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Source: *The American Economic Review*, Vol. 82, No. 3 (Jun., 1992), pp. 615-625
Published by: American Economic Association
Stable URL: https://www.jstor.org/stable/2117325
Accessed: 27-08-2018 14:15 UTC

# On the Theory of Piecemeal Tariff Reform: The Case of Pure Imported Intermediate Inputs

*By* RAMÓN LÓPEZ AND ARVIND PANAGARIYA*

What is the effect of a tariff reduction that applies only to a subset of commodities subject to tariffs? This important question was addressed systematically for the first time by James Meade (1955 Ch. 13) in his classic work *Trade and Welfare*. After a careful analysis, Meade concluded, "[T]here is more likely to be a gain in economic welfare if the rate of duty is high on the primary imports which will come in in increased volume and is low on the secondary imports which will come in in reduced volume" (p. 208).[1]

This result was proved formally by Trent J. Bertrand and Jaroslav Vanek (1971), who demonstrated that, in a small open economy, if the highest tariff rate is reduced to the next highest one, welfare will rise provided the import demand for the good with the highest tariff exhibits gross substitutability with respect to all other goods.[2] Subsequently, following a different strand of the literature as exemplified in John Green (1961), Tatsuo Hatta (1973, 1977) and Peter Lloyd (1974) independently proved similar results in terms of Hicksian substitutability.[3]

In deriving their results, Bertrand and Vanek allowed for the use of final goods as intermediate inputs (i.e., interindustry flows).[4] However, neither they nor the subsequent writers (including Hatta and Lloyd) allowed for the existence of "pure" imported intermediate inputs that are not produced domestically. Therefore, a natural question is whether the piecemeal policy prescription derived by them remains valid in the presence of pure imported intermediates.

This question is particularly important for developing countries for two reasons. First, by far the bulk of the imports of developing countries are intermediate and capital goods. According to the World Bank, during the period 1975–1985 50 percent of developing countries' imports were accounted for by intermediate inputs, and an additional 30 percent were capital goods. A sizable proportion of both capital and intermediate goods are neither produced nor directly consumed in these countries.

Second, the Meade-Bertrand-Vanek-Hatta-Lloyd result has been the cornerstone of trade policy reform in many developing countries, especially during the last decade. In most countries, trade reform has been based on the so-called "concertina" approach, under which the highest tariffs are reduced to the next highest ones and then to the next highest ones, and so on. Thus,

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[1]In this quotation, "primary imports" refers to the goods on which tariffs are reduced, while "secondary imports" refers to other importables subject to tariffs.

[2]Robert Lipsey and Kelvin Lancaster (1956) had proved the basic result of Bertrand and Vanek in a one-factor, three-good model with a Cobb-Douglas utility function.

[3]More recently, Takashi Fukushima (1979) has proved the validity of the Hatta-Lloyd result when the highest tariff is shared by several commodities, while Rodney Falvey (1988) has done the same in the presence of quantitative restrictions on imports.

[4]Although Hatta (1973, 1977) did not allow explicitly for interindustry flows, his results can also be shown to be valid in the presence of such flows.

trade reforms in Chile during the 1970's and those in Guatemala, Costa Rica, Tanzania, Indonesia, and Venezuela in recent years provide the purest examples of the concertina method (e.g., Michael Michaely et al., 1991; Vinod Thomas et al., 1991). According to the detailed study of trade liberalization in developing countries by Michaely et al., many other countries have carried out reforms that combine the concertina method with elements of across-the-board proportionality rules.

In this paper, we revisit the basic Meade result (henceforth, the "concertina theorem") in a model with a pure imported input that is not produced domestically. We demonstrate that when such an input is present, it may be impossible to satisfy the substitutability condition of the concertina theorem. At most, one can assume that final goods exhibit substitutability with respect to each other. As long as the Rybczynski relationship holds with respect to the imported input—and it necessarily does for most of the standard models of international trade —a rise in the price of the input (which is equivalent to a decline in the total supply of the input) will be accompanied by an expansion of at least one final good. That is to say, the required substitutability condition between the imported input and all final goods is impossible to satisfy.

We demonstrate that any one of the following cases is sufficient to give rise to complementarity between the pure imported input and at least one final good: (i) the imported input is used in fixed proportions; (ii) the number of inelastically supplied primary factors equals the number of produced final goods, as in the Heckscher-Ohlin model; or (iii) there is one commonly shared factor and one specific factor in each sector, as in the Ricardo-Viner model, and not all goods use the imported input. Observe that in case (i), substitution is allowed among primary factors of production, while in cases (ii) and (iii) substitution is allowed among all factors including the imported input.

