Saving Dolphins:

Boycotts, trade sanctions, and unobservable technology[*]

Kaz Miyagiwa

Emory University

Correspondence: Kaz Miyagiwa, Department of Economics, Emory University, 1602 Fishburne Drive, Atlanta, GA, 30322-2240, U.S.A.; E-mail: kmiyagi@emory.edu; Telephone: (404) 727-6363; Fax: (404) 727-4639

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Abstract

Consumers often boycott imported goods because they do not approve the way they are manufactured, e.g., children are employed or animals are killed. We examine the effect of boycotts and trade policy in influencing the way the goods are manufactured when domestic consumers cannot observe the actual production. We find that boycott threats can give the manufacturer the incentive to choose the production mode consumers prefer. If boycotts have a negligible demand effect, tariffs and quotas can reinforce the boycotts. However, if boycotts have a substantial demand effect, the imposition of ad valorem tariffs yields the opposite outcome.

1. Introduction

Over the past quarter of a century consumers have become increasingly vocal about the particular ways the articles they purchase are manufactured. For example, in the late 1980s the widespread manifestation of consumer concern over dolphin deaths led to the canned-tuna boycott in the U.S., followed by embargoes of tuna imports from countries whose fishing fleets allegedly killed more dolphins than U.S. fishermen did. In Europe, consumers launched a boycott of handmade carpets from India in response to reports that they were made by children in conditions of bonded labor. In the late 1990s, American consumers, this time concerned over turtle deaths, called for a boycott of wild shrimp imported from East Asian countries. A boycott has also been called for against clothes and sporting goods for suspicions of child labor or poor working conditions, cosmetics and pharmaceutical products for alleged testing on animals, and oil and computer products for lack of environmental safety.

Despite such highly visible cases of consumer activism, there is little formal analysis investigating how boycotts affect the way targeted firms and industries manufacture their products. The objective of this paper is to initiate such investigation. This paper highlights the fact that the quality of the goods targeted for a boycott does not depend on the way they are manufactured. After all, tuna are tuna, whether or not they are caught with dolphin-safe nets. Thus, inspection and consumption of the products reveal no information on the actual production process in which they are manufactured.[1] The primary goal of this paper is to

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[1] Thus, the good is distinct from the experience good, whose quality can be learned by use, and the credence good, whose quality can be revealed by hiring experts.

examine whether, when consumers never observe the actual production, boycott threats can steer the manufacturer to the production process favored by consumers.

Since targeted goods are mostly foreign-made, consumer groups also pressure the government to limit or ban importation of the goods. However, restricting imports is often criticized because tariffs and quotas are blunt policy instruments hurting all the exporters regardless of the way they manufacture. The secondary goal of this paper therefore is to evaluate the efficacy of trade policy instruments on the furtherance of consumer concerns.

Our model is outlined as follows. We suppose that a foreign firm exports a certain product to the domestic market. The foreign firm can manufacture the product with either the high-cost or the low-cost technology. The latter entails employment of child workers or neglect of animal, workplace, and environmental safety, etc. Further, whichever technology the firm uses, the quality of the good is the same so domestic consumers never find out which technology is actually used. Consumers however use the price to infer the technology, and threaten to boycott if there is some suspicion that it is manufactured with the low-cost technology.

The problem is that the foreign manufacturer may share consumers' concerns. But consumers cannot observe this human side of the manufacturer. Therefore, even if he does not succumb to the temptation to use the low-cost technology for a greater profit, the manufacturer still faces the problem of convincing suspicious consumers that he uses the high-cost technology.

The general conclusion we obtain here is that, even though consumers lack the wherewithal to verify the manufacturer's production, boycott threats can be effective enough to steer the manufacturer towards the high-cost technology. Restricting import yields the same

qualitative effect when boycott threats are weak, meaning that tariffs and quotas can be used to supplement boycotts. However, when boycotts have a substantial impact on demand, the imposition of ad valorem tariffs gives the manufacturer less of an incentive to employ the high-cost technology.

Our paper is most closely related to the recent works of Jinji (2003a, b), who develops the model in which the domestic country imports food from the dominant firm producing genetically modified food and the competitive fringe that produces GMO-free food. Domestic consumers prefer GMO-free food but cannot distinguish it from food containing GMOs. Although the situation he analyzes is similar to ours, there are important differences. The primary difference is that in his model the firm's technology is exogenously given, while influencing the firm's technology choice is our central concern. Because the technology is given, the firm's only concern is concealment of its identity among exports from the fringe. Secondly, his analysis focuses on the effect of product labels while we study the effect of boycotts and trade policy on the firm's technology choice. Further, he assumes the label to be truthful, which implies that the firm's technology is verifiable. This assumption is reasonable under the fixed technology, but may be inappropriate when the firm can easily change production modes or independent oversight of the firm is impossible.

The present paper is also related to the recent research on child labor; see, e.g., Basu and Van (1998), Swinnerton and Rogers (1999), Baland and Robinson (2000), and Bommier and Bubois (2004). While this literature examines the supply (household) side of the child labor problem, this paper studies its demand (firm) side, emphasizing the informational aspects of derived demand for child labor.

In a broader context, this paper also contributes to the strand of literature on international monopoly under incomplete and imperfect information, see, e.g. Bagwell and Staiger (1989), Bagwell (1991), Collie and Hviid (1994), and Kolev and Prusa (2002). In particular, our model shares a number of features with that of Bagwell (1991). In his model a foreign firm produces a new good that goes through two phases: introductory and mature. Consumers do not know the quality of the good in the first phase but gain full knowledge of it by purchase, and if the quality is high they demand more in the second phase. Thus, the firm must resist the temptation to choose the low quality for a short-run profit and also convince consumers that the quality is high. Thus, both moral hazard and adverse selection problems are also present in Bagwell's model.

The next section sets up the model. Section 3 characterizes the equilibrium of the model. Section 4 analyzes the effect of boycotts and Section 5 the effect of tariffs and quotas. Section 6 concludes. The appendix contains proofs of the lemmas and propositions presented in the text.

2. The Model

Consider a foreign firm exporting to the home country market. The firm can produce the good with technology H or technology L. The unit production cost is constant at c_i (i = H, L), with $c_H > c_L \geq 0$. The unit cost under technology L is lower because it entails employment of child labor or neglect of animal, workplace or environment safety. If the manufacturer chooses technology H (L), we call him the high-cost (low-cost) type. Whichever technology the manufacturer chooses, the quality of the product he produces is the same, so consumers never find out which technology he has actually used. Consumers however use the price p to

form beliefs, $\mu(p)$, as to the probability that the firm uses technology H. Beliefs $\mu(p)$ are common but consumers react differently to μ as their preferences towards technology L differ. In particular, we assume that, whenever $\mu < 1$ so that there is some suspicion that technology L is used, there are always some consumers who refuse to buy the product or buy it only if it becomes sufficiently inexpensive. We refer to such behavior as "boycott".

We assume for simplicity that the firm has no sales in the foreign market. Relaxing this assumption has no effect of substance on our results, and is discussed in the concluding section of the paper. Home country demand is affected by the extent of a boycott. Write the demand function as $D[p, b(\mu)]$, where $b(\mu)$ denote the extent of a boycott that results when consumers hold beliefs μ.

Assumption 1:

(A)) $D[p, b(\mu)]$ is continuous and decreasing both in p and $b(\mu)$.

(B) For each μ, there is a choke price $p^c(\mu)$ so that $D[p, b(\mu)] = 0$ for all $p \geq p^c(\mu)$.

Thus, the boycott, $b(\mu)$, is a shift parameter in the demand function, but itself depends on beliefs μ as to the probability that the firm uses technology H. We express this dependence as a function b; that is, $b(\mu)$ is the image of beliefs μ under b, which we call a boycott function.

Assumption 2: The (boycott) function b: $[0, 1] \to [0, \infty)$ is (weakly) monotone decreasing, with $b(1) = 0$ and $b(\mu) > 0$ for all $\mu < 1$.

