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Credibility and the Cost of Export Subsidies

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Abstract

Recurring balance of payments crises in countries that pursued import substitution have led some of them to establish a variety of export incentives, in particular subsidies, as a way to revive and re-orient their economies. However, exporters are likely to be uncertain of the government's commitment to export promotion because of the years of neglect. This paper analyzes the issue of the credibility of export subsidies and suggests that a government is able to convince exporters of its commitment only at a cost, which reduces the attractiveness of promoting exports by means of subsidies.

JEL Classification Numbers
C70, C72, F13

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Contents

Summary

This paper analyzes the cost of export subsidies when the commitment of the government to export promotion is uncertain. This situation can arise when the government in the past has neglected exports by pursuing import substitution policies.

Exporters, when facing a new export regime, are uncertain about the government's interest in promoting exports. A government that has low-export preferences has the incentive to trick exporters into investing more, in order to reduce the budgetary expense of its export promotion program. Exporters are naturally skeptical of a government that merely claims commitment to high-export levels, as it may prove to be a low-export government in disguise.

It is shown, that while a government that is committed to high level of exports will be able to reach its target, by signalling unequivocally its export preferences. This signal will consist of a higher export subsidy than would have been necessary had the export preferences known with certainty.

Illustrative simulations to determine the order of magnitude of the cost of achieving credibility suggest that the costs involved will range between 15-35 percent of total outlays of the export subsidy program--roughly 0.2-0.5 percent of GDP. These cost estimates are troublesome for a policy of export promotion via export subsidies. It may be preferable to stimulate exports by reducing the anti-export bias by other means rather than trying to offset the bias with subsidies.

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I. Introduction

This paper extends the literature on credibility to the case of export subsidies and examines it through a dynamic game-theoretic model. Time inconsistency, which has received significant attention in the context of monetary policy games, 1/ has not been discussed extensively when it comes to trade issues. The few available studies include Calvo (1986), who considered the time inconsistency of trade liberalization, and Matsuyama (1990) and Tornell (1991) who have considered time inconsistency of temporary import protection schemes. There are, however, that look specifically at the role of subsidies in promoting exports.

Export subsidies present policymakers and exporters alike with a policy dilemma. When a government announces a new policy exporters are uncertain about what its true intentions will be. A government that follows low export-oriented policies has an incentive to trick exporters into investing more, in order to reduce the budgetary expense of its export promotion program. Exporters will naturally be skeptical of a government that merely claims commitment to high export levels, since it may in fact prove to be a low-export-oriented government in disguise. Thus, gaining the confidence of exporters can be a problem, particularly when the policymakers have failed to maintain a favorable history regarding to export incentives, i.e. kept overvalued exchange rate and/or generated high domestic inflation.

In such a case, policymakers will need to unequivocally signal their commitment to export promotion. By setting export subsidies high enough to make a stated export target credible, exporters will be convinced the government is serious about export growth. They in turn will perceive that significant export-oriented investment projects are in their interest and that if they make such investments, exports will grow as targeted.

This analysis emphasizes the strategic behavior that can occur in an economy that wishes to move from years of import substitution to the promotion of exports. 2/ The need to establish the government's commitment to export growth will drive up the budgetary costs required to achieve the targeted level of exports. The additional cost will depend on exporters' perception of the government's export objectives and on the relative difference between the goals of the high- and low-export oriented governments. For exporters, while

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1/ For recent surveys of this literature, see Fischer (1986, 1990) and Cukierman (1985).

2/ Strategic trade policy, as discussed by Brander and Spencer (1985), Dixit and Grossman (1986) and Gruenspecht (1988), has emphasized the international strategic aspects of export subsidies. Export subsidies are thus viewed as a mechanism to transfer rents to a local producers. However, this literature does not address the intra-national strategic behavior emphasized in this paper.

a policy of epxort subsidies increases the profitability of investment, such investment can potentially reduce future subsidies by increasing the productivity of labor.

The case of Costa Rica can help illustrate this point. Table 1 below presents the relevant data. Nontraditional exports had been subsidized in Costa Rica since 1974, but in 1984--in the aftermath of the 1980-82 balance of payments crisis--the export promotion program was significantly expanded. The "export contract" was established to coordinate and enhance export incentives; backed by an increase in budgetary expenditures, from an average of 0.3 percent of GDP to 0.8 percent of GDP; export growth increased sixfold (Table 1). While it could be claimed that the increase in Costa Rica's exports was exclusively due to the establishment of a commitment to export promotion, the experience clearly demonstrates that export growth requires policies that are consistent with its promotion.

Table 1. Costa Rica: Budgetary Cost of Export Subsidies

Period	Average Expenditure	Average Growth of Subsidized Exports
	(Percent of GDP)	(In percent)
1979-83	0.3	2.0
1984-89	0.8	12.3

Source: Ministry of Finance, and the Central Bank.

Turkey had a similar experience with export promotion during the early 1980's. Milanovic (1986) reports that subsidies averaged roughly 0.2 percent of GDP from 1980-82, and increased to an average of about 1.6 percent during 1983-84. Exports in turn grew an average of 45 percent per year.

However, other countries have not been as successful promoting exports. In general, exporters respond not only to export subsidies as such, but to the entire macroeconomic environment. And in this context many factors contribute to the perception of commitment to export promotion. This paper focuses upon the role of export subsidies, accepting that other factors will also have a significant effect on export performance.

The rest of the paper is organized as follows. Section II presents a theoretical model to address the credibility issue of export subsidies. Section III analyzes the case where government can precommit to a subsidy; Section IV looks at the case where precommitment is not feasible. Finally, Section V presents a summary of the major results.

II. The Model

The model has two players, the government and exporters. The analysis is set in the framework of two periods. The government's objective is to achieve its long-run, that is, in the second period, target level of exports with the least expenditure. Its instrument is an export subsidy that is aimed at the export sector at large. The export sector is modeled as atomistic, so that exporters maximize profits--given the expected subsidy in period two--disregarding how their individual actions affect other firms in the sector. The importance of this feature of the model will become evident when discussing investment.

In period one, the government sets the first period subsidy, s_1, and announces the subsidy of period two, s_2. Given s_1, exporters hire labor L_1 and supply output according to their short-run supply functions using existing capital stock of K_1. In period one exporters also determine their investment, I_1, based on their expectation about s_2. Investment does not have an immediate effect on production; instead, its effect is to reduce costs in period two. In period two the government can revise its announced subsidy s_2, and set it to reach its export target level. The game ends when exporters observing s_2, hire labor L_2 and supply output along their new short run supply functions with their second-period capital stock of $K_2=K_1+I_1$.

Consider the exporter. The individual exporter's profit function evaluated in period one is:

$$\pi = P_1 f(l_1, k_1) - w l_1 - P_I i_1 + P_2 f(l_2, k_1 + i_1) - w l_2 \qquad (1)$$

where $P_1=(1+s_1)P$ and $P_2=(1+E[s_2])P$. 1/ Profit maximization will determine implicitly the following factor demands for an individual export firm: 2/

$$\begin{aligned} l_1^* &= l_1^*\left[\overset{(\cdot)}{P_1}, \overset{(-)}{w}, \overset{(\cdot)}{K_1}\right] \\ l_2^* &= l_2^*\left[\overset{(\cdot)}{P_2}, \overset{(-)}{w}, \overset{(-)}{P_I}, \overset{(0)}{k_1}\right] \\ i_1^* &= i_1^*\left[\overset{(\cdot)}{E[P_2]}, \overset{(-)}{w}, \overset{(-)}{P_I}, \overset{(-)}{k_1}\right] \end{aligned} \qquad (2)$$

1/ The notation allows for a non-zero subsidy in period one, which will be important in the asymmetric information case discussed later. For simplicity the discount rate equals zero.

2/ These factor demands are provided in the Appendix. The signs are determined by the neoclassical production function and second order conditions.

The sign of the partial derivative is denoted above each argument. The combined actions of atomistic export firms will determine total labor demand, L_1 and L_2, and sector investment I_1. Throughout the paper upper case symbols will denote sector variables, while lower case symbols will denote variables for individual firms.

Consider the government. As mentioned before, the government's objective is to reach a target level of exports in period two, minimizing the use of tax revenues. This means that intermediate export targets are unimportant, consequently, the cost function is: 1/

$$C = C\left(\overset{(\cdot)}{s_1}, \overset{(-)}{K_2^*}, \overset{(\cdot)}{\bar{NX}}\right) = s_1 P \cdot NX(s_1, K_1) + s_2 P \cdot NX(s_2, K_2^*(E[s_2])) \tag{3}$$

where $\bar{NX}$ is the long-run export target, the NX(s,K)'s are the short-run export supply functions; K^*_2 is the desired capital stock and therefore the desired investment is $I^*_1=K^*_2-K_1$. 2/

The government determines the subsidy to announce for period two, by using the exporters' optimum behavior, i.e. labor demand functions and the investment function described by equation (2). This announced subsidy, $\bar{s}$, is determined implicitly by: 3/

$$\bar{NX} = NX(\bar{s}, K_2^*(E[s_2])) \tag{4}$$

Note that K_2^* depends upon the expected subsidy, which must be dealt with explicitly by the policymaker. In the precommitment case, the government treats $E[s_2]$ as parametric, equal to its announced level $\bar{s}$; while in the no precommitment case $E[s_2]$ is not parametric and can change with the government's action in period one.

