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EMBARGO THREAT, LEARNING AND DEPARTURE FROM COMPARATIVE ADVANTAGE

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This paper extends the current analysis of trade embargo threats, initiated by Bhagwati and Srinivasan, Mayer, and others using general-equilibrium analysis, to a situation where there is the possibility of lowering the future cost of production of the potentially embargoed good as a result of learning-by-doing.

1. Introduction

There has recently been renewed interest in the phenomenon of trade disruption. In the setting of adjustment costs in production, Bhagwati and Srinivasan (1976) have considered optimal trade contraction policies when the probability of disruption depends upon the volume of trade; Mayer (1977) has readdressed the classic national defence tariff argument; and within a partial equilibrium setting Tolley and Wilman (1977) have suggested policy solutions when there are adjustment costs in consumption as well as production. This paper takes up the focal question of this literature[1] – the response of a trading economy threatened with trade disruption – in a setting where the motivation for policy is the opportunity for learning-by-doing. We consider the problem of a small trading economy which is confronted by an embargo threat and which, via the acquisition of current experience, has available to it the means of lowering future domestic production costs of the potentially embargoed good.

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[1]Analytical studies of embargo first appear in the modern literature in Henry Wan's M.I.T. dissertation, and noted in Kemp (1964, ch. 15). For a review of the history of international trade embargoes, see Muir (1974) and also Boorman III (1974). Muir proposed that, notwithstanding the focus of interest in the Middle East, 'there can be no doubt that the incentive and opportunity for adoption of boycotts will recur in the future' (p. 187). A survey of the historical experience leads Muir to conclude that: 'It is evident that the boycott is a frequently used instrument for the advancement of foreign policy objectives. Undoubtedly, it is an instrument of coercion lying somewhere between war and diplomacy in the scale of force' (p. 192).

While not being a necessary feature of the model, we may illustratively take the potentially embargoed good as providing defence services.[2] Other consumption consists of a Hicksian composite good, so permitting the formulation of the problem within the familiar two-good model of international trade. To specify the production side, we adopt the simplification of a Ricardian economy, so enforcing specialization in a free-trade equilibrium.

The problem is posed in a two-period setting: in the current period, free-trade is assured, but not in the future.[3] Since learning takes place in continuous time and is related to the length of the time period over which experience is acquired, the first period may be interpreted as running over continuous time up to a specified planning horizon, for which the second period is the focus. For example, with an economy exhibiting a current comparative disadvantage in the production of defence equipment, there may be uncertainty as to whether in the mid-1980s current commitments of foreign supply will be renewed.[4] We assume that learning does not offer the opportunity for securing comparative advantage in the future. So there is no infant-industry motive for undertaking domestic production of the good threatened with embargo. In the absence of an embargo threat, the economy would specialize to the composite consumption good in both periods, satisfying its defence needs via imports. An embargo threat raises the possibility of future reliance on domestic production, and thereby raises the likelihood that it may be desirable to depart from the current-period specialization equilibrium indicated by comparative advantage. For balanced against the dead-weight loss of not producing according to comparative advantage is the benefit of lower future domestic production costs in an embargoed equilibrium. On the other hand, if there is no embargo, the Ricardian technology assures future production specialization to the com-

[2]U.S. bilateral treaties of friendship, commerce and navigation generally proscribe that parties act 'solely in accordance with commercial considerations' in the conduct of international trade, while article XI of GATT states that 'no prohibitions or restrictions other than duties, taxes or other charges' may be placed on trade. However, U.S. FCN treaties generally include exceptions for trade in arms and for measures 'necessary to fulfil the obligations of a party for the maintenance or restoration of international peace and security, or necessary to protect its essential security interests'. The GATT article also permits a country to have regard for its 'essential security interest relating to fissionable materials, traffic in armaments, or measures taken in time of war or other emergency in international relations'. Treaty quotes taken from Muir (1974, pp. 200–202).

[3]The two-period model extends readily, as in Bhagwati–Srinivasan, to a multiperiod setting. However, for the sake of brevity this extension is not undertaken in the paper.

