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ABSTRACT

We investigate whether a welfare-maximizing government ought to pursue a *program* of strategic trade intervention or instead commit itself to free trade when, in the former case, domestic firms will have an opportunity to manipulate the government's choice of the level of intervention. Domestic firms may overinvest in physical and knowledge capital in a regime of strategic intervention in order to influence the government's choice of subsidy. In the event, a commitment to free trade may be desirable even in settings where profit-shifting would be possible. We analyze the desirability of such a commitment when the government is well informed about firms' types and actions, and when it suffers from an informational disadvantage.

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1 Introduction

Ever since James Brander and Barbara Spencer established that, when global markets are imperfectly competitive, export subsidies and import tariffs might be used strategically to enhance a country's national welfare, trade economists have fretted the practical significance of their findings. An initial concern addressed the robustness of their conclusion: Is strategic support for domestic oligopolists always desirable, many readers asked, or might the case for such policies be limited to certain economic environments? This concern spawned numerous theoretical studies, and it was soon established that the argument for subsidies and tariffs rests on particular assumptions about the number of domestic and foreign competitors, the mode of oligopolistic conduct, the opportunity cost of public funds, the general equilibrium interaction between the industry in question and other oligopolistic sectors, and other considerations (see Brander, 1995, and the papers cited therein).

There was, however, an even more pervasive worry about the Brander-Spencer finding, albeit one that was not as well articulated. Many commentators feared that enacting a program of strategic trade policy would somehow be tantamount to opening Pandora's box. In a setting ripe with strategic opportunities, and one where the government would likely have limited information about the parameters needed to design optimal policy, it was felt that the policymakers might fall prey to strategic manipulation and political pressures, and that policy outcomes under an interventionist regime would be so far from the Brander-Spencer ideal that it would be better in fact to have no strategic policies at all. To a large extent, this reaction reflected the *a priori* bias of trade economists against trade activism, rather than being the implication of rigorous analysis. Unfortunately, little effort was made to identify the political and economic conditions under which these misgivings would indeed be justified.

In this paper, we propose to peek into Pandora's box. We will consider whether a benevolent government seeking to maximize national welfare[1] and having the opportunity to introduce a *program* of strategic trade policy ought to do so, or, alternatively, whether the government would be better off committing itself to free trade. The government we study may have perfect or imperfect information. In either case, if it opts for a program of active policy intervention it will leave itself open to strategic manipulation by the private sector. Its vulnerability arises from our assumption that firms can take some actions after the program has been enacted but before the specific level of the policy instrument has been set. These actions can be used to influence the policymaker's choice of the policy level.[2]

Firms might have various tools for engaging in such strategic manipulation, including some that are political in nature and some that are purely economic. In the political realm, for example, firms might offer campaign contributions to politicians who set a favorable level of the policy instrument or they might "lobby" the politicians by providing bits of information that bolster their case. Economic instruments would include any actions the firms might take to alter the government's perception of the optimal intervention. In this paper we focus on only one such action, namely up-front investments in capital or knowledge. These investments reduce marginal production costs for the firms, and so typically increase the size of the welfare-maximizing subsidy or tariff (see Neary, 1994). If the government is imperfectly informed about firms' abilities, the investments might also be used by the more efficient firms to signal that they are worthy of a large subsidy. Since the private benefits from such investments

[1]In this paper, we do not address the realistic prospect that a government might be induced to pursue objectives other than aggregate welfare for its own political gain. However, our methods could readily be applied to examine the value of commitment to free trade when a government with opportunities for strategic trade intervention is politically motivated. See, for example, Maggi and Rodriguez-Clare (1996), who examine a similar question in a competitive setting.

[2]Schulman (1997) also models strategic trade policy as an initial discrete choice between free trade and activism, with the level of intervention being set later, after firms have had an opportunity to react to the existence of the program. However, the firms in his model choose only whether to enter the industry stay out, and so they are unable to manipulate the government strategically.

(which include the induced effect on the policymaker as well as the direct effect on costs and the strategic effect on the rival foreign firms) exceed the social benefits, the manipulative firms tend to over-invest in capital. This potential for over-investment represents a social cost of the policy program that must be weighed against its potential strategic benefits. The question of whether it is better to have a regime of strategic intervention or one of commitment to free trade becomes an issue of rules versus discretion, in the sense described by Kydland and Prescott (1977) in their seminal paper on the topic.

Our analysis suggests two main conclusions. First, a program of strategic trade policy is likely to generate national benefits relative to a commitment to free trade when the cost of investment is either very large or very small. When large, the firms will not have much incentive to manipulate the government. And when small, the social cost of any strategic over-investment will be modest. In contrast, a government may have reason to commit to free trade for moderate values of the parameter reflecting the cost of capital. Second, the range of parameters for which a commitment to free trade is desirable is likely to be larger when the government is imperfectly (and asymmetrically) informed than when it gains complete information about the productivity of domestic firms. This finding lends some support to many trade economists' instinctive belief that a lack of information among the relevant policymakers would reduce the attractiveness of strategic trade intervention.[3]

The remainder of the paper is organized as follows. In the next section, we compare a regime of strategic trade intervention to a commitment to free trade in

[3]This is not the first paper to examine how the presence of asymmetric information affects optimal trade policy choices. Qiu (1994) and Maggi (1997) have investigated the optimal design of incentive-compatible trade policies when the government does not know firms' costs. However, they focus on settings in which the firms act only after the policy schedule has been set, and so the firms have no ability to influence the government's choice of policy. The focus of these papers is quite different from ours, inasmuch as they are not concerned with the potential benefits of a commitment to free trade as a way to foreclose strategic manipulation by domestic firms.

a familiar Brander-Spencer setting in which the government is fully informed, but the (single) domestic firm can install capital prior to the policymaker's choice of an optimal export subsidy. In Section 3 we extend the analysis to situations in which the government does not know the "type" (efficiency) of the domestic firm. The concluding section summarizes our findings and contains a brief discussion of possible extensions.

2 Free Trade vs. Strategic Trade with Full Information

We follow Brander and Spencer (1985) in examining the simplest setting in which strategic trade policy might be attractive. A single home firm competes with a single foreign firm for sales in an export market. The two firms produce a homogeneous good with inverse demand $p(x + x^*)$, where x and x^* represent sales of the home and foreign firm, respectively. The foreign firm has a constant and known marginal cost of c^*. The home firm's marginal cost is given by $c(k; \theta)$, where k is the firm's capital stock (or, alternatively, the amount of its "knowledge capital") and θ is a parameter describing the efficiency or "type" of the firm. We assume that $c(\cdot)$ is continuous and differentiable, that a firm of a given type has a lower marginal cost the greater its capital stock, that "higher types" have higher costs, and that both marginal cost and the marginal gain from additional capital are finite. More formally,

Assumption 1: *$c(\cdot)$ is smooth, with $c_k < 0$, $c_{kk} > 0$, $c_\theta > 0$, $c(0; \theta)$ finite and $c_k(0; \theta)$ finite.*

