Flexibility Versus Commitment in Strategic Trade Policy Under Uncertainty: A Model of Endogenous Policy Leadership

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Flexibility Versus Commitment in Strategic Trade Policy Under Uncertainty: A Model of Endogenous Policy Leadership

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ABSTRACT

I consider a noncooperative game between rival governments where the strategic variable is an export subsidy. Governments can choose their policy level either prior to observing the random, demand intercept or subsequent to this observation. It is assumed that a policy choice made ex ante is completely irreversible ex post. I show that the resulting equilibrium will frequently involve asymmetric timing of policy choice. One government will move first and, in effect, become the leader in the trade-policy game. The other government will delay its commitment, thereby better tailoring its policy to the actual economic environment. Equilibrium with asymmetric timing of commitment exists when there is not too much noise in the system or, even in the large noise case, when the number of firms differs across countries. When there are two such equilibria, one of these equilibria may be focal, i.e., the governments might agree on which should be the leader. In the large noise case, the equilibrium with asymmetric timing of commitment is the unique equilibrium of the overall game.
I. Introduction

Export subsidies pose an enigma for economic theory. Within the traditional small country (competitive) and large country (monopoly) paradigms of international trade, no economic rationale for export subsidies exists. Since these models account for both extremes in market structure, one may wonder whether it is possible to rationalize export subsidies on the basis of domestic Pareto improvement. Yet, as demonstrated in the seminal paper by Brander and Spencer (1985), an export subsidy can be explained by a "profit shifting" motive which emerges when the industry in question is oligopolistic.

Brander and Spencer consider a two stage game where, in stage one, rival governments choose their trade policies and then, in stage two, producers in each country choose their strategic variables given the joint trade policy choice of the rival governments made in the previous stage. In analogy to the capacity investment by an incumbent firm, e.g., Dixit (1980), an export subsidy by the domestic government shifts the reaction function of the domestic industry, thereby moving the resulting equilibrium along the foreign country's reaction function.

When the domestic industry is characterized by single firm operation, the effect of an export subsidy on domestic profits via the direct effect on the domestic industry is negligible, to a first order approximation, because the domestic industry was already maximizing profits prior to the subsidy. However, such a subsidy significantly

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1 An alternate, readily available explanation is that export subsidies are a form of patronage to the targeted domestic industry and result even if some other sector of the economy suffers. The recent Japanese experience suggests otherwise. Moreover, even if export subsidies are nothing but patronage, it is still a mystery why export subsidies rather than some other form of patronage result when so much of the benefit from an export subsidy is captured by importing countries.
affects domestic profits via its affect on the actions taken by foreign producers. In the case of Cournot competition in the product market, an export subsidy increases the market share of the domestic producer while lowering the product price. Then, a small export subsidy raises domestic profits while lowering overall industry profits, since the Stackelberg leadership output exceeds the Cournot output; ergo, profit shifting.

Though export subsidies might emerge in an equilibrium when rival governments compete over their trade policies, it is not necessarily the case that subsidies will result from such government competition. Indeed, it is possible that export taxes are the outcome. This is the point of the paper by Eaton and Grossman (1986).

To understand why this is the case, first suppose the Cournot assumption is maintained but allow any prespecified number of firms to operate in either country. As the domestic industry gets less concentrated, the domestic reaction function shifts outward. If the domestic industry is sufficiently competitive, the "cartelization" motive will dominate the profit shifting motive and the optimal policy for the domestic government will be a tax rather than a subsidy. Second, suppose the assumption concerning single firm operation in each country is maintained but firms produce imperfect substitutes and are Bertrand competitors choosing price rather than Cournot competitors choosing quantity. Again, an export tax is optimal as such a tax will encourage a higher foreign price. In general, the optimal policy will depend on industry concentration as well as on whether domestic and

2 I am assuming that revenue and cost functions satisfy standard convexity conditions and also that there is a unique equilibrium which is stable.
foreign firms compete in strategic substitutes or strategic complements. (See Bulow, Geanakoplos, and Klemperer (1985).)

