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THE FAILURE OF STRATEGIC INDUSTRIAL POLICIES DUE TO THE MANIPULATION BY FIRMS

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Why Industrial Policies Fail: Limited Commitment

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Abstract

The strategic effects of subsidies on output and subsidies on investment differ substantially in dynamic models where a government's commitment ability is limited. Output subsidies remain effective even as the period of commitment vanishes, but investment subsidies may become completely ineffective. This difference has been obscured because most existing models of strategic trade policy are static.

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The Failure of Strategic Industrial Policies Due to the Manipulation by Firms

Strategic policies may have adverse effects if either domestic or foreign firms can substantially change their investments to influence these policies. American politicians and newspaper pundits often argue that Asian and European countries successfully use strategic industrial policies and, therefore, so should the United States. Where nations differ in their ability to lower costs of production through investment, however, one may benefit from the unilateral use of strategic industrial policies where another is harmed by them. Even where nations are the same, unilateral strategic policies can be disadvantageous.

In the models in most of the existing strategic trade literature, a government first selects the level of some policy (e. g., an export subsidy) and firms then choose output or price. Because the government acts first, export subsidies increase current welfare if firms sell in imperfectly competitive markets (Spencer and Brander, 1983; Dixit, 1984; and Brander and Spencer, 1985).[1] If, however, firms chose their investment levels (e. g., plant size, equipment, land, research and development) before the governments set output subsidies, optimal *ex post* (after investment) output subsidies may reduce *ex ante* (before investment) welfare, which is profits from production minus investment costs. In a many period economy, even if the government acts first in each period, the firms' current investment precedes the government's future subsidy unless the government can commit to a path of subsidies once and for all in the initial period. A government that cannot

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[1] Even in such models that ignore investment, however, the optimal policy depends critically on the specification of the game (Krugman, 1984; Eaton and Grossman, 1986; Carmichael, 1987; Cheng, 1987, 1988; Gruenspecht, 1988; Markusen and Venables, 1988; de Meza, 1989; and Neary, 1989).

make such commitments may behave strategically in each period to obtain the *ex post* benefit and, as a result, may suffer an *ex ante* harm.[2]

To present these results as clearly as possible, we assume all players have complete information and, initially, preclude the possibility of retaliation by the foreign government, thereby biasing the model in favor of intervention by the home government. Assuming a standard model in which a domestic and a rival firm play a quantity-setting game and sell in a third country, it is optimal for the home government to subsidize exports in order to shift profits from the foreign to the home firm (Spencer and Brander, 1983). In the Nash-in-quantities equilibrium to the game between firms, the home firm ignores the dependence of its rival's output on its own sales. The subsidy by the home government removes this "distortion" and increases the home firm's output to the Stackelberg leader's level.

A nation may suffer from the use of strategic trade policies, however, due to the anticipatory actions of the domestic and foreign firms. If the firms have rational expectations, they anticipate that their investments, which alter their production costs, will alter the *ex post* optimal subsidy, which depends on the production costs of the two firms.

In reasonably general circumstances, the equilibrium domestic subsidy is an increasing function of domestic investment and a decreasing function of foreign

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[2] The possibility of adverse *ex ante* effects from *ex post* optimal policies has been illustrated in a variety of other settings. Rodrik (1987) and Matsuyama (1990) show that standard rules on optimal targeting need not hold if distortions are endogenous as occurs where an agent behaves strategically toward the government. Karp (1987) and Maskin and Newbery (1990) give examples of disadvantageous tariffs. Similarly, cooperation can be disadvantageous (Rogoff, 1985; Kehoe, 1989; and Gatsios and Karp, 1989). Gatsios and Karp also examine the role of investment as is done here.

investment.[3] Thus, both firms have an incentive to increase their investment in order to alter the subsidy. There are, however, offsetting incentives, and, in general, it is not possible to say whether the equilibrium levels of investment increase or decrease as a result of the anticipation of government intervention in the home country. Intervention may increase either domestic investment or foreign investment. If the marginal cost of investment at home is relatively low, excessive domestic investment is likely. Greater domestic investment increases the wedge between the private and social marginal benefit of investment and that may lower domestic welfare. If the marginal cost of investment in the rival country is relatively low, anticipation of the subsidy may increase investment abroad, which causes the domestic firm to face a lower cost rival than otherwise. The ability to "shift profits," made possible by the use of the subsidy, may not be enough to compensate for this effect and domestic welfare may fall.

If the cost of capital is relatively high in one country, cost-reducing investments are relatively unlikely to occur in that country. It is found in most empirical studies that the real cost of capital is substantially higher in the United States than in other major trading countries (e. g., Hatsopoulis and Brooks, 1986; Bernheim and Shoven, 1987; Ando and Auerbach, 1988; and McCauley and Zimmer, 1989).

