

Using equation (19) and the fact that security is the only term in the welfare function which is negatively affected by an increase in the proportion of quality exported, we can see that the government of the security concerned country will restrict the quality exported by the domestic firm only if the concern about security is sufficiently high.

2.2 Price Arbitrage

We now analyze what happens in our model when we introduce perfect price arbitrage between the two countries. Since firm B sells the same quality in the domestic and foreign market, it must charge the same price in both

markets. If the export price were lower than the domestic price, consumers in country B could always buy the good with the same quality and a lower price in the international market and viceversa.

2.2.1 Firms' problem

Using equation (1) and taking into account that the price of firm B under perfect price arbitrage coincides in both markets, i.e., $P_B^* = P_B$ (we use P_B in what follows) we obtain the following export demand for firm A:

$$x = \frac{\gamma q_A - q_B + P_B - P_A^*}{2\lambda} + \frac{1}{2}. \tag{21}$$

Similarly, we get firm A's domestic demand:

$$y = \frac{q_A - q_B + P_B - P_A}{2\lambda} + \frac{1}{2}. \tag{22}$$

Notice that the non arbitrage condition (equation 3) on P_A and P_A^* is fulfilled iff $y > x$. We will proceed under the assumption that the arbitrage constraint is not binding for firm A. The intuition for this is that since the home firm is not restricted in the domestic market, competition there is more intense; therefore the consumer will be always obtain a 'better deal' there. We will then check that the assumption is indeed satisfied in equilibrium.

Substituting x and y (equations (21) and (22)) in the profit maximization problem of firm A (equation (6)) we derive the first order conditions:

$$P_A = \frac{q_A - q_B}{2} + \frac{P_B}{2} + \frac{\lambda}{2}. \tag{23}$$

$$P_A^* = \frac{\gamma q_A - q_B}{2} + \frac{P_B}{2} + \frac{\lambda}{2}. \tag{24}$$

Using equations (23) and (24), it can be seen that the arbitrage condition is fulfilled.

Firm B must now set the same price in the export and domestic market due to the existence of perfect price arbitrage between the two countries:

$$\underset{\{P_B\}}{Max} \pi_B^* + \alpha \pi_B = P_B \left(1 - x + \alpha \left(1 - y\right)\right). \tag{25}$$

Substituting x and y into equation (25) we get the first order condition for firm B:

$$P_B = \frac{\lambda}{2} + \frac{q_B}{2} - q_A \frac{(\gamma + \alpha)}{2(1+\alpha)} + \frac{P_A^* + \alpha P_A}{2(1+\alpha)}. \tag{26}$$

Equations (23), (24) and (26) are the reaction functions of firms A and B. Note that they are upward sloping with respect to the competitors' price.

We now have a three equation system in P_A, P_A^* and P_B. In order to derive the equilibrium prices, first introduce equations (23) and (24) into equation (26) and isolate P_B in order to obtain its equilibrium value:

$$P_B = \lambda + \frac{q_B}{3} - q_A \frac{\gamma + \alpha}{3(1+\alpha)}. \tag{27}$$

It is interesting to compare the no arbitrage prices with the prices we get with perfect price arbitrage between the two countries. The export price that firm B sets if there is no arbitrage is smaller than the price it sets when there is arbitrage. However, its domestic price without arbitrage is higher than the price firm B sets when there is perfect price arbitrage. The reason is that firm B cannot discriminate between foreign and domestic consumers, hence, it must set a unique price for its good which lies in-between the two prices it sets when there is not perfect price arbitrage.

The properties of firm B's equilibrium price are also affected by the fact that, due to the existence of perfect price arbitrage, firm B cannot discriminate between domestic and foreign consumers. The price of firm B is decreasing in the proportion of quality exported by the competitor. If firm B could set different prices in markets A and B, a variation in the quality restriction for firm A would only affect the domestic price of firm B. With price arbitrage, however, a variation in the quality gap with firm A in the domestic market affects the price of firm B in both markets.

Also, notice that the price of firm B is decreasing in the relative size of the market of country A (i.e., α) as long as there is a restriction on the quality that firm A can export (i.e., if $\gamma < 1$). Since firm B must face the highest quality from the competitor in country A, if firm B could set different prices, it would set a lower price in market A than in market B. Since it cannot discriminate between the foreign and home markets it sets a price that is in-between the two prices it would set if it could discriminate. However, if the importance of market A increases (i.e., if α increases), firm B will set its price closer to the optimal price it would set in market A if it could discriminate.

Now, substituting equation (27) into equations (24) and (26) we get the equilibrium domestic price of firm A:

$$P_A = \lambda - \frac{q_B}{3} + \frac{q_A}{2}\left(1 - \frac{\gamma + \alpha}{3\,(1+\alpha)}\right). \tag{28}$$

The price that firm A sets in its home market is decreasing in the proportion of quality exported. The intuition is that an increase in the proportion of quality that firm A can export makes the price of the competitor decrease. This leads firm A to decrease its domestic price as well. Hence, even though the variation in quality exported does not directly influence the domestic price of firm A (since it does not affect the quality of its domestic product), there is an induced effect due to the existence of perfect price arbitrage between the two countries.