1/ This cost function is used for simplicity. An objective function where first period exports are included does not alter the basic results. Specifically, the subsidy in period one could be positive, and the no precommitment subsidy will be larger under asymmetric information than under symmetric information.

2/ Notice that in equation (3) the short-run supply function in period two is evaluated at the optimum level of capital stock K^* (given as $E[s_2]$), so that it equals the long-run supply function.

3/ For simplicity, factor prices have been omitted from the notation.

A credible export promotion policy induces a level of investment in period one that eliminates the government's incentive to revise its announced subsidy. In this case the actual subsidy in period two equals the announced subsidy. Consider why this might not be the case. Low investment in period one will reduce the marginal product of labor in period two, so that reaching the targeted level of exports will require a higher subsidy rate. Thus, the actual subsidy in period two will be greater than the announced subsidy. Exporters behaving strategically might find it profit-maximizing to reduce their investment in period one so as to induce a higher subsidy in period two.

III. Precommitment Case

Although by definition credibility is not an issue in this case, it is useful to briefly discuss the situation. The first period subsidy s_1 serves no purpose: the expectation of s_2 is independent of s_1, and thus cost minimization will require setting it equal to zero. 1/ The solution for s_2 is determined implicitly from (4) $\bar{s} - s\left(\overset{(\cdot)}{NX}\right)$. 2/

The effect of this subsidy is depicted in Figure 1, where the $Psr=P(NX,K_i)$ are the short-run supply curves for the two periods and $Plr=P(NX,K^*(NX))$ is the long-run supply curve. In period one, $s_1=0$. The government determines $s_2=\bar{s}$, that is $\bar{P}=(1-\bar{s})P$, by reading the long-run supply at $\overline{NX}$. Individual exporters take the announced $\bar{s}$ at face value, so $i_1^*=i_1^*(\bar{s})$. Since the export sector is atomistic, sector investment will consist of the summation of individual investment functions from equation (2). Figure 2 shows the sector investment to be I1* and period two capital stock equals Kc. In period two, the government sets the subsidy to $\bar{s}$ and exports will equal $\overline{NX}$ in Figure 1. 3/ 4/

1/ This is analogous to the zero inflation equilibrium in monetary games obtained with precommitment. However, since period one exports are not important, strict cost minimization implies setting a tax on exports (negative subsidy) equal to the inverse of the price elasticity of the short run supply curve. This will achieve the greatest amount of tax revenues in period one, that would in turn be used to finance outlays in period two. This paper rules out the possibility of taxing exports as they do not seem appropriate for export promotion.

2/ This corresponds to the open-loop solution.

3/ Notice that the open loop subsidy is inversely related to the long run price elasticity of supply.

4/ The first-period capital stock is assumed to be in long-run equilibrium, such that no new investment will occur, unless a positive subsidy is expected. Notice that as investment increases, it becomes less responsive to the subsidy, due to the nature of the neoclassical production function.

In a sense, the government under precommitment behaves as a leader. It uses exporters' supply curves to determine the subsidy that will induce exporters to produce the targeted level of exports. Exporters, by taking the announced export promotion policy at face value, behave as followers. 1/ The level of investment is such that even if the government was allowed to revise its second period subsidy, it would choose not to do so.

IV. No Precommitment Case

Consider government incentives under no precommitment. The government's problem in period two--when the investment decision has already been implemented--differs from the problem in period one before the investment is in place. Now the subsidy necessary to reach the target is obtained from:

$$\bar{NX} = NX(L_2^*(s^a), K_2) \quad . \tag{5}$$

where K_2 is fixed. This implicitly determines the actual subsidy in period two, s_2^a, to be:

$$s_2^a = s\left(\overset{(+)}{\bar{NX}}, \overset{(-)}{K_2}\right) \quad . \tag{6}$$

Note the effect of contemporaneous capital K_2 on the subsidy. Without binding commitments, the government's incentive to deliver the announced subsidy $\bar{s}$ in period two depends upon K_2. This suggests that in period two, the government reacts "passively" to the level of capital stock. In this sense, the lack of precommitment could force the government to surrender its leadership role if the capital stock in period two is less than $Kc=K_2^*(\bar{s})$. 2/ However, for this to occur exporters must find it profitable to reduce investment to increase the subsidy, even though this increases production costs.

In this Section two situations discussed. The first case is when the official export target is fully known by exporters, that is, when there is "symmetric information." Interestingly, when the export sector is atomistic and exporters know the export target, credibility--specifically time

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1/ That is, under precommitment, the government behaves as a Stackleberg leader. Exporters behave as if their actions did not affect the government's behavior, that is they behave Nash.

2/ That is, if the capital stock in period two is smaller than $K_2^*(\bar{s})$, exporters would become Stackelberg leader, while the government would be behaving Nash against exporters. Thus, the lack of commitment can potentially reverse the situation discussed before.

Figure 1: Precommitment Subsidy

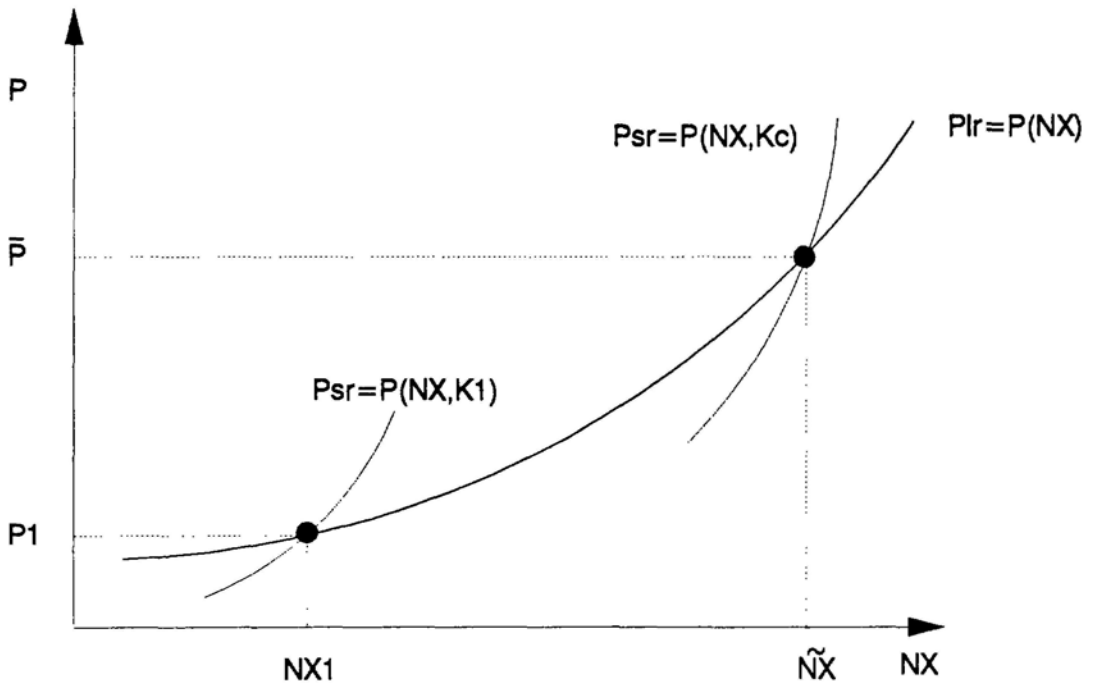
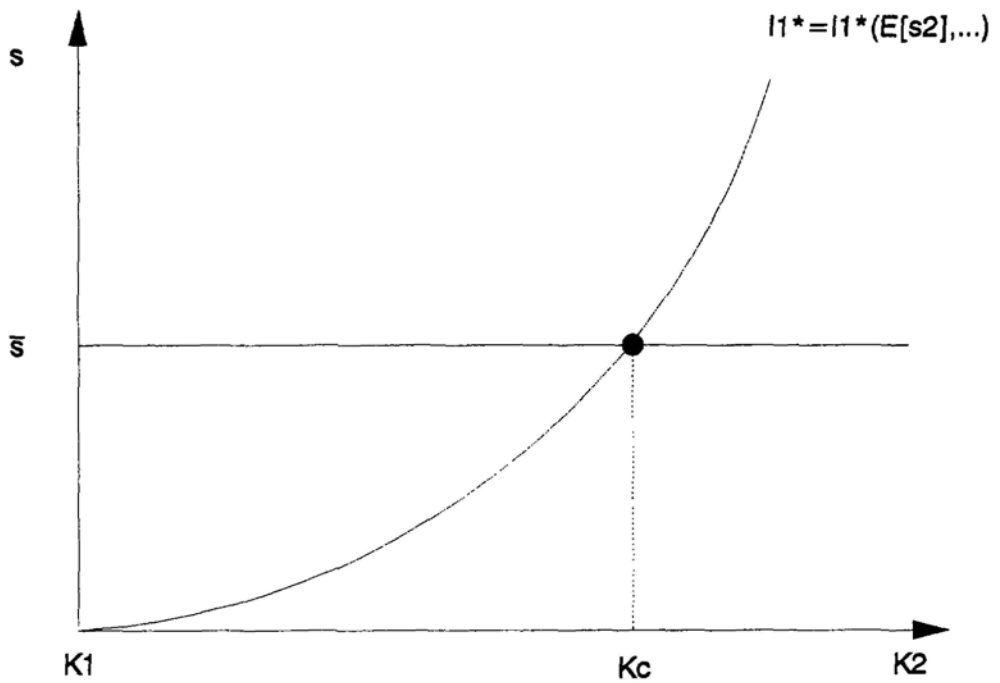


Figure 2: Precommitment Investment



inconsistency--will not be an issue. The second and more realistic case is when the government's export target is uncertain; this condition of uncertainty is described as "asymmetric information." When exporters have imperfect information about the extent to which a new government is committed to increasing exports, credibility will be an issue. 1/ This section ends with illustrative simulations to gauge the order of magnitude of the costs involved to credibly signal an export target.