Figure 1 graphs one such function. The specifications on the values of the boycott function say that unless $\mu = 1$ there are consumers who boycott in the sense defined above. The boycott function in general need not be continuous. Monotonicity ensures that, the higher μ, the fewer consumers boycott. The usefulness of all this formalism is that it enables us to analyze the effect of an exogenous change in consumers' propensity to boycott as a point-wise shift of a boycott function at all $\mu < 1$, as illustrated in Figure 1. We refer to this exogenous shift in the boycott function as a change in consumers' propensity to boycott or more simply a change in boycotts.

Example:

We give a simple example of market demand that satisfies the above assumptions. Suppose that domestic consumers vary in their preference for the product, with preference types θ distributed uniformly over the unit interval $\Theta = [0, 1]$. Normalize the consumer mass to unity. Assume each consumer purchases at most one unit of the good. If consumers know the product is produced with technology H, i.e., $\mu = 1$, a consumers of type θ derives a net utility $(\theta - p)$ from purchasing a unit, and zero utility otherwise. Consumers of type θ who are indifferent between buying and not buying the product are identified by the equation: $\theta - p = 0$, leading to the market demand: $D[p, b(1)] = 1 - p$

If the consumers are all convinced that technology L is used ($\mu = 0$), some consumers (a fraction λ) feel the compunction from purchase of the good. For such consumers the net utility of consuming the good falls to u $= \theta - (p + \gamma(\theta))$, with $\gamma(\theta)$ (>0) denoting this compunction in utility units. The remaining consumers (fraction $1 - \lambda$) do not care and behave the same way as

they do when $\mu = 1$. Assume that) and are independent of . Then the market demand is given by

$$D[p, b(0)] = (1 - p -)) + (1 -)(1 - p) = (1 - p) -).$$

For $1 > \mu > 0$, assume that the fraction of consumers buy the product if and only their expected utilities are positive, or $\mu(- p) + (1 - \mu)(-) - p) = - p - (1 - \mu))$ 0. Then, the corresponding market demand is

$$D[p, b(\mu)] = (1( )(1 - p) + [1 - p - (1 - \mu))] = 1(p -)(1 - \mu).$$

Let the (value of the) boycott function be given by

$$b(\mu) \quad)(1 - \mu), \qquad \mu \quad [0, 1].$$

The boycott function and the demand function evidently satisfy assumptions 1 and 2.[2]

Returning to the general case, given the boycott function, let $\pi_i[p, b(\mu)]$ be the profit to the manufacturer that uses technology i and faces boycott $b(\mu)$:

$$\pi_i[p, b(\mu)] \quad \max \{D[p, b(\mu)](p - c_i), 0\}.$$

Assume that $\pi_i[p, b(\mu)]$ is strictly concave in p where it assumes positive values. Figure 2 depicts four profit functions. The two solid curves represent the profits obtainable when consumers' beliefs are correct. If the manufacturer uses technology H and successfully convinces consumers ($\mu = 1$), the profit is $\pi_H[p, b(1)]$, depicted by the solid curve through point c_H. If the manufacturer uses technology L and consumers infer correctly ($\mu = 0$), the profit is $\pi_L[p, b(0)]$, represented by the solid curve through c_L. Define $p_H^* \quad \text{argmax} \{\pi_H[p, b(1)]\}$ and

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[2] Alternatively, if we assume $b(\mu) = b(0)$ for all $\mu < 1$, we have the most unforgiving consumers, for the slightest suspicion that the firm uses technology L induces the consumers to boycott with as much intensity as when they are 100 percent certain that the firm uses technology L.

p_L^* argmax $\{\pi_L[p, b(0)]\}$ and refer to them as the full-information (profit-maximizing) prices.

Since consumers cannot verify the firm's technology, errors can also occur. The dotted curves in Figure 2 represent the profits in such cases. If the manufacturer uses technology L and succeeds in fooling consumers into believing that it uses technology H, the firm gets the profit $\pi_L[p, b(1)]$, the dotted curve through c_L. On the other hand, if the firm uses technology H but consumers do not believe it, the profit is $\pi_H[p, b(0)]$, the dotted curve through c_H.

The final element of the model is that the manufacturer shares consumers' concerns. However, consumers are not sure to what extent he does. We capture this uncertainty by assuming that the manufacturer can be of any type , $[0, \bar{\,}]$. Consumers do not observe the actual , but believe that , is distributed over full support $[0, \bar{\,}]$ with distribution $F(,)$.

Consumers know that the manufacturer of type , derives a utility $\{\pi_L[p, b(\mu)] - , \}$ when using technology L and $\pi_H[p, b(\mu)]$ when using technology H. In this sense, , , measures the guilt or compunction the manufacturer feels when using technology L. An alternative interpretation is that , represents the extent of law enforcement in the foreign country to eradicate child labor or enforce use of dolphin-safe nets, etc. In this interpretation, higher , means stronger law enforcement so that the manufacturer, if caught using technology L, suffers a greater loss. However, consumers cannot observe how stringently the laws are enforced in the foreign country.

Formally, the model is a one-shot extensive-form game with three stages. In stage one, Nature selects a firm type , from the interval $[0, \bar{\,}]$ according to distribution $F(,)$, where $\bar{\,} > 0$. In stage two, the manufacturer chooses a technology from $\{H, L\}$ and a price p from $[0, \quad)$ to maximize his utility

$$u(,\ ) = \max\ \{\pi_H[p, b(\mu)],\ \pi_L[p, (\mu)] - ,\ \}.$$

In stage 3, consumers observe the price but neither the firm type , nor the technology. Consumers use the price to form beliefs $\mu(p)$ as to the probability that the firm uses technology H, and then make purchasing decisions.

3. Sequential Equilibrium

We solve the game using sequential equilibrium as a solution concept (Kreps and Wilson, 1982). Roughly speaking, a sequential equilibrium consists of strategies and beliefs such that strategies are best responses, given the other players' strategies and beliefs (sequential rationality), while beliefs are Bayes-consistent on the equilibrium path. Since sequential equilibrium places only mild restrictions on beliefs off the equilibrium paths, the model yields a plethora of equilibria, including separating and pooling. To prune the equilibria supported by unreasonable out-of-equilibrium beliefs, we apply the Cho-Kreps (1987) intuitive criterion.

A moment's reflection reveals that the manufacturer never uses technology H if $\bar{,} = 0$ i.e., the manufacturer is concerned only with profits. That is because, once he chooses technology H and offers a price that wins consumers' trust, he has the incentive to maintain that price to keep the demand high and secretly switch to technology L. However, consumers see through his motive and never trust him. Thus, beliefs are $\mu(p) = 0$ for all p. Then it is optimal for the manufacturer to choose technology L and sell at p_L*. This reasoning extends to a more general setting.

Proposition PE1: If b(0) and $\bar{,}$ are small enough to satisfy

(1) $\qquad \pi_L[p_L{}^*, b(0)] > \pi_H[p_H{}^*, b(1)] + \bar{,},$

the model possesses a unique equilibrium outcome, in which the manufacturer always chooses

technology L and sets the price at p_L*. The equilibrium beliefs are $\mu(p_L$*$) = 0$.

Call this pooling equilibrium outcome PE1. Condition (1) says that the manufacturer has no

incentive to choose technology H regardless of his compunction. In equilibrium consumers'

beliefs prove correct. [3] PE1 can be visualized in Figure 3, which shows only the profit to the

high-cost type and the low-cost type at $\mu = 1$. In Figures 3A and 3B, PE1 occurs when the

equilibrium profit $\pi_L[p_L$*$, b(0)]$ is high enough to be in the zone labeled PE1.

A separating equilibrium occurs if the manufacturer chooses different technologies and

the prices that reveal the technology choices.[4] Let p_H (p_L) denote the price for the high-cost

(low-cost) type. Lemma 1 gives the equilibrium price set by the low-cost type.