For example, Bernheim and Shoven (1987) find that the real cost of capital (calculated at the average interest and inflation rates for the 1980s using 1985 tax codes) was 5.48% in the United States, which is double that in Japan, half again as high as in the

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[3] That is, export subsidies are a decreasing function of firms' costs, which are a decreasing function of previous investment. This assumption is consistent with the oft-made statement by politicians that "winners" should be backed (e. g., the Clinton administration's justification for support for high-tech industries). There are, of course, contrary examples of subsidies given to relatively inefficient firms in dying industries as a means of easing adjustment.

United Kingdom, and a quarter more than in West Germany. Equity capital is also more costly in the United States.

McCauley and Zimmer (1989), after adjusting for inflation, tax rates, and other factors, find that for 1988 the cost of capital for factories with physical lives of 40 years is 10.2 in the United States, which is double that in Japan, 89% more than in Germany, and 29% more than in the United Kingdom. They also find that the cost of capital in the United States is 56% more than in Japan for equipment and machinery with physical lives of 20 years, 133% more for research and development projects with 10-year payoff lags, 16% more for expensed items with physical lives of 3 years, and nearly double for land. Based on these differences in costs, we would expect greater anticipatory responses to subsidies by foreign firms than by U. S. firms.

The next section presents a model of strategic trade policies in which governments subsidize or tax exports. In the second section, the ability of governments to use investment taxes or subsidies to prevent the adverse investment responses to strategic trade policies is discussed. A linear example presented in the third section illustrates our major results. The final section contains conclusions.

I. The model

Strategic intervention by a government may be disadvantageous whether or not the foreign government retaliates. In our model, a government chooses its policy before firms produce but after firms invest. That is, the government cannot "precommit" to its policies.[4] In this section, the government's only policy is an output tax or subsidy — it

[4] In view of the difficulty that governments have in adhering to even the simplest promises, this assumption that governments cannot commit to long-run policies is realistic. One of the more amusing recent examples concerns the California State Legislature, which bound itself to finish business by a certain time on a certain date. In

cannot tax or subsidize investment. In the next section, we discuss how our results are modified if the government can also tax or subsidize domestic investment.

The home and foreign firms produce a homogeneous product and no new firms in any country can enter. The firm in the home country produces q_h units of output and the firm in the foreign country produces q_f. Both firms sell in a third country at a price of $p(q)$, where $q \equiv q_h + q_f$ is total output. The total production costs for Firm i in the current period are $c_i(k_i, q_i)$, where k_i is Firm i's level of capital, which is determined by previous investment.

Initially, we assume that only the home government can intervene (that is, it has no fear of retaliation by the foreign government). After firms make their investment decisions, the home country chooses a subsidy of s_h per unit so that domestic *ex post* profits inclusive of the subsidy (but ignoring investment) are

$$\pi_h \equiv (p(q) + s_h)q_h - c_h(k_h, q_h),$$

and foreign profits are

$$\pi_f \equiv p(q)q_f - c_f(k_f, q_f).$$

Each firm chooses output in order to maximize its profits, taking the subsidy as given. Thus, the equilibrium output rules may be written as $q_i(\mathbf{k}, s_h)$, where $\mathbf{k} \equiv (k_h, k_f)$.

The home government takes the firms' output rules, $q_i(\mathbf{k}, s_h)$, as given and sets the subsidy to maximize domestic profits net of the subsidy. The optimal subsidy rule is $s_h = s_h^*(\mathbf{k})$. Substituting this function into the firms' output rule gives the equilibrium output as q_i

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order to comply with the rule, the hands were taken off the clock at the State capitol, which enabled the legislators to finish by the prescribed time.

$= q_i^*(\mathbf{k})$. Firm i's equilibrium level of profits, net of investment costs, can then be written as $\pi_i(\mathbf{k})$, for i = h, f. The equilibrium transfer to the home firm is $S_h^*(\mathbf{k}) \equiv s_h^*(\mathbf{k})q_h^*(\mathbf{k})$.

The cost of investment by Firm i is $I_i(k_i)$. At the investment stage, which occurs before the government chooses its subsidy, Firm i takes k_j as given and chooses k_i to maximize *ex ante* profits,

$$\Pi_i(\mathbf{k}) \equiv \pi_i(\mathbf{k}) - I_i(k_i).$$

The equilibrium to this game is $\mathbf{k}^* = (k_h^*, k_f^*)$. The home government's level of welfare is[5]

$$W_h(\mathbf{k}^*) \equiv \Pi_h(\mathbf{k}^*) - S_h^*(\mathbf{k}^*).$$

If both governments can credibly commit themselves not to intervene at the production stage, the equilibrium level of investment is $\hat{\mathbf{k}} = (\hat{k}_h, \hat{k}_f)$ and the equilibrium payoff (revenue minus variable costs minus investment costs) to Firm i is $\hat{W}_i$, where the "^" indicates the free-trade equilibrium. In the absence of intervention, domestic welfare equals the home firm's *ex ante* profits: $\hat{W}_h = \hat{\Pi}_h$.