An alternate critique of the Brander and Spencer approach has been offered by Cooper and Riezman (1989). These authors are concerned with the arbitrary restriction to a linear tax or subsidy. Nonlinear policies also have the effect of shifting reaction functions. But if nonlinear policies are allowed in the first stage of the game, a plethora of equilibria results. There does not appear to be a compelling way to make an equilibrium selection in this case.

Cooper and Riezman suggest a way out of this dilemma. They allow for some actual uncertainty which is unresolved until after governments have committed to their policy choices. Then, a policy must be evaluated on the basis of how it performs for all realizations of the underlying random variable rather than on just how it performs when this random variable takes on its expected value. Policies which perform badly as the environment changes slightly are ruled out and the set of equilibria is reduced.

One possible way to proceed at this juncture is to maintain the two stage structure and, following Weitzman (1974), allow governments to choose arbitrary nonlinear incentive schemes in the first stage. Klemperer and Mayer (1989) take this type of an approach in an oligopoly model where the firm commits itself ex ante to a supply function and ex post chooses a point along this supply function. In the trade context, it seems unreasonable to assume that governments can directly choose an aggregate supply function for their domestic producers, at least when there is more than one firm. But, in a model where the government chooses a unit subsidy which depends on aggregate output, difficulties
are created owing to intractability, lack of realism, and nonexistence of equilibrium. As a consequence, Cooper and Riezman offer a highly stylized model where it is assumed that the only nonlinear, admissible policy is a fixed quantity regime.

Fixed quantity policies are completely inflexible in the face of uncertainty and would never emerge in the equilibrium of a two stage game. Cooper and Riezman consider a three stage game, where governments announce their policy type in the first stage, either tax-subsidy or fixed-quantity, and choose their policy level in the second stage, given their first stage policy type choice. Consideration of this three stage game introduces a new wrinkle. The stage one policy type choice can affect the rival government's stage two policy level choice. Then, a fixed-quantity policy may be attractive because, by adopting such a policy in stage one, the government immunizes its country from the rival government's profit shifting in the ensuing subgame. Since a tax-subsidy policy allows firms to better approximate the ex post optimum, a tradeoff is created between being immune to the rival government's profit shifting, on the one hand, or being vulnerable to profit shifting but being flexible in the face of (demand) uncertainty, on the other. The optimal choice depends on the noisiness of the system. Following Jones and Ostroy (1985), Cooper and Riezman show that in the low noise case the equilibrium yields an inflexible fixed-quantity regime while in the high noise case a more flexible tax-subsidy regime emerges.

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3 As pointed out by Myerson (1982), existence of equilibrium is problematic in such an unrestricted environment. Fershtman and Judd (1987) offer these existence problems as justification for looking at linear incentive schemes.

4 Spencer and Brander (1989) analyze this type of extensive form in an oligopoly model and provide a variety of interesting applications for this structure.
While the tradeoff between commitment and flexibility in trade policy is an important one, it is not obvious that this tradeoff is modelled best via a choice of policy type. Nor is it obvious that governments are capable of temporally separating their choice of policy type from their choice of policy level. In other words, it might be more appropriate to collapse the first two stages of the Cooper and Riezman model into a single stage.

One interpretation for this temporal separation in decision is that government is hierarchical and different individuals in the hierarchy are making the moves at the different stages. Higher ups commit to a general policy type in stage one while lower level appointees pursue the policy level choice in stage two. This interpretation has immediate plausibility. Yet even this interpretation does not produce the Cooper and Riezman extensive form unless it is also assumed that the rival government can observe the internal, policy type directive at the time this decision is made. If, instead, the rival government can only observe an actual policy level decision, their model collapses into a two stage model.

An alternate, and perhaps more natural way to model the commitment versus flexibility tradeoff is to posit a fixed policy type but allow governments to determine the frequency with which policy levels are adjusted. The more frequent the adjustment, the more flexible the policy. This is the approach taken in my model. The motive for adjusting policy is that governments learn about the economic

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5 I am indebted to James Brander for providing this interpretation to me.
environment and can base their policy choice on what they have learned. For simplicity, the three stage structure is maintained.