Assuming case (i) and that *final* goods exhibit substitutability with respect to each other, we also derive two specific results. First, if the highest tariff rate applies to the imported input, a decrease in it will be unambiguously welfare-reducing, provided the final importables enjoy positive effective protection and the least protected good also uses the imported input least intensively. Even if this latter condition is not satisfied, a reduction in the tariff is not necessarily welfare-improving. Second, if the highest tariff applies to a final importable, a reduction in it will not be necessarily welfare-improving. An unambiguous improvement in welfare requires the additional condition that the good with the highest nominal tariff also be subject to the highest effective rate of protection.[5]

At this point, it is useful to relate the present paper to the literature on pure imported inputs. This literature includes inter alia V. K. Ramaswami and T. N. Srinivasan (1968), López and Dani Rodrik (1990), and Panagariya (1992). Our paper is related to Panagariya (1992), in which some tariff reform issues are analyzed in the presence of a revenue constraint. Panagariya (1992) does not question the validity of the concertina theorem; indeed, that paper assumes that the theorem is valid, and its primary concern is whether a country continues to gain from a reduction in the highest tariff when it has to offset the resulting revenue loss by an increase in the lowest tariff applicable to imported inputs.[6] By contrast, our concern in the present paper is with a more fundamental point, namely, that the concertina

[5]The results described in this paragraph will also obtain, albeit under slightly different conditions, in cases (ii) and (iii). Thus, the assumption of fixed proportions with respect to the imported input simplifies the exposition but is not necessary to obtain the results.

[6]It is of utmost importance to note that the effects of a reduction in the highest tariff and those of an increase in the lowest tariff are not symmetric. More explicitly, given substitutability, a reduction in the highest tariff is welfare-improving, but an increase in the lowest tariff need not be. Therefore, the increase in the lowest tariff rate to maintain a constant revenue can counter the welfare gain from the reduction in the highest tariff. Panagariya (1992) derives conditions under which an increase in the lowest tariff rate does not lead to a welfare loss in the case when the lowest tariff applies to inputs. The results of Panagariya (1992) are entirely consistent with the concertina theorem.

theorem itself may be invalid in the presence of imported inputs.

The paper is organized as follows. In Section I we outline the model, while in Section II we demonstrate that the existence of pure imported inputs must give rise to complementarity in a variety of models. In Section III we impose the assumption of fixed-coefficients technology with respect to the imported input and analyze the case when the highest tariff applies to the imported input. In Section IV we consider the case when the good subject to the highest tariff is a final importable. Finally, conclusions are presented in Section V.

## I. The Model

Consider a small open economy consuming and producing three final goods: 1, 2, and 3. Goods 1 and 2 are importables, while good 3 is exportable. All three goods are produced with primary factors and an imported input not produced at home. We assume perfect competition in all markets. In order to rule out the possibility of complete specialization, we assume that there are three or more primary factors available in fixed supply and that world prices are such that an internal production equilibrium exists. We denote the vector of primary inputs by $\mathbf{z}$. As the country is small, we can set the world prices of all goods including the input equal to unity. The ad valorem tariff on the $i$th importable is denoted $t_i$ $(i=1,2)$, and the tariff on the imported input is $\tau$. The domestic prices of final importables, the exportable, and the imported input will be $1+t_1$, $1+t_2$, 1, and $1+\tau$, respectively.

Assuming that tariff revenue is redistributed among consumers in a lump-sum fashion, the economy's budget constraint may be written

$$(1)\quad E(1+t_1,1+t_2,1;\mu) = \pi(1+t_1,1+t_2,1,1+\tau;\mathbf{z}) - \tau\pi_\tau + t_1(E_1-\pi_1)+t_2(E_2-\pi_2)$$

where $E(\cdot)$ is the standard expenditure function, $\pi(\cdot)$ is the revenue function, and $\mathbf{z}$ is the factor-endowments vector. We assume that $E(\cdot)$ and $\pi(\cdot)$ have all the standard properties (Avinash Dixit and Victor Norman, 1980 Ch. 2). $E_i$ and $\pi_i$ $(i=1,2,3)$ represent the first partials of the expenditure and revenue functions, respectively, with respect to the $i$th argument. As usual, $E_i$ is the quantity demanded, and $\pi_i$ is the quantity supplied of good $i$; $\pi_\tau$ is the first partial of the revenue function with respect to $1+\tau$ and equals the negative of the total quantity of the imported input used in the production of final goods. Finally, $\mu$ stands for the level of utility.