In choosing its capital stock, the home firm bears a cost of investment given by $\alpha i(k)$, where α is a positive parameter. We assume that the elasticity of $i(\cdot)$ is positive and bounded away from zero; i.e., it obeys

Assumption 2: *$\iota(k) \equiv ki'(k)/i(k) \geq \bar{\iota} > 0$ for all k.*

In this section we assume that the firm's type is known to the home government (and to the firm's foreign rival). We therefore omit the argument θ for the time being. The home firm's profits then are given by $\Pi = [p(x+x^*)-c(k)+s]x-\alpha i(k)$, where s is a (per-unit) export subsidy, while the foreign firm's profits are $\Pi^* = [p(x+x^*)-c^*]x^*$. The home government's objective is to maximize the home firm's profits net of any subsidy costs. This can be written as $W = [p(x+x^*)-c(k)]x-\alpha i(k)$. The timing is as follows. First, the government decides whether to initiate a program of strategic intervention or whether to commit itself instead to a policy of free trade.[4] After the government has made this decision, the firm chooses how much to invest . Following the investment decision, the government sets the level of its export subsidy s, where of course $s = 0$ if the government has committed itself to free trade. Finally, the two firms engage in Cournot competition to maximize their profits.[5]

Consider first the chain of events when the government enacts a program of strategic intervention at the initial decision stage. In the event, the government will set its subsidy after the home firm's marginal cost has been fully determined. As Brander and Spencer (1985) have shown, the optimal subsidy s is given by

$$s = xp'(X)\frac{1+\sigma^* R}{2+\sigma^* R} \tag{1}$$

[4]We do not address the issue of how the government can make this commitment. Also, we do not allow the government to commit to an alternative trade policy besides free trade. This assumption requires justification. Presumably it takes longer for the government to initiate a program of strategic intervention, which involves setting up an administering body and a set of bureaucratic procedures, than it does for a firm to alter the level of its capital stock. However, once such a program is in place, the government would appear to be able to adjust the level of the subsidy (or tax) relatively quickly compared to the time needed for changes in the firm's capital.

[5]This timing is reminiscent of the one studied by Goldberg (1995). However, she does not allow an initial stage with a potential government commitment to free trade. Moreover, the firms in her model choose only a maximum output level (i.e., "capacity") and not a capital stock that affects subsequent production costs. The capacity choice affords firms no ability to influence the policy choice of their government.

where $X = x + x^*$ is aggregate sales, $\sigma^* = x^*/X$ is the foreign firm's market share, and $R = Xp''/p'$ is a measure of the concavity of demand. The optimal subsidy is positive provided that $1 + \sigma^* R > 0$, which is true if and only if the home and foreign goods are *strategic substitutes* in the sense of Bulow et al. (1985). We will henceforth assume this to be the case.

The optimal subsidy depends on the home firm's costs, because the various variables on the right-hand side of (1) do. Herein lies the firm's opportunity for strategic manipulation. In addition to the other considerations that determine the firm's optimal investment, it has an incentive to choose k so as to induce the government to grant a large subsidy. This means choosing a larger k than otherwise if $ds/dc < 0$ and choosing a smaller k than otherwise if $ds/dc > 0$.

As Neary (1994) has shown, the sign of ds/dc cannot be told in general. But there are several cases where the optimal strategic subsidy definitely rises as the home firm's marginal cost declines. For example, $ds/dc < 0$ when demand is linear. Also, if the demand function has a constant elasticity and the home and foreign goods are strategic substitutes (as we have assumed), then ds/dc must be negative.[6] In these cases and others like them, the opportunity for strategic manipulation augments the marginal private benefit of investment.

Next we argue that, when $ds/dc < 0$, the firm installs more capital than is socially optimal. The first-best level, $\hat{k}$, would emerge if the government could choose the capital stock (instead of the firm) along with its choice of an optimal subsidy rate. Note that the firm's objective diverges from the government's by the extent of the subsidy payments, $s(k)x(s(k), k)$, which enter the firm's profits but not net welfare. It is straightforward to show that total subsidy payments are increasing in k. The unit subsidy s is increasing in k, because investment reduces c and a lower c induces a higher s. Furthermore, the output level x increases with k for two reasons: first, investment reduces the true marginal cost, and this induces the firm to increase

[6]When demand has a constant elasticity e, strategic subsitutability requires $e < \sigma^*/(\sigma^* - 1)$. Meanwhile, $e < (\sigma^* + 1)/(\sigma^* - 1)$ is sufficient for $ds/dc < 0$ in the case of constant-elasticity demand.

output (both as a direct response and as a strategic response to the contraction in the foreign firm's output); second, investment induces a higher subsidy (as we just argued) and hence decreases the perceived marginal cost $c - s$.

Having established that investment increases total subsidy payments, it is a short step to conclude that $k > \hat{k}$. If $S(k)$ denotes total subsidy payments, we have $\Pi = W + S$. Since $\frac{dW}{dk} = 0$ at $\hat{k}$, and $S'(k) > 0$, it follows that $\frac{d\Pi}{dk} > 0$ at $\hat{k}$, hence the firm will choose a level of k higher than $\hat{k}$.

In short, the existence of a strategic trade program distorts the firm's allocation decision.[7] This distortion can be avoided if the government commits itself to a policy of free trade. However, such a commitment means foregoing the benefits of profit-shifting.[8] Therein lies the trade-off confronting the welfare-maximizing government.

The potential superiority of a commitment to free trade is illustrated in Figure 1. In the figure, the curve SS depicts the optimal export subsidy as a function of the size of the capital stock. The curve KK shows the first-best capital stock for each subsidy level. The *optimum optimorum* is at point O, where the two curves intersect. But the profit-maximizing firm does not choose a point on KK, and so outcome O is not achieved. Instead, it chooses a point such as E^{STP}, where an iso-profit locus (indicated by the broken curve) is tangent to SS. Iso-welfare loci are ellipses that emanate from point O and that are horizontal where they cross KK and vertical where they cross SS. A commitment to free trade generates an outcome at E^{FT}, which, in the case illustrated, yields higher total surplus than the outcome at E^{STP}.

We are now prepared to state the main result of this section, which is

[7] This conclusion is foreshadowed in Spencer and Brander (1983), who argued that an optimal regime of industrial and trade policy combines an export subsidy with an investment *tax*. As they note, "The tax on [investment] is exactly as required to undo the [investment] bias and induce the domestic firm to minimize costs." (p.717)

[8] The home firm can achieve some of the benefits from the optimal export subsidy by using investment as a strategic weapon à la Dixit (1980). However, investment uses resources whereas the subsidy does not, so the latter is a more efficient means of effecting profit-shifting.

Proposition 1 *Assume that home and foreign exports are strategic substitutes, that the investment and production technologies obey Assumptions 1 and 2, and that the optimal export subsidy declines with marginal cost. Then there exist scalars* α_1 *and* α_2 *such that domestic surplus is higher in a program of strategic export promotion than under a commitment to free trade for all* $\alpha \leq \alpha_1$ *and* $\alpha \geq \alpha_2$.

Proof. See appendix.