As in the Cooper and Riezman model, the first two stages of my model are reserved for government decisions. In the first stage, each government either chooses a tax-subsidy policy or opts to delay this choice until the second stage. Between the first and second stage some information about the economic environment becomes known to the governments. If a government did not select a policy in stage one, it must do so in stage two. It is assumed, however, that if a government has selected a policy in stage one, this choice cannot be altered in stage two, regardless of what the government learns about the economic environment. In stage three, domestic and foreign producers play a Cournot quantity game, as in the Cooper and Riezman model.

The primary consequence from adopting this alternative extensive form is that the nature of the equilibrium changes. In equilibrium of the Cooper and Riezman model, both governments adopt inflexible, fixed-quantity policies in the low noise case. In contrast, there does not exist an equilibrium of my model where both governments make the relatively rigid decision to commit to a tax-subsidy scheme in stage one. This follows because it is strictly dominant for at least one of

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6 An important question which is not considered in the paper is how governments credibly commit to a rigid policy when such a policy is not optimal ex post. In the paper, it is merely assumed that governments have such a commitment capability.

7 More realistically, committing to a policy in stage one imposes an adjustment cost in stage two that could have been foregone were the government to delay its policy choice. In the paper I restrict attention to the infinite adjustment cost case.

8 This type of equilibrium does exist if, with probability one, governments learn nothing about the economic environment between stages one and two.
the governments to delay its policy choice till stage two given that its rival has chosen a policy in stage one. ⁹

In the low noise case there are typically two equilibria of my model. In such an equilibrium one government acts like a Stackelberg leader by choosing its policy in stage one while the other government acts like a Stackelberg follower by choosing its policy in stage two. One of these equilibria may be focal in that it Pareto Dominates the other equilibrium. ¹⁰ Note that this Stackelberg outcome occurs in spite of the fact that neither government has a first mover advantage. ¹¹ In this respect my model is similar to the model of Green and Sa danand (1990) who consider endogenous Stackelberg leadership in oligopoly.

However, my model differs from those mentioned above in its prediction for the high noise case. In these other models, all the players adopt more flexible policies when the environment is sufficiently noisy. In contrast, it is possible for there to be a unique equilibrium of my model in the high noise case and this equilibrium entails leadership on the part of one of the two governments. This occurs when the follower government's tax-subsidy policy is negatively correlated with the underlying uncertainty. Then, the leader government encourages both its firms and the firms in the other country to adjust to uncertainty by allowing greater variability

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⁹ Weak dominance is obvious because in stage two each government could always choose the policy it would have chosen in stage one. Strict dominance for at least one government occurs because for this government the second stage best response is not constant in the underlying uncertainty.

¹⁰ This result contrasts with the finding of Dowrick (1986). In his model either both players prefer to be the leader or both prefer to be the follower.

¹¹ Arvan (1985) demonstrates a similar result in a two-period duopoly model with inventories.
in the follower government's policy response. This is achieved by the leader government adopting an inflexible policy.

II. The Model

Following Riezman and Cooper, consider the market for a homogeneous good which is produced by a relatively small number of firms, F, and consumed by a large group of consumers. \( N_1 \) of the firms operate in country 1 and \( N_2 \) of the firms operate in country 2. (Hence, \( F = N_1 + N_2 \).) Assume that the number and location of the firms is fixed. Each firm is assumed to operate at constant marginal cost. This marginal cost is given by \( c_1 \) for firms in country 1 and by \( c_2 \) for firms in country 2. That is, cost functions across firms are identical within a country. Let \( p \) denote the product price. Then, the profit for a firm which operates in country \( i \) and produces \( q_i \) units of output is given by

\[
\pi_i = (p - c_i)q_i, \tag{1}
\]

for \( i = 1,2 \).

As is now common in this literature, it is assumed that consumers reside in a third country. This assumption is made so that governments can pursue profit shifting and cartelization motives without having to be concerned with the welfare of their consumers. For simplicity, assume that the market demand curve is linear with random intercept. The inverse demand curve is given by

\[
p = a + \theta - bQ, \tag{2}
\]
where \( Q \) is total output, \( a \) and \( b \) are parameters with \( a, b > 0 \), and \( \theta \) is a random variable with zero mean and finite, nonzero variance. Let \( \alpha \) denote the ex post value of the demand intercept; \( \alpha = a + \theta \).