We will first demonstrate the importance of the substitutability assumption for the concertina theorem.[7] To highlight the importance of the imported input, we assume that $\tau$ is the highest tariff rate. Differentiating (1) with respect to $\tau$ and solving for the change in $\mu$, we obtain

$$(2)\quad N(d\mu/d\tau) = -(t_1\pi_{1\tau}+t_2\pi_{2\tau}+\tau\pi_{\tau\tau})$$

where $N \equiv E_\mu - t_1E_{1\mu} - t_2E_{2\mu}$, $E_\mu$ is the first partial of $E(\cdot)$ with respect to $\mu$, and $E_{i\mu}$ $(i=1,2)$ is the partial effect of a change in utility on the demand for good $i$. Following Hatta (1973, 1977), we rule out inferiority in consumption, which guarantees $N>0$. By the convexity of the revenue function, $\pi_{\tau\tau}$ is positive. Moreover, if we assume that the imported input exhibits complementarity with *all* the other importables subject to tariffs, we have $\pi_{1\tau},\pi_{2\tau}>0$. In this case, a reduction in $\tau$ will be unambiguously welfare-improving. Intuitively, the tariff reduction expands imports of all goods subject to tariffs, a change which brings the economy closer to the efficient (free-trade) equilibrium.

This result has not played much of a role in the literature. The reason is that the

[7]Throughout the paper, goods $i$ and $j$ are defined as substitutes if a rise in the price of $i$ leads to an increase in the compensated excess demand (i.e., demand minus supply) for good $j$. In the case of the pure imported input, the excess demand coincides with the input demand in production.

assumption of complementarity across all goods subject to tariffs is not very realistic. Therefore, theorists have focused more on the substitutability case. Inspection of (2) shows that if one or more goods subject to tariffs exhibit substitutability with respect to the imported input, the effect of a reduction in the tariff on the latter will be ambiguous in general. It is at this point that the conditions of the concertina theorem come into play.

Making use of the property that $\pi_\tau(\cdot)$ is homogeneous of degree 0 in all prices, we can transform (2) into

$$(2') \quad N(d\mu/d\tau) = [1/(1+\tau)] \times [(\tau - t_1)\pi_{1\tau} + (\tau - t_2)\pi_{2\tau} + \tau\pi_{3\tau}].$$

If we assume that $\tau$ is the highest tariff rate and that the imported input exhibits net substitutability with all other goods implying $\pi_{i\tau} < 0$ $(i = 1,2,3)$, a reduction in $\tau$ will necessarily improve welfare.

Intuitively, imports of the good that is liberalized (the input in the present case) rise, and given substitutability, imports of other goods subject to tariffs fall. The former change is welfare-increasing, while the latter change is welfare-reducing. The net effect depends on which of the two effects dominates. Substitutability across all goods implies that the tariff reduction will increase exports. As trade is balanced, expansion of exports implies a net expansion of imports (valued at world prices) as well. In other words, imports of the good that is liberalized rise more than the decline in the imports of other goods subject to tariffs. This result and the fact that the good that is liberalized is subject to the highest tariff imply that the welfare-increasing effect of the tariff reduction must dominate the welfare-reducing effect.[8]

## II. Can All Goods Be Substitutable with the Imported Input?

We are now in a position to address the question that is central to this paper: can all goods exhibit substitutability with respect to the imported input? We now demonstrate that, in most of the plausible cases, all goods cannot exhibit substitutability with the imported input. We consider first the case in which the imported input is used in fixed proportions but substitution is permitted among primary factors.

### A. *Fixed Coefficients with Respect to the Imported Inputs*

In this case, the production function for good $i$ is written

$$(3) \quad x_i = \min\{G^i(\mathbf{z}_i), m_i/a_i\} \qquad i = 1,2,3$$

where $x_i$ is the output of good $i$, $\mathbf{z}_i$ is the vector of primary factors, $m_i$ is the quantity of imported input, and $a_i$ is the imported-input-to-output coefficient. Function $G_i(\mathbf{z}_i)$ is linearly homogeneous in $\mathbf{z}_i$ and may be interpreted as value added in sector $i$.