Lemma 1: In a separating equilibrium, having chosen technology L, the manufacturer always

sets price equal to p_L* and earns the full-information maximum profit, $\pi_L[p_L$*$, b(0)]$.

As for the determination of the equilibrium price for the high-cost type, we distinguish

two kinds of separating equilibrium. We have a fist kind if

(2) $\qquad \pi_L[p_H$*$, b(1)] \le \pi_L[p_L$*$, b(0)] \le \pi_H[p_H$*$, b(1)] + \bar{,}.$

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[3] An equilibrium consists of strategies and beliefs. Although the equilibrium outcome of the proposition is unique, out-of-equilibrium beliefs are not. We put $\mu(p) = 0$ for p not equal to p_L*.

[4] Separation refers to the fact that prices reveal the manufacturer's technology, not his compunction. Since there is a continuum of compunction types, this equilibrium is, strictly speaking, semi-pooling vis-à-vis compunction in that the compunction types are partitioned into two and all types in each group select the same technology.

In Figure 3A, (2) is satisfied if $\pi_L[p_L{}^*, b(0)]$ is high enough to be in the zone labeled SE2. The first inequality says that the low-cost type receives a greater profit revealing his technology than masquerading as the high-cost type. Thus, once having chosen technology L, the manufacturer has no incentive to masquerade as the high-cost type even at the most favorable beliefs ($\mu = 1$). That would be the case if a boycott has a relatively small effect on demand. On the other hand, the second inequality reverses the one in (1) and says that the manufacturer of the most compunctious type prefers to use technology H if setting the price equal to $p_H{}^*$ convinces consumers of his technology choice. Thus, there exists

(3) $\tilde{}[b(0)]$ $\pi_L[p_L{}^*, b(0)] - \pi_H[p_H{}^*, b(1)]$ $[0, \bar{}]$.

Proposition SE2: Suppose condition (2) holds. Then

(A) The model yields a unique intuitive separating-equilibrium outcome, in which the manufacture chooses technology H if he is type , $\geq \tilde{}[b(0)]$ and technology L otherwise.

(B) The high-cost type sets price equal to $p_H{}^*$, and the low-cost type $p_L{}^*$.

(C) The ex ante probability of technology H being used is $\{1 - F(\tilde{}[b(0)])\}$.

Call this separating equilibrium outcome SE2.

A second type of separating equilibrium arises if the first inequality in (2) is reversed:

(4) $\pi_L[p_L{}^*, b(0)] \leq \pi_L[p_H{}^*, b(1)]$.

This case occurs when the profit $\pi_L[p_L{}^*, b(0)]$ is in the zone SE3 in Figure 3A and Figure 3B. This case is also illustrated in Figure 2. (4) says that, having chosen technology L, the manufacturer has the incentive to masquerade as the high-cost type if choosing the price $p_H{}^*$ is enough to win the consumers' trust. Thus, in a separating equilibrium the high-cost type must

distort the price away from p_H^* sufficiently to deter mimicry by the low-cost type. That is, p_H must satisfy:

(5) $\qquad \pi_L[p_L^*, b(0)] \quad \pi_L[p_H, b(1)].$

Although the equilibrium profit to the high-cost type is smaller than at p_H^*, he should still be able to earn at least as much as he could earn under the most pessimistic belief assessment (i.e., $\mu = 0$). That is, p_H should also satisfy:

(6) $\qquad \pi_H[p_H, b(1)] \geq \max_p \{\pi_H[p, b(0)]\} \quad \pi_H^*[b(0)].$

To sum, a second type of separating equilibrium requires that p_H satisfy both (5) and (6). It can be shown (see Figure 2 and lemma 4 in the appendix) that both conditions are satisfied if and only if $p_H \quad [\underline{p}, \overline{p}]$, where $\underline{p}$ and $\overline{p}$ are, respectively, the upper root of the equations

(5') $\qquad \pi_L(p_L^*, 0) - \pi_L[p, b(1)] = 0,$

and

(6') $\qquad \pi_H[p, b(1)] - \pi_H^*[b(0)] = 0.$[5]

Although any price belonging to the interval $[\underline{p}, \overline{p}]$ qualifies as a candidate equilibrium price, we show, in the appendix, that an appeal to the Cho-Kreps intuitive criterion prunes all but the lowest price $\underline{p}$ as an equilibrium price.[6]

Define

(7) $\qquad \overset{\wedge}{,} (\underline{p}) \quad \pi_L[p_L^*, b(0)] - \pi_H[\underline{p}, b(1)] \quad (0, ,).$

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[5] These roots exist because the profit functions are concave and there are choke-off prices.

[6] Lemma 4 in the appendix shows $[\underline{p}, \overline{p}]$ is an interval.

Proposition SE3: Suppose (4) holds

(A) The model yields a unique intuitive separating-equilibrium outcome, in which the manufacture chooses the high-cost technology if he is type , $\geq \hat{,}(\underline{p})$ and the low-cost technology otherwise.

(B) The high-cost type set the price equal to $\underline{p}$ $(> p_H{}^*)$ and the low-cost type $p_L{}^*$.

(C) The ex-ante probability of technology H being used is $\{1 - F[, \hat{}(\underline{p})]\}$.

Call this separating equilibrium outcome SE3.

We next consider pooling equilibria. We have already seen one type of pooling equilibrium, namely, PE1, in which the manufacturer, regardless of compunction types, chooses technology L and sets price equal to $p_L{}^*$. It turns out that that is the only type of pooling equilibrium yielded by this model.

Proposition 4: The model yields no intuitive pooling equilibrium outcome, in which the manufacturer chooses different technologies, depending on his compunction level, and yet charges an identical price.[7]

4. The effect of a boycott

In this section we examine the effect of exogenous changes in the consumers' propensity to boycott on the firm's technology choice; that is, a point-wise upward shift in the

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[7] The restrictions on $b(\mu)$ in Assumption 2 are crucial for this result. If $b(\mu) = 0$ for μ (0, 1] there are pooling equilibria that survive refinements based on the intuitive criterion or criterion D1.

boycott function b at all $\mu < 1$. However, we need be concerned only with an increase in b(0), since by Proposition 4 we can ignore the pooling equilibrium.

It is inferred from Propositions PE1, SE2 and SE3 that the low-cost type always receives $\pi_L[p_L*, b(0)]$. An increase in b(0) reduces demand and $\pi_L[p_L*, b(0)]$ by Assumption 1. But if this has a negligible effect on demand, we are likely to be in PE1, provided that $\overline{}$ is small enough to satisfy (1). However, as b(0) increases, $\pi_L[p_L*, b(0)]$ falls, thereby eventually leadingto SE2 or SE3. We consider two cases depicted in Figure 3.[8]

Case I: $\pi_L[p_H*, b(1)] \leq \pi_H[p_H*, b(1)] + \overline{}$,

This case corresponds to Figure 3A. The inequality satisfies condition (2) for SE2. Thus, as $\pi_L[p_L*, b(0)]$ steadily declines, the equilibrium shifts from PE1 to SE2. In SE2, the profit for the high-cost type remains constant at $\pi_H[p_H*, b(1)]$. Thus, a further rise in b(0) induces switching to technology H at the margin.

When $\pi_L[p_L*, b(0)]$ falls to equal $\pi_L[p_H*, b(1)]$, we move into SE3. In SE3, a further fall in $\pi_L[p_L*, b(0)]$ makes masquerading more attractive, so the high-cost type must distort the price $\underline{p}$ further to deter mimicry. That is, in SE3 an increase in consumer's propensity to boycott hurts both the high-cost and the low-cost type. If the profit to the high-cost type falls more relative to the profit to the low-cost type, an increase in boycott or boycott threats would discourage use of technology H. To examine this possibility we find this next lemma useful.