Suppose the government in country \( i \) institutes a per unit production subsidy equal to \( s_i \) and suppose that all firms engage in a Cournot output game. It is assumed that firms know the realization of the random demand intercept when playing this game. Then, the typical firm in country \( i \) solves the following problem

(3) \[
\max_{q} \left( \alpha - bQ_a - bq - c_i + s_i \right)q,
\]

where \( Q_a \) denotes the aggregate output of all other firms. This yields the following output reaction function for a firm in country \( i \)

(4) \[
q_i^r = \frac{\alpha - bQ_a - c_i + s_i}{2b}.
\]

It is straightforward to derive the aggregate output, country reaction function from the above assuming the firms in country \( i \) have achieved Cournot equilibrium. Since each firm in country \( i \) produces the same output in Cournot equilibrium, this equilibrium condition is given by \( Q_a = (N_i - 1)q_i^r + Q_j \), where \( Q_j \) is the aggregate output of firms in the country other than \( i \). Then, we have

(5) \[
q_i^* = \frac{1}{(N_i - 1)b} \left[ \alpha - bQ_j - c_i + s_i \right] \text{ and }
Q_i^r = \frac{N_i}{(N_i + 1)b} \left[ \alpha - bQ_j - c_i + s_i \right] = N_i q_i^*.
\]

\(^{12}\) It is assumed that parameter values are restricted so as to always yield an interior solution.
It is convenient to think of the number of firms in country $i$ as determining the slope of country $i$'s output reaction function. This slope moves from $-1/2$ to $-1$ as $N_i$ moves from 1 to $\infty$. Then, it is convenient to think of the unit subsidy in country $i$ as a shifter of the reaction function intercept.

It is also straightforward to derive the overall Cournot equilibrium. The equilibrium country outputs, $Q_i^*$ and $Q_j^*$, are given by

\begin{equation}
Q_i^* = \frac{N_i}{(F + 1)b} \left[ \alpha + (N_j + 1)(s_i - c_i) - N_j(s_j - c_j) \right]
\end{equation}

for $i, j = 1, 2; i \neq j$. Then, the equilibrium price, $p^*$, is given by

\begin{equation}
p^* = \frac{\alpha - N_i(s_i - c_i) - N_j(s_j - c_j)}{F + 1}.
\end{equation}

Finally, it is assumed that there are no distortions created in raising the revenue to finance the subsidies, i.e., in accounting for aggregate profit subsidies can be ignored. Then, the equilibrium country profits, $\Pi_i$ and $\Pi_j$, are given by

\begin{equation}
\Pi_i = \frac{N_i}{(F + 1)^2b} \left[ \alpha + (N_j + 1)s_i - (N_j + 1)c_i - N_j(s_j - c_j) \right]
\end{equation}

\[ X \left[ \alpha - N_is_i - (N_j + 1)c_i - N_j(s_j - c_j) \right] \]

for $i, j = 1, 2; i \neq j$, where $\Pi_i = (p^* - c_i)Q_i^*$.

Consider the following three stage game which is designed to capture strategic competition between governments. In stage one the government in country $i$ chooses an indicator variable, $d_i$, and a unit subsidy, $s_{i1}$. Here, $d_i$ denotes whether the government in country $i$ commits to a policy, $d_i = 1$, or defers its policy choice until stage two, $d_i = 0$, while $s_{i1}$ is the unit subsidy that is in effect in country
i if the government has committed to a policy in stage one. Governments are ignorant of the realization of θ in stage one though its distribution is common knowledge. Governments are assumed to move simultaneously in this stage.

Between stage one and stage two governments get to observe θ. If the government of country i has not committed to a policy in stage one, it chooses a unit subsidy in stage two, s_{i2}, on the basis of its observation of θ and its knowledge of the play in stage one. For analytic convenience, it is assumed that governments make a stage two move in all cases. Then, a strategy for the government in country i is \(\sigma_i\), where \(\sigma_i = (m_{i1}, m_{i2})\), \(m_{i1} \in \{0,1\} \times \mathbb{R}\), and \(m_{i2} \in \{0,1\}^2 \times \mathbb{R}^3 \rightarrow \mathbb{R}\). That is, \(m_{i1} = (d_i, s_{i1})\) and \(m_{i2}(m_{i1}, m_{j1}, \theta) = s_{i2}\). Governments are also assumed to move simultaneously in this stage. After play in both stage one and stage two has been completed, the unit subsidy that is in effect in country i, \(s_i\), is given by \(s_i = d_i s_{i1} + (1 - d_i) s_{i2}\).