Note that this proposition does not ensure the existence of circumstances under which a commitment to free trade is preferable to a regime of strategic intervention. Rather, it says that, if such a commitment to free trade ever is desirable, it must be so for an intermediate range of parameters describing the cost of investment. The intuition for the result is straightforward. If α is large, then the marginal cost of capital is high, and the firm has little incentive to engage in strategic over-investment. On the other hand, if α is small, the firm does over-invest, but the social cost of the extra capital is small. In either case, the welfare loss associated with the sub-optimal investment is outweighed by the gain generated with the strategic export subsidy. But if α is not extreme, there is no guarantee that this is so.

A Linear-Quadratic Example

To illustrate that a commitment to free trade may be optimal for some intermediate range of parameter values, we present a linear-quadratic example. Suppose that demand takes the form $X = A - bp$ and that the cost of capital is given by $i(k) = \alpha k^2$. Installed capital reduces marginal production cost according to $c = \theta - k$, for $k \leq \theta$. For $k > \theta$, we have $c = 0$.[9] Finally, assume that $A + c^* > 2\theta$, so that the home firm would make positive export sales even if no capital were installed.

[9]Note that this cost function does not quite satisfy the requirements of Assumption 1. In particular, it is not differentiable at $k = \theta$. Nonetheless, the example preserves the spirit of the trade-offs present in the more general setting, and allows the potential superiority of a commitment to free trade to be seen quite clearly.

Consider first the regime with free trade. If we take k as given for the moment, then we can solve the Cournot game in the usual manner to find p and x as functions of k. Then the optimal investment for the home firm is the one that maximizes $[p(k) - c(k)]x(k) - \alpha k^2$. Solving this problem, we find

$$k_{FT} = \begin{cases} \frac{2}{9\alpha b-4}(A + c^* - 2\theta) & \text{if } \alpha \geq \frac{2(A+c^*)}{9\theta b} \\ \theta & \text{if } \alpha < \frac{2(A+c^*)}{9\theta b} \end{cases} . \tag{2}$$

Notice that the firm drives marginal cost to zero when either the cost of capital or the price responsiveness of demand is small. Otherwise, the investment problem has an interior solution. Substituting back into the Cournot solution gives the free-trade exports,

$$x_{FT} = \begin{cases} \frac{3\alpha}{9\alpha b-4}(A + c^* - 2\theta) & \text{if } \alpha \geq \frac{2(A+c^*)}{9\theta b} \\ \frac{A+c^*}{3b} & \text{if } \alpha < \frac{2(A+c^*)}{9\theta b} \end{cases} . \tag{3}$$

Finally, we can insert the expression for k_{FT} into the formula for net profits, to compute total welfare, since welfare and profits are identical in the absence of trade policy. This yields

$$W_{FT} = \begin{cases} \frac{\alpha}{9\alpha b-4}(A + c^* - 2\theta)^2 & \text{if } \alpha \geq \frac{2(A+c^*)}{9\theta b} \\ \frac{(A+c^*)^2}{9b} - \alpha\theta^2 & \text{if } \alpha < \frac{2(A+c^*)}{9\theta b} \end{cases} . \tag{4}$$

Now consider what happens when the government opts for a program of strategic trade policy. The government's objective is to maximize producer surplus net of subsidy costs, or $W = [p - c(k)]x - \alpha k^2$. At the time that the subsidy rate is set, the size of the capital stock will already have been chosen. The government sets s to induce the Stackelberg outcome in the export market, which implies

$$s = \frac{A + c^* - 2c(k)}{4}, \tag{5}$$

with $c(k) = \max[\theta - k, 0]$. Thus, the subsidy rate increases with the size of the capital stock in the range where investment reduces production costs. This gives the firm a strategic incentive to over-invest, as we have already discussed.

The firm chooses its capital stock to maximize profits net of investment costs, including of course the receipts it collects from the export subsidy. The optimal k maximizes $[p(k) + s(k) - c(k)]x(k) - \alpha k^2$. It is easy to derive the equilibrium capital stock, k_{STP}, that emerges when the government has opened the door to trade intervention. We find

$$k_{STP} = \begin{cases} \frac{1}{2(\alpha b-1)}(A + c^* - 2\theta) & \text{if } \alpha \geq \frac{A+c^*}{2\theta b} \\ \theta & \text{if } \alpha < \frac{A+c^*}{2\theta b} \end{cases} . \tag{6}$$

Now we can calculate the optimal subsidy rate using (5), and then the equilibrium export volume from $x = (A + c^* - 2c + 2s)/3b$. This yields

$$x_{STP} = \begin{cases} \frac{\alpha}{2(\alpha b-1)}(A + c^* - 2\theta) & \text{if } \alpha \geq \frac{A+c^*}{2\theta b} \\ \frac{A+c^*}{2b} & \text{if } \alpha < \frac{A+c^*}{2\theta b} \end{cases} . \tag{7}$$

Comparing (3) and (7), it is apparent that a greater volume of exports results when the government operates a program of strategic subsidies than when it commits itself to free trade. Finally, we compute total surplus under the strategic trade regime. Using the formula for W, we find

$$W_{STP} = \begin{cases} \frac{\alpha(\alpha b-2)}{8(\alpha b-1)^2}(A + c^* - 2\theta)^2 & \text{if } \alpha \geq \frac{A+c^*}{2\theta b} \\ \frac{(A+c^*)^2}{8b} - \alpha\theta^2 & \text{if } \alpha < \frac{A+c^*}{2\theta b} \end{cases} . \tag{8}$$

We are now prepared to compare welfare outcomes under the alternative regimes. Notice first that if $\alpha < 2(A + c^*)/9\theta b$, then both k_{FT} and k_{STP}, and indeed the first-best level of the capital stock, are equal to θ. In the event, there can be no over-investment, and realized welfare must be greater under a program of strategic intervention than under a commitment to free trade. On the other hand, if α is large enough, then the firm will choose $k < \theta$ under either regime. In these circumstances, we can compare the top row of (4) with the top row of (8), from which we conclude that $W_{STP} > W_{FT}$ if $\alpha > 6/b$. Now refer to Figure 2. The top panel corresponds to the case in which $A + c^* > 12\theta$. Then $k_{STP} = \theta$ for all $\alpha \leq (A + c^*)/2\theta$, and it is readily seen that $W_{STP} > W_{FT}$ over this entire range. For $\alpha > (A + c^*)/2\theta$,

$k_{FT} < k_{STP} < \theta$. But since $\alpha > 6/b$ throughout this region of the parameter space, we have that $W_{STP} > W_{FT}$ here as well. Thus, there are no parameter values for which a commitment to free trade is desirable when $A + c^* > 12\theta$.

The bottom panel of Figure 2 depicts the situation when $A + c^* < 12\theta$. Then $k_{FT} = \theta$ for $\alpha < 2(A + c^*)/9\theta b$, while $k_{STP} = \theta$ for $\alpha < (A + c^*)/2\theta b$. For $6/b > \alpha > (A+c^*)/2\theta b$, the optimal investment leaves positive production costs under both regimes, and welfare is higher when the government commits to free trade than when it does not. Indeed the commitment to free trade is desirable for all $\alpha \in (\tilde{\alpha}, 6/b)$, where $\tilde{\alpha}$ is the greater root of the quadratic equation $(A + c^*)^2/8b - \alpha\theta^2 = \alpha(A + c^* - 2\theta)^2/(9\alpha b - 4)$.