[4]An example of the problem we seek to model is provided by the question whether Israel ought to produce its own warplanes. As a consequence of past decisions, Israel produces the Kfir fighter-bomber. The question which is now being addressed is whether domestic production of the next generation plane for the 1980s (the Arye) should be undertaken, or whether reliance should be placed on the availability of future imports.

posite consumption good, and hence there is no realization of benefits from past experience.[5]

Section 2 describes the embargo-threatened economy, derives its equilibrium condition, and considers the mode of policy intervention. Comparative statics properties of the equilibrium are considered in section 3: the nature of responses is established to changes in the perceived likelihood of embargo, current and (anticipated) future free-trade contingent terms of trade, current and future income, current production costs of the potentially embargoed good, and learning ability. Since international trade is assumed to be balanced in each period, income cannot be transferred intertemporally via the trade balance, and consequently changes in present and future income need to be considered separately.[6]

In deriving these above results, it is assumed that the probability of embargo is subjective and exogenous. However, the paper concludes in section 4 with a brief consideration of the consequences of endogenizing the probability of embargo by having it depend, as in Bhagwati–Srinivasan, on the volume of trade.

2. The embargo-threatened economy

The embargo-threatened economy is a classical small trading economy with a Ricardian transformation frontier between two goods, one a composite consumption good and the other a final good, yielding for example defence services. If the example of defence services is followed through (it is not necessary, merely illustrative), then the first good is a private good and the second a public good. A Pareto-efficient allocation of resources to provision of the two goods accordingly satisfies the Samuelson (1954) condition, and how such an allocation might be arrived at given preference revelation problems is a well-known topic unto itself. We shall assume, perhaps not too unrealistically, that a domestic equilibrium is not arrived at in a decentralized manner, but rather that the government employs a preference function ostensibly representative of the electorate (or the median

[5]We do not consider the storage option. This is discussed by Tolley and Wilman (1977). Since we do not allow for the possibility of storage, the potentially embargoed good must be taken as having prohibitive storage costs relative to the learning option, or as being physically nonstorable (perishable). Notice that defence equipment falls into the latter category because of the need for spare parts. One can always, however, store spare parts. A more important aspect of perishability of defence equipment arises via obsolescence.

[6]Permitting unbalanced trade enters additional complexities, for then there are two alternative means of self-insurance available to the embargo-threatened economy. In addition to learning, self-insurance may be provided by the direct transfer of income intertemporally via international borrowing or lending. The case of unbalanced trade is studied in Arad and Hillman (1978).

voter) to determine a centralized solution. Domestic production of the composite consumption good is undertaken by profit-maximizing competitive firms which employ constant-returns-to-scale production technologies and hire labor in a competitive factor market. Output of the defence good may be viewed as government production, or also as produced by competitive private firms with the government as the sole purchaser of firms' output. The government also has a domestic trading monopoly in the defence good. Government purchases (or production) of the defence good are financed by lump-sum taxes on domestic consumers, who supply labor inelastically. Individual consumers optimize by maximizing utility subject to their post-tax budget constraints, and their demand functions for the goods composing the Hicksian consumption aggregate are accordingly conditional on the government's choice of consumption of defence services.[7]

The government plans up to a time-horizon encompassing two periods. In the current period, commitments from the sole foreign supplier are believed to ensure availability of imports.[8] However, such commitments do not extend into a future period, in which there is a perceived likelihood of embargo. Denoting the future state of the world in the event of embargo by θ_1 and in the event of free trade by θ_2, the government holds the respective probabilities of outcomes to be $\Pr(\theta_1)=\xi$ and $\Pr(\theta_2)=1-\xi$, where ξ is subjective and exogenous.

The composite consumption good is the numeraire, current terms of trade offered by the sole foreign supplier are P_0 and the anticipated future terms of trade for θ_2 are $P(\theta_2)=P_1$.