We now explain why, even with perfect information and no threat of retaliation, "optimal" *ex post* government intervention may be disadvantageous, in the sense that $W_h < \hat{W}_h$. We then note that, if both countries use strategic policies, these results are strengthened.

Given that the firms choose quantities at the production stage, the optimal *ex post* subsidy is positive. Without placing additional structure on the model, it is not possible to determine how the equilibrium subsidy depends on levels of capital. The ambiguity

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[5] This measure ignores the possibility in rent that may result in an increase in demand for the investment good.

occurs because the sign of $\partial s_h^*/\partial k_i$ depends on the two cross-partial derivatives $\partial^2 q_j/\partial k_i \partial s_h$, $j = h, f$. For specificity, we henceforth assume that the effect of an increase of the home (foreign) firm's capital on the home government's subsidy is positive (negative):

$$\frac{\partial s_h^*}{\partial k_h} > 0 > \frac{\partial s_h^*}{\partial k_f}. \tag{1}$$

These inequalities hold for the example in the next section, and it is plausible that they hold quite generally: An increase in k_h lowers the production costs at home relative to those of the foreign firm, making the latter more vulnerable to government intervention and thus making it more attractive to subsidize the home firm. The converse holds for an increase in k_f. The inequalities in (1) are consistent with the frequently made political argument that the government should back winners: the government should support firms whose relatively low costs gives them a competitive advantage.

The *ex post* optimal subsidy may be disadvantageous for two completely different reasons. First, anticipation of the subsidy may lead to excessive investment by the home firm. Second, it may result in increased foreign investment.

In choosing its investment level, the home firm sets its shadow value of capital, $\partial \pi_h(\mathbf{k})/\partial k_h$, equal to the marginal cost of capital, $\partial I_h(k_h)/\partial k_h$. From the standpoint of the home government, the social marginal value of home capital is

$$\frac{dW_h}{dk_h} \equiv \frac{\partial \pi_h(k)}{\partial k_h} - \frac{\partial S_h^*(k)}{\partial k_h} + \left[\frac{\partial \pi_h(k)}{\partial k_f} - \frac{\partial S_h^*(k)}{\partial k_f}\right]\frac{dk_f}{dk_h},$$

where dk_f/dk_h is the slope of the foreign firm's best response function for investment. The difference between the social and private marginal value of investment, $-\partial S_h^*(\mathbf{k})/\partial k_h + (\partial \pi_h(\mathbf{k})/\partial k_f - \partial S_h^*(\mathbf{k})/\partial k_f)(dk_f/dk_h)$, is a "distortion."

The anticipation of the export subsidy may so increase the distortion at the investment stage that the export policy is disadvantageous. This adverse effect is more likely if the home marginal investment cost is small so that the home firm invests heavily. If the marginal cost of investment is very large, investment is approximately 0 whether or not a subsidy is anticipated, and there is little excessive investment. The model in the previous literature is the limiting case where the marginal cost of investment is infinite, hence the subsidy is beneficial. Therefore, in order for the subsidy to be disadvantageous due to excessive domestic investment, marginal investment costs cannot be "very large".

The possibility that the production subsidy could lead to increased investment by the foreign firm is more surprising. The lower the foreign firm's relative investment cost, the more likely is this response. For example, suppose that $dI_h(k_h)/dk_h$ is extremely large for all values of k_h so that the equilibrium k_h is approximately zero regardless of the size of the export subsidy, but that $dI_f(k_f)/dk_f$ is relatively small. Here, the foreign firm may alter its equilibrium level of investment in anticipation of a production subsidy by the home government, whereas the home firm does not alter its investment level. The subsidy has conflicting effects on the foreign firm's incentives to invest. For given $\mathbf{k}$ the subsidy reduces the equilibrium value of q_f, which reduces the marginal value of k_f to the foreign firm. However, given the second inequality in (1), the foreign firm has an incentive to invest in order to make it less attractive for the government to subsidize home exports. Without considering specific functional forms, it is not possible to determine which of these effects dominate.

In our model, a firm may overinvest in the first stage so that the government gives it a subsidy in the second stage. In the second stage, the government induces the firm to produce at the Stackelberg level by subsidizing it. If, instead, the government induced the firm to produce at the Stackelberg level in the second stage by penalizing it if it deviated from that level, the overinvestment in the first stage could be avoided. We ignore this latter possibility because it is not observed, whereas subsidized are frequently observed.