The results for the linear-quadratic example confirm our earlier discussion. A program of strategic trade is preferable to a commitment to free trade when the parameter reflecting the cost of investment is either very large or very small, whereas a commitment to forego strategic trade opportunities *may* be desirable for an intermediate range of parameter values.

3 Asymmetric Information

The design of an optimal strategic policy requires that the government have detailed information about the cost parameters for domestic and foreign firms, the demand conditions in the targeted industry, the nature of oligopolistic conduct, and so on. It has been argued that few governments will have such information, and that the attractiveness of strategic intervention is diminished as a result. But if this simple argument were correct, it would speak against all forms of government intervention, inasmuch as policymakers rarely have all the information they need to implement the policies prescribed by economic theory.

In this section we examine a more subtle form of the information argument. We argue that firms are likely to have better information about their own cost conditions than is available to the policymaker, and that this *information asymmetry* can create an incentive for costly signalling. The signalling, like the over-investment of the last section, represents a form of strategic manipulation of the government by private agents in response to a *program* of policy intervention. Accordingly, asymmetric information may tilt the balance in favor of a commitment to free trade in situations where an active trade policy would be indicated were policymakers better informed.

Let us revisit the duopolistic competition for exports and profits, but now let the domestic participant be one of two types. If $\theta = \theta_L$, the firm is a "low-cost" or "more-efficient" type, with per-unit production costs of $c(k, \theta_L)$. If $\theta = \theta_H > \theta_L$, the firm is instead a "high-cost" or "less-efficient" competitor, with per-unit production costs of $c(k, \theta_H)$. We will consider whether the government should commit to a policy of free trade at a time when it knows only the probability distribution over types. To make meaningful statements about the implications of asymmetric information we need to define a symmetric-information benchmark. Our benchmark scenario will be one in which the policymaker anticipates that nature will reveal the true value of θ to all observers before any investment or policy decisions must be taken. In the alternative scenario, nature will leave the policymaker and firms asymmetrically informed. The industry participants will learn θ before the investment decision must be made, but the policymaker will be left to infer what she can from the actions that are taken. We let q be the prior probability that $\theta = \theta_L$ in either case.

In the benchmark scenario, events unravel exactly as in the previous section. The government knows that, for each possible value of θ, strategic over-investment will occur if a program of export promotion is in place. The government can calculate the investments that will be made by each possible type, and the subsidy rates it will be induced to select. Therefore, it can calculate $W_{STP}(\theta)$, the welfare level that will result with export subsidies when the firm is of type θ, and $\mathcal{E}W_{STP} = qW_{STP}(\theta_L) + (1 - q)W_{STP}(\theta_H)$, the expected welfare under a program of strategic intervention. This it compares to $\mathcal{E}W_{FT} = qW_{FT}(\theta_L) + (1 - q)W_{FT}(\theta_H)$, the expected welfare in a regime without subsidies, when considering the desirability of a commitment to free trade.

Now consider the alternative scenario, where the government foresees its impending informational disadvantage. Of course, if it commits to free trade, it will have no policies to set, and so its lack of information will be of no consequence. As in the benchmark scenario, the government garners expected welfare of $\mathcal{E}W_{FT} = qW_{FT}(\theta_L) + (1-q)W_{FT}(\theta_H)$ if it makes this choice. However, outcomes may differ from the benchmark scenario if a program of strategic intervention is adopted instead.

We will focus on separating equilibria, i.e. equilibria in which the two types of firms choose different capital levels, thereby revealing their identities to the government.[10] To make the relevant points in a sharper way, we will assume that demand is linear; we will remark later on how our results generalize to the case of nonlinear demand.

Since the optimal strategic subsidy declines with cost when demand is linear, a low-cost firm would wish the government to be fully informed about its type. This is so because, if the government knew its type, it would set a higher subsidy than the one that maximizes expected welfare in the face of uncertainty. A low-cost firm might attempt to communicate its identity to the government by "signalling"; i.e., by making an investment that would be unprofitable for a high-cost type to imitate.

To describe how this would work, we need some additional notation. Let $\Pi^i_j(k)$ be the profits net of investment costs that a firm with cost parameter θ_i would earn in the Cournot competition if it installed a capital stock of size k and the government set the strategic subsidy that is optimal for a firm with costs $c(k;\theta_j)$. Let $\bar{\Pi}^i_j \equiv \max_k \Pi^i_j(k)$ and $\bar{k}^i_j \equiv \arg\max_k \Pi^i_j(k)$. Notice that $\bar{k}^i_i$ is the capital that a firm of type i would install in a regime of strategic intervention if the government were fully informed. It is straightforward to show that the set of separating equilibria is given by all pairs $(\bar{k}^H_H, k_L)$ such that k_L satisfies the following two conditions:

$$\bar{\Pi}^H_H \geq \Pi^H_L(k_L) \tag{9}$$

[10]More precisely, we look at separating Perfect Bayesian Equilibria (PBE). Pooling PBE equilibria may exist in this game, but we note that they would not satisfy Cho and Kreps' (1987) "intuitive criterion", so our focus on separating equilibria does not appear too restrictive.

and

$$\Pi_L^L(k_L) \geq \bar{\Pi}_H^L \ . \tag{10}$$

The first condition ensures that a high-cost type would not wish to mimic the investment behavior of low-cost type. The low-cost type sets a level of investment k_L that is intended to reveal its identity to the policymaker. The message will be compelling only if a high-cost type would earn lower profits by choosing k_L itself, thereby invoking a high subsidy, than by choosing the optimal investment for its type, $\bar{k}_H^H$, and accepting the lower subsidy. The second condition guarantees that the low-cost type prefers to send the signal than to deviate to any other level of capital.[11]

Our next task is to characterize the functions $\Pi_j^i(k)$ and to identify the values of k_L that satisfy the two incentive-compatibility constraints. We focus on the interesting case in which (i) a separating equilibrium exists, and (ii) the full-information outcome cannot be supported as a separating equilibrium (i.e., $\Pi_L^H(\bar{k}_L^L) > \bar{\Pi}_H^H$).[12] Notice, first, that $\bar{\Pi}_L^L > \max(\bar{\Pi}_H^L, \bar{\Pi}_L^H)$ and $\bar{\Pi}_H^H < \min(\bar{\Pi}_H^L, \bar{\Pi}_L^H)$. These observations follow from the envelope theorem and the fact that profits are increasing in the subsidy rate and decreasing in the parameter describing production costs. They are reflected in our depictions of the various $\Pi_j^i(k)$ curves in Figure 3.

