

**PITFALLS IN THE THEORY OF INTERNATIONAL TRADE POLICY:  
CONCERTINA REFORMS OF TARIFFS,  
AND SUBSIDIES TO HIGH-TECHNOLOGY INDUSTRIES\***

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**ABSTRACT**

This paper explores the links between international trade theory and the practice of trade and industrial policy in open economies, with special attention to three areas where theoretical lessons have been misunderstood in policy debates. I argue that the "concertina rule" for tariff reform justifies reductions in high tariffs but not moves towards uniformity and particularly not *increases* in low tariffs. I show that the basic principles of tariff reform are the same in unilateral, multilateral and customs union contexts. Finally, I suggest that the theory of strategic trade policy does not justify subsidies to high-technology industries.

Keywords: Trade Liberalisation; Tariff Reform; "Concertina Rule"; Customs Unions;  
Strategic Trade Policy; Industrial Policy

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# **PITFALLS IN THE THEORY OF INTERNATIONAL TRADE POLICY: CONCERTINA REFORMS OF TARIFFS, AND SUBSIDIES TO HIGH-TECHNOLOGY INDUSTRIES**

## **I. Introduction**

Among the many difficulties of economic policy-making is the need to understand the relevant economic theory. In this paper, I want to illustrate the delicate and subtle steps from theory to policy advice by means of some examples from recent work in international trade.

To set the scene, let me start with three policy questions:

1. What kinds of tariff change will raise welfare in a small open economy?
2. Should countries liberalize trade unilaterally or only multilaterally?
3. Should export-oriented high-technology firms be subsidized?

I think it is self-evident that these questions are important and interesting. They arise in many real-world contexts and non-economists care about the answers. By contrast, consider the following three theoretical questions:

1. Should models of tariff reform contain a numeraire good?
2. How many *distinct* theorems of tariff reform are there?
3. Do governments have greater commitment power than firms?

Clearly, these are not questions which would ever occur to a non-economist. I suspect that even many economists would find them dry and uninteresting. Their focus on the literature rather than on the real world suggests that only specialists, and pedantic ones at that, are likely to care about the answers.

Yet, as I hope to show, the answers to the three theoretical questions above are intimately bound up with the answers which our current knowledge allows us to offer to the three policy questions. Moreover, I believe that misunderstandings of the theoretical

subtleties involved have led to some misleading if not downright wrong policy recommendations. I say "misunderstandings" rather than "errors" because as a profession we are well trained in rooting out analytic mistakes and there are none such in the literature I review below. However, we may be less sensitised to appreciating the qualifications which need to be made in applying theoretical results. I illustrate this in the three sections which follow. Each deals with one of the three policy questions posed above, drawing attention to statements in the literature which are at best redundant and at worst highly questionable.

## **II. Tariff Reform in a Small Open Economy**

The first topic I consider is that of tariff reform in a perfectly competitive economy which cannot influence its external prices. The main results in this area are well-known since the work of Hatta (1977) and others. In the absence of externalities or "non-economic" motives for protection, such a small open economy should not impose tariffs. If it does so, then the first-best policy is to abolish them. If this is not feasible, then there are two types of "piecemeal" change which are guaranteed to raise welfare. One is a uniform radial reduction of tariffs; the other is a "concertina" reform, i.e., a reform which compresses the tariff structure. The concertina reform rule (subject to a well-known qualification about substitutability which I discuss below) is widely advocated in practice and is often used, by the World Bank and others, to justify tariff reforms which reduce the variance of the tariff structure, lowering exceptionally high and raising exceptionally low tariffs.

Exactly how well-founded in theory are these policy recommendations? To examine this I need to review the theory of tariff reform. Before doing so, I want to note three results which have been derived in the literature in models without a numeraire good. These results are correct as stated but I will argue later that they are not very helpful in policy contexts.

So, I label them “POMPs” for “Potentially Misleading Propositions”! They are:

POMP 1: [Diewert, Turunen-Red and Woodland (1989)] A tariff change of the form

$$d\tau = \delta\pi^* - \varepsilon\tau, \delta + \varepsilon > 0, \text{ must raise welfare.}$$

Here  $\tau$  and  $\pi^*$  are vectors of specific tariffs and world prices of *all* goods respectively, while  $\delta$  and  $\varepsilon$  are arbitrary scalars. Hence POMP 1 states that welfare will rise if tariffs are increased in proportion to world prices or decreased in proportion to their initial levels.

POMP 2: [Diewert et al. (1989)] There always exists some increase in tariffs which will raise welfare.

This is just a corollary of POMP 1, with  $\varepsilon$  set equal to zero, so the tariff change takes the form  $d\tau = \delta\pi^* > 0$ .

POMP 3: [Hatta (1977), Fukushima and Hatta (1989)] An increase in the lowest tariff rate will raise welfare, provided the good in question is a net substitute for all others.

This completes my list of POMPs. In order to substantiate my criticisms of them, I need first to present the basic theory of tariff reform.<sup>1</sup>

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<sup>1</sup> The exposition which follows is based on Neary (1995). For extensions to economies with quotas and non-traded goods as well as tariffs, see Falvey (1988), Anderson and Neary (1992) and Neary (1995).