1. Symmetric Information

Exporters are aware of the contemporaneous effect of capital upon s_2^a and they know the export target, $\bar{NX}$. Their individual profit functions--that include the government's passive reaction to K_2 given by equation (6)--can be expressed as:

$$\pi = P_1 f(l_1, k_1) - w l_1 - P_I i_1 + P_2^a(\bar{NX}_2, w, P_I, K_1 + I_1) \cdot f(l_2, k_1 + i_1) - w l_2 \quad . \tag{7}$$

First order conditions for profit maximization imply: 2/

$$\begin{aligned} l_1^* &= l_1^*\left[\overset{(+)}{P_1}, \overset{(-)}{w}, \overset{(+)}{k_1}\right] \\ l_2^* &= l_2^*\left[\overset{(+)}{P_2^a}, \overset{(-)}{w}, \overset{(+)}{P_I}, \overset{(0)}{k_1}\right] \\ i_1^* &= i_1^*\left[E\left[P_2^a\left(\bar{NX}, \overset{(+)}{K_1} + I_1, \ldots\right)\right], \overset{(-)}{w}, \overset{(-)}{P_I}, \overset{(-)}{k_1}\right] \end{aligned} \tag{8}$$

Notice that individual investment--and sector investment, as the sum of horizontal sum of individual investment--is directly related to the expected subsidy and this subsidy depends upon the capital stock in period two. 3/

1/ We are here primarily concerned with asymmetric information as the source of credibility.

2/ Where $\partial I_1 / \partial i_1$ has been implicitly set equal to zero consistent with an atomistic export sector.

3/ It is implicitly assumed that individual firms invest simultaneously. Assuming--as in Farrel and Saloner (1985)--that investment decisions are sequential, but the actual implementation of investment is simultaneous, does not affect the results.

Figure 3 will aid the discussion of the equilibrium in this case. It depicts the investment function of the atomistic exporting sector and the government reaction function given by equation (6). Notice that the latter is downward sloping as the subsidy needed to reach the target decreases as the capital stock increases. The corresponding equilibrium is denoted as "e", where $K_2=K^*$ and $s_2=s^*$. For this to be an equilibrium, exporters must expect $K_2=K^*$ in period one, thus--using the government's reaction curve--$s_2=s^*$ would be expected. Investment is made accordingly, $I_1^*=K^*-K_1$. In period two, the government observes $K_2=K^*$, and sets s_2--using its reaction function--equal to s^*. Expectations are correct, and no one has an incentive to change their behavior unilaterally after the fact. 1/ In this analysis s_1 plays no role, so that once again cost minimization will require it to be set to zero.

Furthermore, this equilibrium is unique. Consider any other expected capital stock. Without loss of generality, assume exporters expect K_2 to be $K_w<K^*$, then s_2 is expected to be equal to s_w and investment is such that $K_2=K'$. In period two, the government observes $K_2=K'$, and sets $s_2=s'$ which is lower than the expected subsidy s_w. Each individual exporter can do better, given other exporters' actions, by investing less. Thus, it is not a Nash equilibrium. 2/

How does this equilibrium--obtained with symmetric information--compare with the binding commitment case where s_2 equals its announced value of $\bar{s}$? Given exporters' knowledge of $\mathcal{NX}$, s^* will equal $\bar{s}$: lack of precommitment with symmetric information will not change the equilibrium s_2. Consider why this is the case. Assume that $s^*<\bar{s}$, that is, exporters will expect s_2 equal to s^*. Their combined investment will render $K^*<K_c$. Now the government to reach $\mathcal{NX}$ needs to set s_2 higher than s^*, because the capital stock in period two is less than K_c. This situation is not a Nash equilibrium, as each individual exporter can do better by unilaterally investing more. 3/ Thus, it has been shown that the Nash equilibrium remains unchanged with symmetric information. 4/

It should be emphasized that this result depends upon the atomistic nature of the exporting sector. Since individual exporters discount the effect of their individual investment on total investment, they perceive that the cost of investment to be P_I, and they do not perceive individually the additional cost of investment of driving down the subsidy in period two by increasing the capital stock. A collusive export sector would immediately realize that investment--by increasing the capital stock--has an additional

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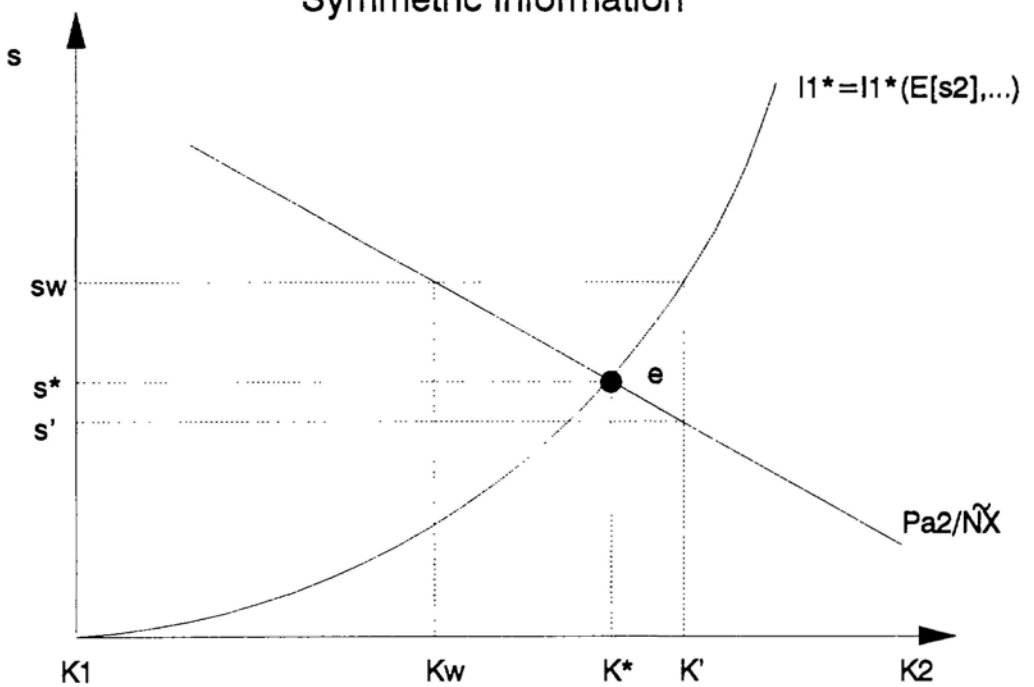
1/ Thus, this equilibrium is a Nash equilibrium.

2/ A similar argument applies to any other expected capital stock, besides $K_2=K^*$.

3/ A similar argument can be made for $s^*>\bar{s}$.

4/ Note that the situation is formally identical to that of precommitment. The investment function described by (2) is identical to (8) since firms are playing Nash against each other ($\partial I_i/\partial i_i=0$); also the government's reaction function is the same.

Figure 3: No Precommitment
Symmetric Information



cost in the form of a lower future subsidy. Since this cost is non-negative, the investment function will lie above and to the left of the precommitment investment. Thus, under symmetric information, the solution obtained with precommitment will be non-credible. 1/

2. Asymmetric Information

The analysis begins with a new government taking office--following years of import substitution policies--and announcing that export promotion will be emphasized. In such a case, exporters do not know with certainty what the actual export preferences are, because the government has the incentive to overstate its targeted level of exports. In essence, the export target is known to the government, but exporters face uncertainty with regard to the target. In this situation, exporters form an expected export target calculated on the basis of prior probabilities assigned to export targets, in other words, exporters have incomplete information. 2/ 3/

To simplify matters, it is assumed that there are only two types of government: (1) a high-export government and (2) a low-export government. The difference between them is their export target $\bar{NX}$. Let the targets be denoted as $\bar{NX}_H$ and $\bar{NX}_L$, where $\bar{NX}_H > \bar{NX}_L$. Let s_L or s_H correspond to the government's announcement under symmetric information, where $s_H > s_L$. 4/

Now the game begins with the government setting the first period subsidy. With asymmetric information, the government might consider signalling export preferences by setting a non-zero first period subsidy. Exporters have assigned a priori probability, ρ, that is likely to be small because of the past neglect. Exporters use the information contained in the signal to update this probability to obtain their posterior probability $\tilde{\rho}$. With this updated

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1/ This result is analogous to the results provided by Tornell (1991), Rotenburg (1987) and Matsuyama (1990), where the domestic market structure is modeled as monopolist. These studies find that temporary import protection is not credible as it is time inconsistent when information is symmetric. If export subsidies are targeted at specific firms, or in highly concentrated industries, export subsidies will be time inconsistent even when information is symmetric.