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[8] Note that, if $\pi_L[p_H*, b(0)] \leq \pi_H[p_H*, b(1)] + \overline{}$, PE1 does not exist.

Lemma 2: In SE3, the manufacturer uses technology H if and only if his compunction level exceeds

$$(8) \qquad \overset{\wedge}{,}(\underline{p}) = D[\underline{p}, b(1)](c_H - c_L).$$

Proof: $\qquad \overset{\wedge}{,}(\underline{p}) \quad = D[\underline{p}, b(1)](\underline{p} - c_L) - D[\underline{p}, b(1)](\underline{p} - c_H)$

$$\qquad\qquad\qquad = D[\underline{p}, b(1)](c_H - c_L),$$

where the first equality is the definition and the second follows from (5'). $\qquad\qquad\square$

Now, recall that in SE3 an increase in boycotts increases $\underline{p}$, which reduces the demand $D[\underline{p}, b(1)]$. Then, by lemma 2 $\overset{\wedge}{,}(\underline{p})$ decreases, meaning that technology H is adopted with a greater probability.

<u>Case II</u>: $\qquad \pi_L[p_H{}^*, b(1)] > \pi_H[p_H{}^*, b(1)] + \bar{,}$

This case is depicted in Figure 3B. In this case, as consumer's propensity to boycott increases, the equilibrium outcome moves from PE1 to equilibrium SE3. Once in SE3, the effect of the spreading of boycotts is the same as in Case I.

Proposition 5:

(A) With a sufficiently strong consumer's propensity to boycott, the model yields a separating equilibrium outcome. A further increases in propensity to boycott raises probability of technology H being used.

(B) In SE3, an increase in the propensity to boycott hurts the manufacturer even when using technology H.

We have shown that an increase in boycotts gives the manufacturer more of an incentive to adopt technology H. When technology H has actually been adopted, there are no more dolphin deaths or other undesirable outcome associated with technology L. However, in our model use of technology L occurs with positive probability, so one may wonder if, given that technology L is chosen, an increase in boycotts can lead to fewer dolphin deaths? If dolphin deaths are proportional to the level of output under technology L, the answer is generally in the affirmative. As demand falls as a result of more boycotts, the optimal output level declines for the low-cost type, and hence fewer dolphin deaths occur. However, depending on how boycotts affect the market demand, it is conceivable that more boycotts lead to more dolphin deaths. As a simple example, take the setting in the example given in Section 2. Set $= 1$ so that every consumer potentially boycott when technology L is used. Assume further that beliefs $\mu = 0$ reduce the reservation utility of consumers of type $> b(0)$ to $[1 - b(0)]$. We then have $D[p, b(0)] = 1 - p$ for $p \leq 1 - b(0)$ and zero demand otherwise. With this truncated demand, the profit-maximizing output is the corner solution: $x_L^* = b(0)$ for $b(0)$ sufficiently large. As $b(0)$ increases, output rises, causing more dolphin deaths.

5. Import restrictions

In the previous section we showed that an increase in consumers' propensity to boycott raises the probability of technology H being used under the assumption that an increase in boycotts reduce demand sufficiently. In this section we study the effect of import restrictions while holding the boycott function constant. The problem with trade policy in general, as noted in the introduction, is that tariffs and quotas are blunt instruments, hurting the manufacturer

regardless of the technology he employs. Thus, there is no a priori assurance that they can reinforce boycotts in inducing use of technology H.

In this section we thus examine the effect of three popular policy instruments: ad valorem tariffs, specific tariffs, and import quotas. For ease of exposition we assume that the profit function is continuously differentiable in p. Before examining the effect of these trade policy instruments, however, let us present

Proposition 6: In equilibrium the low-cost type exports a greater quantity than the high-cost type.

Proof. If the proposition is false, then in SE2 we have $D[p_H{}^*, b(1)] \geq D[p_L{}^*, b(0)]$, and hence

$$D[p_H{}^*, b(1)](p_H{}^* - c_L) > D[p_L{}^*, b(0)](p_L{}^* - c_L).$$

Similarly, in SE3 we have $D[\underline{p}, b(1)] > D[p_L{}^*, b(0)]$ and hence

$$D[\underline{p}, b(1)](\underline{p} - c_L) > D[p_L{}^*, b(0)](p_L{}^* - c_L).$$

In either case the low-cost type mimics the high-cost type, disturbing the equilibrium. $\square$

This result may seem intuitive enough since the high-cost type charges a higher price but not so obvious once you recall that the low-cost type is boycotted.

5.1 Ad valorem tariffs

Suppose we are in PE1 or SE2, in which the manufacturer compares the full-information profits when choosing the technology. We thus evaluate the relative effect of the

ad valorem tariff, t, on the full-information profits. Let T ᴝ 1/(1 + t). Then the tariff-ridden profit is written

$$\pi_i[p_iT, b(\mu)] = D[p_i, b(\mu)](p_iT - c_i),$$

where p_i is the price consumers pay. As p_i^* is optimally chosen, by the envelope theorem

$$d\pi_L[p_L^*T, b(0)]/dt - d\pi_H[p_H^*T, b(1)]/dt$$

$$= \{p_L^*D[p_L^*, b(0)] - p_H^*D[p_H^*, b(1)]\}dT/dt,$$

with $dT/dt < 0$. Thus, the relative impact of the ad valorem tariff depends on the difference in sales revenue (value of pre-tax sales) to the firm under the two technologies. Assuming decreasing marginal revenue, a fall in price raises revenue, but since demand is lower with a boycott, we cannot a priori tell the revenue difference.

If a boycott has a negligible effect on demand in the sense that $D[p, b(0)] - D[p, b(1)]$ at all prices, the revenue is greater at p_L^* than at p_H^* and hence

$$d\pi_L[p_L^*T, b(0)]/dt < d\pi_H[p_H^*T, b(1)]/dt < 0;$$

that is, the ad valorem tariff hurts the low-cost type more than the high-cost type, and therefore encourages use of technology H at a margin. On the other hand, when a boycott has a substantial impact on demand so that the revenue is smaller for low-cost type than for the high-cost type, then an increase in the ad valorem tariff rate hurts the high-cost type more, thereby discouraging use of technology H.

The above analysis does not quite apply in SE 3, as the high-cost type does not earn the full-information profit. In SE3, by lemma 2 the borderline compunction level is given by

$$\hat{\gamma}(\underline{p}) = D[\underline{p}, b(1)](c_H - c_L)$$

which depends on the distorted consumer price $\underline{p}$ but not directly on the tariff rate.[9] Since $\hat{,}(p)$ is decreasing in $\underline{p}$, an increase in the tariff rate encourages use of technology H only if it increases $\underline{p}$. To determine the effect of the tariff on $\underline{p}$, use the fact that the profit to the low-cost type from mimicking $\underline{p}$ is equal to his equilibrium profit; that is, $\underline{p}$ is given by

$$\pi_L[p_L*T, b(0)] - \pi_L[\underline{p}T, b(1)] = 0,$$

analogously to (5'). Differentiating yields

$$\partial\underline{p}/\partial t = (dT/dt)\{p_L*D[p_L*, b(0)] - \underline{p}D[\underline{p}, b(1)]\}/\{\partial\pi_L[\underline{p}T, b(1)]/\partial\underline{p}\}.$$

Since the denominator on the right-hand side is negative, the effect again depends on the revenue difference. If a boycott has a negligible effect on demand, we have $\partial\underline{p}/\partial t > 0$ and hence the tariff raises the probability of technology H being used. However, we are likely to be in SE3 because boycotts substantially reduce demand. In such cases, the imposition of ad valorem tariffs reduces probability of technology H being used.