II. Investment Taxes or Subsidies

If the government were able to intervene in the investment decision of domestic firms by using an investment subsidy or tax, it could eliminate the domestic distortion in investment. Even with investment policies, however, strategic export policies may be *ex ante* disadvantageous. That is, domestic welfare may be lower than the free trade level when the home government (unilaterally) uses both export and investment policies. The incentives for investment *both at home and abroad* are altered by the export policy and an investment policy is only one additional instrument to influence these two variables.

The inequalities in (1) do not enable us to sign the investment distortion, although it is implied by the first inequality in (1) that the home firm has an incentive to invest in order to induce the government to provide a larger subsidy. This incentive effect tends to

make the distortion negative,[6] which implies that the investment is excessive so that the government would like to tax investment.[7]

Thus, the ability to use investment policies does not guarantee that export policies are advantageous. If export policies are disadvantageous because of anticipatory excessive domestic investment, then investment polices may render the export policies advantageous; if, however, export policies are disadvantageous because of excessive foreign investment, domestic investment policies are not likely to help. This difference can be illustrated by using two extreme cases.

First, suppose that domestic average and marginal investment costs are low and foreign investment costs are very high. That is, foreign levels of capital do not vary much across policy regimes, but the export subsidy may induce excessive domestic investment. A domestic firm's tendency to invest excessively can be reduced by an investment tax without a large change in foreign investment. The combined export and investment policies are then advantageous.

Second, suppose that the foreign average and marginal investment costs are low and domestic costs are very high. The home government would not want to subsidize investment because of the domestic firm's high marginal cost. In addition, the home government need not tax investment because the high marginal cost is a sufficient disincentive. Therefore, the ability to use an investment subsidy or tax gives the government

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[6] If foreign investment costs are sufficiently high so that dk_f/dk_h is approximately 0, the distortion is certainly negative whenever (1) holds and domestic investment costs are not very high.

[7] Spencer and Brander (1983) show that, if the government were able to announce both the production and investment subsidy before investment, it would be optimal to subsidize production and tax investment. The model here is more complicated because of the assumption that the government cannot precommit to the post-investment export subsidy.

essentially no additional leverage; if export subsidies are disadvantageous, investment policies do not help.

III. A Linear Example

We use a linear example to show that *ex post* optimal subsidies may lower *ex ante* welfare under plausible circumstances. The formal analysis of this linear model is presented in the Appendix. Let the inverse demand curve be

$$p = \beta - q_h - q_f,$$

where p is the price of the homogeneous good, and the average production cost for Firm i is

$$C_i = \upsilon - k_i,$$

i = h, f, so Firm i's variable profits exclusive of subsidy are

$$\pi_i = (\theta + k_i - q_h - q_f)q_i,$$

where $\theta \equiv \beta - \upsilon$.[8] Units of capital are chosen so that one unit of capital reduces production costs by one dollar. As before, the subsidy payment to the home firm is $S_h = s_h q_h$. Firm i chooses q_i taking q_j and s_h as given. The home government takes the firms'

[8] Agents' decisions and payoffs depend on θ but not directly on β or υ; therefore, for given θ and any finite equilibrium value of k_i, we can choose υ sufficiently large (by choosing β large) that the production costs are non-negative. Consequently, it is unnecessary to impose an upper limit on the equilibrium value of k_i.

equilibrium decision rules as given and maximizes domestic profits net of the subsidy. The equilibrium subsidy is given by

$$s = .25\theta + .5k_h - .25k_f, \tag{2}$$

which satisfies the inequalities in (1).

Let Firm i's cost of investing k_i be

$$I_i(k_i) \equiv (\sigma_i + .5\rho_i k_i)k_i,$$

so the marginal cost of investment is $\sigma_i + \rho_i k_i$. Even though firms have identical production functions (for a given level of capital), they may face different costs of investment as empirical studies show.[9] Because Firm i's restricted profit function is convex in k_i, ρ_i must be sufficiently large to insure that the firm's investment problem is concave.

The linear example makes it easy to compare different trade regimes. When both governments use subsidies, the outcome is the Nash equilibrium to the noncooperative game between governments. Regardless of whether one, both, or neither of the governments uses a strategic subsidy, the firms' profit functions, $\pi_i(\mathbf{k})$, are quadratic. We now compare these equilibrium payoffs in the cases of both symmetric and asymmetric firms.