Given (3), the economy's revenue function may be written

$$(4) \quad R = R(\nu_1(\mathbf{q}), \nu_2(\mathbf{q}), \nu_3(\mathbf{q}); z) = R(\boldsymbol{\nu}(\mathbf{q}); \mathbf{z}),$$

where $\mathbf{q} \equiv (1+t_1, 1+t_2, 1, 1+\tau)$ and $\nu_i(\mathbf{q}) \equiv 1 + t_i - a_i(1+\tau)$, is the unit value added in industry $i$ $(i = 1,2)$ (Panagariya, 1992). We have also defined $\boldsymbol{\nu}(q) \equiv [\nu_1(q), \nu_2(q), \nu_3(q)]$ for compactness. We assume that all $\nu_i(\mathbf{q})$ are positive.

Given that $R(\boldsymbol{\nu}(\mathbf{q}); \mathbf{z})$ is linearly homogeneous in $\boldsymbol{\nu}$, it will also be linearly homogeneous in $\mathbf{q}$. As $R_\tau(\cdot)$ is the first partial of

[8]More explicitly, let $M_i$ $(i = 1,2)$ be the imports of good $i$, and let $m$ be the imports of the input. Then, given balanced trade, $dM_1 + dM_2 + dm > 0$, because a tariff cut must increase exports by the substitutability assumption. This inequality, along with the facts that $dm > 0$ and that $dM_1, dM_2 < 0$, implies that $t_1\,dM_1 + t_2\,dM_2 + \tau\,dm > 0$ if the highest tariff is cut.

$R(\cdot)$ with respect to $1+\tau$ which is an element in $\mathbf{q}$, this partial derivative must be homogeneous of degree 0 in $\mathbf{q}$. Finally, as is easily verified, $R_\tau(\cdot)$ must also be homogeneous of degree 0 in $\boldsymbol{\nu}$. We immediately have

$$(5) \qquad \nu_1 R_{\tau 1} + \nu_2 R_{\tau 2} + \nu_3 R_{\tau 3} = 0.$$

This equation implies that at least one $R_{\tau i}$ must be positive; that is, it is impossible to rule out complementarity.[9]

An important question is whether the assumption of a fixed-coefficients technology with respect to the imported input is the driving force behind this strong result. We demonstrate below, however, that the result remains valid for a wide class of models when the production technology is non-Leontief.

### B. *The Heckscher-Ohlin Framework*

Consider the case when the number of primary factors equals the number of produced goods, (i.e., $\mathbf{z}$ is $1 \times 3$). Under the usual long-run competitive equilibrium conditions, prices of primary factors depend solely on the exogeneously given prices, $\mathbf{q}$. Indeed, it is easily shown that these prices are linearly homogeneous in $\mathbf{q}$. Letting $\mathbf{w}(\mathbf{q})$ be the $1 \times 3$ vector of primary-factor prices the imported-input-to-output ratio may be written $a_i(\mathbf{w}(\mathbf{q}), 1+\tau)$ where $a_i(\cdot)$ is homogeneous of degree 0 in $\mathbf{w}(\mathbf{q})$ and $1+\tau$ or, equivalently, in $\mathbf{q}$. Moreover, all $a_i(\cdot)$ functions are independent of output levels.

For a given $\mathbf{q}$, the $a_i(\mathbf{w}(\mathbf{q}), 1+\tau)$ are thus constant. Therefore, as we demonstrate formally in the Appendix, the revenue function in the present case exhibits the same properties with respect to the elements of vector $\mathbf{q}$ as in the fixed-coefficients case, and the substitutability condition of the concertina theorem fails to hold.

### C. *The Ricardo-Viner Framework*

Finally, let us consider a Ricardo-Viner type of model in which each sector employs one specific and one common factor and technology is of a general form. In addition, assume that at least one sector, say sector 3, does not use the imported input.

Consider now a rise in the tariff on the imported input. This change reduces the demand for labor in sectors 1 and 2, which use the imported input, but leaves the demand in sector 3 unchanged. The wage rate declines, and sector 3 expands by making use of cheaper labor. That is to say, good 3 exhibits complementarity with respect to the imported input.