2/ These prior probabilities will likely be influenced by recent history and institutional settings regarding export promotion. It is conceivable that in an economy where import substitution has been practice for several years, the prior probability of a high export government will be relatively low.

3/ This situation is a game in which players have incomplete information, and is formally equivalent to an imperfect information game with an additional third player: Nature. Nature moves first and determines the export target, and informs only the government. Then the game proceeds as before.

4/ That is, the underlying production technology has decreasing returns to scale in the long run. If the long run production technology has constant returns to scale, exports can be increased infinitely with a infinitesimal subsidy; this hardly corresponds to the reality of developing countries.

probability they determine their optimum investment decision. The game ends with the government observing the capital stock in period two, and setting the actual subsidy to reach its target.

This game structure describes a signaling policy game, in which the government is the sender and the exporters are the receivers. This policy game can be analyzed by the using the concept of perfect Bayesian equilibrium (PBE). This type of equilibria are determined by two conditions known as perfectness conditions. The first perfectness condition states that exporters react optimally to the government's action, given their posterior beliefs about the government. That is, exporters invest to maximize expected profits by extracting all the information contained in the first period subsidy. The second perfectness condition states that the government exhibits optimal Stackelberg behavior; it considers the effect of its action, the subsidy, on exporters' action, i.e., investment (through expectations). The Bayes' rule is used where applicable--that is only for non-zero probability events. A subsidy which is not part of either government's equilibrium strategy--out-of-equilibrium--is a zero probability event, for which any posterior beliefs are admissible.

It is precisely this indetermination of posterior beliefs that allows for multiple PBE. However, among these equilibria some are more sensible economically than others. To narrow down the number of equilibria, tests conditions are applied to discriminate between sensible and nonsensical equilibria. This paper will use the "intuitive criterion" to narrow the number of equilibria. 1/ This refinement of PBE basically states that strategies whose results are worse (higher cost and/or lower expected profits) to those results of the equilibrium are disregarded. 2/

a. Perfectness conditions

To begin the analysis of perfect Bayesian equilibrium, consider the perfectness conditions. The first condition requires that exporters invest so as to maximize expected profits, extracting all information from the first period subsidy. The exporters' profit function under asymmetric information is:

$$E\pi = P_1 \cdot f(l_1, k_1) - w l_1 - P_I i_1 + [\tilde{\rho} P_2^a(\tilde{NX}_H, K_2) + (1-\tilde{\rho}) P_2^a(\tilde{NX}_L, K_2)] \cdot f(l_2, k_1 + i_1) - w l_2 \quad , \tag{9}$$

where exporters are weighting the possible government reaction functions --Pa2(...)--by their posterior probabilities.

1/ Other refinements have been suggested in the literature, see Tirole (1988). Cho and Kreps (1987) presents the intuitive criterion.

2/ Basically, the intuitive criterion involves the elimination of equilibrium weakly dominated strategies from the analysis.

The profit-maximizing level of investment is:

$$i_1^* = i_1^*\left[\tilde{\rho}\, P_2^a(\tilde{NX}_H, K_2) + (1-\tilde{\rho}) P_2^a(\tilde{NX}_L, K_2), \overset{(-)}{w}, \overset{(-)}{P_I}, \overset{(-)}{k_1}\right] \tag{10}$$

If s_1 reveals government export preferences, the analysis here is the same as that under symmetric information. Consider $\tilde{\rho}=1$, so that exporters know they face a high-export-oriented government. In equilibrium they expect $K_2=K_H$, and expectations will be fulfilled and the government will set s_2 to equal s_H. If $\tilde{\rho}=0$, exporters face a low-export-oriented, the expectation of $K_2=K_L$ will be fulfilled, and the government then sets $s_2=s_L$. Figure 4 depicts the situation.

When s_1 does not reveal policy orientation, $0<\tilde{\rho}<1$. Exporters will then expect $K_2=K^*$, corresponding to a weighted average of the two possible government reaction functions. In equilibrium, "e", exporters will on average correctly anticipate s_2. 1/

Consider now the second perfectness condition regarding the behavior of the government. Figure 5 depicts the situation. The two government types--high- and low-export--are depicted. P_L and P_H denote the subsidy-inclusive supply prices of exports in the case of symmetric information for each government. Capital stocks under symmetric information are denoted by K_H and K_L.

Consider the cost of export promotion when $s_1=0$. Exporters form their posterior probabilities after observing this subsidy. 2/ The optimal investment decision determines a second-period capital stock K^*, such that $K_L < K^* < K_H$. 3/

Notice that when $K=K^*$, a high-export government will need to increase its subsidy to s_2^a/K^* which is greater than the subsidy under symmetric information. This suggests that a high-export government reaches its target with higher costs. Also notice that, a low-export government will reach its target with a lower subsidy than under symmetric information, thus implying a cost savings. These observations could lead a high-export government to try

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1/ Formally, the first perfectness condition can be expressed as:

$$i^*(s_1) \in \arg\max_{i} \sum_{\tilde{NX}_j} \tilde{\rho}(\tilde{NX}_j \mid s_1) \cdot \pi(s_1, i, \tilde{NX}_j)$$

where $\tilde{\rho}$ corresponds to the posterior probability of $\tilde{NX}_j$ given s_1, so that i* denotes exporters' optimum investment (action) given the observed subsidy.

2/ The updating mechanism is discussed in the next subsection.

3/ This implies that $\tilde{\rho}$, the posterior probability of a high-export government, lies within the closed interval [0, 1]. As discussed below this is not always the case.

to reduce costs by signaling its export preferences, whereas a low-export government might consider trying to conceal its target so as to reduce costs in period two. Thus, s_1 could be positive. 1/

b. Perfect Bayesian equilibria

Two perfect Bayesian equilibria are possible. 2/ First a pooling equilibrium is an equilibrium where both types of government choose the same subsidy in period one. In a pooling equilibrium, exporters do not update their prior beliefs when observing the equilibrium outcome: $\tilde{\rho}(NX_H|s_1) = \rho$. Second, a separating equilibrium where governments choose different export promotion policies in period one. This means that the subsidy in period one will give exporters perfect information about government export preferences:

$$\tilde{\rho}(NX_H|s_H) = 1 \quad \text{and} \quad \tilde{\rho}(NX_H|s_L) = 0 \tag{11}$$

Consider pooling equilibria. Let sp denote the common period one subsidy. The incentive constraints placed on sp are such that both types prefer an equilibrium of s_1=sp, to $s_1 \neq$sp that is:

$$\begin{aligned} C(s_p, K_1 + I^*(s_p), NX_H) &< C(s_1 \neq s_p, K_1 + I^*(s_1 \neq s_p), NX_H) \\ C(s_p, K_1 + I^*(s_p), NX_L) &< C(s_1 \neq s_p, K_1 + I^*(s_1 \neq s_p), NX_L) \end{aligned} \tag{12}$$

Clearly, this will depend on the out-of-equilibrium beliefs held by exporters when observing $s_1 \neq$ sp. Out-of-equilibrium beliefs such that $\tilde{\rho}(NX_H | s_1 \neq s_p) = 0$ will support a pooling equilibrium, since in this case the non-pooling cost of reaching their targets will be greater for both types of government.

This implies that there is a range of s_1 that can constitute pooling equilibria, for which $s_1 \geq 0$. Notice that this range has an upper bound since the benefits of pooling for a low-export government--enjoying $I_1 = I^*(s_p)$ as opposed to $I_1 = I_L$ out-of-equilibrium--are finite. Also notice that this upper

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1/ The second perfectness condition can be described as follows:

$$s_1^*(NX_i) \in \arg\min_{s_1} C(s_1, i^*(s_1), NX_i)$$

where government will choose its signal, s_1, according to its export target, to minimize the cost of the program, using exporters' optimum reaction.

2/ A third type of PBE is mentioned in the literature: a hybrid or semi-separating equilibrium. In this equilibrium, government types randomize between pooling and separating. We have constructed hybrid equilibrium from the efficient pooling of s_1=0 and the least cost separating equilibrium. This equilibrium and its implications are discussed in the Appendix.