The current domestic cost of producing the defence good is $\phi_0 > P_0$, indicating a comparative disadvantage in that good. The future domestic cost of the defence good, ϕ_1, is determined endogenously by previous learning. Following Arrow's (1962) specification of learning-by-doing, we assume that learning takes place within firms, is a function of accumulated industry output, and manifests itself as an industry-wide public input. So the precise number of firms is of no significance; correspondingly, in the event of government production, nor is the number of plants.[9]

Future production costs ϕ_1 are related to the current cost ϕ_0 and accumulated current-period output q via[10] (subscripts denote partial derivatives)

$$\phi_1 = \phi_0 + f(q) = \phi(q): \qquad f_q < 0, f_{qq} > 0, f(0) = 0. \tag{1}$$

[7]On conditional demand functions, see Pollak (1969).

[8]The sole foreign supplier need not be a world monopolist, but rather may be the only remaining world producer prepared to supply the economy.

[9]See also Sandmo (1972).

[10]As noted in the introduction, learning takes place over time and is related to the length of the learning period, so more precisely, in place of (1), we ought to have ϕ_0 decreasing over time throughout the current period. Similarly, learning should continue in the future period, so that

Let $q^{\max}$ be the current output arrived at by specialization to the defence good. We assume that $\phi(q^{\max})>P_1$, which specifies that the current direction of comparative advantage is expected to be maintained in the future.

Current resource endowment and technology determine current national income, which when evaluated in terms of the numeraire good at the world terms of trade is $\bar{I}_0$. This is the national income that would obtain were the economy to specialize according to comparative advantage. Insofar as such specialization does not occur, current national income is determined endogenously by

$$I_0=\bar{I}_0-q(\phi_0-P_0). \tag{2}$$

This incorporates the cost of departure from comparative advantage. Each unit of q produced results in a loss of income equal to the difference between the domestic marginal cost of production ϕ_0 and the world price P_0.

Future national income I_1 is exogenously given by the future technology and resource availability. It is independent of the future state of the world, for whether there is embargo or free trade, the same maximal quantity of the numeraire good is potentially available. Trade is balanced in each period, and so I_0 and I_1 are also respective period expenditures.

The government is risk averse and maximizes expected welfare. The welfare function is assumed to be intertemporally additively separable, so that with V^0 denoting current indirect utility, and $V^{\theta i}$ $(i=1,2)$ denoting discounted future state-contingent indirect utility, expected welfare is[11]

$$\begin{aligned} EV[q,P_0,P_1,\bar{I}_0,I_1,\phi_0,\xi] &= V^0+\xi V^{\theta 1}+(1+\xi)V^{\theta 2} \\ &= V^0[P_0,\bar{I}_0-q(\phi_0-P_0)]+\xi V^{\theta 1}[\phi(q),I_1]+(1-\xi)V^{\theta 2}(P_1,I_1). \end{aligned} \tag{3}$$

The sole discretionary variable in this expression is q. If $\xi=0$, EV is maximized by $q=0$. However, for ξ sufficiently large, the solution satisfies $0<q\leqq q^{\max}$, and assuming production diversification $(q<q^{\max})$, the equilibrium

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ϕ_1 ought to continue falling. These dynamic elements may be readily incorporated in the model by specifying a terminal time horizon, say T^*, and a demarcation T between the period of assured import supply and the period of embargo threat. The loss in income terms from current period departure from comparative advantage is then, for example,

$$\int_0^T q(t)[\phi_0(t)-P_0(t)]e^{-\delta t}\,dt$$

(where δ is a discount factor) rather than simply $q(\phi_0-P_0)$ [see (2) below]. Similar amendments are readily implied for other expressions. The use of the two-period setting and notation provides a simplification without abstracting in any substantive manner from the essence of the problem.

[11] EV is continuous, differentiable and strictly concave.

condition is

$$V_I^0(\phi_0 - P_0) = \xi V_\phi^\theta \, \phi_q. \tag{4}$$

Noting Roy's theorem, that $-V_\phi^{\theta 1}/V_I^{\theta 1} = Q(\theta_1)$, where $Q(\theta_1)$ is future embargo-contingent consumption of the potentially embargoed good, this condition may be expressed as

$$V_I^0(\phi_0 - P_0) = -\xi V_I^{\theta 1} Q(\theta_1)\phi_q. \tag{4a}$$

The left-hand side of (4a) is the marginal loss in current income, expressed in utility terms, due to the production of q, while the right-hand side is the expected marginal benefit from current marginal investment in learning. This benefit derives from the compensating variation arising from the fall in the embargo-contingent domestic marginal cost of producing q, and is expressed in utility terms and weighted by the probability of embargo. While the loss in producing a marginal unit of q is certain, the gain is state contingent: in equilibrium condition (4) which, given the production subsidy, is consistent loss.[12]