This model can also be used to illustrate the importance of the assumption that the input is not produced domestically. Thus, suppose that of the three goods, good 1 is the input. Then, an increase in $\tau$ will increase demand for labor in sector 1 and lower the demand for labor in sector 2. If we impose the additional assumption that the former effect is stronger, the net effect of the increase in $\tau$ will be to increase the total demand for labor in the economy. In this instance, output of good 1 (the imported input) will expand, while outputs of other goods will contract; the substitutability conditions of the concertina theorem can be satisfied.

In the present section, we have shown that if there is an imported input that is neither consumed nor produced domestically, the substitutability condition of the concertina theorem is impossible to satisfy for a wide class of models. Recalling, however, that the substitutability condition is sufficient but not necessary for welfare improvement following a reduction in the highest tariff, the question remains whether we can still rely on the concertina method for piecemeal tariff reform to yield higher levels of welfare. In the following sections, we provide two examples to demonstrate that extreme caution is necessary in this regard and that under plausible circum-

[9]As an example, suppose that the input is used in goods 2 and 3 only. Then a reduction in $t_1$ which causes sector 1 to contract and sectors 2 and 3 to expand will lead to an increase in the use of the input. That is to say, good 1 and the input are complements.

stances it is altogether possible for welfare to decline when the highest tariff is lowered. For clarity of exposition and tractability, these examples assume that the imported input is used in fixed proportions as in Subsection II-A above. We note, however, that the basic message of the ensuing analysis will hold for the cases considered in Subsections II-B and II-C, where substitution is allowed among all inputs.

### III. Welfare Effects of a Tariff Reduction When the Highest Tariff Applies to the Input

We first consider the case when the highest tariff applies to the imported input. Observe that this case is not a mere theoretical curiosity and may, indeed, have substantial policy relevance. Many developing countries tax imported inputs heavily. In some of these countries, trade taxes constitute a major source of government revenue, and imports of most final consumption goods are essentially banned or controlled via quantitative restrictions. Therefore, the burden of trade taxes falls most heavily on imported inputs. For example according to the World Bank, in Brazil, electrical communications equipment and machinery were subject to ad valorem nominal tariffs of 71 percent and 48 percent, respectively, during 1980–1981. The only sector that was subject to a higher tariff than these sectors was pharmaceuticals (97 percent). Similarly, in Argentina, capital goods were subject to the second-highest nominal tariff (32 percent) in the year 1987. The same basic story applies to India, where in 1987 the average tariff for intermediate goods was higher than the average tariff for consumer goods. In several other major developing countries, such as Bangladesh, China, and Mexico, overall tariffs on intermediate and capital goods, are not significantly lower than those on consumption goods. Observe that even if tariffs on imported inputs are not the highest but second- or third-highest, as the process of reforms progresses, the issue of lowering them must be confronted.

Assuming a fixed-coefficients technology with respect to the imported input, the relevant revenue function is given by equation (4). The economy's budget constraint may be written

$$(6)\quad E(1+t_1,1+t_2,1;\mu) = R(\nu_1(\mathbf{q}),\nu_2(\mathbf{q}),\nu_3(\mathbf{q});\mathbf{z}) + t_1(E_1-R_1)+t_2(E_2-R_2) + \tau(a_1R_1+a_2R_2+a_3R_3).$$

In the remainder of this section, we will assume that the imported input is not used in the production of the exportable. We make this assumption for simplicity; none of our results is affected by it. The effect of a change in $\tau$ on welfare can be written as

$$(7)\quad E_\mu\frac{d\mu}{d\tau} = t_1\frac{dM_1}{d\tau}+t_2\frac{dM_2}{d\tau}+\tau\frac{dm}{d\tau} = (t_1-a_1\tau)\frac{dM_1}{d\tau}+(t_2-a_2\tau)\frac{dM_2}{d\tau}$$

where $M_1$, $M_2$, and $m$ stand for imports of goods 1, 2, and the input, respectively. We assume that the final importables are subject to positive effective protection. This assumption implies that the terms in parentheses in the second equality of (7) are positive. Then, a reduction in $\tau$ will improve welfare if it increases final imports. Intuitively, however, a reduction in $\tau$ works like a production subsidy on goods 1 and 2 at different rates. Other things equal, a production subsidy on good $i$ expands production, lowers $M_i$, and hence reduces welfare.