The two panels of the figure show two possible orderings of the optimal capital stocks, $\bar{k}_j^i$. The top panel has $\bar{k}_L^L > \max(\bar{k}_H^L, \bar{k}_L^H)$ and $\bar{k}_H^H < \min(\bar{k}_H^L, \bar{k}_L^H)$. That is, an efficient firm known by the government to be efficient would invest more than either an inefficient firm thought to be efficient or an efficient firm thought to be inefficient. And an inefficient firm known by the government to be inefficient would invest less

[11] We can support the separating equilibria with the out-of-equilibrium beliefs for the policymaker that any capital stock different from k_L indicates that the firm has high costs. These are the "worst" beliefs for the government to hold, hence they support the largest possible set of separating equilibria. If the government holds these beliefs, any deviation by a low-cost type will induce the policymaker to believe $\theta = \theta_H$, leaving the firm with profits of at most $\bar{\Pi}_H^L$. Condition (10) ensures that no such deviation is profitable.

[12] These conditions are somewhat restrictive in this two-type model, but one can show that in a continuous-type version of this model they would be satisfied under weak regularity conditions.

than either an inefficient firm thought to be efficient or an efficient firm thought to be inefficient. The following lemma provides a sufficient condition for this ordering to arise:

Lemma 1 *If* $c_{k\theta} \geq 0$ *and product demand is linear, then* $\bar{k}_L^L > \max(\bar{k}_H^L, \bar{k}_L^H)$ *and* $\bar{k}_H^H < \min(\bar{k}_H^L, \bar{k}_L^H)$.

Proof. See appendix.

The condition $c_{k\theta} \geq 0$ is a plausible one. It says that when comparing two firms with the same capital stock, the more efficient one (lower θ) will achieve an equal or greater reduction in cost from a given marginal investment than the less efficient one. If it happens, however, that $c_{k\theta}$ is negative, the ordering of the optimal capital stocks may be reversed, giving rise to a situation such as that depicted in panel (b).[13] We defer discussion of this case until later in the section.

Suppose then that the ordering of the optimal capital stocks is as depicted in panel (a). Using the figure, we can identify the potential equilibrium values of k_L. Condition (9) requires that k_L be no smaller than k_L^S. This is the minimum investment that a low-cost type can make such that a high-cost type would have no desire to follow suit. Condition (10) dictates that k_L must lie in the interval between k_L' and k_L''. Combining the two, a separating equilibrium must have $k_L \in [k_L^S, k_L'']$. Since we have assumed that a separating equilibrium exists, it must be that $k_L'' > k_L^S$. And since we have assumed that the full-information outcome cannot be supported as an equilibrium, it must be that $k_L^S > \bar{k}_L^L$. Thus, a low-cost firm must *increase* its investment relative to the full-information level in order to signal its type.[14]

Let us summarize the discussion up until this point. A program of strategic intervention may give low-cost firms an incentive to signal their type to the policymaker, if

[13]In fact, for $c_{k\theta}$ *sufficiently* negative, the situation in panel (b) must obtain; see the appendix.

[14]We note that, among the levels of k_L that satisfy the conditions for a Perfect Bayesian Equilibrium, the unique level that also satisfies the "intuitive criterion" (Cho and Kreps [1987]) is the least-cost signal, k_L^S.

the latter is imperfectly informed about the firm's cost parameters. If more-efficient firms tend to invest more than less-efficient firms, then a low-cost firm can distinguish itself by investing even more than it otherwise would. This extra investment is costly for the firm to undertake, but would be even more costly for a high-cost firm to carry out. Accordingly, the policymaker can infer that only a low-cost type would be willing to send this signal.

Now we are ready to pose the main question of this section: How does asymmetric information about firms' costs affect the desirability of an *ex ante* commitment to free trade? We compare the range of cost-of-investment parameters α for which a commitment to free trade would be desirable when the policymaker is imperfectly informed and subject to an informational disadvantage with the range of parameters for which commitment is optimal in the symmetric-information benchmark. In the latter case, the policymaker eventually learns a firm's type without having to infer anything from its behavior. In making this comparison, we assume of course that the potential types of the firms (θ_L and θ_H) are the same in the two scenarios, and so is the prior probability q that a firm will have low costs.

As the following proposition states, this question admits a clear-cut answer in the case where demand is linear and $c_{k\theta} \geq 0$:

Proposition 2 *If $c_{k\theta} \geq 0$, product demand is linear, and asymmetric information results in a separating equilibrium, then the range of parameters α for which a commitment to free trade is socially preferable to a regime of strategic intervention is larger with asymmetric information than in the symmetric-information benchmark.*

Proof. The proof of the proposition is straightforward in the light of our previous discussion. First note that, for a given value of α, the expected welfare of a commitment to free trade is the same in the benchmark scenario as in the scenario with asymmetric information. Since the government takes no action, a firm of a given type makes the same investment irrespective of what information is available to the government. Also, if the government chooses a regime of strategic intervention and the firm happens to be a high-cost type, the realized welfare will be the same in either scenario. To see this, notice that: (i) the high-cost type invests $\bar{k}_H^H$ in the scenario with asymmetric information, which is the same as what it invests when the government learns its type; (ii) in a separating equilibrium the policymaker infers the firm's type from its investment, hence she sets the same subsidy rate as in the symmetric-information benchmark; and (iii) with the same capital stock and the same subsidy rate, the competing duopolists make the same output choices. So all outcomes are the same under the alternative scenarios when it happens that the firm is an inefficient type.

In contrast, the two scenarios yield different outcomes when the government opts for a program of strategic trade and nature happens to choose a low-cost type. In the benchmark scenario, the firm makes the full-information investment choice, $\bar{k}_L^L$, and the government sets the subsidy $s[c(\bar{k}_L^L;\theta_L)]$. Under asymmetric information, the firm signals its type by choosing $k = k_L \geq k_L^S > \bar{k}_L^L$. The policymaker infers that $\theta = \theta_L$ in a separating equilibrium, and so the subsidy is $s[c(k_L;\theta_L)]$. Now recall from Section 2, and in particular the discussion surrounding Figure 1, that investment by a firm of any known type exceeds the first-best level. If a low-cost firm invests even more than $\bar{k}_L^L$ in order to signal its type, then the resulting welfare level must be lower than in the full-information case. It follows that if $k_L > \bar{k}_L^L$, the expected welfare under a program of strategic trade carried out in an environment of asymmetric information falls short of the expected welfare from the program in the benchmark scenario. Since this is true for any value of α, the introduction of asymmetric information must tilt the choice in favor of a commitment to free trade.

Our result lends some (limited) support to the view that imperfect information on the part of the policymaker diminishes the attractiveness of a program of strategic export subsidies. Our argument requires not only that the government be imperfectly informed, but also that it suffer an informational disadvantage relative to participants in the industry. Then, if low-cost firms expand their investment in order to signal that they are worthy of a larger subsidy, this "signalling distortion" will exacerbate the distortion owing to strategic manipulation. In the event, a commitment to free trade will be desirable for an even larger range of investment-cost parameters than would be the case if the government could directly observe a firm's costs before setting its trade policy.