## II.1 Tariff Reform in a Small Open Economy with a Numeraire Good

I consider a small open economy which consumes and produces  $n+1$  goods which it trades at fixed world prices. For the present, I choose one good, indexed by zero, as numeraire and I denote by  $p$  and  $p^*$  the  $n$ -by-one vectors of domestic and world prices of non-numeraire goods respectively. It turns out to be very convenient to summarise the behaviour of consumers and firms in terms of a single function. Following Neary and Schweinberger (1986) I call this the trade expenditure function, defined as the difference between consumer spending and GNP. These in turn are equal to standard expenditure and GNP functions respectively:

$$E(p,u) \equiv e(p,u) - g(p). \quad (1)$$

This function embodies a number of assumptions: consumer spending is the outcome of a single utility-maximising individual's decisions; and all goods and factor markets are perfectly competitive with no barriers to efficient intersectoral factor movements. These assumptions are standard but still heroic. They can be justified as allowing a clear focus on the contribution of trade policy to efficiency. The great convenience of the trade expenditure function is that its price derivatives (denoted by a subscript " $p$ ") equal the economy's compensated net import demand functions:

$$E_p(p,u) = e_p(p,u) - g_p(p) = m(p,u). \quad (2)$$

(This follows because, by Shephard's and Hotelling's Lemmas,  $e_p$  and  $g_p$  equal the economy's consumption and net output vectors, respectively.) Moreover, these import demand functions

are well-behaved: the substitution matrix  $S \equiv -E_{pp} = -m_p$  may be assumed to be positive definite.<sup>2</sup> Finally, the utility derivatives of the trade expenditure function equal those of the household expenditure function. Thus,  $E_u = e_u$ , the marginal cost of utility, which it is convenient to normalise to equal one initially; and  $E_{pu}/E_u = x_p$ , the vector of Marshallian income derivatives.

We are now ready to summarise the equilibrium of a tariff-distorted small open economy. First, domestic prices equal world prices plus tariffs (by definition there is no tariff on the numeraire good “0”, so  $p_0 = p_0^* = 1$ ):

$$p = p^* + t. \quad (3)$$

Second, tariff revenue is redistributed costlessly and so equals net spending by the private sector:

$$E(p, u) = t' m, \quad (4)$$

where a prime denotes the transpose of a vector. Totally differentiating equations (2) to (4) gives the basic expression for the welfare effects of tariff changes in a small open economy:<sup>3</sup>

$$(1 - t' x_p) du = - t' S dt. \quad (5)$$

The coefficient of welfare change on the left-hand side may reasonably be assumed to be positive: if it was not, then the government could raise welfare by imposing a lump-sum *tax*

<sup>2</sup> The full  $(n+1)$ -by- $(n+1)$  matrix of substitution effects (including those between the numeraire and other goods) is singular and so only positive semi-definite. Provided there is some substitutability between the numeraire good and at least one other good, the  $n$ -by- $n$  matrix  $S$  will be positive definite and it is convenient to assume this henceforward.

<sup>3</sup> To obtain this equation, totally differentiate (4), setting  $dp=dt$  from (3) and using (2) to eliminate  $dm$ .

on the private sector and destroying the proceeds.<sup>4</sup> Hence our concern is with the right-hand side of (5).

The uniform reduction result follows immediately. Since  $S$  is positive definite, a tariff change of the form  $dt = -\varepsilon t$ ,  $\varepsilon > 0$ , must raise welfare. However, the more difficult question is what can be said when tariff changes are not equi-proportionate. This is where the concertina rule comes in.

To derive the concertina reform result, disaggregate the tariff vector into  $t_1$  (a scalar) and  $t_2$ ; and assume that  $t_2$  is fixed. Partitioning the  $S$  matrix conformably into its submatrices allows (5) to be written as:

$$(1 - t'x_p) du = - (t_1 S_{11} + t_2' S_{21}) dt_1 \quad (6)$$

$$= - [t_1 + t_2' S_{21} S_{11}^{-1}] S_{11} dt_1. \quad (7)$$

Now, if we switch from specific tariffs  $t_i$  to *ad valorem* tariffs,  $r_i = t_i/p_i$ , and make use of the linear homogeneity of  $E$  in all prices  $(p_0, p)$ , this equation can be written as:<sup>5</sup>

$$(1 - t'x_p) du = - (r_1 - \sum_{i \neq 1} \omega_{i1} r_i) p_1 S_{11} dt_1. \quad (8)$$

Recalling that  $S_{11}$  is positive, this equation states that a cut in the tariff on good 1 ( $dt_1 < 0$ ) will raise welfare provided the tariff rate on good 1 exceeds a weighted average of the tariff rates

<sup>4</sup> The inverse of this coefficient,  $(1 - t'x_p)^{-1}$ , is known as the "shadow price of foreign exchange", since it measures the welfare effect of a unit transfer of the numeraire good to this country. If the economy were so distorted that this term were negative, it would be unnecessary to seek small tariff changes which would raise welfare. See Smith (1982, 1987) and Neary (1995) for details and references.

<sup>5</sup> Linear homogeneity of  $E$  in all prices implies that  $p_0 S_{01} + p_1 S_{11} + p_2' S_{21} = 0$ . Rearranging and recalling that  $S_{11}$  and  $p_1$  are scalars gives  $p_1 S_{11} = -\sum_{i \neq 1} p_i S_{i1} > 0$ , where the summation is over all goods *except* good 1 but *including* the numeraire. Dividing by  $p_1 S_{11}$  leads to the weights  $\omega_{i1} = -p_i S_{i1} / p_1 S_{11}$ ,  $i = 0, 2, 3, \dots, n$ , which must sum to unity:  $\sum_{i \neq 1} \omega_{i1} = 1$ .

on all other goods (including the zero "tariff" on the numeraire). This is where substitutability comes in. The expression in (8) is not a true weighted average unless all the weights  $\omega_{il}$  are positive. This in turn requires that good 1 be a general equilibrium net substitute for every other good:  $\omega_{il} > 0$  if and only if  $S_{il} < 0$ . Hence we finally reach our statement of the concertina rule:

Proposition 1: If good 1 has the highest tariff rate, a sufficient condition for a reduction in  $r_1$  to raise welfare is that good 1 is a net substitute for all other goods.