Optimal policy intervention requires that the government provide a subsidy to domestic production of the defence good equal to the difference between the world price P_0 and domestic marginal (average) cost ϕ_0. Because of the linear transformation function, such a subsidy does not yield a unique profit-maximizing equilibrium output combination for firms; rather, profit maximization is consistent with any Pareto-efficient output combination. The government then, as the purchaser of domestic output of the defence good, sets required industry supply at the value of q satisfying the equilibrium condition (4) which, given the production subsidy, is consistent with profit-maximization; or, as producer of the defence good, the government itself produces the equilibrium output.

Given equilibrium output, the defence good may be in either excess

[12]For similar results indicating conditions for production diversification contrary to comparative advantage in a Ricardian model, see Kemp and Liviatan (1973) and Turnovsky (1974). Both of these papers are concerned with international trade under uncertainty. Kemp and Liviatan introduce uncertainty into a Ricardian trade model via exogenous random output of a nontradeable good. This implies technological uncertainty, but also has the interpretation of preference uncertainty for a partial preference map defined over the two tradeable goods in the model. In distinction, the embargo model portrayed in this paper exhibits neither technological nor preference uncertainty. There is, however, price uncertainty induced by uncertainty about the continuation of free trade. Turnovsky derives conditions for optimal departure from comparative advantage when the terms of trade is a random variable [see also Ruffin (1974)]. In the embargo-learning model, the distribution of prices is binary: either P_1 obtains or, if the embargo obtains, the autarkic price is endogenously determined by discretionary learning. For surveys of the literature on trade under uncertainty, see Kemp (1976 and Helpman and Razin (1979).

demand or excess supply (or, possibly, the equilibrium could be autarkic[13]); if in excess supply, so that defence goods are exported, inefficiency in the current period is reflected in the location of the consumption equilibrium in the interior of the economy's transformation set. In what follows we shall, without loss of generality, assume that this is not the case, but rather that defence goods remain in excess demand and hence are imported. The consumption equilibrium is accordingly outside the transformation set.

With defence goods imported, a tariff could serve to raise the domestic price received by firms to the level of domestic marginal cost. However, since the government is concerned only with a production goal, a production subsidy is necessarily a Pareto-superior instrument [see Bhagwati (1971)].[14]

3. Comparative statics

The consequence of a change in an exogenous variable follows from (4) as

$$dq/d\alpha = -EV_{q\alpha}/EV_{qq}, \tag{5}$$

where $\alpha = \{\xi, P_0, P_1, \bar{I}_0, I_1, \phi_0, l\}$. The last of these variables has not been previously introduced: we define $l \equiv -\phi_q$ as marginal learning ability.

Since q maximizes EV, the term EV_{qq} in (5) is negative. Accordingly, comparative statics results may be ascertained from

$$\frac{dq}{d\alpha} \gtreqless 0, \quad \text{as} \quad EV_{q\alpha} \gtreqless 0. \tag{6}$$

The responses implied by (6) are summarized in table 1. RRA denotes relative risk aversion and ε is the income elasticity of demand for the defence good. Only for $\alpha = \{\xi, P_1, \bar{I}_0\}$ are the outcomes independent of the relation

Table 1

Change in equilibrium q in response to:						
$\Delta\xi$	ΔP_0	ΔP_1	$\Delta \bar{I}_0$	ΔI_1	$\Delta\phi_0$	Δl
(+)	(+) $RRA \leqq \varepsilon$ (?) $RRA > \varepsilon$	0	(+)	(+) $RRA < \varepsilon$ 0 $RRA = \varepsilon$ (−) $RRA > \varepsilon$	(−) $RRA \leqq \varepsilon$ (?) $RRA > \varepsilon$	(+) $RRA \leqq \varepsilon$ (?) $RRA > \varepsilon$

[13]That is, autarkic with respect to the defence good. In the background we may assume that the individual components of the consumption composite good are traded at exogenous world prices in a balanced trade equilibrium.