Next we discuss how our conclusions might change if $c_{k\theta}$ were negative, and in particular if it were negative enough to make the ordering of the optimal capital stocks such as that depicted in panel (b) of Figure 3, i.e. $\bar{k}_L^L < \min(\bar{k}_H^L, \bar{k}_L^H)$ and $\bar{k}_H^H > \max(\bar{k}_H^L, \bar{k}_L^H)$.[15] In this case, condition (10) again requires that $k_L \in [k_L', k_L'']$, but (9) requires that k_L be no *larger* than k_L^S. The equilibrium values of k_L are now those between k_L' and k_L^S, all of which are smaller than the full-information level, $\bar{k}_L^L$. In this case, a low-cost firm signals its type by holding back on investment, that is, by choosing $k_L < \bar{k}_L^L$. The intuition is that, if more-efficient firms invest less than others in the absence of any asymmetric information, then an effective signal will require these firms to cut back on their investment; this signal is costly, but it would be even more costly for the high-cost type to imitate.

If the low-cost firm signals its identity by cutting back on its investment, the result of Proposition 2 may be reversed; since investment by a firm of any known type exceeds the first-best level, the resulting welfare level may be higher than in the full-information case, if the reduction in k is not too great. If this is the case, the range of parameters α for which a commitment to free trade is desirable will be smaller with asymmetric information than in the symmetric-information benchmark.[16]

[15]This case obtains, for example, if $c(k,\theta) = \theta e^{-\beta k}$, with β sufficiently high.

[16]We note here how our results generalize when the assumption of linear demand is relaxed. If demand is approximately linear, our results hold exactly as stated. but if demand is highly nonlinear, the condition $c_{k\theta} \geq 0$ is no longer sufficient for Proposition 2 to hold; the result is ensured only if $c_{k\theta}$ is sufficiently positive. At any rate, it remains true that the impact of asymmetric information is determined in a critical way by the ordering of the optimal capital stocks: if this is as depicted in panel (a), Proposition 2 holds; if panel (b) is the relevant one, the result is likely to be reversed.

4 Concluding Remarks

In this paper we have taken a first step toward examining an argument frequently levied against strategic trade activism — that, by enacting a program of intervention, a government leaves itself open to strategic manipulation by the private sector the consequences of which can be so damaging that it would be better to have no strategic policies at all. We have focused on one specific type of action that a domestic firm might take to influence a government's choice of trade policy, namely, irreversible investment to reduce manufacturing costs, and we have considered two forms that the strategic manipulation might take. First, by augmenting its capital stock, a firm of any known type can induce its government to apply a larger subsidy. Second, by investing differently from a high-cost firm, a more efficient firm can signal its type to the government, thereby ensuring a higher subsidy. The key question we have addressed is: Under what conditions would it be desirable to commit to a regime of free trade rather than enact a program of strategic intervention?

Our analysis suggests two main conclusions. First, a program of strategic trade policy generates national benefits when the cost of investment is either large or small, whereas a commitment to free trade is likely to be preferable for intermediate values of this cost parameter. Second, the presence of asymmetric information between the government and domestic firms (in the sense that firms have better information about their own productivity) tends to strengthen the case for commitment to free trade.[17]

Before concluding, we wish to discuss briefly some possible extensions of the analysis. First, in examining the implications of asymmetric information, we have focused on a single parameter describing the domestic firm's productivity. One might also wish to explore the implications of information asymmetries regarding other key pa-

[17] It is worth stressing that all of our results have been derived assuming a passive foreign policy. If several governments might be simultaneously active in trade intervention, a commitment by all of them to free trade may be desirable not only for the reasons discussed here, but also as a way out of the prisoner's dilemma of strategic profit-shifting.

rameters, including some that might appear more crucial than our cost parameter. For example, the government may have limited information about the mode of competition, and in particular it may not know whether firms compete à la Cournot or à la Bertrand. Here, the domestic firm would try to persuade the government that the market is of the Cournot sort, since in this case the optimal strategic policy is a subsidy, whereas a tax is indicated in the Bertrand case. Under symmetric information, the "Cournot" firm invests more than the "Bertrand" firm (because the strategic scope for cost-reduction is greater under Cournot competition). Under asymmetric information, since it is the "Bertrand" firm that has the incentive to deceive the government, the "Cournot" firm would signal its type by overinvesting relative to the full-information level. Thus, our result that an informational asymmetry exacerbates the investment distortion, and hence strengthens the case for commitment to free trade, should hold in this setting as well.

Second, one could consider other instruments that firms might utilize to alter the government's perception of the optimal trade policy. For example, firms may be able to invest in "hard" information, i.e. they may seek direct evidence that supports their case for a large subsidy and present such evidence to the government. If the government is uncertain about the firms' costs, firms will try to provide evidence that they are highly efficient, and thus deserve a high subsidy. Our result that a commitment to free trade tends to be desirable when the cost of investment is moderate is likely to hold also in this setting. The same basic mechanism as in our model should be at work: when the cost of investment (here, in information acquisition) is great, firms have little incentive to manipulate the government; when it is slight, the social cost of any distortion in the investment level will be small.

If firms can manipulate the government by producing evidence that bolsters their case, the government may have others weapons besides committing to free trade regime for insulating itself from strategic manipulation. For example, the agency that sets trade policy might be able to foreclose access to industry advocates, refusing to consider the possibly "tainted" evidence they might submit. Such an institutional "rule" would have the advantage of preventing firms from wasting resources on information manipulation, but the disadvantage that the agency might miss out on potentially valuable information. An interesting task for future research would be to compare the effectiveness of alternative institutional rules, such as foreclosing access by lobby groups versus committing not to use strategic policies, designed to neutralize strategic manipulation by the private sector.

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Appendix

Proof of Proposition 1

(i) We show first that $\lim_{\alpha\to 0}(W_{STP}-W_{FT})>0$. Let $\tilde{\pi}(\tilde{c})$ be the reduced-form expression for the home firm's operating profits, when $\tilde{c}=c-s$ is the firm's per-unit cost net of any export subsidy. Let $\tilde{x}(\tilde{c})$ be the corresponding output level for the home firm. Then

$$\begin{aligned} W_{STP}-W_{FT} &= \tilde{\pi}[c(k_{STP})-s(c(k_{STP}))]-s(c(k_{STP}))\tilde{x}[c(k_{STP})-s(c(k_{STP}))]-\tilde{\pi}[c(k_{FT})] \\ &\quad -\alpha[i(k_{STP})-i(k_{FT})]. \end{aligned} \tag{A1}$$

As $\alpha\to 0$, $k_{STP}\to\infty$ and $k_{FT}\to\infty$. Let $c(\infty)\equiv c_\infty$. Then $\tilde{\pi}[c(k_{STP})-s(c(k_{STP}))]\to\tilde{\pi}[c_\infty-s(c_\infty)]$ and $\tilde{\pi}[c(k_{FT})]\to\tilde{\pi}(c_\infty)$. Moreover, $\tilde{\pi}[c_\infty-s(c_\infty)]-s(c_\infty)\,\tilde{x}[c_\infty-s(c_\infty)]>\tilde{\pi}[c_\infty]$, because $s(c_\infty)$ is the optimal strategic subsidy when costs are c_∞. So the first three terms on the right-hand side of (A1) sum to a strictly positive number as $\alpha\to 0$.