Figure 4: No Precommitment
Asymmetric Information

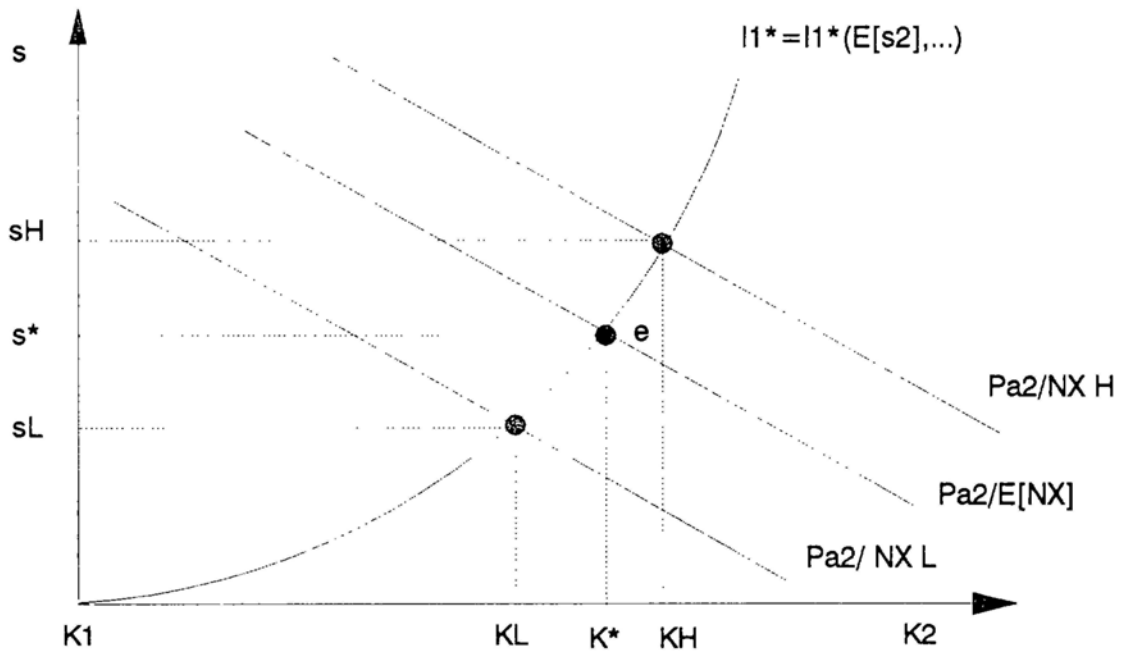
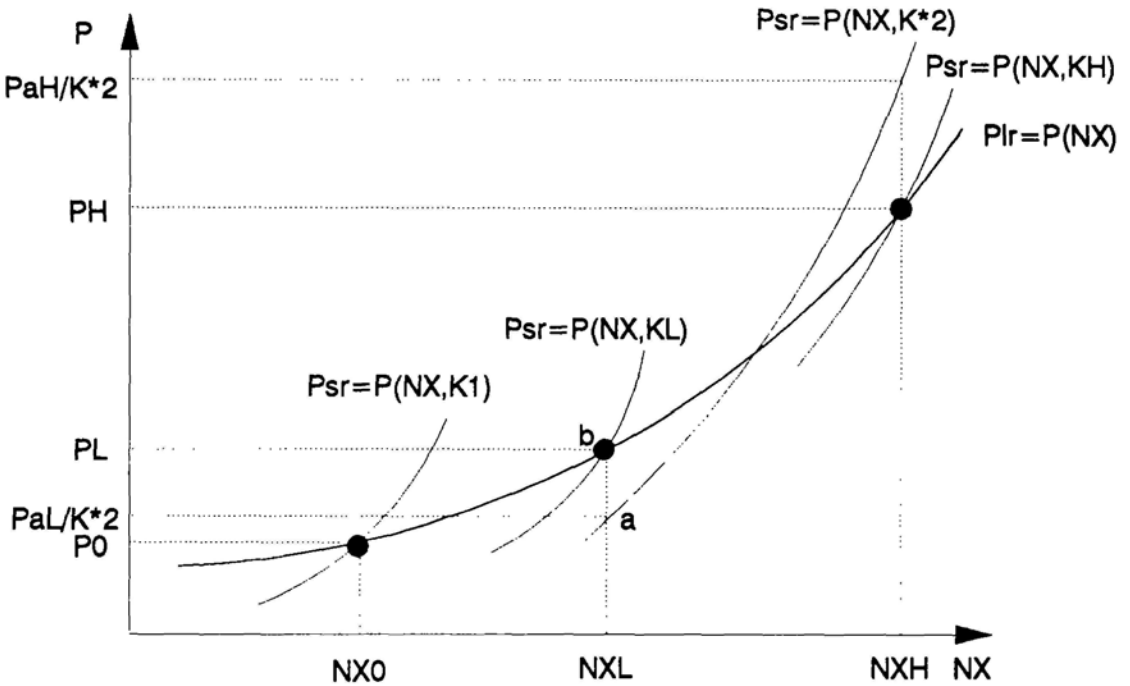


Figure 5: Government Cost



bound--given the export targets--increases with ρ. When $\rho=0$, the upper bound becomes $s_1=0$, while when $\rho=1$ the upper bound will equal the least cost separating subsidy. 1/ For the simulations below, it is important to note, for the simulations presented below, that the benefits of pooling versus separating increases as the distance between these two supply curves increases; this distance is related to the ratio of export targets, NX_H/NX_L, and to ρ. 2/

Graphically the upper bound is given by the subsidy such that its implicitly expenditure equals the rectangle $P_L P_1^e / K_2^*$ab in Figure 5. Notice that this area increases, i.e. the upper bound for sp increases, as the second period supply curve in the pooling equilibrium--Psr=P(NX,K*2)--shifts away and to the right of supply curve for a low-export government under symmetric information, Psr=P(NX,KL).

Now consider separating equilibria. A separating equilibrium is such that each government type chooses a different s_1, and neither has the incentive to choose the other's s_1. As mentioned before, in this case exporters are able to distinguish between government types after observing s_1, thus posterior probabilities of a high-export government will be either 0 or 1.

Let s_H^* and s_L^* --where the subscript corresponds to government type--denote the first period subsidy in the separating equilibria. Consider the incentive constraints placed on these subsidies. The subsidy s_H^* must be such that the high-export government finds the benefits--in terms of convincing exporters of its true export preference--exceed the costs. In terms of the government cost function this implies that:

$$C(s_H^*, K_1 + I_H, \bar{NX}_H) < C(0, K_1 + I_L, \bar{NX}_H). \tag{13}$$

It must also be true that the low-export government finds the cost of setting $s_1 = s_H^*$ to exceed the benefits, or

$$C(s_H^*, K_1 + I_H, \bar{NX}_N) > C(0, K_1 + I_L, \bar{NX}_N). \tag{14}$$

Thus, s_H^* must be greater than zero and has a finite upper bound, which is given by the benefits gained by the high-export government in revealing its export targets to exporters.

1/ The latter will become evident below.

2/ These pooling equilibria imply that the high-export government will reach its target with a lower capital intensity compared with precommitment, while the reverse is true for a low-export government.

Now consider s_L^*. The constraints placed on s_H^* rule out $s_L^* > s_H^*$ thus s_L^* must be less than s_H^*. Actually, all subsidies less than s_H^* are candidates for s_L^*. After exporters observe the equilibrium separating subsidy s_L^*, their posterior probability will be $\tilde{\rho}(N^*X_H \mid s_L) = 0$ and their investment $I_1 = I_L$. Cost minimization will require that the low-export government set $s_L^* = 0$.

It can be proved that there is a range of positive subsidies, $s_H^* \in [s_{min}, s_{max}]$, that meet the necessary conditions--given by equations (13) and (14)--for the existence of separating equilibria. 1/ Within this range, the least-cost separating subsidy $s_1 = s_{min}$ is such that the low-export government is just indifferent between setting the first period subsidy equal to zero or s_{min}. The upper bound of the separating range is given by the benefits that accrue to a high-export government by convincing exporters that its policy orientation is in fact export promoting. 2/

The least-cost separating equilibrium--when the high-export government sets s_1 equal to s_{min}--is important for policy making. It shows how a government that is committed to increasing exports via an export subsidy, can do so. That is, by incurring this cost the government is able to unequivocally signal its export preferences to exporters. It is important to emphasize that the magnitude of the cost to signal export preference depends upon the cost reduction that a low-export government obtained in the pooling versus the separating equilibrium. This should be kept in mind for the simulations that are presented below.

In the separating equilibrium the low-export government will incur the same cost of promoting exports here as in the precommitment case, since it sets $s_1=0$. But the high-export government will bear an additional cost--compared to the precommitment case--of separating from the low-export government. This additional cost of export promotion stems directly from the lack of credibility surrounding export subsidies due to asymmetric information and no precommitment. 3/

Summing up, this game has multiple PBE consisting of range of pooling and separating equilibria. The intuitive criteria, Cho and Kreps (1987), is used to narrow down the number of equilibria. Consider the pooling equilibrium where $s_1=0$ with certainty. Suppose that a $s_1>0$ can be found with the

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1/ A sufficient condition for the existence of a separating equilibrium is that export supply curves have constant price elasticity. Details are described in the Appendix.

2/ The out-of-equilibrium beliefs of exporters that support a separating equilibrium are: (1) the government is of low-export orientation when $s_1 < s_H^*$ and (2) the government is high-export when $s_1 \geq s_H^*$ is observed. The following beliefs are ruled out: (i) if $s_1 < s_H^*$ then the government is high-export, and (ii) $s_1 \geq s_H^*$ then the government is a low-export type. This means that the beliefs supporting the $s_1=0$ pooling equilibrium are ruled out.