Note that the requirement that good 1 be a net substitute for all other goods is an over-strong sufficient condition. All that is required is that  $r_1 > \sum \omega_{il} r_i$ . For example, complementarities *per se* (some  $\omega_{il} < 0$ ) are not a problem. Lowering the highest tariff can only reduce welfare if the good in question is a sufficiently strong complement for some goods that it is also strongly *substitutable* for some other goods which are subject to high tariffs.

## II.2 Tariff Reform in a Small Open Economy *without* a Numeraire Good

Having reviewed the theory of tariff reform when one good is explicitly selected as numeraire, let me now follow the same route in the same model but using a notation which treats all  $n+1$  goods symmetrically. This cannot change the substantive results, of course. However, it can open the way to misunderstandings.

Since the model is unchanged, its specification is as before, except that I use Greek letters to denote  $(n+1)$ -by-one vectors which include the numeraire good. Thus, paralleling equations (2) to (4), excess demand equals net imports:

$$E_{\pi}(\pi, u) = \mu; \quad (9)$$

domestic prices equal world prices plus tariffs:

$$\pi = \pi^* + \tau, \quad \pi = \{p_0, p\}, \quad \pi^* = \{p_0^*, p^*\}, \quad \tau = \{t_0, t\}; \quad (10)$$

and net spending at world prices is zero:

$$\pi^{*/\mu} = 0, \quad \mu = \{m_0, m\}. \quad (11)$$

Totally differentiating yields a slightly different version of equation (5):

$$\pi^{*/X_I} du = \pi^{*/S_{\pi\pi}} d\tau, \quad (12)$$

where  $X_I$  is the  $(n+1)$ -by-one vector of income derivatives of demand for all goods and  $S_{\pi\pi}$  is the full  $(n+1)$ -by- $(n+1)$  matrix of price responses and is positive semi-definite. As before, we assume that the coefficient of  $du$ ,  $\pi^{*/X_I}$ , is positive,<sup>6</sup> so the efficacy of tariff reform hinges on the sign of the right-hand side term.

### II.3 Why “POMPs” are POM

We are now ready to see why the theorems I presented at the outset may be described as "potentially misleading". Consider first POMP 1, which states that a tariff change of the form  $d\tau = \delta\pi^* - \varepsilon\tau$  must raise welfare. Using this expression to eliminate  $d\tau$  from (12), it is easy to prove the result.<sup>7</sup> But what exactly does this prove? From (10), a tariff reform of the kind specified in the proposition,  $d\tau = \delta\pi^* - \varepsilon\tau$ , is the same as  $d\tau = \delta\pi - (\delta + \varepsilon)\tau$ ; in words it

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<sup>6</sup> This is sometimes called the “Hatta normality term” and is easily seen to equal the left-hand side coefficient in (5):  $\pi^{*/X_I} = (\pi - \tau)' X_I = I - t' x_I$ , using homogeneity and setting  $t_0 = 0$ .

<sup>7</sup> The proof makes use of the linear homogeneity of the trade expenditure function in the vector of *all* prices  $\pi$ . This implies that  $S_{\pi\pi}\pi = 0$ , which, since  $\pi = \pi^* + \tau$ , implies in turn that  $S_{\pi\pi}\tau = -S_{\pi\pi}\pi^*$ . It follows immediately from (12) that the change in welfare is proportional to  $(\delta + \varepsilon)\pi^{*/S_{\pi\pi}}\pi^*$ . Assuming that  $\delta + \varepsilon$  is positive, this is proportional to a quadratic form in the positive semi-definite matrix  $S_{\pi\pi}$  and so is always non-negative and is strictly positive provided  $S_{\pi\pi}$  is of rank  $n$  and  $\pi^*$  is not proportional to  $\pi$ .

is the same as raising all tariffs, by a factor  $\delta$ , in proportion to *domestic* prices and then lowering them, by a factor  $\delta+\varepsilon$ , in proportion to their initial values. The only difficulty with this is that, since raising all tariffs in proportion to domestic prices does not change relative prices, it cannot affect any real magnitudes. In particular, it has no effect on welfare! All it amounts to is a rescaling of domestic prices; or put differently, to a change in the numeraire. Hence, the tariff change  $d\tau=\delta\pi^*-\varepsilon\tau$  is equivalent to a proportional reduction of tariffs of  $(\delta+\varepsilon)\%$ , no more and no less: POMP 1 is just a restatement of the uniform radial reduction rule.

The same argument applies to POMP 2. It is technically true that welfare will increase if all tariffs are increased in proportion to world prices. But such a tariff change (of the same form as before with  $\delta>0$  and  $\varepsilon=0$ ) is really a uniform tariff *reduction* of  $\delta\%$ .