Now consider the term $\alpha[i(k_{STP})-i(k_{FT})]$. Suppose for the moment that this term is strictly positive for all α; i.e., $\lim_{\alpha\to 0}\alpha[i(k_{STP})-i(k_{FT})]\geq\delta>0$ for some δ. Then the domestic firm could increase its profits in the strategic-trade regime by changing its capital stock from k_{STP} to k_{FT}. This would save a discrete positive amount δ in investment costs, but would leave the firm with higher production costs and a smaller subsidy. However, $\lim_{\alpha\to 0}[c(k_{FT})-c(k_{STP})]=0$ and $\lim_{\alpha\to 0}[s(c(k_{FT})-s(c(k_{STP}))]=0$. Therefore, the discrete savings in investment costs would exceed the negligible loss of operating profits. This contradicts the fact that k_{STP} is optimal given α. Thus, $\lim_{\alpha\to 0}\alpha[i(k_{STP})-i(k_{FT})]=0$ and $W_{STP}>W_{FT}$ for α small enough.

(ii) Next we show that $\lim_{\alpha\to\infty}(W_{STP}-W_{FT})>0$. Clearly, $k_{STP}\to 0$ and $k_{FT}\to 0$ as $\alpha\to\infty$. Let $c(0)\equiv c_0$. Then as $\alpha\to\infty$, $\tilde{\pi}[c(k_{STP})-s(c(k_{STP}))]\to\tilde{\pi}[c_0-s(c_0)]$ and $\tilde{\pi}[c(k_{FT})]\to\tilde{\pi}(c_0)$. Moreover, $\tilde{\pi}[c_0-s(c_0)]-s(c_0)\,\tilde{x}[c_0-s(c_0)]>\tilde{\pi}[c_0]$, because $s(c_0)$ is the optimal strategic subsidy when costs are c_0. So the first three terms on the right-hand side of (A1) sum to a strictly positive number as $\alpha\to\infty$.

Again consider the term $\alpha[i(k_{STP})-i(k_{FT})]$. This can be written as

$$\alpha[i(k_{STP})-i(k_{FT})]=\alpha i'(k_{STP})\left[\frac{i(k_{STP})}{i'(k_{STP})}-\frac{\alpha i'(k_{FT})}{\alpha i'(k_{STP})}\cdot\frac{i(k_{FT})}{i'(k_{FT})}\right]. \tag{A2}$$

The first-order condition for k_{FT} implies that $\lim_{\alpha\to\infty}\alpha i'(k_{FT})=\tilde{\pi}'(c_0)c_k(0)$, while that for k_{STP} implies $\lim_{\alpha\to\infty}\alpha i'(k_{STP})=\tilde{\pi}'(c_0)[1-s'(c_0)]c_k(0)$. Therefore, $\lim_{\alpha\to\infty}\frac{\alpha i'(k_{FT})}{\alpha i'(k_{STP})}=1/[1-s'(c_0)]>0$. Meanwhile, Assumption 2 implies $\lim_{\alpha\to\infty}\frac{i(k_{STP})}{i'(k_{STP})}=\lim_{\alpha\to\infty}\frac{i(k_{FT})}{i'(k_{FT})}=0$, since $k_{STP}\to 0$ and $k_{FT}\to 0$. It follows that the term in square brackets converges to zero, and so therefore does the cost of over-investment, $\alpha[i(k_{STP})-i(k_{FT})]$. This proves that $W_{STP}>W_{FT}$ for α large enough.

Proof of Lemma 1

We can write $\Pi_j^i(k) = \tilde{\pi}[c(k;\theta_i) - s(c(k;\theta_j)] - \alpha i(k)$. The optimal capital stock $\bar{k}_j^i$ obeys the first-order condition, $\partial\Pi_j^i/\partial k = 0$, and the second-order condition, $\partial^2\Pi_j^i/\partial k^2 < 0$. The lemma relates the sizes of the various $\bar{k}_j^i$, so we need to know how $\bar{k}_j^i$ varies with θ_i and θ_j. The comparative statics are given by $\partial\bar{k}_j^i/\partial\theta_i = -[\partial^2\Pi_j^i(k)/\partial k\partial\theta_i]/[\partial^2\Pi_j^i/\partial k^2]$ and $\partial\bar{k}_j^i/\partial\theta_j = -[\partial^2\Pi_j^i(k)/\partial k\partial\theta_j]/[\partial^2\Pi_j^i/\partial k^2]$. By the second-order conditions, these have the same signs as $\partial^2\Pi_j^i(k)/\partial k\partial\theta_i$ and $\partial^2\Pi_j^i(k)/\partial k\partial\theta_j$, respectively.

We calculate

$$\frac{\partial^2\Pi_j^i}{\partial k\partial\theta_i} = \tilde{\pi}''(\cdot)c_\theta(\cdot)c_k(\cdot)[1 - s'(c)] + \tilde{\pi}'(\cdot)c_{k\theta}(\cdot) \tag{A3}$$

and

$$\frac{\partial^2\Pi_j^i}{\partial k\partial\theta_j} = -\tilde{\pi}''(\cdot)s'(c)c_\theta(\cdot)c_k(\cdot)[1 - s'(c)] - \tilde{\pi}'(\cdot)[s''(c)c_\theta(\cdot) + s'(c)c_{k\theta}(\cdot)]. \tag{A4}$$

When demand is linear, $\tilde{\pi}''(\tilde{c}) = \frac{8}{9} > 0$, and since $c_\theta > 0$, $c_k < 0$ and $s'(c) = -\frac{1}{2}$, the first terms on the right-hand sides of (A3) and (A4) are both negative. Also, $\tilde{\pi}'(\tilde{c}) < 0$ and $s''(c) = 0$, so the second term in each expression is non-positive so long as $c_{k\theta} \geq 0$. Therefore, when demand is linear, $c_{k\theta} \geq 0$ implies $\partial\bar{k}_j^i/\partial\theta_i < 0$ and $\partial\bar{k}_j^i/\partial\theta_j < 0$, which in turn implies $\bar{k}_L^L > \max(\bar{k}_L^H, \bar{k}_H^L)$ and $\bar{k}_H^H < \min(\bar{k}_L^H, \bar{k}_H^L)$.

Note also that $\pi'(\tilde{c}) < 0$ for any demand function. Therefore, the right-hand sides of (A3) and (A4) must be negative in general for $c_{k\theta}$ sufficiently positive, and they must be positive in general for $c_{k\theta}$ sufficiently negative.