Further insight into the effects of a change in $\tau$ can be obtained by substituting for $dM_1/d\tau$ and $dM_2/d\tau$ in terms of the revenue and expenditure functions and making use of the homogeneity property of the revenue function. After some simplifications, we obtain

$$(7') \quad N\frac{d\mu}{d\tau} = -(1+t_1)(1+t_2) \times A\frac{\nu_1^*\nu_2^*}{\nu_1\nu_2}\left(\frac{\nu_1}{\nu_1^*} - \frac{\nu_2}{\nu_2^*}\right)R_{12} - \left[a_1\left(\frac{\nu_1 - \nu_1^*}{\nu_1}\right)R_{13} + a_2\left(\frac{\nu_2 - \nu_2^*}{\nu_2}\right)R_{23}\right]$$

where $N$ was defined in the context of equation (2) and is positive. In addition, $\nu_i^*$ ($\equiv 1 - a_i$) is obtained by setting $t_i = \tau_i = 0$ in $\nu_i$ and $A \equiv a_1/(1+t_1) - a_2/(1+t_2)$. Intuitively, $\nu_i^*$ is the unit value added in industry $i$ under free trade. As an example, consider the special case when $a_2 = t_2 = 0$. In this case, good 1 is the only protected good. A reduction in $\tau$, working like a production subsidy to good 1, causes that good to expand and, given substitutability among final goods, causes other goods to contract. All of these changes move the economy further away from the Pareto-efficient allocation and worsen welfare.

In order to interpret (7′), let us assume that the input is subject to the highest tariff ($\tau > t_i$) and that both final importables are protected relative to the exportable ($\nu_i - \nu_i^* > 0$).[10] Observe that since $\nu_i - \nu_i^* = (1+t_i) - a_i(1+\tau) - (1-a_i) = t_i - a_i\tau$, these assumptions are both satisfied if $a_i/t_i > \tau > t_i$. Then, if good 1 is protected more than good 2 ($\nu_1/\nu_1^* - \nu_2/\nu_2^* > 0$), (7′) implies that a small reduction in the highest tariff, $\tau$, will lead to (i) an unambiguous decline in welfare if $A > 0$ and (ii) an ambiguous effect on welfare if $A < 0$. That is to say, the concertina result that a reduction in the highest tariff to the next highest one must increase welfare does not hold. If good 2 is more protected than good 1, a reduction in $\tau$ will worsen welfare if $A < 0$ and will have an ambiguous effect if $A > 0$.

These results can be best understood by thinking of the reduction in $\tau$ as a production subsidy to goods 1 and 2 at different rates. Remembering that the domestic price of the $i$th importable is $1 + t_i$ initially, a reduction in $\tau$ equal to $d\tau$ implies an ad valorem production subsidy of $a_i\,d\tau/(1+t_i)$ to good $i$. If $A > 0$, the rate of subsidy will be higher on good 1 than on good 2 ($a_1\,d\tau/[1+t_1] > a_2\,d\tau/[1+t_2]$). If good 1 is protected more than good 2 initially and if both importables are protected relative to the exportable, this reduction in $\tau$ will make the existing distortion worse, and welfare will decline unambiguously. In the case when $A < 0$, the production subsidy via a reduction in $\tau$ is lower on good 1 than on good 2. To the extent that both importables are protected initially, a further production subsidy to them is welfare-reducing. However, since good 1 is protected more initially and the rate of implicit production subsidy is lower on this good, the reallocation effect between the two importables works in the opposite direction. Thus, the net effect on welfare is ambiguous.

How does this explanation of our result relate to the conditions of the concertina theorem? Recall that the substitutability condition of the concertina theorem requires that, in order for welfare to improve unambiguously, the decline in $\tau$ must lead to a contraction in the compensated excess demand for *every* other good. As the decline in $\tau$ is not accompanied by a change in any final goods prices, this condition is equivalent to the condition that outputs of all final goods expand. However, as we have seen, this is impossible in the cases considered above, for a decline in $\tau$ necessarily leads to a contraction of the exportable. Formally, letting $R_{3\tau}$ be the partial of $R_3$ with respect to $\tau$, we can verify that, given $a_3 = 0$,

$$(8) \qquad R_{3\tau} = -(a_1 R_{31} + a_2 R_{32}) > 0$$

[10] Equation (7′) applies in general when tariff rates are not subject to these restrictions. Indeed, it can be shown that at $\tau = 0$ and $t_1, t_2 > 0$, the right-hand side is necessarily positive.

where the sign of the right-hand side follows from the assumption that $R_{31}, R_{32} < 0$.