A. *Symmetry*

If the two firms and countries have identical investment and production functions so that the slope of the investment cost functions are identical ($\rho_h = \rho_f \equiv \rho$) and both

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[9] Equivalently, the model can be interpreted as one in which the investment costs are the same in both countries, but the production functions may be different. With this interpretation, Firm i chooses to spend I_i dollars, which lowers its marginal cost by the amount $k_i = J_i(I_i)$, where $J_i(\cdot) \equiv I_i^{-1}(\cdot)$.

intervene, social welfare is lower than under free trade, regardless of the value of ρ.[10] It benefits the home government to intervene regardless of the strategy of the other government only if the investment cost function is relatively steep (so that the firms' investment responses are limited).

As illustrated in Table 1, where $\sigma_h = \sigma_f = 0$ and $\theta = 5$, the effects of intervention vary with the slope of the investment cost function, ρ. As before, $\Pi_i = \pi_i - I_i$ equals Firm i's *ex ante* profits; and W_i is government i's *ex ante* welfare, defined as Π_i minus the transfer to Firm i. The free trade equilibrium is compared to one in which only the home government uses subsidies at the production stage ("Home Only") and to another in which both countries set subsidies and the equilibrium of the subsidy game is Nash ("Both"). In these examples, a firm's *ex ante* profits are higher when its government subsidizes for given policy by the rival government. For example, when $\rho = 5$, if the foreign government does not subsidize, the home firm's profits are 3.5 times larger than with free trade. If the foreign government subsidizes, the home firm's profits are 9 percent of the free trade level if the home government subsidizes and 95 percent of the free trade level if the home government does subsidize — a ten fold increase in profits. (INSERT TABLE 1 HERE)

Nonetheless, for low values of ρ (5 or 9), the use of subsidies is socially disadvantageous (domestic welfare, W_h, is less than 100 percent of the free trade level) *whether or not the rival government uses subsidies.* Indeed, where $\rho = 5$, if both governments subsidize, the governments' payoff measures are negative (and, of course, less than the free trade values). If ρ is large (13), it pays for a government to subsidize *whether or not*

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[10] The joint optimum export policy is for both governments to tax exports to induce firms to behave as a cartel. Given the concavity of the welfare functions, a positive export subsidy, such as the Nash equilibrium to the subsidy game, results in lower welfare than a 0 subsidy (free trade).

the rival government uses subsidies. If the foreign government does not subsidize, then home welfare if 103 percent of the free trade level if the home government subsidize. If the foreign government subsidizes, home welfare is 42 percent of the free trade level if the home government does not subsidize and 47 percent if it does.

In all cases, the anticipation of a subsidy by the home government leads to an increase in domestic investment whether or not the rival government subsidizes. Foreign capital falls (relative to free trade) if only the home government subsidizes but rises if both subsidize. For example, when $\rho = 5$, home capital more than triples as a result of anticipating a subsidy by only the home government, whereas foreign capital falls to nearly a third of its free trade level. If both governments subsidize, each firm's capital is more than double the free trade levels.

The anticipation of a subsidy has a weaker effect as ρ increases; and in the limit as $\rho \to \infty$, the subsidy has no effect on domestic or foreign investment. In that (symmetric) case, given the behavior of the other government, it is advantageous for a government to use subsidies.[11]

B. *Asymmetry*

If the firms have asymmetric investment costs ($\rho_h \neq \rho_f$), it may be advantageous for one country, but not the other, to use subsidies. The country with the relatively low marginal investment costs is more likely to encourage excessive domestic investment than is the country with relatively high marginal investment cost.

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[11] From (2) the equilibrium subsidy is finite for finite $\mathbf{k}$. Thus, the marginal benefit of capital, $\partial\pi_i/\partial k_i$, is finite when the home government uses export subsidies. It is also true when the government does not subsidize. Therefore, for any $\varepsilon > 0$, we can choose ρ sufficiently large that in equilibrium $k_i < \varepsilon$ regardless of whether the home government subsidizes. Because the export policy can be disadvantageous only if it has a nonnegligible effect on k, for large ρ the policy must be advantageous.

Table 2 illustrates that, when only the home government subsidizes, home welfare falls if ρ_h and ρ_f (which range from 5 to 15) are both relatively low, where $\sigma_h = \sigma_f = 0$ and $\theta = 5$. For ρ_h less than 8, the subsidy lowers home welfare for all values of ρ_f shown. For ρ_h of 9 or 10, the lower is ρ_f, the more likely is home welfare to be higher with the subsidy. For ρ_h greater than 10, the subsidy always helps for the range of ρ_f shown, and it helps by more the lower is ρ_f. (INSERT TABLE 2 HERE)

It is possible that, where one government benefits from strategic policy, the other country loses, as shown in Table 3 for $\rho_h = 5$ and $\rho_f = 10$. If the foreign government does not subsidize, welfare in the home country is 55 percent of the free trade level if the home government subsidizes. In contrast, if foreign government unilaterally subsidizes, then its welfare is 102 percent of its free trade level. Here, only the country whose firm has relatively high marginal investment costs benefits from the unilateral use of subsidies. If both countries subsidize, however, both are worse off than if only their rival subsidizes or neither subsidizes. (INSERT TABLE 3 HERE)

Despite the harm of intervention to domestic welfare, the home firm always wants to be subsidized. A domestic subsidy increases its profits, regardless of whether the foreign government subsidizes. Indeed, if both countries subsidize, the home firm's profits are 285 percent of the free trade level, whereas the foreign firm profits are only 4 percent of the free trade level. The foreign firm prefers free trade to the Nash subsidies when both countries intervene.