We can also see that when $\gamma < 1$, firm A's domestic price is decreasing in the size of the home market due to the indirect negative effect that this has on firm B's price. As we know when there is a restriction ($\gamma < 1$), the higher the relative size of market A the smaller the price of firm B and this induces a lower domestic price of the restricted firm, firm A.

Finally, we derive the equilibrium export price of firm A:

$$P_A^* = \lambda - \frac{q_B}{3} + \frac{q_A}{2}\left(\gamma - \frac{\gamma + \alpha}{3\,(1+\alpha)}\right). \tag{29}$$

Firm A's export price is increasing in the proportion of quality exported. An increase in this proportion allows the firm to set a higher price for any given P_B. Even though firm B reacts to the increase in A's quality by decreasing its price, the net effect on P_A^* is clearly positive. Also, for the same reason as before, the export price is decreasing in the size of the home market.

We can now compare the equilibrium prices of firm A with those that prevail in the absence of price arbitrage. Firm A's domestic price is higher when there is arbitrage than when there is not. Meanwhile, firm A's export price is smaller when there is perfect price arbitrage than when there is not. The intuition is based on the fact that the competitor sets an export price which is smaller than the unique price it could set with perfect price arbitrage. Since the competitor's export price is now smaller, firm A's domestic price becomes smaller too. The same argument follows for the export price of firm A.

Substituting the equilibrium prices in equation (21) and (22) we derive the foreign and domestic demand for firm A:

$$x = \frac{1}{2\lambda}\left(\frac{q_A}{2}\left(\gamma - \frac{\gamma+\alpha}{3\left(1+\alpha\right)}\right) - \frac{q_B}{3}\right) + \frac{1}{2}, \tag{30}$$

$$y = \frac{1}{2\lambda}\left(\frac{q_A}{2}\left(1 - \frac{\gamma+\alpha}{3\left(1+\alpha\right)}\right) - \frac{q_B}{3}\right) + \frac{1}{2}. \tag{31}$$

Both the domestic and foreign demands of firm A are decreasing in the relative size of market A. An increase relative size of market A has a negative effect on firm B's price and this effect outweighs the decrease in the prices of the domestic firm and therefore reduces its domestic and export demand. An increase in the proportion of quality allowed to be exported has a positive effect on the foreign demand of firm A and a negative effect on the domestic demand of firm A. Let us recall that firm B must sell at the same price in both markets. The increase in the quality exported by firm A makes firm B reduce the price of its good, this makes firm B's product more attractive for the consumers in country A.

Comparing the above expressions with equations (15) and (16) we see that the foreign demand of firm A is smaller with perfect price arbitrage between the two countries; however its domestic demand is higher. In Figure 1, x and y are closer in the absence of price arbitrage.

Let us summarize the main properties in the following proposition:

Proposition 1 *When there is perfect price arbitrage between countries, an increase in the proportion of quality exported has a negative effect on the price of the nonrestricted firm and the domestic price of the restricted firm and a positive effect on the export price of the restricted firm. Also, an increase in the proportion of exported quality has a positive effect of the export demand of the restricted firm and a negative effect on its domestic demand. An increase in the importance of the home market of the security concerned country has a negative effect on all prices as well as on the domestic and foreign demand of the restricted firm.*

We now analyze the optimal security policy of the security concerned government. The government in country A sets the proportion of quality which the domestic firm can export.

2.2.2 Country A's problem

Using equation (19) and the equilibrium prices and quantities derived above, we analyze the effect of a variation in the proportion of quality exported on the different elements of the welfare function.

We first analyze the effect of a decrease in the restriction on the consumer surplus in country A.

Proposition 2 *Under perfect price arbitrage, an increase (decrease) in the proportion of quality exported has a positive (negative) effect on domestic consumer surplus.*

Proof.

$$\frac{\partial CS}{\partial \gamma} = (R + q_A - P_A - \lambda y)\frac{\partial y}{\partial \gamma} - y\frac{\partial P_A}{\partial \gamma} -$$

$$-(R + q_B - P_B - \lambda(1-y))\frac{\partial y}{\partial \gamma} - (1-y)\frac{\partial P_B}{\partial \gamma}.$$

Substituting $\frac{\partial y}{\partial \gamma}$ above we get

$$\frac{\partial CS}{\partial \gamma} = -(1-y)\frac{\partial P_B}{\partial \gamma} - y\frac{\partial P_A}{\partial \gamma} = \frac{q_A}{3(1+\alpha)}\left(1 - \frac{y}{2}\right) > 0. \blacksquare$$

The intuition is that an increase in γ has a negative effect on the prices that domestic consumers must pay for buying the good from either the domestic or the foreign firm.

We now derive the effect of an increase in the proportion of quality exported on profits.