3/ Note also that the capital intensity in this situation is the same as in the precommitment case.

following properties: (1) the low-export type government strictly prefers (in comparison with the equilibrium: $s_1=0$) not to set $s_1>0$, regardless of how exporters interpret it, and (2) the high-export government prefers to set $s_1>0$, if it can convince exporters that it is a high-export government. Then, given (2), exporters should not entertain the hypothesis that the $s_1>0$ came from a low-export type government, but should instead infer that it is a high export government.

It has been shown that $s_1=s_{min}$ is such a subsidy. Thus, if the high-export government knows this $s_1=s_{min}$, it should set its first period subsidy at that level. From this, exporters conclude that the government is high export type, thereby upsetting the pooling equilibrium. 1/ This implies that none of the pooling equilibria described above survives the "intuitive criterion." 2/

Thus, a range of separating PBE survives the intuitive criterion: the high-export government sets a positive subsidy in period one to signal its export policy setting $s_H^* \in [s_{min}, s_{max}]$, and the low-export government sets a zero subsidy. The high-export government is subject to the additional cost of the signal.

c. Credibility cost simulations

How important is the cost of signaling export preferences to exporters? The answer depends on the cost that a high-export government will incur to separate from a low export government. As discussed before, this signaling cost will equal the cost savings that a low-export government has by pooling versus separating. The least cost separating subsidy ($s_1=s_{min}$) will be such that the low-export government will be indifferent between setting this subsidy (so that $K=K^*$) and $s_1=0$ (consequently $K=K_L$). The size of this cost savings--identified before in Figure 5 as $P_t P_t^e / K_2^* ab$--is determined by two types of factors. The first group includes items that underlie the production process of exports, for example the ratio of the long-run to short-run price elasticity of supply. Intuitively, an increase of the long-run to short-run price elasticity ratio makes export supply, when capital is in place, relatively less responsive to price (and to export subsidies). In a pooling equilibrium a low-export government will have greater cost savings as it will be able to reach its target with a smaller export subsidy. Thus, in general, an increase of the long-run to short-run price elasticity will tend to increase the relative cost for a high-export government to separate from a low-export government. 3/

1/ This argument can be applied to other pooling equilibria with the same result.

2/ The failure of all pooling equilibria was also found by Kreps (1984).

3/ Graphically, an increase of this ratio can be viewed as a steeper short run supply curves. It should be clear that this will increase the cost savings rectangle for low export governments, thus the long run cost will be relatively smaller.

The second set of elements are specific to the credibility issues discussed in the paper, two of which are of particular relevance to this discussion. Both of these elements increase the cost savings to the low-export government by increasing the capital stock in period two. The first is the ratio of the high-export target relative to the low-export target. As this ratio increases, the high-target supply curve shifts to the right--relative to the low-export supply--and with it the pooling supply curve shifts. The second is the probability of high-export government. Investment increases with ρ, implying that in Figure 5 the pooling supply curve shifts to the right and closer to the high export supply curve.

To determine the order of magnitude of the credibility cost, illustrative simulations have been performed over values of ρ for different export target ratios. The supply curves have been obtained from a Cobb-Douglas technology, and have been calibrated so that the ratio of the long-run to short-run price elasticity was roughly 4, which is about the median for the range of 1.2-11 reported by Goldstein and Khan (1985). 1/

Exports subsidies usually target so-called nontraditional products. This nontraditional export sector is normally much smaller than total exports. To calculate GDP, subsidized exports were set to an average of 8 percent of GDP. This corresponds roughly to an economy that has developed through import substitution, but is now promoting exports. In this situation, the probability of a high-export government is relatively low, and is expected to be less than 50 percent.

In these simulations, the period two subsidy that a low-export government sets in the separating equilibrium is equal to 10 percent. For a high-export government, this same subsidy is determined by calibration so that the required export target ratio obtains; resulting in 26, 24 and 21 percent for export target ratios of 1.5, 1.4 and 1.3 respectively. Table 2 contains the simulation results.

Column 2 in Table 2 presents the average for the two periods of the total expenditure made on the export subsidy, expressed in terms of GDP. 2/ The results in column 2 show an average export subsidy expenditure between 1.0 percent and 1.5 percent. As a point of reference, recall from Table 1 that in Costa Rica, the cost averaged more than 1 percent during 1988-89, while in

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1/ The short-run supply curve used has a price elasticity equal to 0.7, about the average reported by Goldstein and Khan (1985).

2/ It is likely that in period two, subsidized exports will be a greater proportion of GDP than in the first period. The results presented in Table 2 do not account for this, and thus tend to understate total costs. In an effort to account for this, the simulations were repeated setting the first period export sector equal to 4 percent of GDP, while in the second period it equaled 12 percent; maintaining the average equal to 8 percent. This tends to increase the total cost by 50 percent, while cutting in half the relative cost of credibility presented in column 4.

Table 2. Simulation Results

ρ (1)	Average Total Cost (2)	Average Credibility Cost (3)	(3)/(2) (4)	Actual Subsidy (5)	Separating Subsidy (6)
	(Percent of GDP)			(In Percent)	
		(NX_H/NX_L = 1.5)			
0.1	1.3	0.3	19.8	5.0	6.4
0.2	1.5	0.5	30.9	0.6	11.6
0.3	1.5	0.5	31.9	---	12.2
		(NX_H/NX_L = 1.4)			
0.1	1.2	0.2	18.6	5.8	5.5
0.2	1.4	0.4	29.6	1.8	10.1
0.3	1.5	0.5	33.7	---	12.2
		(NX_H/NX_L = 1.3)			
0.1	1.0	0.2	17.0	6.7	4.3
0.2	1.2	0.3	27.6	3.7	8.0
0.3	1.3	0.5	34.8	0.8	11.2
0.4	1.3	0.5	36.8	---	12.2

Turkey export subsidies averaged about 1.6 during 1983-84. Thus, these average total costs are roughly of the same magnitude experienced by these countries.

The average credibility cost, associated with the separating subsidy are shown in column 3. This ccnsists exclusively of the expenditure in period one necessary for a high-export government separate from a low-export government. These costs range between 0.2 and 0.5 percent of GDP, corresponding to 15-35 percent of total cost of the export subsidy program.

Column 5 in Table 5 contains the period two subsidy that a low-export government would have set to reach its target in the pooling equilibrium. Notice that as ρ--the prior probability of a high-export government--increases the "actual subsidy" required falls. As mentioned before the cost savings to the low-export government increases with ρ, and correspondingly the subsidy that the high-export government requires to separate increases as evident from column 6 in Table 5. 1/

1/ Notice that Table 5 stops whenever the actual subsidy reaches zero. This is because at this point the cost savings reaches its highest level. Thus a higher ρ (and/or higher NX_H/NX_L) does not increase the separating subsidy, and no additional information is provided by extending the Table.

This implies good and bad news for export promotion in general. The good news is that when an economy has pursued many years of import substitution, exporters are likely to place a very low value for ρ. Thus, investment will tend to be smaller in the pooling equilibria, and the cost saving for low-export governments is small. In this case, the credibility cost is relatively small, which according to Table 2 ranges between 17-20 percent of total outlays on the subsidy program--roughly 0.2-0.3 percent of GDP. 1/ Thus, it is less costly to separate in this situation.

The bad news is for economies that have alternated between periods import substitution and export promotion. In this model such changes in policy orientation imply that nominal export subsidies have increased and decreased over time. However, this does not seem to be the case in countries that have promoted exports. Nonetheless alternating between high-export and low-export governments could be reinterpreted as economies where the effective value of nominal subsidies has varied with domestic inflation, and/or the real exchange rate. In this situation, governments that have controlled domestic inflation and managed sensibly the exchange rate are viewed as high export while governments that have not been able to do so, are viewed as low export. Thus, countries that have alternated between high and low inflation (and/or periods of overvalued and undervalued exchange rates) would tend to increase the probability that exporters view a new government as high export, which tends to increase ρ. As is clear from Table 2, as ρ increases, the cost of separating increases.

This seems to suggest that it is important for policymakers to maintain their commitment to high exports over time, or else it will become more and more costly for them to promote exports in the future. Notice that for moderately high values of ρ the cost of separating increases to the range of 30-35 percent of total export subsidies outlays--roughly 0.4-0.5 percent of GDP.

These illustrative simulation results suggest that while credibility costs associated with export subsidies are not huge, they do tend to increase the cost of the export program significantly. The results in Table 2 are suggestive of orders of magnitude and should not be interpreted literally. Nonetheless, these costs reduce the attractiveness of promoting export via subsidies.

V. Conclusions

Many countries have introduced export subsidies following years of import substitution policies. In this context, exporters are not certain of the government's commitment to this policy as exports have been repeatedly neglected in the past. Subsidies present a dilemma to exporters. By

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1/ As ρ tends to zero, so does the cost of separating from a low export government.

increasing the profitability of investment they tend to increase the capital stock. However, as the capital stock increases, the subsidy needed to reach a target level of exports falls. Thus, export subsidies might lack credibility.