A more surprising result is that the foreign firm loses when the two governments play a subsidy-setting game (foreign profits are 4 percent of their free trade level), relative to when only the home government uses subsidies (foreign profits are 9 percent of the free trade level). This additional harm to the foreign country occurs because the

foreign intervention leads to even more home investment (from 315 to 419 percent of the free trade level). The foreign firm loses more from facing a lower-cost rival than it gains from the subsidy. This example shows that a firm, and not only a government, may find strategic intervention disadvantageous.

In this example the unilateral subsidy is disadvantageous when used by the country with relatively low marginal investment costs because the subsidy widens the gap between the social and private marginal benefit of capital and induces excessive domestic investment. If a tax on investment could be used, the gap between private and social benefit would be eliminated. Here, welfare is higher than the free trade level when both the (unilateral) investment and export policies are used.

The example also illustrates the possibility that the country with high marginal costs may find the subsidy disadvantageous due to increased investment by the rival. Here, a domestic tax or subsidy on investment may not remedy the problem. In order to illustrate this possibility more simply, we consider the extreme case where $\sigma_h = 0$ and $\rho_h \to \infty$ so that domestic investment is approximately 0 under every regime. The home government would never want to subsidize investment, even if it were in a position to do so because the social cost of capital is too high.[12] When k_h is fixed at 0, the first-order condition to the foreign firm's investment problem implies

$$k_f^* = \frac{.375\theta - \sigma_f}{\rho_f - 1.125}, \tag{3}$$

[12] In the alternative interpretation of the model where production functions rather than investment costs differ across countries, the limitations on complementary inputs to production may cause the marginal increase in efficiency to be very low at home.

when it anticipates that the home government will use a subsidy. When the home government is committed to free trade, the equilibrium foreign investment is

$$\hat{k}_f = \frac{.444\theta - \sigma_f}{\rho_f - .89}. \tag{4}$$

A necessary and sufficient condition for foreign investment to be higher when a domestic subsidy is anticipated is

$$z(\rho_f) \equiv \frac{\rho_f - .89}{\rho_f - 1.125} > \frac{.444\theta - \sigma_f}{.375\theta - \sigma_f} \equiv y(\sigma_f; \theta). \tag{5}$$

To insure that the foreign firm's investment problem is concave under both regimes, we require $\rho_f > 1.125$. To guarantee that investment is nonnegative under both regimes, we require that $\sigma_f < .375\theta$. For ρ_h arbitrarily large, the standard "stability condition" is satisfied (the Jacobian of the firms' first-order conditions to the investment game is negative definite). The function $y(\sigma_f; \theta)$ increases over the interval $(0, .375\theta)$ so its minimum is at 0: $y(0; \theta) = 1.184$. The function $z(\rho_f)$ decreases over the interval $(1.125, \infty)$; $z(\rho_f)$ approaches 1 as ρ_f goes to ∞; and $z(2.402) = 1.184$. Thus, for any value of ρ_f in the interval (1.125, 2.402), we know:

(i) The foreign firm's problem is concave and the investment game is stable.

(ii) For $\sigma_f \in (0, y^{-1}(z(\rho_f)))$, the anticipation of the home subsidy increases foreign investment.

In other words, there is a family of foreign marginal cost curves for investment for which foreign investment is exactly the same with or without the home subsidy. This family is given by $y^{-1}(z(\rho_f)) + \rho_f k_f$ for $\rho_f \in (1.125, 2.402)$. If the slope of the marginal cost curve lies

within this interval, the anticipation of the production subsidy by the firms decreases foreign investment if and only if the intercept is greater than $y^{-1}(z(\rho_f))$. This result has an intuitive interpretation: if foreign investment costs are large, the foreign firm is less likely to invest heavily in an attempt to discourage the future subsidy offered to its rival.