An increase in the proportion of quality allowed to be exported has a positive effect on the profits that firm A obtains from selling in the foreign market, i.e., $\frac{\partial \pi_A^*}{\partial \gamma} > 0$ and a negative effect on the profit it obtains in the home market, i.e., $\frac{\partial \pi_A}{\partial \gamma} < 0$.

$$\frac{d\pi_A^*}{d\gamma} = \frac{\partial x}{\partial \gamma}P_A^* + \frac{\partial P_A^*}{\partial \gamma}x = \frac{q_A}{3}\frac{2+3\alpha}{(1+\alpha)}x > 0,$$

$$\frac{d\pi_A}{d\gamma} = \frac{\partial y}{\partial \gamma} P_A + \frac{\partial P_A}{\partial \gamma} y = -\frac{q_A}{3\left(1+\alpha\right)} y < 0.$$

The negative effect of an increase in the quality allowed to be exported on firm A's domestic profits is due to the fact that firm B must sell its good at the same price in both markets. As a consequence of the increase in the proportion of quality exported, firm A faces a lower price from firm B. This reduces the profits that firm A gets in the home market.

We can now compare the incentives to introduce a quality restriction with perfect price arbitrage and without price arbitrage.

Proposition 3 *The introduction of restrictions to the quality of exported dual use equipment is less likely in the presence of price arbitrage.*

Proof. We first calculate the effect of a variation in the proportion of quality exported on the domestic firm's profits evaluated at $\gamma = 1$. Note that, when $\gamma = 1$, $x = y$, therefore, using (30) and (31), we get

$$\left.\frac{\partial\left(\alpha\pi_A + \pi_A^*\right)}{\partial\gamma}\right|_{\gamma=1} = \frac{q_A}{3\lambda}\left(\lambda + \frac{q_A - q_B}{3}\right).$$

Note that this coincides with the effect of a variation in the proportion of quality exported on the domestic firm's profits evaluated at $\gamma = 1$ when there is no price no price arbitrage, equation (20). As was said, in the absence of perfect price arbitrage, a variation in the proportion of quality exported does not affect the sum of consumer surplus. Finally, from the previous proposition, under perfect price arbitrage, a reduction in the proportion of quality exported will have a negative effect on consumer surplus. ■

We could discuss now what would happen if the government assigned a different weight on the welfare function to consumers' and producers' interests. In the case of no price arbitrage, a different weight on consumers would not have an impact on the decision to introduce an export control. We saw that with no price arbitrage export controls did not affect domestic consumer surplus. Therefore, the crucial factor deciding the introduction of export controls without price arbitrage remains the relative weight on security with respect to profits in the welfare function.

The introduction of perfect price arbitrage does not change things much. As seen in our last proposition, restrictions on exported quality have a negative impact on both producer profits and domestic consumer surplus. There-

fore, the higher the weight on producers' or consumers' interests, the less likely the introduction of an export control will be.

3 CONCLUDING REMARKS

It is becoming increasingly difficult to define the boundaries between military and civil technology since nowadays the spin-offs between them go in both directions. For this reason, the restrictions on the quality that the firms of security concerned countries are allowed to export affect a wide range of civil products. The most important examples are information technology and computers.

This paper has analyzed the effect of unilateral export controls on the domestic and foreign producers' profits and the welfare of the country that sets the export controls with and without perfect price arbitrage.

It has been proved that when there is perfect price arbitrage between countries, a looser restriction on the quality of the security sensitive product which is allowed to be exported makes the price of the foreign competitor of the restricted firm and the domestic price of restricted firm lower and the exports price of the restricted firm higher. By contrast, in the absence of price arbitrage between countries, a looser restriction only affects the market in which the restricted quality is sold. It has a positive effect on the home firm export price and the export demand for the domestic firm and a negative effect on the competitor's domestic price.

The effect on welfare of the introduction of quality controls with and without price arbitrage has also been analyzed . In the absence of perfect price arbitrage a looser restriction has a positive effect on the export profits of the restricted firm. Due to the negative effect that a restriction has on the domestic consumer surplus, the introduction of such restriction is less likely in the presence of price arbitrage. In other words, under the existence of price arbitrage the perceived negative security consequences of exporting state-of-the-art dual use goods must be higher for restrictions to be introduced.

The weight given in the welfare function to national security relative to consumer surplus and domestic firm's profits is a crucial factor in the decision of whether or not to impose and export control. Such weight is likely to be influenced by the lobbying activities carried by the producers and consumers of dual-use products and defence authorities.

The paper assumes that the non restricted qualities are exogenous. Relax-

ing this assumption would imply having to make a further set of assumptions on the timing of the decisions and firm cost structures. Depending on the commitment power of the government, the export control stage could go before or after the stage where firms compete in qualities. Also, some asymmetry on cost structures would have to be included to reflect the idea that the restricting country is technologically more advanced. An initial analysis of the impact of export controls on quality can be found in Garcia-Alonso(2000). However, further research in that area is currently being developed.

Finally, given the impact that increased market integration may have over export control decisions, more empirical evidence is needed on the importance of international price arbitrage in state-of-the-art computer products.

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