A simple analytical approach is taken to discuss this issue. Since export subsidies are usually set for a large variety of nontraditional exports, the export sector is modeled as atomistic. In this situation, export subsidies are time consistent when the export target is known with absolute certainty (symmetric information). However, since the policy of export promotion represents a change from the past development strategy, it is likely that the export targets will be uncertain (asymmetric information). In this case export subsidies lack credibility. A government committed to a high level of exports will be able to separate itself from one that is not--thereby achieving its export target--by setting a high subsidy in the first period. However, doing so is costly. The initial high subsidy, which signals commitment, drives up the budgetary cost of the export promotion program.

This model extends strategic trade policy to the case of intra-national strategic behavior that is involved in the situation described above. A further extension of the model could discuss reputation in the context of repeated games. The goal of this paper was to highlight that export subsidies are a costly way to promote exports, a fact that is partially due to the credibility problem. The simplest possible model was formulated to illustrate this point. Nonetheless, a repeated analytical game could be used to formalize the case where a government pursues export promotion for a number of years. Doing so the government builds up a reputation as being pro-exports. A low-export government might find it worthwhile to initially build up a reputation of being pro-exports as the capital stock will be increased. Once the costs of pretending a policy of export promotion exceed the benefits, the situation could reverse itself. A model of this type might be useful to understand the incentives that governments face over time. And it could provide some insight into factors that cause some countries to revert to import substitution while others continue with export promotion.

An attempt has been made to try to determine the order of magnitude of the costs involved in signaling export preference. The simulations suggest that the cost involved will range between 15-35 percent of total outlays of the export subsidy program--roughly 0.2 and 0.5 percent of GDP. The magnitude depends basically on two factors. First, the ratio of the high-export to low-export targets. The higher this ratio, the more costly it will be to signal commitment to export promotion. Second, is the exporters' perception of the likelihood that the government is pro-exports. Following a long period of import substitution policies, exporters have accordingly assigned a low probability that the government is high-export. In this case the incentive for the low-export government to pose as high-export is small, such that relatively small export subsidies are worth setting. A new high-export government can take advantage of this situation, and shatter any mis-perception about its commitment to export promotion with a relatively small export subsidy. However, a country that has alternated between high and low export governments, i.e. between high and low inflation and/or between

over and under-valued currency will tend to face higher costs to separate and effectively promote exports. This illustrates the importance of maintaining a record of sensible economic policies so as to promote exports.

These simulations suggest that a significant proportion of total outlays on export subsidies will be used to signal export commitment. This is troublesome for a policy of export promotion via export subsidies. It seems that export subsidies are a costly way to promote exports, and in that sense inefficient. It may be possible to stimulate exports by reducing the anti-export bias rather than by trying to offset the bias. Nonetheless, this alternative also could suffer from credibility problems of its own.

Analytics of the Model

This Appendix provides an outline of the analytical work in the text, in which a general neoclassical production function and standard use of the implicit function theorem were specified. Since the analysis for period one, in which only l_1 is determined, is obvious and it is not included here. The analysis below covers period two, which requires more elaboration.

1. Precommitment

The first order conditions for profit maximization are:

$$\begin{aligned} & P_1 f_1(l_1^*, k_0) = w \\ & P_2 f_1(l_2^*, k_0 + i_1^*) = w \\ & E[P_2] f_2(l_2^*, k_0 + i_1^*) = P_I \quad . \end{aligned} \tag{A1}$$

Second order conditions require $f_{11}<0$ and $f_{11}f_{22}-f_{12}^2>0$. Factor demands are obtained by taking partial derivatives of the last two equations in (1A) with respect to all the variables involved: P_2, w, P_I, and k_0. The derivative of each partial will determine a system, from which the appropriate partial is solved.

The system of equations will have the following general form:

$$\begin{bmatrix} \frac{\partial L_2^*}{\partial x} \\ \frac{\partial I_1^*}{\partial x} \end{bmatrix} = \frac{1}{det} \cdot \begin{bmatrix} f_{22} & -f_{12} \\ -f_{21} & f_{11} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \quad , \tag{A2}$$

where $det=f_{11}f_{22}-f_{12}^2 >0$, and $x=P_2$, w, P_I, k_0. The following table gives the specific form of the right-most vector for each variable x:

Table A1. Binding Commitments

x	V′
P_2	$[-f_1/P_2, \quad -f_2/P_2]$
w	$[1/P_2, \quad 0]$
P_I	$[0, \quad 1]$
k_0	$[-f_{12}, \quad -f_{22}]$

2. Non Precommitment

Under symmetric information (full disclosure of information), the first order conditions for profit maximization are:

$$
\begin{aligned}
& P_1 f_1(l_1^*, k_0) = w \\
& P_2^a(\ldots) f_1(l_2^*, k_0 + i_1^*) = w \\
& P_2^a(\ldots) f_2(l_2^*, k_0 + i_1^*) = P_I + \frac{\partial P_2^a}{\partial I_1} \cdot \frac{\partial I_1}{\partial i_1} f(L_2^*, k_0 + I_1^*)
\end{aligned}
\tag{A3}
$$

The first order conditions have the same form here as those in a binding commitment case, with the exception of the third term of the last equation in (2A). Specifically, consider: $\partial I_1/\partial i_1$. This term captures the effect of an individual firm's investment on the total investment by the exporting sector. It is zero here because the exporting sector as a whole is assumed to be atomistic. If export promotion is targeted at specific industries, however, it would be necessary to consider the market structure of that industry and how the investment decisions of firms within the industry are interrelated. Equation (2A) is otherwise identical with (1A).

To obtain the factor demand equations, the partial derivatives of the last two equations in (2A) with respect to all the variables involved are taken: P_2, w, P_I, and k_0. The derivative of each partial will determine a system, from which the appropriate partial is solved.

The system of equations will have the same general form as before. Now the determinant is:

$$
P_2^2 \left\{ f_{22} f_{11} - f_{12}^2 + \eta (f_{11} f_2 - f_{12} f_1) \frac{1}{I_1} \right\} > 0 \quad , \tag{A4}
$$

and the system matrix is given by:

$$\begin{bmatrix} P_2 f_{22} + f_2 \cdot \partial P_2/\partial I_1 & -P_2 f_{12} \\ -P_2 f_{21} + f_1 \cdot \partial P_2/\partial I_1 & P_2 f_{11} \end{bmatrix} . \tag{A5}$$

All the elements in this matrix are negative, except element a_{21}. We have assumed this element to be negative, which implies that: $P_2 f_{21} > f_1 \cdot \partial P_2/\partial I_1$. The following table specifies the rightmost vector:

Table A2. No Binding Commitment

x	V'
$N\tilde{X}_2$	$[-\partial P_2/\partial N\tilde{X}_2 \cdot f_1 ,\quad -\partial P_2/\partial N\tilde{X}_2 \cdot f_2]$
w	$[1 - \partial P_2/\partial w \cdot f_1 ,\quad -\partial P_2/\partial w \cdot f_2]$
P_I	$[-\partial P_2/\partial P_I \cdot f_1 ,\quad 1 - \partial P_2/\partial P_I \cdot f_2]$
k_0	$[-P_2 f_{12} - \partial P_2/\partial k_0 \cdot f_1 ,\quad -P_2 f_{22} - \partial P_2/\partial k_0 \cdot f_2 + \partial P_2/\partial I_1 \cdot f_2]$

When information is asymmetric (limited or no disclosure of information), the profit function is given by:

$$\begin{aligned} E\pi = {} & P_1 \cdot f(l_1, k_1) - w l_1 - P_I i_1 + [\rho P_2^a(N\tilde{X}_H, K_2) + (1-\rho) P_2^a(N\tilde{X}_L, K_2)] \\ & \cdot f(l_2, k_1 + i_1) - w l_2 . \end{aligned} \tag{A6}$$

The first order conditions are:

$$\begin{aligned} & P_1 f_1(l_1^*, k_1) = w \\ & [\rho P_2^a(N\tilde{X}_H, K_2) + (1-\rho) P_2^a(N\tilde{X}_L, K_2)] \cdot f_1(l_2^*, k_2^*) = w \\ & [\rho P_2^a(N\tilde{X}_H, K_2) + (1-\rho) P_2^a(N\tilde{X}_L, K_2)] \cdot f_2(l_2^*, k_2^*) = P_I . \end{aligned} \tag{A7}$$

Notice that as the probability that a government is high-export reaches 1, i* approaches i_H; while this probability tends to be 0, i* approaches i_L. This suggests the following linear approximation:

$$i^* \approx \rho i_H + (1-\rho) i_L . \tag{A8}$$

a. Separating equilibria

The lower bound on the separating equilibria, s_{min}, is such that a low-export government will find that its cost just exceed its benefits:

$$C(s_H^*, I_H, \tilde{NX}_L) \geq C(0, I_L, \tilde{NX}_L) \quad . \tag{A9}$$

The cost functions above may be specified as:

$$s_H^* \cdot P \cdot NX[(1+s_H^*)\cdot P, K_1] + s_2^a(K_1 + I_H, \tilde{NX}_L)\cdot P \cdot \tilde{NX}_L \geq \tag{A10}$$
$$s_2^a(K_1 + I_L, \tilde{NX}_L)\cdot P \cdot \tilde{NX}_L \quad .$$