Even if (5) holds, it is not necessarily the case that the home government's subsidy is disadvantageous because, at the production stage, the government can shift profits. However, it is easy to find examples where the subsidy is disadvantageous because it encourages foreign investment. For example, if $\theta = 5$, $\sigma_h = 0$, $\rho_h = 5{,}000$, $\sigma_f = 1.525$, and $\rho_f = 1.3$, then k_h is approximately 0 whether or not the government uses a production subsidy. With a subsidy, $k_f^* = 2$, whereas, with free trade, $\hat{k}_f = 1.7$. With the subsidy, home welfare is 1.1, whereas the free trade welfare is 1.2. The home firm's *ex ante* profits with the subsidy, 2.25, are greater than under free trade, 1.21; and foreign profits with the (home) subsidy, 1.9, are smaller than under free trade, 3.7.

In short, the subsidy increases profits of the home firm but reduces home welfare and foreign profits.[13] The ability to use an investment subsidy would not alter this result because the optimal investment subsidy would be 0.

IV. Conclusions

The use of strategic trade policies may lower domestic welfare below the free trade level. The critical assumption for this conclusion is that an intervening government is unable to make commitments about its future policies. That is, a government that attempts to use trade policy strategically tends to set policies so they are *ex post* optimal.

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[13] The use of subsidies is sometimes defended as means of increasing market share rather than welfare. In the last example, the subsidy increases the home firm's market share to .35 from .28.

Such behavior is *ex post* logical but, when other agents are strategic, it may have perverse *ex ante* effects. Perverse effects from strategic industrial policies occur in a model that is biased in favor of export subsidies: firms choose output, domestic consumption is absent, there is complete information, and there is no foreign retaliation.

Strategic policies may widen the gap between the private and social marginal value of capital. Where the domestic marginal cost of capital is low, there may be excessive domestic investment. Alternatively, anticipating such policies, foreign firms may invest more to affect the subsidy. This effect may be strong enough that the use of the subsidy may decrease firm profits, rather than simply domestic welfare, in the country that imposes the subsidy. Excessive foreign investment is likely if the foreign marginal cost of capital is low relative to domestic costs. Moreover, even if strategic trade policies are used in conjunction with investment policies, they may be disadvantageous.

Given these conclusions, it is important to determine the indirect effects of trade policies — especially the effects on investment. That is, one should compare investment costs across nations. As discussed above, the cost of capital is substantially higher in the United States. As a result, strategic U. S. export subsidies may result in increased investment (and lower future costs of production) in Japan. According to some empirical studies, however, even in the United States, real capital rates are low enough that strategic U. S. subsidies may cause excessive U. S. investment. Given asymmetric investment costs, there is a strong possibility that, although one country benefits from the unilateral use of strategic trade policy, if another country adopts such policies, its welfare may fall. This last discussion is, of course, speculative because the actual outcome depends on many factors. At the very least, however, the results of our model, together

with the empirical evidence, indicate that it is likely that strategic trade policies are counterproductive for some countries.

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Appendix

Using the linear example, we derive the equilibrium where only the home government subsidizes. We start by examining the firms' production decisions. The home firm's profits may be written as

$$\pi_i = (\theta + k_i + s_h)q_h - 0.5\mathbf{q}'B_h\mathbf{q},$$

where $\mathbf{q}' = (q_h, q_f)$ and $B_h = \begin{pmatrix} 2 & 1 \\ 1 & 0 \end{pmatrix}$. The first-order conditions, assuming both firms play Nash in quantities, for the home and foreign firms may be written in matrix form as

$$\mathbf{q} = Ae\theta + A\mathbf{k} + Ae_h s_h,$$

where $e' = (1, 1)$, $e_h' = (1, 0)$, and $A = \begin{pmatrix} 2 & 1 \\ 1 & 2 \end{pmatrix}^{-1} = \begin{pmatrix} 2/3 & -1/3 \\ -1/3 & 2/3 \end{pmatrix}$.

The government's problem is

$$\max_{s_h} (\theta + k_h)e_h'\mathbf{q} - .5\mathbf{q}'B_h\mathbf{q}.$$

The government's *ex post* optimality condition is

$$s_h = C_3 + C_4\mathbf{k},$$

where $C_4 = C_2^{-1}C_1$, $C_3 = C_2^{-1}C_0$, $C_2 = e_h'AB_hAe_h$, $C_1 = e_h'Ae_he_h' - e_h'AB_hA$, and $C_0 = \theta e_h'Ae_h - e_h'AB_hAe\theta$. The equilibrium exports are

$$\mathbf{q} = C_5 + C_6\mathbf{k},$$

where $C_6 = A + Ae_hC_4$ and $C_5 = Ae\theta + Ae_hC_3$. Substituting $\mathbf{q}$ into the firms' profit functions, we obtain