In stage three, firms choose output. This stage has been described extensively above. Indeed, (6) readily yields the equilibrium of the third stage subgame. In this subgame the equilibrium output of each firm in country i is \(Q_i^*/N_i\). It is assumed that the government of country i is interested in maximizing the expected aggregate profits of the firms located in country i. Then, (8) along with the distribution over θ induces a map from joint strategies into joint expected profits.

III. The Stage Two Subgame
Suppose the government in country i has set \(d_i = 0\) in stage one. From (8) and the first order condition, \(\frac{\partial \Pi_i}{\partial s_i} = 0\), one obtains the stage two, tax-subsidy reaction function
for \( i, j = 1, 2; i \neq j \). From (9) it is easy to obtain the following proposition.

**Proposition 1:** \( \text{sign } \frac{\partial s_i^r}{\partial s_j^r} = - \text{sign } \frac{\partial s_j^r}{\partial \alpha} \). Moreover,

\[
\frac{\partial s_i^r}{\partial s_j^r} < 0 \quad \text{when } N_i < N_j + 1, \\
= 0 \quad \text{when } N_i = N_j + 1, \text{ and} \\
> 0 \quad \text{when } N_i > N_j + 1.
\]

Finally, when \( N_i = N_j + 1 \), \( s_i^r = 0 \), i.e., it is optimal for the government to pursue a laissez-faire policy regardless of the demand shock or the policy in country \( j \).

Since the slope of the tax-subsidy reaction function plays such an important role in the later analysis, it is appropriate to provide some insight into the determinants of this slope. Some intuition is provided by an examination of figure 1.

In the figure there are two output reaction functions for country 2, \( Q_2^r |s_2^0 \) and \( Q_2^r |s_2^1 \) with \( s_2^0 < s_2^1 \), and an output reaction function for country 1, \( Q_1^r \). The subsidy level in country 1 that determines \( Q_1^r, s_1 \), is such that \( s_1 = s_1^r(s_2^0) \). This can be seen by noting that 1's isoprofit curve through the Cournot country outputs, point A, is tangent to 2's output reaction function.13 Now consider the (undrawn) isoprofit curve for 1 which is tangent to \( Q_2^r |s_2^1 \). If the tangency point happens to be at

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13 Recall that these unit subsidies shift the output reaction function but are not counted in the profit calculation. Hence, 1's isoprofit curve need not be horizontal where it crosses 1's reaction function, as must be the case when \( s_1 = 0 \).
B, then 1's tax-subsidy reaction function is perfectly inelastic. If the tangency point is to the right of B along \( Q_2^r \mid s_2^1 \), then 1's tax-subsidy reaction function is upward sloping. That is, it is necessary to shift 1's output reaction function upwards to obtain the tangency point as the equilibrium of the third stage subgame. Similarly, the tax-subsidy reaction function is downward sloping when the tangency point is to the left of B along \( Q_2^r \mid s_2^1 \).

Recall that the number of firms in country 1 affects the slope of country 1's output reaction function. As \( N_1 \) increases, country 1's output reaction function through A gets flatter and the point B moves to the left along \( Q_2^r \mid s_2^1 \). But, the number of firms in country 1 does not affect the shape of the isoprofit curves. The tangency points remain unchanged as \( N_1 \) increases. Consequently, for small values of \( N_1 \) the tangency is to the left of B while for large values of \( N_1 \) the tangency is to the right of B. This explains why the slope of the tax-subsidy reaction function depends on the relative number of firms in the two countries.

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14 As \( N_1 \) increases, the subsidy needed to sustain point A as the Nash equilibrium of the third stage subgame also changes.