Finally, what about POMP 3? There is no need to prove the concertina rule a second time, since the proof already given makes explicit the role of all  $n+1$  goods. Equation (8) as it stands shows that welfare will definitely increase when the tariff rate on good 1 is *increased*, provided it is *lower* than that on all other goods and good 1 is a net substitute for all of them. But in the absence of a numeraire, what does it mean to "raise the lowest tariff"? Either the lowest tariff is negative or it is not. If it is negative, then it is in effect an import *subsidy* and "raising" it really means *reducing* a distortion, since the subsidy rate is moved closer to zero. Alternatively, if the lowest tariff rate is not negative, then we can, without changing any real magnitudes, rescale all domestic prices in the manner already described until one tariff rate becomes zero. Now, raising this tariff rate is equivalent from homogeneity to an equiproportionate reduction in the tariffs on all other goods. In this case, POMP 3 (like POMP's 1 and 2) is just another restatement of the uniform reduction rule.

In conclusion, I should stress that the papers where these propositions originate make

many important contributions other than the ones which I have criticised.<sup>8</sup> However, I believe that propositions of this sort have done potential harm in appearing to provide a case for tariff increases in distorted small open economies.<sup>9</sup> For example, the World Bank appears to have implemented this advice in some of its structural assistance packages in sub-Saharan Africa. There may of course be other justifications for raising some tariffs: the desire to avoid a loss of tariff revenue is one possibility.<sup>10</sup> However, to the extent that the models I have surveyed here are relevant they do *not* justify raising tariffs. In the real world, the conditions for the concertina theorem to apply are unlikely to hold in the case where low (but positive) tariffs are raised, since there are typically many goods (such as exports) with zero or even negative trade distortions.

### III. Unilateral versus Multilateral Reform of Trade Policy

The second topic I review is that of multilateral tariff changes. Here I do not want to suggest that there are misleading results in the literature but rather that the fundamental similarity between apparently different results has not been appreciated. These results I therefore label “ART’s” for “Arguably Redundant Theorems”. Consider the following:

ART 1: Proportional reductions in tariffs raise welfare in a small open economy.

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<sup>8</sup> Their authors also join a distinguished group whose conclusions have been criticised for failing to recognise the implications of excluding a numeraire good. See, for example, the criticisms of Hotelling (1938) by Frisch (1939); of Dixit (1970) by Sandmo (1974); and of Deaton (1979) by Stern (1986).

<sup>9</sup> Michaely, Papageorgiou and Choksi (1991) review the experience of trade liberalisation in developing countries.

<sup>10</sup> Though, if this is the case, they should be modelled explicitly. Attempts to do this to date do not provide clear support for increases in low tariffs. See, for example, Falvey (1994) and Anderson (1997).

ART 2: Given substitutability, concertina reforms of tariffs raise welfare in a small open economy.

ART 3: Proportional reductions in tariffs by all countries are Pareto-improving.

ART 4: Given substitutability, concertina reforms of tariffs by all countries are Pareto-improving.

ART 5: [Ohyama (1972), Kemp and Wan (1976)] If a group of countries keeps its net external trade fixed, then a Pareto-improving tariff reduction exists.

ART's 1 and 2 repeat the two small-open-economy results considered in Section II. I have already noted (as is well known) that they are both special cases of the general expression for welfare-improving tariff changes, (5). ART's 3 and 4, by contrast, relate to a very different substantive question, pioneered by Vanek (1964): when will coordinated tariff changes by all countries in the world lead to a welfare improvement for all of them? Finally, ART 5 deals with yet another problem, that of characterising the tariff changes which will ensure a welfare improvement for a customs union. The Ohyama-Kemp-Wan theorem is one of the few clearcut results in the whole of customs union theory.

As in the last section, I first begin by sketching an analytic framework. Fortunately, much of the necessary work has already been done. Consider a world with many countries, indexed by  $j = 1, \dots, m$ , each of which can be characterised in just the same way as the small open economy of Section II.1. Thus in each country (indexed by a superscript  $j$ ) net imports equal the derivatives of the trade expenditure function:

$$E_p^j(p^j, u^j) = m^j, \quad j = 1, \dots, m; \quad (13)$$

domestic prices equal world prices plus tariffs:

$$p^j = p^* + t^j, \quad j = 1, \dots, m; \quad (14)$$

and net domestic spending equals tariff revenue:

$$E^j(p^j, u^j) = t^j m^j, \quad j = 1, \dots, m. \quad (15)$$

This gives  $3m$  equations for the  $3m$  country-specific endogenous variables,  $\{u^j\}$ ,  $\{p^j\}$  and  $\{m^j\}$ .

The specification of world equilibrium is completed by adding the requirement that world markets must clear:

$$\sum_k m^k = 0. \quad (16)$$

This last equation determines the remaining unknown,  $p^*$ .

Solving the model in full is complicated. Fortunately, we do not need to do this, since all we seek are conditions for Pareto-improving tariff changes. First, differentiate (13) to (15) as in the small open economy case, and then sum over all countries:<sup>11</sup>

$$\sum_j (1 - t^j x_l^j) du^j = - \sum_j t^j S^j dp^j, \quad (17)$$

where the notation of Section II is extended to the multi-country case in an obvious way. (For example, country  $j$ 's substitution matrix is:  $S^j \equiv -E_{pp}^j$ .) To simplify further, we need an expression for the change in world prices, which comes from differentiating (16):

$$dp^* = S^{-1} \sum_k (x_l^k du^k - S^k dt^k), \quad (18)$$

where  $S \equiv \sum S^k$  is the world substitution matrix. Finally, substitute in (17) and collect terms:

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<sup>11</sup> The term  $-\sum m^j dp^*$  vanishes because of (16).

$$\sum_j (1 - T^{j/x_j^j}) du^j = - \sum_j T^{j/S^j} dt^j, \quad (19)$$

where:

$$T^{j/l} = t^{j/l} - \sum_k t^{k/l} S^k S^{-1}. \quad (20)$$

Equation (19) is the key equation in this section. I have deliberately written it in a notation which brings out its similarities with equation (5) in the small open economy case, but it clearly differs from it in two respects. First, the left-hand side is not the change in utility in one country but a weighted sum of utility changes in all countries. This is because we seek only tariff changes which are *potentially* Pareto-improving; or, put differently, which ensure efficiency gains for the world as a whole. Translating these gains into *actual* Pareto improvements requires that international lump-sum transfers be available.<sup>12</sup> The assumption that lump-sum transfers are available also allows us to sign the coefficients of  $du^j$ . They must all be positive since otherwise a Pareto improvement could be achieved by transferring the numeraire good from countries with negative towards those with positive coefficients.

The second difference between equation (19) and the small open economy equation (5) is that in the latter the substitution and income effects are multiplied by actual tariffs  $t$  whereas in the former they are multiplied by  $T^j$ , the deviations of each country's tariffs from their worldwide weighted average,  $\sum t^{k/l} S^k S^{-1}$ . (The weights are positive definite matrices and sum to the identity matrix:  $\sum S^k S^{-1} = I$ .) Thus in the multi-country context it is relative rather than absolute tariff levels which are crucial for welfare reform. I will refer to the  $T^j$  terms as "shadow premia" since it is easy to show that they equal the differences between domestic

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<sup>12</sup> Making such transfers explicit requires adding a term  $b^j$ , with  $\sum b^k = 0$ , to the right-hand side of (13). Conditions for actual Pareto improvements in the absence of lump-sum transfers are much more stringent. See Turunen-Red and Woodland (1993).

prices in each country and world shadow prices.<sup>13</sup>

We can now state a single general result which follows immediately by inspection of (19) and which encompasses all five ART's:<sup>14</sup>

Proposition 2: A necessary and sufficient condition for a potential Pareto-improving tariff change is that the right-hand side of (19) is positive.

Proposition 2 is a powerful result. It shows that, as far as efficiency is concerned, international tariff harmonisation is always desirable. Moreover, the number of countries which choose to harmonise their tariffs does not matter. It can be only a single country harmonising its tariffs with the world average (as envisaged in ART's 1 and 2) or all countries in the world (as envisaged in ART's 3 and 4) or any intermediate group of countries. Note that, if all countries have identical tariff structures, then no further Pareto gains are possible. This is because if the same relative prices prevail in all countries, the remaining common tariffs are equivalent to lump-sum taxes and have no welfare cost.

It is straightforward to show that all five ART's are corollaries of Proposition 2. ART's 1 and 2 follow trivially. In this context, a small open economy is one whose substitution effects are negligible relative to the world matrix  $S$ :  $S^k S^{-l}$  is zero. Ignoring tariffs

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<sup>13</sup> From (20),  $T^{j'} = p^{j'} - (p^{*j} + \sum t^{k'} S^k S^{-l})$ . The term in parentheses (which is independent of country  $j$ ) measures the increase in potential world welfare (measured by the left-hand side of (19)) as a result of lump-sum increases in world endowments of goods. Note that these shadow prices are *not* equal to world prices, unlike in the well-known Little-Mirrlees (1968) result which applies to the small open economy of Section II.

<sup>14</sup> Essentially the same result is obtained by Turunen-Red and Woodland (1991) using Motzkin's theorem of the alternative. However, they do not interpret the shadow premia as deviations from a weighted average and they do not note the general applicability of the result as I do here.

in other countries, the usual uniform reduction and concertina reform results follow as in Section II. ART's 3 and 4 also follow straightforwardly. The only qualification is that, to ensure a Pareto improvement with many countries, the theorems must be stated in terms of the shadow premia (20). Thus, the uniform reduction result requires that all tariffs in a given country are reduced in proportion to their shadow premia; and the concertina reform result requires that (given substitutability) the tariff on the good with the highest shadow premium rate (not the highest tariff rate) should be reduced.

Finally, what about ART 5, the Ohyama-Kemp-Wan result? Formally, this is just another corollary of Proposition 2: Pareto-improving reforms of tariffs by all members of a customs union exist, provided their external trade is kept fixed. The interpretation is different because the countries considered comprise only a subset of the world. In deriving ART's 1 to 4, we could invoke the differential of (16),  $\Sigma dm^k=0$ , because there were no other countries in the world; now it holds (even though  $\Sigma m^k=0$  does not) because the union's common external tariff is adjusted as necessary to ensure that its external trade does not change. Note finally, that this version of the Ohyama-Kemp-Wan result is constructive in that it characterises a sequence of internal tariff changes which ensure successive Pareto improvements rather than merely showing that the abolition of all internal tariffs (given a fixed volume of external trade) is Pareto-improving. Proposition 2 thus extends the existing theory of tariff reform in significant ways as well as encompassing all the earlier theorems.