$$\pi_h = D_0 + D_1\mathbf{k} - .5\mathbf{k}'D_2\mathbf{k}$$

and

$$\pi_f = E_0 + E_1\mathbf{k} - .5\mathbf{k}'E_2\mathbf{k},$$

where $D_0 = (\theta + C_3)e_h'C_5 - .5C_5'B_hC_5$, $D_1 = (\theta + C_3)e_h'C_6 + C_5'e_h(e_h' + C_4) - C_5'B_hC_6$, $D_2 = C_6'B_hC_6 - (e_h + C_4')e_h'C_6 - C_6'e_h(e_h' + C_4)$, $E_0 = \theta e_fC_5 - .5C_5'B_fC_5$, $E_1 = \theta e_f'C_6 + C_5'e_fe_f' - C_5'B_fC_6$, $E_2 = C_6'B_fC_6 - e_fe_f'C_6 - C_6'e_fe_f'$, $e_f' = (0, 1)$, and $B_f = \begin{pmatrix} 0 & 1 \\ 1 & 2 \end{pmatrix}$. Home welfare is

$$W_h = F_0 + F_1\mathbf{k} - .5\,\mathbf{k}'F_2\mathbf{k},$$

where F_i is the same as D_i and where C_3 and C_4 have been set equal to 0.

In the investment stage, the home firm's objective is

$$\max_{k_h} D_0 + D_1\mathbf{k} - .5\mathbf{k}'D_2\mathbf{k} - \sigma_1 e_h'\mathbf{k} - .5e_h\mathbf{k}'e_he_h'\mathbf{k}.$$

The foreign firm's problem is similar. The system of first-order conditions for the Nash investment game is

$$\mathbf{k} = G_1^{-1}G_0,$$

where

$$G_0 = \begin{pmatrix} e_h' D_1' - \sigma_h \\ e_f' E_1' - \sigma_f \end{pmatrix} \quad \text{and} \quad G_1 = \begin{pmatrix} e_h'(D_2 + e_h e_h e_h') \\ e_f'(E_2 + e_f e_f e_f') \end{pmatrix}.$$

The analysis is similar where both governments set subsidies, $\mathbf{s}' = (s_h, s_f)$, and play a Nash game. To obtain that equilibrium, rewrite C_0, C_1, and C_2 as matrices with two rows, where the first row is the same as before and the second row substitutes "f" for "h." All the equations then follow as before. For the free trade equilibrium, constrain the subsidies to equal 0 and then use the equations from above.

Table 1
Effects of Subsidies
As a Percentage of the Free Trade Levels

	$\rho = 5$		$\rho = 9$		$\rho = 13$	
	Home Only	Both	Home Only	Both	Home Only	Both
Profits (%)						
Π_h	353	95	270	123	253	131
Π_f	9	95	34	123	42	131
Welfare (%)						
W_h	59	-17	97	32	103	47
W_f	9	-17	34	32	42	47
Capital (%)						
k_h	329	243	265	231	244	222
k_f	35	243	65	231	72	222
Output (%)						
q_h	220	136	177	128	166	125
q_f	31	136	59	128	65	125
Subsidy (level)						
s_h	2.0	1.2	1.6	1.1	1.4	1.1
s_f	0	1.2	0	1.1	0	1.1

Table 2
Home Welfare Where only the Home Government Subsidizes
As a Percentage of the Free Trade Level, $100W_h^*/\hat{W}_h$,
Varies with ρ_h and ρ_f

	ρ_f										
ρ_h	5	6	7	8	9	10	11	12	13	14	15
5	59	57	56	56	55	55	54	54	54	54	53
6	80	78	77	76	76	75	75	75	75	74	74
7	90	89	88	87	86	86	86	85	85	85	85
8	96	95	94	93	93	92	92	92	91	91	91
9	100	99	98	97	97	96	96	96	95	95	95
10	102	101	100	100	99	99	99	99	98	98	98
11	104	103	102	102	101	101	101	101	100	100	100
12	106	105	104	103	103	103	102	102	102	102	102
13	107	106	105	105	104	104	104	104	103	103	103
14	108	107	106	106	105	105	105	105	104	104	104
15	108	108	107	106	106	106	106	105	105	105	105

Table 3
Effects of Subsidies
With Asymmetric Costs
As a Percentage of the Free Trade Levels
$\rho_h = 5$ and $\rho_f = 10$

	Only Home Government Subsidizes	Only Foreign Government Subsidizes	Both Governments Subsidize
Profits (%)			
Π_h	328	39	285
Π_f	9	273	4
Welfare (%)			
W_h	55	39	-51
W_f	9	102	1
Capital (%)			
k_h	315	71	419
k_f	32	264	36
Output (%)			
q_h	212	64	235
q_f	29	176	21
Subsidy (level)			
s_h	2.1	0	2.3
s_f	0	1.5	.2