[14]Private competitive firms would not internalize an embargo threat. Intervention is necessary since, without a subsidy, firms producing the embargo-threatened good are assured of a current loss, but independently of learning, can best expect zero profits in the future.

between RRA and ε. Increases in ξ and $\bar{I}_0$ always result in greater current output of the potentially embargoed good, while a change in the anticipated future free-trade contingent terms of trade leaves the equilibrium unaffected. The response to a reappraisal of the likelihood of embargo is readily understood as an increase in self-insurance via increased investment in learning. With more current income, the embargo-threatened economy increases its allocation for self-insurance, and hence also increases the investment in learning.

The lack of response to a change in the free-trade contingent terms of trade follows in that a change in the terms of trade in state-of-the-world θ_2 affects neither the current loss due to domestic production of the potentially embargoed good, nor the benefit from learning which accrues in state-of-the world θ_1.[15]

The other outcomes, for $\alpha=(P_0, I_1, \phi_0, l)$, depend upon the relationship between the degree of relative risk aversion exhibited by the government preference function and the income elasticity (ε) of demand for the potentially embargoed good. Since the presumption is that RRA increases with wealth, the results for $RRA>\varepsilon$ may be suggestively inferred as pertaining to a richer economy, and those for $RRA<\varepsilon$ to a poorer economy.

Consider for example the response to a deterioration in the current-period terms of trade. The nature of this response is determined by evaluating

$$EV_{qp_0}=V_I^0-(\phi_0-P_0)\,[V_{IP_0}^0+V_{II}^0 q]. \tag{7}$$

In (7) V_I^0 is the current marginal utility of income, which is positive. Risk aversion implies that V_{II}^0 is negative, and it follows from the direction of comparative advantage that (ϕ_0-P_0) is positive. The remaining term is the cross-derivative of the indirect utility function, which may be expressed as

$$V_{IP_0}^0=Q_0 V_I^0(RRA-\varepsilon)/I_0, \tag{8}$$

where Q_0 is current consumption of the potentially embargoed good.[16] It is evident that the sign of (8) varies as $RRA \gtreqless \varepsilon$. This implies that in (7) $EV_{qp_0}>0$ if $RRA \leqq \varepsilon$, and $EV_{qp_0} \gtreqless 0$ if $RRA>\varepsilon$. Accordingly, with the income elasticity ε as the benchmark, the response to a deterioration in the current terms of trade is an unambiguous increase in domestic output of the potentially embargoed good if the government is not too risk averse; but a more risk-averse government may respond by decreasing output.

[15]These results respectively follow from (6) by observing that

$$EV_{q\xi}=V_\xi^\theta \phi_q>0; \qquad EV_{qI_1}=-(\phi_0-P_0)V_{II}^0>0; \qquad EV_{qP_1}=\xi\phi_q V_{\phi P_1}^\theta=0.$$

[16]Eq. (8) is obtained by applying Roy's theorem and differentiating $V_{IP}=\partial(-V_I Q)/\partial I$, while noting that $RRA\equiv(-V_{II}V_I^{-1}I)$ and $\varepsilon\equiv(\partial Q/\partial I)I/Q$.

The adoption of some further assumptions, however, yields an unambiguous response. If direct utility is homothetic, then $\varepsilon=1$; and as a guide to the value of RRA, Arrow (1965) proposed that 'broadly speaking, the relative risk-aversion must hover around 1, being, if anything somewhat less for low wealths and somewhat higher for high wealths'.[17] Assuming homotheticity and setting $RRA=1$ results in (8) equal to zero, so the marginal utility of income is independent of the terms of trade. In that case, in (7) $EV_{qp_0}>0$, and consequently a deterioration in the current period terms of trade necessarily leads to increased production of the potentially embargoed good.