#### **IV. Subsidies to High-Technology Firms**

The third substantive issue I wish to review is whether governments should support export-oriented high-technology firms. Since such firms typically compete in oligopolistic industries, traditional trade theory, with its focus on perfectly competitive general equilibrium

models, has relatively little to say on this topic. However, in the past fifteen years an explosion has taken place in the field of strategic trade policy, applying the insights of modern industrial organisation theory to open economies. The result in my view has been a rich crop of novel theoretical insights but as yet no robust recommendations for policy. The latter point has been made by a number of writers (such as Krugman (1987)) yet the impression persists that new and important guidelines for policy have been developed. Among the strong and non-so-strong claims which have been made, let me single out three, which I label "QUART's" for "Questionable Assertions Resembling a Theorem":

QUART 1: [*The Economist* (1996)] Export subsidies should be targeted towards firms in high-technology sectors.

QUART 2: [Brander (1995)] Subsidies to pre-competition variables (such as investment or R&D) are a more robust recommendation than subsidies to market-period variables (output or price) because the former are more likely to be strategic substitutes.

QUART 3: [*The Economist* (1996)] The strategic case for subsidies is strengthened by R&D spillovers.

Once again, to put my claims in context I need to devote a little time to an exposition of the theory. I will concentrate on a canonical model, due to Brander and Spencer (1985) which considers the case for subsidising a single domestic firm which exports all its output (so domestic consumption can be ignored) in competition with a single foreign rival.

#### **IV.1 The Optimal Export Subsidy in a One-Period Duopoly**

QUART 1 resembles the basic result of Brander and Spencer (1985). They showed that if the home and foreign firm engage in a one-shot Cournot game, then an export subsidy

is optimal. This result has subsequently been shown to be sensitive to a relaxation of many of the model's assumptions (a fact of which *The Economist* is clearly aware). For example, if firms play a Bertrand price-setting game rather than a Cournot quantity-setting game, then the result is reversed. To see this, consider a general setting where the firms choose an unspecified "action", which could be either output or price,  $a$  for the home firm and  $b$  for the foreign firm. (This specification follows Brander (1995).) The home firm's profits equal its net revenue from production and sales,  $R(a,b)$ , plus the revenue it receives from a subsidy to its action at a rate  $s$ :

$$\pi(a,b,s) = R(a,b) + sa. \quad (21)$$

This specification encompasses both the Cournot case, where  $a$  and  $b$  are home and foreign output respectively and output is subsidised; and the Bertrand case, where  $a$  and  $b$  are home and foreign prices respectively and price is subsidised. (In Bertrand competition, a subsidy to price has the same allocative effect as, and so is equivalent to, a *tax* on the (differentiated) domestic good.) Finally, the home government is assumed to maximise domestic welfare which equals profits less subsidy income:

$$W(a,b) = \pi(a,b,s) - sa = R(a,b). \quad (22)$$

The basic result is now easily obtained. The home firm's first-order condition is:

$$\pi_a = R_a + s = 0. \quad (23)$$

A symmetric problem faced by the foreign firm leads to a similar condition, though with no subsidy term, since I assume for simplicity that the foreign government is passive:  $R_b^*(b,a)=0$ . The latter condition implicitly defines the foreign firm's reaction function, which relates its action to that of the home firm:

$$b = B(a). \quad (24)$$

This reaction function is downward-sloping (so its derivative  $B_a$  is negative) if and only if the foreign firm's action is a *strategic substitute* for the home firm's.<sup>15</sup> This is usually considered the normal case in Cournot competition, for example.

Now, totally differentiate the welfare function (22):

$$dW = R_a da + R_b db. \quad (25)$$

Setting this equal to zero and substituting from (23) and the total differential of (24) gives the solution for the optimal subsidy:

$$s = R_b B_a. \quad (26)$$

The Brander-Spencer result follows immediately. In Cournot competition when goods are substitutes in demand,  $R_b$  is negative; and  $B_a$  is negative in the normal case where outputs are strategic substitutes. Hence the left-hand side is positive and the optimal policy is an export subsidy. The counter-result of Eaton and Grossman (1986) also drops out. In Bertrand competition,  $a$  and  $b$  are prices;  $R_b$  is positive assuming the goods are substitutes in demand; and  $B_a$  is positive (the foreign reaction function is upward-sloping) in the normal case where prices are strategic complements. Once again the left-hand side is positive, but now this means that *price* should be subsidised, which is equivalent to an export *tax*.

While the sign of the optimal subsidy differs between the Cournot and Bertrand cases, the rationale for government intervention is the same in both. The government is assumed

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<sup>15</sup> To see this in more detail, totally differentiating the foreign firm's first-order condition gives:  $B_a = -R_{ba}^*/R_{bb}^*$ . The denominator  $R_{bb}^*$  must be negative from the foreign firm's second-order condition; while the numerator  $R_{ba}^*$  is negative if and only if the foreign firm's action is a strategic substitute for the home firm's, meaning that its marginal profitability is reduced by an increase in  $a$ .

to have the power to commit credibly to a subsidy or tax which affects the environment in which the two firms take their decisions. Optimal policy requires that the government exercise this power to do what the home firm cannot credibly do alone: move the equilibrium to the one which would prevail if the home firm had a first-mover Stackelberg advantage. This allows us to answer the third theoretical question posed in Section I: strategic trade policy is justified provided the home government has superior commitment power to the home firm.