The above expression can be further rearranged to give:

$$s_H^* \cdot P \cdot NX[(1+s_H^*)\cdot P, K_1] \geq \tag{A11}$$
$$\{s_2^a(K_1 + I_L, \tilde{NX}_L) - s_2^a(K_1 + I_H, \tilde{NX}_L)\}\cdot P \cdot \tilde{NX}_L \quad .$$

This expression determines the lower bound of the separating range, within which a low-export government will set s_1=0. An upper bound on the separating range also exists because the benefits of separating for the High-export type are finite. The s_1 chosen by the high-export government is such that:

$$C(s_H^*, I_H, \tilde{NX}_H) \leq C(0, I_L, \tilde{NX}_H) \quad . \tag{A12}$$

Specifying the cost functions and rearranging as above renders:

$$s_H^* \cdot P \cdot NX[(1+s_H^*)\cdot P, K_1] \leq \tag{A13}$$
$$\{s_2^a(K_1 + I_L, \tilde{NX}_H) - s_2^a(K_1 + I_H, \tilde{NX}_H)\}\cdot P \cdot \tilde{NX}_H \quad .$$

For a non-empty separating range to exist, the upper bound must be greater than the lower bound:

$$\{s_2^a(K_1 + I_L, \tilde{NX}_H) - s_2^a(K_1 + I_H, \tilde{NX}_H)\}\cdot P \cdot \tilde{NX}_H > \tag{A14}$$
$$\{s_2^a(K_1 + I_L, \tilde{NX}_L) - s_2^a(K_1 + I_H, \tilde{NX}_L)\}\cdot P \cdot \tilde{NX}_L \quad .$$

Rearranging renders:

$$s_2^a(K_1 + I_L, \hat{NX}_H) \cdot \hat{NX}_H - s_2^a(K_1 + I_L, \hat{NX}_L) \cdot \hat{NX}_L >$$
$$s_2^a(K_1 + I_H, \hat{NX}H) \cdot \hat{NX}_H - s_2^a(K_1 + I_H, \hat{NX}L) \cdot \hat{NX}_L \quad . \tag{A15}$$

Notice that the terms on the left hand side correspond to points along the short-run supply curve when $K_2=K_1+I_L$, while those on the right hand side correspond to points along the short-run supply curve when $K_2=K_1+I_H$.

The actual subsidy in period two, s_2^a, is expressed as a percentage increase over P. This subsidy s_2^a depends upon: (1) the level of investment, and (2) the export target. Let us write the long-run (full capital response) supply curve as: $P^{LR} = P^{LR}(NX, K(NX))$. Expressing it in terms of elasticity renders:

$$s_2^a = 1/\eta_{LR} \cdot \hat{NX} + \psi \cdot \epsilon \cdot \hat{NX} \quad , \tag{A16}$$

where "^" denotes percentage change and,

$$\eta_{LR} = \frac{\partial NX^{LR}}{\partial P^{LR}} \cdot \frac{P^{LR}}{NX^{LR}} > 0$$
$$\psi = \frac{\partial P^{LR}}{\partial K} \cdot \frac{K}{P} < 0 \tag{A17}$$
$$\epsilon = \frac{\partial K}{\partial NX} \cdot \frac{NX}{K} > 0 \quad .$$

In these equations, η^{LR} corresponds to the long-run price elasticity of supply, ψ denotes the contemporaneous effect of capital on P, and ϵ is the elasticity of the conditional demand for capital with respect to NX.

Let us use this notation to express actual subsidies in period two as:

$$s_2^a(K_1 + I_L, \hat{NX}_L) = (1/\eta_{LR} + \psi \cdot \epsilon)\hat{NX}_L$$
$$s_2^a(K_1 + I_H, \hat{NX}_H) = (1/\eta_{LR} + \psi \cdot \epsilon)\hat{NX}_H \tag{A18}$$
$$s_2^a(K_1 + I_L, \hat{NX}_H) = 1/\eta_{LR} \cdot \hat{NX}_H + \psi \cdot \epsilon \cdot \hat{NX}_L$$
$$s_2^a(K_1 + I_H, \hat{NX}_L) = 1/\eta_{LR} \cdot \hat{NX}_L + \psi \cdot \epsilon \cdot \hat{NX}_H \quad .$$

Substituting into equation (A14) renders:

$$\{1/\eta_{LR} \cdot \tilde{NX}_H + \psi \cdot \epsilon \cdot \tilde{NX}_L - (1/\eta_{LR} + \psi \cdot \epsilon) \cdot \tilde{NX}_H\} \cdot P \cdot \tilde{NX}_H >$$
$$\{(1/\eta_{LR} + \psi \cdot \epsilon) \cdot \tilde{NX}_L - 1/\eta_{LR} \cdot \tilde{NX}_L + \psi \cdot \epsilon \cdot \tilde{NX}_H\} \cdot P \cdot \tilde{NX}_L \quad . \tag{A19}$$

Rearranging this, renders:

$$\{\psi \cdot \epsilon \cdot \tilde{NX}_L - \psi \cdot \epsilon \cdot \tilde{NX}_H\} \cdot P\tilde{NX}_H >$$
$$\{\psi \cdot \epsilon \cdot \tilde{NX}_L - \psi \cdot \epsilon \cdot \tilde{NX}_H\} \cdot P\tilde{NX}_L \quad . \tag{A20}$$

Since the elasticities here are evaluated at different points along their respective curves they can differ from term to term in the above expression. A sufficient condition for the existence of the separating range is constant elasticities; given this condition, the above expression implies that $\tilde{NX}_H > \tilde{NX}_L$, which is true by definition.

b. Hybrid Equilibria

There is a third type of perfect bayesian equilibria as noted in Fudenberg and Tirole (1989): a semi-separating or hybrid equilibrium. In this equilibrium, both types of government randomize between their pooling and separating strategies. Exporters' posterior probabilities are updated according to Bayes' rule.

Let us construct a hybrid equilibrium using the least-cost separating equilibrium and the Pareto efficient pooling equilibrium sp=0. The low-export government sets s_1=0 in both the pooling and separating equilibria. In the hybrid equilibrium it will set s_1=0 with certainty. The high-export government randomizes between s_1=0 and $s1=s_{min}$. Exporters' posterior probabilities are given by:

$$\tilde{\rho}(\tilde{NX}_H \mid s_1 = s_{min}) = 1 \qquad \tilde{\rho}(\tilde{NX}_H \mid s_1 = 0) \in [0, \rho] \quad , \tag{A21}$$

where ρ is the prior probability that the government is high-export. After exporters observe s_1=0 the posterior probability of High-export type decreases (low-export government increases), implying that investment is lower than in the pooling equilibrium.

Bayesian updating implies that the posterior probability of high-export government once exporters observe s_1=0, will be:

$$\tilde{\rho} = \tilde{\rho}(\tilde{NX} \mid s_1 = 0)$$
$$= \frac{\tilde{\rho}(s_1 = 0 \mid \tilde{NX}_H) \cdot \rho(\tilde{NX}_H)}{\rho(s_1 = 0)} \quad . \tag{A22}$$

where $\tilde{\rho}(s_1 = 0 \mid N\tilde{X}_H)$ is the conditional probability of observing s_1=0 when the government is high-export, $\rho(N\tilde{X}_H)$ is the prior probability of high-export government, and $\rho(s_1 = 0)$ is the probability of observing s_1=0. Let us denote with α the probability that the high-export government pools, so that $\tilde{\rho}(s_1 = 0 \mid N\tilde{X}_H) = \alpha$. Then:

$$\tilde{\rho} = \frac{\alpha \cdot \rho}{1 - \rho(1 - \alpha)} < \rho \quad . \tag{A23}$$

As is apparent, the posterior probability that the government is of a high-export government (after observing s_1=0) depends upon the prior probability that faces a high-export government and the probability that the high-export government pools. Notice that if α=1, a high-export government always pools, $\tilde{\rho} = \rho$ which corresponds to the pooling equilibrium. Whereas, if α=0 a high-export government always separates, $\tilde{\rho}$=1 corresponding to the separating equilibrium.

In order for the high-export government to randomize, it must be true that it is indifferent between the subsidies it is randomizing. The probability of pooling α is then implicitly determined by the condition that:

$$\alpha \cdot C(0, I' < I^*, N\tilde{X}_H) = (1 - \alpha) \cdot C(s_{min}, I_H, N\tilde{X}_H) \quad . \tag{A24}$$

where I' corresponds to the level of investment forthcoming when the probability of a high-export government is $\tilde{\rho}$ (after observing s_1=0). The variable α will be determined on the basis of exporters' optimum reaction, I=I', to s_1=0.

The expected cost of reaching the high-export target, for the high-export government, consists of the weighted average of the cost in the least-cost separating equilibrium and a cost that is greater than the efficient pooling equilibrium. The expected cost for the high-export government could be smaller than the least-cost separating equilibrium if $C(0, I_1 < I^*, N\tilde{X}_H)$ is less than $C(s_{min}, I_H, N\tilde{X}_H)$, in which case this hybrid equilibrium would survive the intuitive criterion. In this hybrid equilibrium high-export target will be reached with a lower capital-labor ratio and at a higher cost than under the symmetric information case.

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