5.2 Specific tariffs

The above problem with ad valorem tariffs does not arise with specific tariffs. To see this, compare the profits under full information under the specific tariff s. The tariff-ridden profit is $\pi_i[p_i - s, b(\mu)] = D[p_i, b(\mu)](p_i - s - c_i)$. With p_i* chosen optimally, we have

$$d\pi_L[p_L* - s, b(0)]/ds - d\pi_H[p_H* - s, b(1)]/ds$$

$$= D[p_H*, b(1)] - D[p_L*, b(0)].$$

It is easy to check that Proposition 6 holds under the tariff; that is, the low-cost type exports more than the high-cost type in equilibrium under the tariff. Hence,

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[9] See the proof of lemma 2.

$$d\pi_L[p_L{}^* - s, b(0)]/ds < d\pi_H[p_H{}^* - s, b(1)]/ds < 0.$$

As the profit for the low-cost type falls more relative to that for the high-cost type, the specific tariff increases the incentive to use technology H in PE1 or SE2.

The result is the same for SE3. To show this, recall that by lemma 2 the borderline type is given by

$$\hat{\gamma}(\underline{p}) = D[\underline{p}, b(1)](c_H - c_L).$$

This expression depends on the specific tariff indirectly through its effect on $\underline{p}$. $\underline{p}$ is determined by

(9) $$\pi_L[p_L{}^* - s, b(0)] - \pi_L[\underline{p} - s, b(1)] = 0,$$

which is analogous to (5'). Differentiating yields

$$\partial\underline{p}/\partial s = \{D[\underline{p}, b(1)] - D[p_L{}^*, b(0)]\}/\{\partial\pi_L[\underline{p} - s, b(1)]/\partial\underline{p}\} > 0$$

where the inequality is from Proposition 6 and the fact that the denominator is negative. Hence, the tariff raises the price for the high-cost type, which lowers $\hat{\gamma}(\underline{p})$ and raises probability of technology H being used.

The next proposition summarizes the effect of tariffs.

Proposition 7: The imposition of specific tariffs encourages use of technology H. The imposition of ad valorem tariffs has the same effect if a boycott has a negligible impact on demand but the opposite effect if a boycott has a substantial demand effect.

5.3. Import Quotas

We now turn to import quotas. Let Q denote the quota. For the quota to be effective, Q < $D[p_L{}^*, b(0)]$, which is assumed throughout. The effect of a quota is best understood with the

aid of Figure 4. In the figure, the straight line through c_L represents the equation $\pi = Q(p - c_L)$, which cuts the profit curve $\pi_L[p_L, b(0)]$ at $p_L(Q)$, as shown. Therefore, $p_L(Q)$ is the price at which the quota binds exactly when consumer beliefs are $\mu = 0$; that is, $Q \quad D[p_L(Q), b(0)]$. Similarly, the line cuts the profit curve $\pi_L[p_H, b(1)]$ at $p_H(Q)$. Then, $Q \quad D[p_H(Q) b(1)]$; i.e., $p_H(Q)$ is the price at which the quota Q binds exactly at $\mu = 1$. Also, $b(1) < b(0)$ implies $p_H(Q) > p_L(Q)$ as seen in the figure.

A decrease in Q lowers the slope of the line $\pi = Q(p - c_L)$. This raises $p_L(Q)$ and lowers the profit $\pi_L[p_L(Q), b(0)]$ to the low-cost type. But how does it affect the profit to the high-cost type? The next lemma characterizes the equilibrium outcome.

Lemma 3.

(A) In the separating equilibrium (SE2, SE3), the low-cost type meets the quota but the high-cost type does not.

(B) In the pooling equilibrium (PE1), $p_H{}^* > p_H(Q)$.

Proof: If the quota binds for the high-cost type in a separating equilibrium, then $p_H(Q)$ is the equilibrium price for the high-cost type. Then, since $p_H(Q) > p_L(Q)$, we have

$$Q[p_H(Q) - c_L] > Q[p_L(Q) - c_L],$$

meaning that the low-cost type has the incentive to mimic $p_H(Q)$; a contradiction. The same reasoning applies in PE1. If $p_H{}^* \leq p_H(Q)$, the profit is higher at $p_H(Q)$ than at $p_L(Q)$ for the low-type, thereby disturbing the equilibrium. □

Lemma 3 indicates that in PE1 or SE2 we have $p_H^* > p_H(Q)$ so that the imposition of the quota leaves $\pi_H[p_H^*, b(1)]$ unaffected while decreasing $\pi_L[p_L(Q), b(0)]$. A sufficiently tight quota leads form PE1 to SE2 or SE3, and from SE2 to SE3, as technology H becomes more attractive relative to technology L.

In SE3, the high-cost type distorts the price above p_H^* to separate. By lemma 3, in equilibrium the quota is not binding for him. Further, he must choose p_H so as to prevent the low-cost type from masquerading as the high-cost type. Thus, p_H must satisfy:

(10) $\qquad Q[p_L(Q) - c_L] \geq D[p_H, b(1)](p_H - c_L).$

Let $\underline{p}(Q)$ be the upper root p that solves (10'):

(10') $\qquad Q[p_L(Q) - c_L] = D[p, b(1)](p - c_L).$

It is straightforward to check that $\underline{p}(Q)$ is the only price that survives a refinement based on the intuitive criterion. Thus, in SE3 under the quota the high-cost type sets the price equal to $\underline{p}(Q) > p_H(Q)$ while the low-cost type chooses $p_L(Q)$. We illustrate this equilibrium in Figure 4. In this case, lemma 2 applies, identifying the borderline type by

(11) $\qquad \overset{\wedge}{,}[\underline{p}(Q)] = D[\underline{p}(Q), b(1)](c_H - c_L).$

The imposition of the quota in SE3 such that $p_L(Q) = p_L^*$ is weakly binding for the low-cost type but not for the high-cost type. A tightening of the quota reduces the profit on the left-hand side of (10') so that $\underline{p}(Q)$ must be increased. As $\underline{p}(Q)$ increases, demand falls and $\overset{\wedge}{,}[\underline{p}(Q)]$ declines by (11), meaning that the tightening of the quota increases probability of technology H being used.

Proposition 8: The imposition of import quotas increases the probability of technology H being used.

Some intuitive explanation is in order for this section's results. The specific tariff raises the unit cost of exports equally for both the high-cost and the low-cost type. But we have shown that the low-cost type always exports a larger volume than the high-cost type despite the boycott (Proposition 6). Thus, the specific tariff hurts the low-cost type more, thereby making technology H relatively more attractive. On the other hand, the ad valorem tariff hurts the manufacturer more if he sets a higher price. Since the high-cost type charges a higher price than the low-cost type, the high-cost type is taxed more heavily for a given volume of exports. If this effect dominates the volume-of-exports effect given in Proposition 6, the high-cost type is hurt more under the ad valorem tariff. In contrast, import quotas always penalize the low-cost type more than the high-cost type. The reason is again that in the absence of a quota the low-cost type exports a greater quantity than the high-cost type (Proposition 6). Since a quota lowers the exports to the same limit regardless of the cost type, the low-cost type that exports more suffers more heavily than the high-cost type that exports less.

6. Summary and conclusions

Consumers often boycott products if they do not approve the way they are manufactured. We find that, even if consumers cannot verify the manufacturer's technology choice, boycotts can raise probability with which the manufacture chooses the technology favored by consumers. Further, if a boycott has a negligible effect on demand, tariffs and quotas can be used to bring out the outcome desired by consumer activists. However, when a

boycott has a substantial impact on demand, the imposition of ad valorem tariffs yields the opposite effect.

To focus on our issues, we have adopted the simple model structure so that a number of extensions readily suggest themselves. Firstly, the model assumes a single manufacturer. It is a natural extension to consider having more than one firm, both foreign and domestic, and examine how a boycott or trade policy interact with types of competition.

Secondly, the number of markets can be increased. For example, suppose the foreign manufacturer also serves his home market. This extension is straightforward and has no effect on our conclusions, but yields additional results of interest. Suppose that there is no boycott in the foreign country so that without the opportunity to export the manufacturer always uses technology L. Then, as we saw, the opportunity to export can induce him to adopt the high-cost technology (with positive probability) if there are substantial boycott threats in the export market. In this extension, then total embargoes force the manufacturer to withdraw to his home territory and to revert to technology L. Thus, while restricted imports under tariffs and quotas encourage use of technology H, total import bans yield the opposite effect.