What about the corresponding policy question from Section I: does equation (26) justify export subsidies to high-technology firms? Even if we stay with the Cournot case, I claim that it does not, for there is *nothing* in the specification of the model which identifies the industry as a high-technology one. The existence of a duopolistic market structure requires only that barriers to entry are high. While this may be true of the rivalry between Airbus and Boeing in aerospace it is just as true of that between *The Economist* and *Time* and *Newsweek* in newsmagazines; between Unilever and Proctor and Gamble in detergents; or between Bowater and Kimberly-Clark in paper tissues. Indeed, in the Brander-Spencer framework the only consideration determining which firms within a group of oligopolistic industries should be subsidised is which ones have the greatest potential for increasing their profits at the expense of their foreign competitors. (See Neary (1994).) So, to sum up, QUART 1 is not a reasonable restatement of the Brander-Spencer result.

#### **IV.2 Optimal Subsidies to R&D**

How might the model be extended to focus more specifically on high-technology industries? An obvious feature of such industries is that production must be preceded by extensive investment in research and development. This suggests that a two-period framework, in which firms first make such investments and then compete in the product

market, should be more relevant to the high-technology case. Following Spencer and Brander (1983) and Neary and Leahy (1996), the model just presented can be extended in this direction.

Suppose that in period 1 the home firm must incur fixed costs  $F(k)$  which are increasing in the level of its spending on R&D,  $k$ . The payoff to such spending is that it lowers production costs in period 2. This is captured by including  $k$  as an argument in the period-2 revenue function, with  $R_k > 0$ .<sup>16</sup> Finally, R&D spending benefits from a subsidy  $\sigma$ . Under these assumptions the firm's profit function becomes, instead of (21):

$$\pi(k, a, b, \sigma, s) = -F(k) + R(k, a, b) + \sigma k + sa. \quad (27)$$

Now, assume that the home government and the two firms engage in a subgame-perfect three-stage game. In the first stage the government sets the two subsidy rates; in the second stage the firms choose their R&D levels; and in the third stage they choose their actions as before.<sup>17</sup> To solve the model, we work backwards through the stages. In the final stage the firms play a static game just as in Section IV.1 above. The home firm's first-order condition is once again (23). In the second stage the firms choose their optimal levels of R&D, taking account of their effects on the third-stage game. Thus the home firm's choice of R&D spending takes account both of its direct or "non-strategic" effect on future profitability as captured by  $\pi_k$ ; and also of its strategic effect in influencing the environment in which the period-2 game is played. The first-order condition for R&D is therefore:

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<sup>16</sup> For example,  $R(k, a, b)$  might equal  $p \cdot q - c(k) \cdot q$ , where  $p \cdot q$  is sales revenue and  $c(k)$  is marginal cost, independent of output  $q$  and decreasing in  $k$ .

<sup>17</sup> I assume that the government commits to its output subsidy before the firms choose their R&D levels. Reversing this sequencing leads to a four-stage game in which firms have an additional strategic incentive to choose their R&D levels with a view to influencing the output subsidy. The implications of this are considered in Leahy and Neary (1998) and Neary and Leahy (1996).

$$\frac{d\pi}{dk} = \pi_k + \pi_b \frac{db}{dk} \Big|_{k^*} = 0, \quad (28)$$

where:  $\pi_k = -F' + R_k + \sigma$  and  $\pi_b = R_b$ .

The term  $db/dk$  is the effect on the foreign firm's action in the second period which the home firm anticipates will result from an increase in its R&D. It is calculated by solving the two period-2 first-order conditions, which is why it is specified as conditional on the foreign firm's choice of R&D,  $k^*$ .

What is the government's optimal policy in this case? As before, with no domestic consumption, welfare equals profits less subsidy payments:

$$W(k,a,b) = \pi(k,a,b,\sigma,s) - \sigma k - sa = R(k,a,b) - F(k). \quad (29)$$

Totally differentiating this and substituting from the home firm's first-order conditions gives:

$$dW = \left[ -\sigma - \pi_b \frac{db}{dk} \right] dk - sda + R_b db. \quad (30)$$

The government's problem is straightforward. With two instruments at its disposal ( $\sigma$  and  $s$ ), it effectively controls the home firm's choice of  $k$  and  $a$  directly. As for the foreign firm's choice of  $b$ , it controls this indirectly by moving the foreign firm along its reaction function, just as in the one-period model of Section IV.1. The only additional complication is that the relevant reaction function is now more complex, since it is the solution to *both* the foreign firm's first-order conditions, which are (corresponding to (23) and (28)):

$$\frac{\partial \pi^*}{\partial b} = R_b^* = 0 \quad \text{and} \quad \frac{d\pi^*}{dk^*} = R_{k^*}^* + R_a^* \frac{da}{dk^*} \Big|_k = 0. \quad (31)$$

The government solves these conditions to obtain the foreign firm's action as a function of

the home firm's two actions:

$$b = B(a,k). \quad (32)$$

Substituting the derivatives of this into (30) and equating to zero yields the optimal subsidies:

$$\sigma = -\pi_b \left. \frac{db}{dk} \right|_{k^*} + R_b B_k \quad \text{and} \quad s = R_b B_a. \quad (33)$$