The analysis of a change in future income is similar. Since

$$EV_{qI_1}=\xi\phi_q V^{\theta_1}_{\phi I} \tag{9}$$

the direction of response depends upon the sign of $V^{\theta_1}_{\phi I}$. Via (8) $EV_{qI_1}\gtreqless 0$ as $RRA\gtreqless\varepsilon$. Hence, in the more risk-averse economy output of the potentially embargoed good is increased, in a less risk-averse economy it is decreased, and in the case of $RRA=\varepsilon$ (as with homothetic preferences and unitary RRA), response to the embargo threat is independent of future income.[18]

The remaining two variables in table 1 relate to domestic production costs. If either the current domestic marginal cost of the potentially embargoed good were to fall or learning ability were to improve, the condition $RRA\leqq\varepsilon$ ensures that domestic output of the potentially embargoed good (and hence investment in learning) would be increased; however, in a more risk-averse economy, these intuitive responses are not necessary, and outcomes are ambiguous.[19]

4. Endogenous probability of embargo

It is a straightforward matter to incorporate into the model endogeneity of the embargo probability via the degree of dependence on imports. This is done by substituting the concave function $\xi=\xi(Q_0-q)$, $\xi'(\cdot)>0$, $\xi''(\cdot)>0$ for exogenous ξ. In place of (4), the equilibrium condition for current output of the embargo-threatened good is

$$V^0_I(\phi_0-P_0)=\xi V^{\theta_1}_{\phi}\phi_q+[V(\theta_1)-V(\theta_2)]\xi_q, \tag{10}$$

[17]Arrow (1965, p. 37).

[18]The consequences of increases in current and future income are then not symmetric. While an increase in current income unambiguously leads to an increase in q, the response to an increase in future income is not unambivalently established without reference to risk aversion.

[19]The effect of the change in ϕ_0 follows from $EV_{q\phi_0}=-V^0_I+(\phi_0-P_0)qV^0_{II}+\xi\phi_q V^{\theta_1}_{\phi\phi}(\partial\phi_1/\partial\phi_0)$. The sign of $V^{\theta_1}_{\phi\phi}$ depends upon RRA and is positive for $RRA<\varepsilon$ but indeterminate otherwise. For the change in marginal learning ability, $EV_{ql}=-\xi[V^{\theta_1}_{\phi}+V^{\theta_1}_{\phi\phi}(\partial\phi_1/\partial l)l]$ and again the sign of $V^{\theta_1}_{\phi\phi}$ determines the outcome.

which has the additional term $[V(\theta_1)-V(\theta_2)]\xi_q$. Since

$$\xi_q \equiv \frac{\partial \xi}{\partial q} = -\xi'(\cdot)\left[1+(\phi_0-P_0)\left(\frac{\partial Q_0}{\partial I_0}\right)\right]<0$$

and

$$V(\theta_1)-V(\theta_2)=\partial EV/\partial \xi<0,$$

this latter term is positive. It portrays the marginal benefit of domestic production, additional to learning, due to the reduction in the likelihood of embargo.

Furthermore, endogenizing the probability of embargo in this above manner introduces a new decision variable: the current level of imports. This is chosen such that a marginal contraction of trade yields an expected gain via the reduction in the probability of embargo equal to the welfare loss from reducing trade. Optimal trade intervention then consists (as in Bhagwati–Srinivasan) of a tariff which assures the equilibrium trade volume and, noting the production incentives due to the tariff, of an attendant production subsidy which makes equilibrium output consistent with profit maximization.

Since in its endogenous specification ξ depends only on the level of current imports, and consequently is independent of learning ability, the future terms of trade and future income, the comparative statics responses noted for these variables in the previous section carry over. However, since the level of current imports depends upon current production costs, the current terms of trade and current income, endogenizing ξ does affect the comparative statics analysis for these variables. Responses to changes in the domestic production cost ϕ_0 and in the current terms of trade P_0 can be shown to become ambiguous independently of the relation between RRA and ε. However, there is no change in the response to an increase in current income. The reason is that an increase in current income, by increasing domestic consumption, increases imports, thereby increasing foreign dependence and, ceteris paribus, increasing ξ. This increase in the probability of embargo provides an inducement to expand output of the potentially embargoed good, which reinforces the output-expanding response when ξ is constant.

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