A more interesting extension is to consider the case in which there is more than one export market. In this case, some country embargoing imports has the same role as consumers boycotting in our model. Further, in this setting, quotas correspond to the worldwide export quota on the targeted country, like the oil quota imposed on Iraq under Saddam Hussein. The model then can be used to analyze the coordination issues regarding trade sanctions.

Thirdly, as mentioned in the introduction, , can be interpreted as a measure of law enforcement in the foreign country to eliminate the undesirable production methods. Modeling this part explicitly may enable us to examine the effect of a boycott and trade sanctions on the

interaction between the foreign firm and the foreign government's enforcement policy. In the similar vein, we argued that the present model can be viewed as a model of demand for child labor. Thus, merging it with the supply-side models aforementioned will enable us to study the impact of boycotts and trade policy on the market for child labor.

Appendix

This appendix contains the proofs of propositions and lemmas found in the text.

Proposition PE1: If $b(0)$ and $\bar{,}$ are small enough to satisfy

(1) $$\pi_L[p_L^*, b(0)] > \pi_H[p_H^*, b(1)] + \bar{,},$$

the model possesses a unique equilibrium outcome, in which the manufacturer always chooses

technology L and sets the price to p_L^*. The equilibrium beliefs are $\mu(p_L^*) = 0$.

Proof. Use of technology H yields at most $\pi_H[p_H^*, b(1)]$. Technology L yields at least $\pi_L[p_L^*,$

$b(0)]$. But (1) says that the most compunctious firm type (type $\bar{,}$) derives a greater utility using

technology L under the worst condition than using technology H under the best condition (no

boycott). It follows all firm types choose technology L. Consumers see through this and

conjecture correctly that the firm uses technology L. $\qquad\square$

Lemma 1: In a separating equilibrium, having chosen technology L, the manufacturer always

sets price equal to p_L^* and earns the full-information maximum profit, $\pi_L[p_L^*, b(0)]$.

Proof. Suppose contrarily that there is an equilibrium in which the low-cost type chooses p_L

p_L^* so that $\mu = 0$ at that price. Then, because $\pi_L[p_L^*, b(0)] > \pi_L[p_L, b(0)]$ by the definition of

p_L^*, the firm would deviate to p_L^*, disturbing this candidate equilibrium. $\qquad\square$

Proposition SE2: Suppose condition (2) holds. Then

(A) The model yields a unique intuitive separating-equilibrium outcome, in which the

manufacture chooses technology H if he is type $, \geq \tilde{,}[b(0)]$ and technology L otherwise.

(B) The high-cost type sets price equal to p_H^*, and the low-cost type p_L^*.

(C) The ex ante probability of technology H being used is $\{1 - F(\tilde{,}[b(0)])\}$.

Proof. By Lemma 1 the low-cost type has no incentive to deviate from this equilibrium, while the high-cost type earns $\pi_H[p_H{}^*, b(1)]$, the maximum profit under the most optimistic beliefs, $\mu = 1$. Since $\pi_L[p_H{}^*, b(1)] \le \pi_L[p_L{}^*, b(0)]$ type $,\ = 0$ prefers to choose technology L. On the other hand, the fact that (1) fails means that

$$\pi_H[p_H{}^*, b(1)] > \pi_L[p_L{}^*, b(0)] - \overline{,},$$

so type $\overline{,}$ chooses technology H. By continuity there exists type $\tilde{,} = \pi_L[p_L{}^*, b(0)] - \pi_H[p_H{}^*, b(1)]$ $(0, \overline{,})$ that are indifferent between two technologies. All types $, \ < \tilde{,}$ choose technology L and all others choose technology H. $\qquad\square$

Proposition SE3: Suppose (4) holds

(A) The model yields a unique intuitive separating-equilibrium outcome, in which the manufacture chooses the high-cost technology if he is type $, \ \ge \hat{,}(p)$ and the low-cost technology otherwise.

(B) The high-cost type set the price equal to $\underline{p}$ $(> p_H{}^*)$ and the low-cost type $p_L{}^*$.

(C) The ex-ante probability of technology H being used is $\{1 - F[, \hat{,}(\underline{p})]\}$.

We first present:

Lemma 4: $[\underline{p}, \overline{p}]$ is an interval.

Proof. Let $p^*(c) = \arg\max_p D[p, b(1)](p - c)$. Consider the equation

$$g(p, c) = D[p, b(1)](p - c) - \max_p \{D[p^*, b(0)](p^* - c)\} = 0$$

By the implicit-function theorem there exists the function $p(c)$ with the derivative

(A1) $\qquad p'(c) = \{D[p(c), b(1)] - D[p^*(c), b(0)]\}/d\{D[p(c), b(1)][p(c) - c]\}/dc.$

Since $g(\underline{p}, c_L) = 0$ is identical to (4') and $g(\overline{p}, c_H) = 0$ is identical to (6'), $p(c_H) = \overline{p}$ and $p(c_L) = \underline{p}$

and there exists c_o satisfying $c_L \le c_o \le c_H$ such that $\overline{p} - \underline{p} = (c_H - c_L)p'(c_o)$. Evaluating (A1) at

c_o, its denominator is negative because $p(c_o) > p_H{}^*$. To show the numerator is negative, choose

a price p_1 so that $D[p_1, b(1)] = D[p^*(c_o), b(0)]$. Then, $p_1 > p^*(c_o)$ so

$$D[p_1, b(1)](p_1 - c_o) > D[p^*(c_o), b(0)][p^*(c_o) - c_o]$$

But $g(p, c_o) = 0$ implies

$$D[p^*(c_o), b(0)][p^*(c_o) - c_o] = D[p(c_o), b(1)][p(c_o) - c_o]$$

Since marginal profit is falling around $p(c_o) > p^*(c_o)$, these two inequalities imply that $p_1 <$

$p(c_o)$ and therefore that $D[p(c_o), b(1)] < D[p_1, b(1)] = D[p^*(c_o), b(0)]$. Thus the numerator in

(A1) is negative at c_o, and hence $p'(c_o)$ is positive. Then, $\overline{p} - \underline{p} > 0$. ☐

Proof of proposition SE3: By lemma 4 above, the following is a separating equilibrium

outcome: the low-cost type chooses $p_L{}^*$, the high-cost type chooses a price $\hat{p}_H \in [\underline{p}, \overline{p}]$ and

consumers' beliefs on the equilibrium path are $\mu(\hat{p}_H) = 1$ and $\mu(p_L{}^*) = 0$. A deviation is

prevented under the following out-of-equilibrium beliefs: $\mu(p) = 0$ for p other than $\hat{p}_H$ and $p_L{}^*$.

The low-cost type earns the profit $\pi_L[p_L{}^*, b(0)]$ and the high-cost firm earns $\pi_H[\hat{p}_H, b(1)]$.

However, condition (4) states that the low-cost type has no incentive to choose a price

in that interval, given his equilibrium profit $\pi_L[p_L{}^*, b(0)]$. By contrast, since $\hat{p}_H$ is distorted

upward from $p_H{}^*$, $\pi_H[p, b(1)]$ is decreasing in p for $p > \hat{p}_H$. Therefore, for $p \in (p_H{}^*, \hat{p}_H), \pi_H[p,$

$b(1)] > \pi_H[\hat{p}_H, b(1)]$, implying that the high-cost type has an incentive to deviate to $p \in [\underline{p}, \hat{p}_H)$,

should it generate the most favorable belief assessment among the consumers. Then, the

intuitive criterion maintains that domestic consumers place zero probability weight on the low-

cost type when observing $p \in [\underline{p}, \hat{p}_H)$. This restriction on the out-of-equilibrium beliefs

motivates the high-cost type to deviate to p $\in$ [$\underline{p}$, $\hat{p}_H$), disturbing any candidate equilibrium price $\hat{p}_H$ $\in$ ($\underline{p}$, $\overline{p}$]. This reasoning however does not apply if $\hat{p}_H = \underline{p}$ and hence $\underline{p}$ is the unique separating equilibrium price under the intuitive criterion. $\square$

Proposition 5: The model yields no intuitive pooling equilibrium outcome, in which the manufacturer chooses different technologies, depending on his compunction level, and yet charges an identical price.