Figure 1

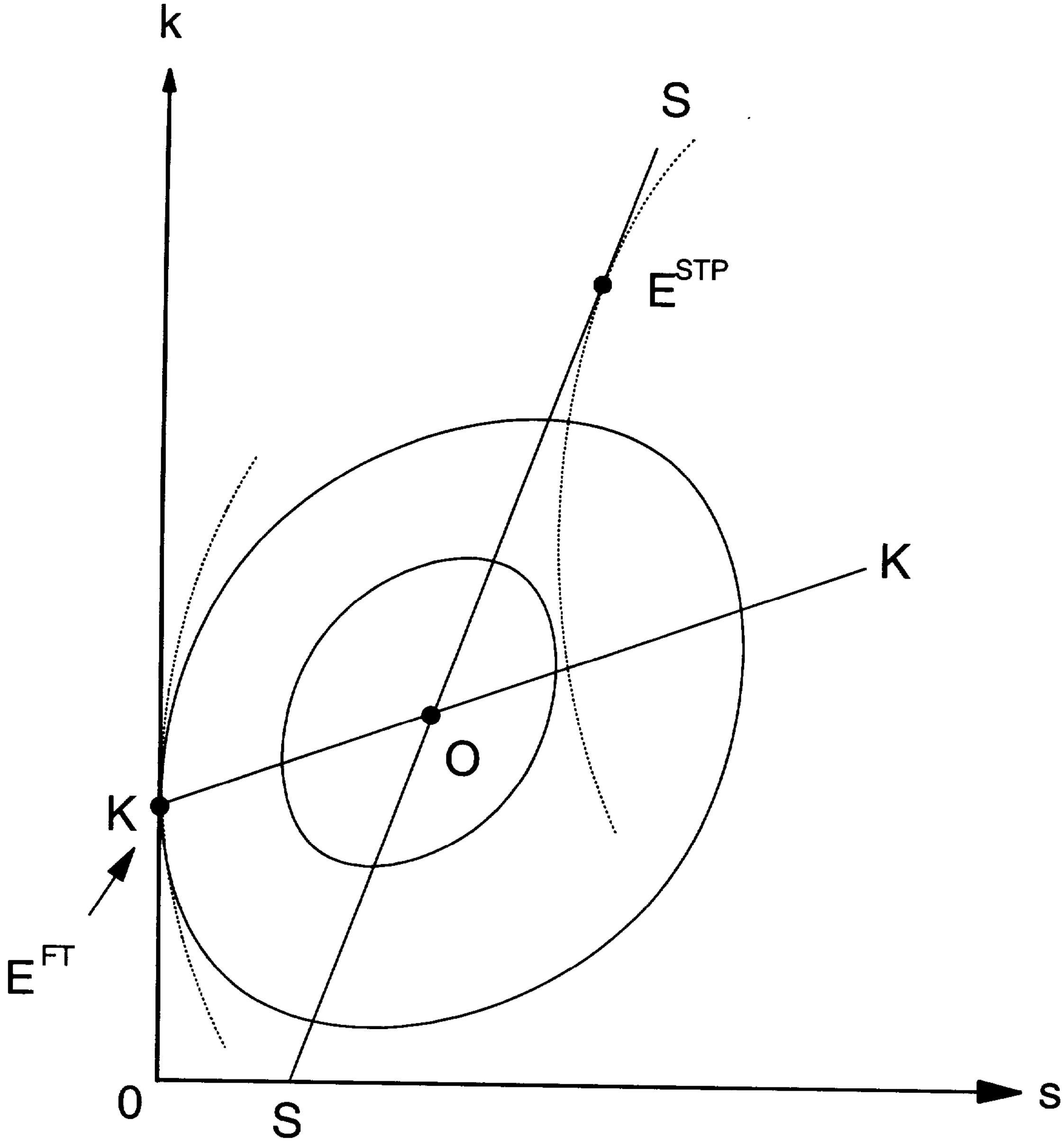
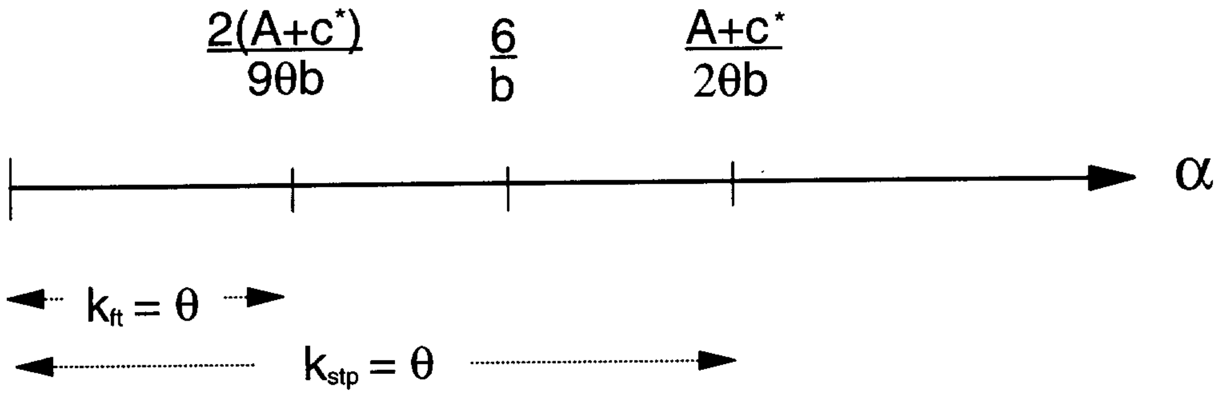
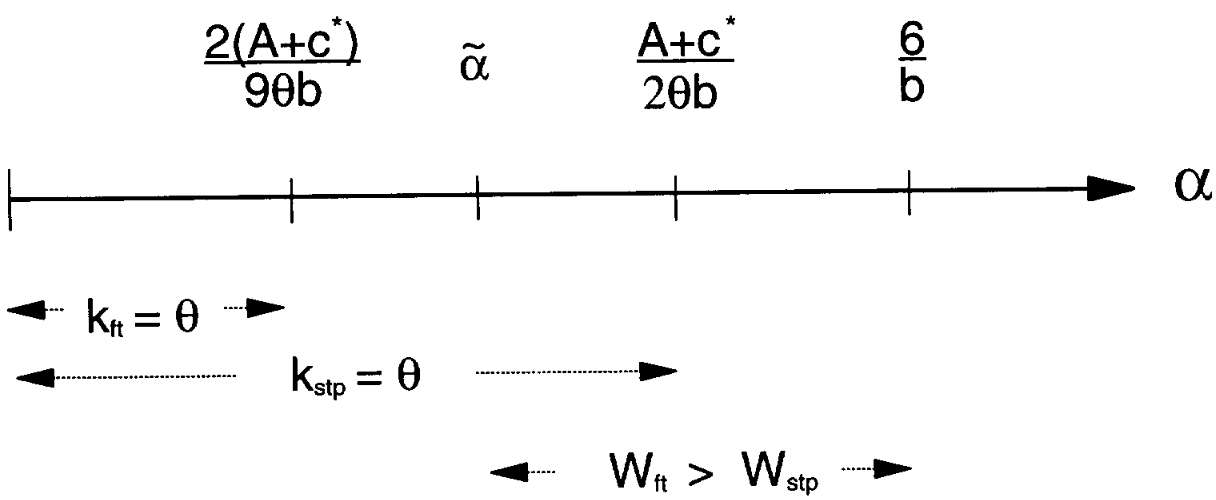


Figure 2



(a) $A+c^{*} > 12\theta$



(b) $A+c^{*} < 12\theta$

Figure 3