15 This is a consequence of the constant marginal cost assumption. If firm costs were strictly convex, this conclusion would be invalid.
Given (9), it is a simple matter to compute the Nash equilibrium subsidies. The Nash equilibrium policy levels of the stage two subgame without prior government commitment are \( s_1^* \) and \( s_2^* \) where

\[
(10) \quad s_i^* = \frac{1}{N_i(F + 3)} \left[ N_j + 1 - N_i \right]\left[ \alpha - (N_i + 2)c_i + (N_i + 1)c_j \right]
\]

for \( i, j = 1, 2; \ i \neq j \). Under the reasonable economic condition that the second square bracketed term in (10) is positive, i.e., that the demand intercept is sufficiently large relative to marginal cost, it follows from (10) that the cartelization motive is never dominant in the country with the more concentrated industry and is dominant in the country with the less concentrated industry only when \( |N_i - N_j| > 1 \). Even in this case, the overall effect is to depress price unless costs are much higher in the country with the more concentrated industry. Moreover, price is made less variable, regardless of cost differentials. This can be seen by substituting the equilibrium policy levels from (10) into (6), taking the resulting quantities, and substituting into (7). The price that results from the Nash equilibrium policies, \( p^{**} \), is given by
This price can be contrasted to the Cournot equilibrium price in the absence of any government interference. This latter price is readily obtained from (7) by setting \( s_1 = s_2 = 0 \).

In the ensuing section I consider the decision to commit to a policy in stage one or delay the policy choice until stage two. As the benchmark against which commitment can be judged, consider the expected payoff from choosing to delay given that the rival government has also chosen to delay. To do so, first consider the equilibrium payoffs in the second stage subgame without prior government commitment. These payoffs are obtained by substituting the equilibrium policy levels from (10) into (8) to yield

\[
\Pi_i^* = \frac{1}{(F + 3)^2} \left[ b \left( N_j + 1 \right) \left( a - (N_i + 2) c_i + (N_i + 1) c_j \right)^2 \right]
\]

for \( i, j = 1, 2; i \neq j \). Then, taking expectations with respect to \( \theta \) yields

\[
E_\theta \Pi_i^* = \frac{1}{(F + 3)^2} \left[ b \left( N_j + 1 \right) \left\{ \left( a - (N_i + 2) c_i + (N_i + 1) c_j \right)^2 + \text{Var } \theta \right\} \right]
\]

for \( i, j = 1, 2; i \neq j \).

IV. Commitment Versus Delay and Optimal Commitment

In this section I focus on the stage one decision by the government of country \( i \). Since governments are assumed to move simultaneously in stage one, the government of country \( i \) cannot base its stage one decision on having observed \( m_j \). For the remainder of this section, let \( m_j \) denote the government of country \( i \)'s point expectation
as to the play that the government of country \( j \) will pursue in stage one.

**Case 1: Commitment By the Rival Government**

From (9), \( s_i^r = 0 \) when \( N_j + 1 = N_1 \). In this case, the government of country \( i \) can duplicate its optimal stage two decision by committing to a laissez-faire policy in stage one. Moreover, it is evident that this constitutes the optimal stage one commitment. Hence, the government of country \( i \) is indifferent to committing or delaying in this case given that \( d_j = 1 \). In all other cases, \( s_i^r \) is not constant. Thus, when \( d_j = 1 \), delay is strictly preferred to commitment for the government of country \( i \), since for every realization of \( \theta \) \( s_i^r \) outperforms any fixed policy that might be chosen before \( \theta \) is observed, unless this policy happens to coincide with \( s_i^r \).

**Case 2: Delay By the Rival Government**

When \( d_j = 0 \) and \( N_j \neq N_1 + 1 \), the government of country \( i \) knows that it can affect the unit subsidy chosen by the government of country \( j \), since \( s_j^r \) is not constant in this case. Hence, if the government of country \( i \) chooses to commit to a policy in stage one, it will do so like a Stackelberg leader in the tax-subsidy game played between the rival governments.

In order to facilitate the intuition of the reader in understanding case 2, I first consider the case where \( \text{Var} \ \theta \) is very small and provide a graphical analysis which is conducted assuming \( \text{Var} \ \theta = 0 \). Without loss of generality, take \( N_1 \geq N_2 \) in what follows.