This can be simplified by setting the term  $B_k$  to zero: since the two firms do not compete directly in the first period, the effect of  $k$  on  $b$  is of second-order importance and may safely be ignored.<sup>18</sup> The optimal policies in (33) then exhibit a clear division of labour. The period-2 export subsidy  $s$  serves to commit the home firm to the Stackelberg choice of period-2 action, while the R&D subsidy  $\sigma$  exactly offsets the strategic effect. Moreover, the signs of these two instruments display exactly the same ambiguity as in the static game. The formula for the period-2 export subsidy is identical to that in the static case and so it too is positive or negative depend on whether period-2 actions are strategic substitutes or complements. As for the R&D subsidy, it has the opposite sign to that of  $s$ . When period-2 actions are strategic substitutes, the strategic effect is positive. In the terminology of Fudenberg and Tirole (1984), the home firm adopts a "top dog" strategy, "over-investing" (relative to the social-cost-minimising optimum where  $R_k=F'$ ) to give itself an advantage in the period-2 game. The optimal policy is an R&D tax to "restrain" the firm. By contrast, when period-2 actions are strategic complements, the firm adopts a "puppy dog" strategy of "underinvestment". For example, in Bertrand competition, the firm has an incentive to reduce

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<sup>18</sup> Foreign profits  $R^*$  are a function of  $(k^*, a, b)$  only and so the derivatives of  $R^*$  in (31) do not depend directly on  $k$ . Hence  $k$  can affect  $b$  directly (i.e., for given  $a$ ) only to the extent that changes in  $k$  affect the slope of the home firm's period-2 reaction function and hence affect the term  $da/dk^*$  in (31). This effect vanishes, for example, in the case of Cournot competition where marginal costs are independent of output: see Spencer and Brander (1983) and Leahy and Neary (1996).

investment in order to raise its rival's price. In this case the optimal policy is an R&D subsidy: the puppy dog should be "encouraged".

The result for strategic substitutes was obtained by Spencer and Brander (1983); that for strategic complements does not appear to have been noted prior to Neary and Leahy (1996). Taken together, these results suggest that this branch of the theory of economic policy exhibits an aesthetically pleasing unity, but they provide little comfort to policy activism. Contrary to the conjecture of Brander (1996) which I have labelled QUART 2, the ambiguity which plagues the static theory of strategic trade policy is magnified rather than reduced when dynamic behaviour is incorporated.

### **IV.3 R&D Spillovers and the Case for Industrial Policy**

The final issue I want to address is the implications for strategic trade policy of allowing R&D to have non-appropriable spillover effects, so that it reduces the costs of firms other than those of the firm which engages in it. QUART 3 suggests that such spillovers strengthen the strategic trade policy case for supporting innovating firms. However, Leahy and Neary (1997b) show that this inference is not valid. Of course, the presence of positive externalities in itself justifies a subsidy (assuming that the private sector cannot internalise them in Coasian fashion). But this is an old argument, due to Pigou rather than to the theory of strategic trade policy. The relevant question is what *additional* basis for intervention, if any, is provided by strategic considerations.

The answer turns out to be surprising. When spillovers accrue to firms in the same industry, a Cournot oligopolist has a strategic incentive to reduce its R&D to reduce the technology transfer to its rivals.<sup>19</sup> This indeed provides a strategic motive for a government

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<sup>19</sup> This incentive has been extensively studied in the closed economy context. See d'Aspremont and Jacquemin (1988) and Leahy and Neary (1997a).

subsidy. But note that the subsidy should be provided even if the firms which benefit from the spillovers are foreign! The point of the subsidy is not to encourage diffusion of new technology but to avoid inefficient underinvestment for strategic reasons. Of course, if the other firms are domestic, it is well known that the strategic case for export subsidies is also weakened.

What if the firms that benefit from the spillovers are domestic but not in the same industry? Now there is a pure Pigovian basis for subsidising R&D. But, if competition is Cournot then, from the previous section, there is also a strategic motive for taxing R&D, to counteract the "top dog" overinvestment behaviour already noted. Thus, the exact type of intervention which is justified is ambiguous and at least in the Cournot case the strategic argument works against rather than in favour of R&D subsidies.

## **V. Summary and Conclusion**

In this paper I have reviewed and extended some recent contributions to three areas in the theory of international trade policy. In each case, I have used a simple canonical model to derive the main results in a compact fashion and I have related this model to the principal results in the literature.

In the case of tariff reform in a small open economy, I have drawn attention to some results in the literature which are potentially misleading. In particular, I take issue with suggestions that tariff *increases* in a small open economy may be desirable. I argue that such recommendations are artifacts of models which do not include a numeraire good. When a numeraire good is included (which is equivalent to saying, when the implications of linear homogeneity in prices are recognised) the case for tariff increases ceases to hold.

Turning to the conditions for Pareto-improving tariff changes I have suggested that a

number of results in the literature can be seen as equivalent. A consequence of this perspective is that the same basic principles of tariff reform apply in unilateral, multilateral and customs union contexts. Moreover, I have shown that the Ohyama-Kemp-Wan theorem can be extended beyond an existence result and have shown how the internal tariffs of a customs union can be adjusted to ensure Pareto gains for the members, provided the union's external trade is kept fixed.

Finally, I have reviewed the theory of strategic trade policy and shown that it does not provide a secure case for subsidies to high-technology firms. Indeed, the basic one-period result due to Brander and Spencer merely justifies subsidies to firms in industries with high barriers to entry. These are just as likely to be technologically unsophisticated incumbents in established markets as high-technology firms in growing sectors. The theory can be extended to allow for investments in R&D prior to the competitive stage, thus more closely approximating the conditions in high-technology industries. But here too the ambiguity which characterises the static theory persists: policies appropriate to firms which compete on quantity are the opposite to those which should be applied to price competitors. Of course, R&D spillovers provide a clearcut justification for subsidising, though in this case too the optimal subsidy may be reduced or even reversed when firms behave strategically. In the light of recent research, the case for subsidising firms in high-technology sectors is not particularly strong.

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