Proof. Suppose that the two types pool at a price p_o and consumers form beliefs $\mu(p_o) = \mu_o < 1$ as to the probability that the firm uses the high-cost technology. Let $D[p_o, b(\mu_o)]$ be the equilibrium demand and $\pi_i[p_o, b(\mu_o)]$ denote the equilibrium profit to the firm using technology_i:

$$\pi_i[p_o, b(\mu_o)] = (p_o - c_i)D[p_o, b(\mu_o)].$$

The price p_o must satisfy

(A2) $\qquad \pi_H[p_o, b(\mu_o)] \geq \max_p \pi_H[p, b(0)]$

(A3) $\qquad \pi_L[p_o, b(\mu_o)] \geq \pi_L[p_L^*, b(0)].$

(A2) says that the equilibrium profit to the high-cost type should be at least as large as the maximum profit it can get under the most pessimistic beliefs (the right-hand side). (A3) says the equilibrium profit to the low-cost type must be at least as large as the maximum profit it earns from disclosing its type.

Consider the equation:

(A4) $\qquad \pi_L[p_o, b(\mu_o)] - \pi_L[p, b(1)] = D[p_o, b(\mu_o)](p_o - c_L) - D[p, b(1)](p - c_L) = 0.$

Now, the assumption that $b(\mu) > 0$ for $\mu < 1$ implies that $b(\mu_o) > 0$. Let p_1 be the upper root of equation (A4). The price p_1 exists because, if not, we would have $\pi_L[p, b(1)] < \pi_L[p_o, b(\mu_o)]$ for all p, which is not rue. Note also that $p_1 > p_o$ because p_1 is the upper root of (A4).

Consider next the expression:

$$\pi_H[p_o, b(\mu_o)] - \pi_H[p_1, b(1)]\_= D[p_o, b(\mu_o)](p_o - c_H) - D[p_1, b(1)](p_1 - c_H).$$

Substituting from (A4) into the above and simplifying yields

(A5) $\qquad \pi_H[p_o, b(\mu_o)] - \pi_H[p_1, b(1)]$

$$= D[p_1, b(1)](p_1 - c_L)(p_o - c_H)/(p_o - c_L) - D[p_1, b(1)](p_1 - c_H)$$

$$= (p_o - p_1)(c_H - c_L)D[p_1, b(1)]/(p_o - c_L) < 0.$$

Thus, the high-cost type would deviate to p_1 if he can convince consumers of his type. Then, since $\pi_H[p_1, b(1)]$ and $\pi_L[p_1, b(1)]$ are both decreasing around p_1, there exists $p_2 = p_1 - .$ (. positive and arbitrary) such that

$$\pi_H[p_o, b(\mu_o)] - \pi_H[p_2, b(1)] < 0$$

by (A5) but (A4) implies

$$\pi_L[p_o, b(\mu_o)] - \pi_L[p_2, b(1)] > 0.$$

Thus, if posting p_2 can convince consumers that he uses technology H, the high-cost type would deviate to p_2 but not the low-cost type. Thus, the equilibrium price p_o fails the intuitive criterion test. Since the choice of p_o was arbitrary, the model possesses no pooling equilibrium that passes the intuitive criterion test. $\qquad\qquad\qquad \square$

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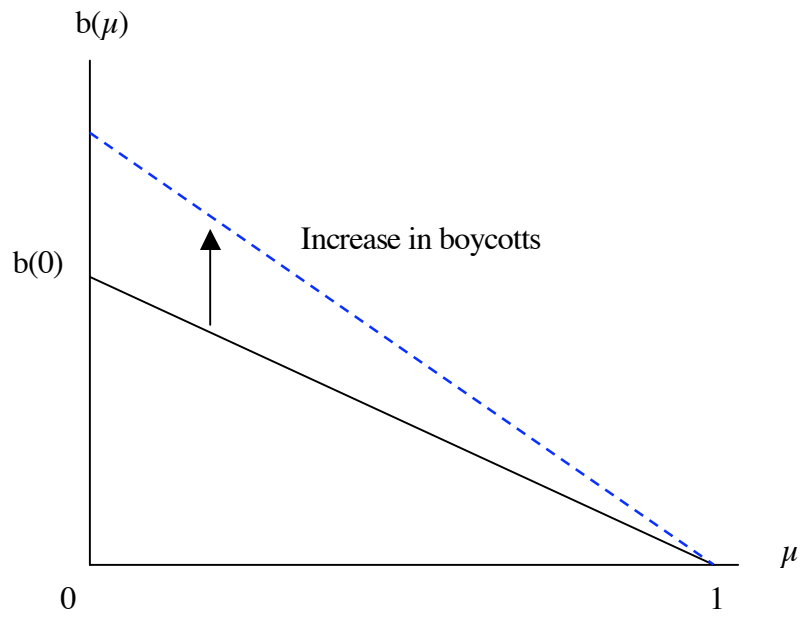
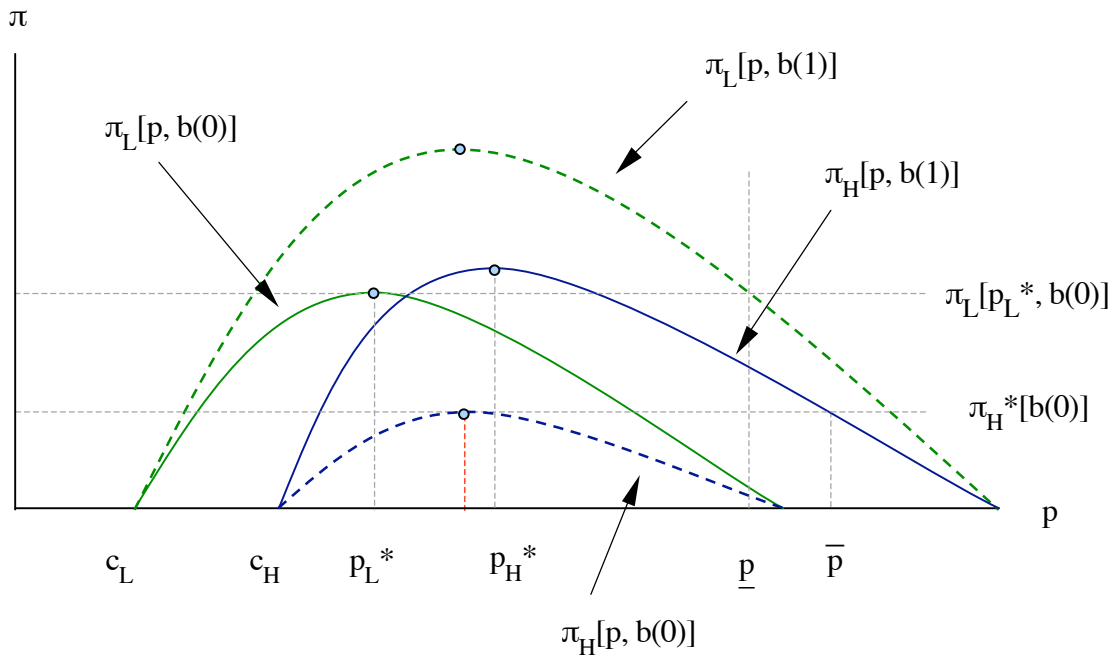Figure 1: An example of a boycott function
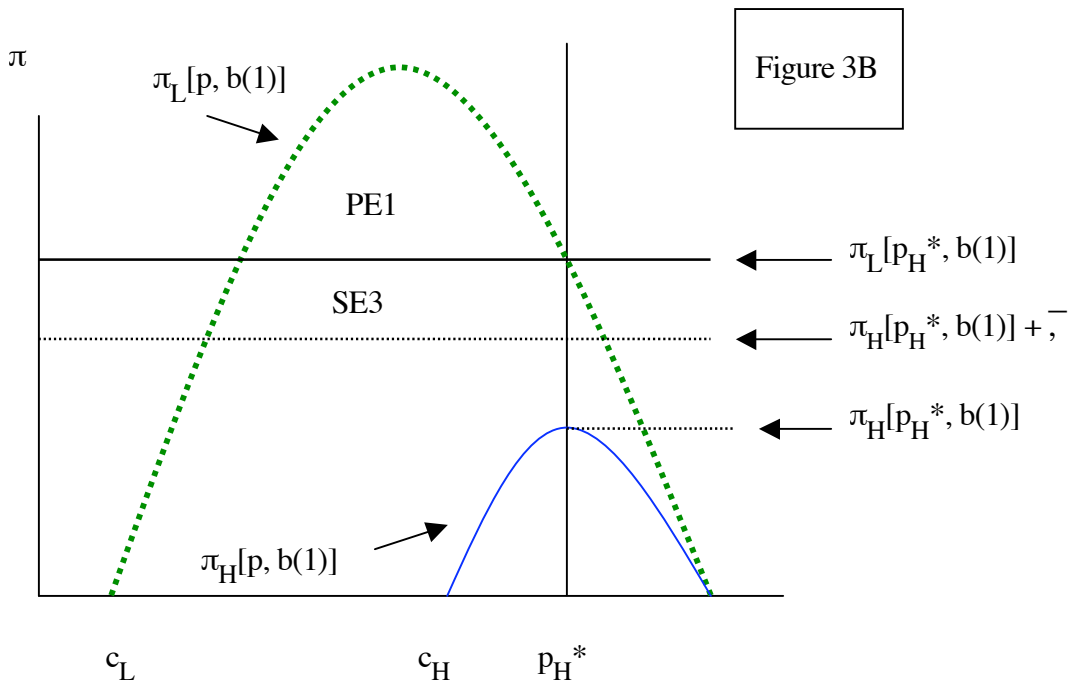
Figure 2: Equilibrium SE3