**Subcase 1: Downward Sloping Reaction Functions**

When \( N_1 = N_2 \) the tax-subsidy reaction functions are downward sloping for both governments. In this case, Stackelberg leadership
entails increasing the subsidy beyond the level that would obtain in the equilibrium of the stage two subgame without prior commitment. Since along j's tax-subsidy reaction function $\Pi_j$ is diminishing in $s_i$, leadership in this case entails additional profit shifting. Either government may emerge the leader.

Subcase 2: Natural Follower and Leader

When $N_1 = N_2 + 1$ the tax-subsidy reaction function of the government in country 1 is perfectly inelastic. In this case, the Stackelberg solution of the tax-subsidy game with country 2 as the leader coincides with the equilibrium of the stage two subgame without prior commitment. That is, the government of country 2 is indifferent to committing in stage one or delaying until stage two. Then, by introducing the least bit of noise into the model, the government of country 2 prefers to delay. Hence, there does not exist an equilibrium of the model where the government of country 2 is the leader. However, there is an equilibrium where the government of country 1 institutes a
positive subsidy in stage one so as to reduce the subsidy level instituted by the government of country 2 in stage two.

Subcase 3: Cooperative Follower and Leader

When \( N_1 > N_2 + 1 \) the tax-subsidy reaction function of the government in country 1 is upward sloping. In this case, there are two candidates for Stackelberg equilibrium and they may be Pareto ranked! When the government of country 2 is the leader it reduces its subsidy from the level that would obtain in the equilibrium of the stage two subgame without commitment. Thus, both countries benefit from country 2's commitment relative to the no commitment case. Indeed, the government of country 1 may prefer to be the follower than to be the leader. This occurs if 1's isoprofit curve through 2's leadership point does not cross 2's reaction function. When this is the case, one might argue that leadership by 2 is focal.

![Figure 3](image)
Increasing the Noise of the Demand Intercept

The above graphical analysis is valid when \( \text{Var} \theta = 0 \) and remains valid for \( \text{Var} \theta \) small, since \( E_\theta \Pi_i | (s_j = s_j^r(s_1)) \) is continuous in \( \text{Var} \theta \).

For larger values of \( \text{Var} \theta \), delay may become a more attractive option. Let \( s_i^s \) denote the optimal tax-subsidy choice for the government of country \( i \) in stage one given that the government of country \( j \) has decided to delay its policy choice until stage 2. Note that \( s_i^s \) is the Stackelberg leadership point for government \( i \) in the induced policy game, i.e., \( s_i^s \) is independent of \( \text{Var} \theta \), because of the linear-quadratic structure of the model.

The graphical analysis remains valid as long as

\[
E_\theta \Pi_i | (s_i = s_i^s, s_j = s_j^r(s_1)) \geq E_\theta \Pi_i^*
\]

for some \( i, j = 1, 2; \ j \neq i \). From (8) and (9) it follows that
(15) \[ E_\theta \Pi_1 | (s_i, s_j = s_j^r(s_i)) = h(s_i) + \frac{N_i}{4(N_i + 1)^2} \text{ Var } \theta, \]

for some function h. From (13) it follows that

(16) \[ E_\theta \Pi_1^* = k_i + \frac{1}{(F + 3)^2} [N_j + 1] \text{ Var } \theta, \]

for some constant \( k_i \). Thus, when

(17) \[ \frac{1}{(F + 3)^2} [N_j + 1] > \frac{N_i}{4(N_i + 1)^2}, \]

for \( i, j = 1, 2; j \neq i \), it must be that when \( \text{ Var } \theta \) is sufficiently large the perfect equilibrium of the game entails both governments delaying their policy choice. Note, however, that these conditions can only be satisfied when \( N_1 = N_2 \). In all other cases, the overall equilibrium necessarily entails some government committing to its policy choice in stage one. In other words, except in the case where countries have the same number of firms, this model predicts a leader-follower relationship between governments. Also note that when (17) is not satisfied for some \( i \), this same \( i \) is the leader in the focal equilibrium of the policy game without uncertainty.

The intuition behind this observation is that when \( i \) is the leader in the focal equilibrium, \( j \)'s tax-subsidy reaction function is negatively correlated with the random, demand intercept. In this case, the government of country \( i \) actually increases the variability of the product price by committing to a policy in stage one. Though the variability of country \( i \)'s aggregate output falls as a result of such a commitment, the covariance between price and country \( i \)'s aggregate output rises, i.e., expected profits rise as well.
The previous discussion is summarized in the following proposition.

**Proposition 2**: The nature of perfect equilibria for the three stage policy game depends on the difference, $N_1 - N_2$, and on $\text{Var} \theta$. The perfect equilibrium correspondence is described below.

a) When $N_1 = N_2$, there exists $\nu$ such that for $\text{Var} \theta < \nu$ there are two equilibria of the overall game. In the first of these equilibria, the government of country 1 commits to a policy in stage one while the government of country 2 delays its policy choice until stage two. In the second of these equilibria, the leader and follower roles are reversed. There exists $\overline{\nu}$, $\nu \leq \overline{\nu}$, such that if $\text{Var} \theta > \nu$ there is a unique equilibrium of the overall game. In this equilibrium both governments delay their policy choice until stage two. If $\nu < \overline{\nu}$, there is also a unique equilibrium when $\nu < \text{Var} \theta < \overline{\nu}$. In this equilibrium, one of the governments commits to a policy choice in stage one.

b) When $N_1 = N_j + 1$, there is a unique equilibrium of the overall game. In this equilibrium the government of country $i$ commits to a policy choice in stage one while the government of country $j$ delays its policy choice until stage two.

c) When $N_i > N_j + 1$, there exists $\nu^*$ such that for $\text{Var} \theta \leq \nu^*$ there are two equilibria of the overall game. In the first of these equilibria, the government of country 1 commits to a policy in stage one while the government of country 2 delays its policy choice until stage two. In the second of these equilibria, the leader and follower roles are reversed. Here, in contrast with (a), the equilibrium where the government of country $i$ commits to its policy in stage one may be focal.
When $\text{Var} \theta > v^*$, there is a unique equilibrium of the overall game where the government of country $i$ commits to its policy in stage one.

V. Conclusion

In this paper I have argued that a critical issue in understanding the strategic interplay between rival governments competing in trade policy is the timing of government commitments. When governments are capable of adjusting the flexibility of their policies, the outcome is likely to be asymmetric in the sense that one government will adopt a rigid policy with strong commitment power while its rival will adopt a more flexible policy which responds better in a changing economic environment. The model predicts this asymmetric outcome except in the case of high noise and an equal number of firms in both countries.

Two results were obtained in analyzing the stage two subgame that seem worthy of some additional comment. When the number of firms in country 1 differs significantly from the number of firms in country 2, it was shown that the tax-subsidy reaction function for the country with the less concentrated industry is upward sloping. In addition, this tax-subsidy reaction function is negatively correlated with the demand shock. It is worth asking whether these results are robust to more general demand and cost structures.

First, observe that these two results are adjuncts when there is a unique Cournot equilibrium of the third stage subgame and this equilibrium is stable. Second, recall that when viewing these results in the joint output space, the crucial determinant was the slope of the locus of tangencies between $i$'s isoprofit curves and $j$'s reaction functions, on the one hand, and the slope of $i$'s reaction function, on the other hand.
In the analysis provided in the paper, i's isoprofit curves were unaffected by a change in the number of firms operating in country i, because of the constant marginal cost assumption. Were firms to operate under rising marginal cost, these isoprofit curves would be affected by such a change. The resulting shift in isoprofit curves would tend to support the conclusions of the paper even when demand is nonlinear, as long as the standard assumptions, that i's marginal revenue is diminishing in both i's output and j's output, hold.

Recall that in the paper it was argued that an increase in the number of firms operating in country i makes i's aggregate, output reaction function more elastic. This is a consequence of the quadratic structure of the model. It is not possible to sign the resulting change in the slope of i's reaction function as the number of firms operating in country i increases, for more general demand and cost structures, because these effects depend on third derivative properties of demand and cost. However, it is evident that when a large number of firms operate in country i, the aggregate, output reaction function coincides, more or less, with the competitive reaction function. Thus, the desired relation between the number of firms operating in country i and the elasticity of the aggregate, output reaction function must hold over some range, under standard assumptions governing demand and cost. The conclusions of my model are valid in a more general framework, when attention is restricted to this range.
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