Figure 3A

π

$\pi_L[p, b(1)]$

PE1

$\pi_H[p_H^*, b(1)] + \bar{,}$

SE2

$\pi_L[p_H^*, b(1)]$

SE3

$\pi_H[p_H^*, b(1)]$

$\pi_H[p, b(1)]$

c_L c_H p_H^*

Figure 3B

π

$\pi_L[p, b(1)]$

PE1

$\pi_L[p_H^*, b(1)]$

SE3

$\pi_H[p_H^*, b(1)] + \bar{,}$

$\pi_H[p_H^*, b(1)]$
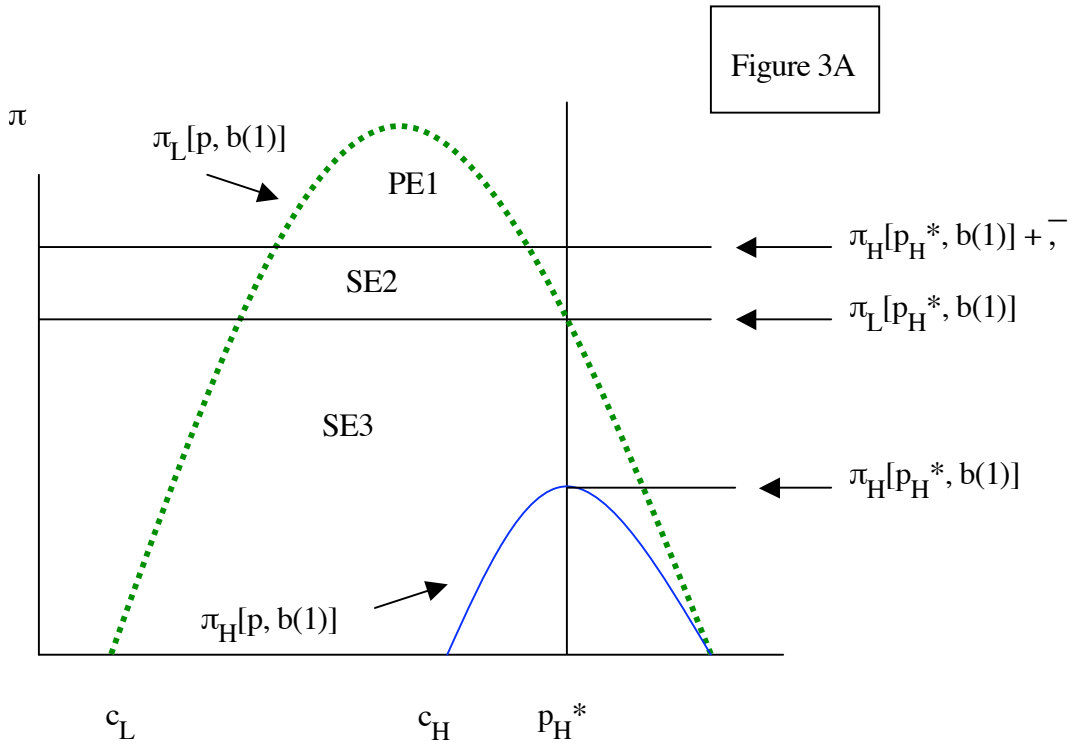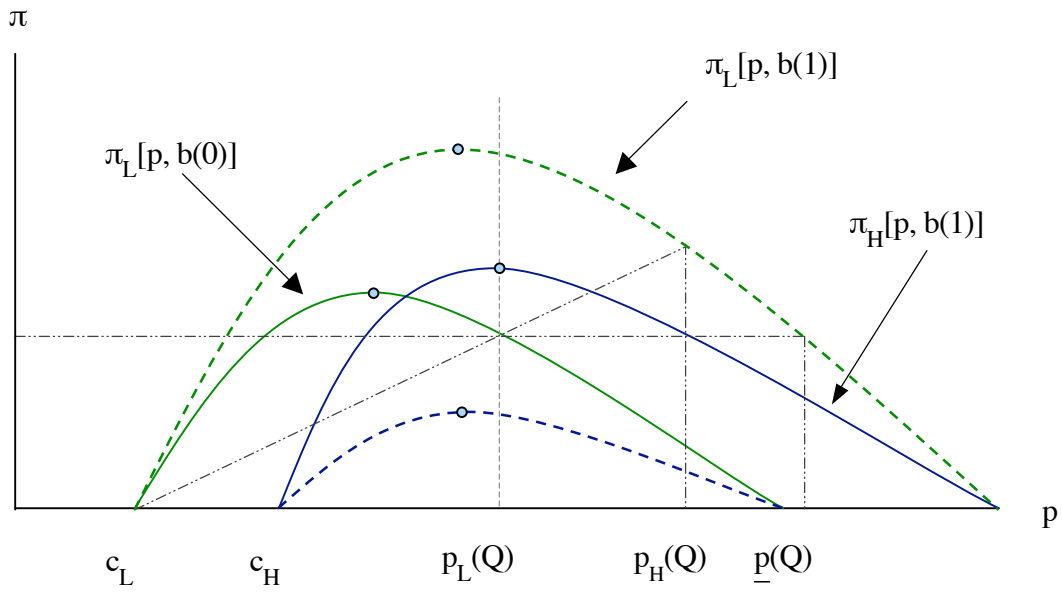
$\pi_H[p, b(1)]$

c_L c_H p_H^*

Figure 3: Boycotts and Equilibrium Shifts

Figure 4: Equilibrium SE3 under the quota Q