## IV. The Highest Tariff Applies to a Final Good

We now turn to the case in which the highest tariff applies to a final importable. We revert to the assumption that $a_3$ is positive. We assume that the highest tariff applies to good 1 (i.e., $t_1 > t_2, \tau$). We are then interested in the effect of a change in $t_1$ on welfare. Differentiating (6) with respect to $t_1$ and making use of the linear homogeneity property of $E(\cdot)$ and $R(\cdot)$, we obtain

$$(9)\quad N\frac{d\mu}{dt_1} = -\frac{1}{1+t_1}[(t_1 - t_2)E_{12} + t_1 E_{13}] + \left[\frac{\nu_1^* \nu_2^*}{\nu_1}\left(\frac{\nu_1}{\nu_1^*} - \frac{\nu_2}{\nu_2^*}\right)R_{12} + \frac{\nu_3}{\nu_1}(\nu_1 - \nu_1^*)R_{13}\right]$$

(recall that $\nu_i$ is the price of value added in the presence of tariffs and $\nu_i^*$ is the price under free trade).

Given $t_1 > t_2$ and net substitutability in demand, the first term on the right-hand side of (9) is negative. Therefore, if we lower $t_1$, this term will contribute positively to welfare. The sign of the second term is ambiguous in general, however. Therefore, the effect of a change in $t_1$ on welfare is also ambiguous in general. For concreteness, assume as before (and in conformity with the concertina theorem) that $R_{12}$ and $R_{13}$ are negative. Also assume that the effective protection on good 1 is less than that on good 2 ($\nu_1/\nu_1^* - \nu_2/\nu_2^* < 0$) and that $\nu_3$ is small ($a_3[1+\tau]$ is close to 1). Then, the second term on the right-hand side will be negative, and the welfare effect of a change in $t_1$ will be ambiguous. A sufficient condition for concertina cuts to improve welfare is that the sector with the higher nominal tariff also has the higher effective tariff.

Intuitively, given $E_{12}, E_{13} > 0$ and $t_1 > t_2$, a reduction in $t_1$ necessarily reduces consumption distortions. However, if good 1 enjoys lower effective protection than good 2, a reduction in $t_1$ has an ambiguous effect on production distortions. To the extent that a contraction of good 1 induces an expansion of the exportable, the change is beneficial; but to the extent that the contraction leads to an expansion of good 2 (the most highly protected good), the change is harmful. The lower the value added per unit in the exportable relative to good 2, the smaller is the contribution of the former effect relative to that of the latter. Therefore, the lower the value of $\nu_3$ relative to $\nu_1$, the more likely it is that the latter (harmful) effect will dominate.

As in the previous section, we can relate this result to the substitutability condition of the concertina theorem. Observe first that there is no difficulty in satisfying the substitutability requirement among final goods. The difficulty arises with respect to the imported input. Substitutability requires that a decline in $t_1$ be accompanied by a decline in the use of the input. However, if the input is used mostly in goods 2 and 3 and not in good 1 (i.e., if $a_2$ and $a_3$ are large but $a_1$ is small), a decline in $t_1$ which causes good 1 to shrink and causes goods 2 and 3 to expand may well lead to an *increase* in the use of the input.[11] Formally, we know that

$$(10)\quad R_{\tau 1} = -[a_1 R_{11} + a_2 R_{12} + a_3 R_{13}].$$

Clearly, if $a_1 = 0$, and $R_{12}, R_{13} < 0$, $R_{\tau 1}$ must be positive.

The usefulness of the concertina theorem declines sharply as we increase the number of importable commodities. To illustrate, consider the case when there are $K$ final importable goods and one exportable (the

[11] Note that a low value of $a_1$ and high value of $a_2$ is consistent with a lower effective protection for good 1 than for good 2 even when $t_1 > t_2$.

$[K+1]$th). Expression (9) generalizes to

$$(11)\quad N\frac{d\mu}{dt_j} = -\frac{1}{1+t_j} \times \left[ \sum_{k \neq j}^{K} (t_j - t_k) E_{kj} + t_j E_{K+1,j} \right] + \frac{1}{\nu_j} \left[ \sum_{k \neq j}^{K} \nu_j^* \nu_k^* \left( \frac{\nu_j}{\nu_j^*} - \frac{\nu_k}{\nu_k^*} \right) R_{kj} \right] + \frac{\nu_{K+1}}{\nu_j} (\nu_j - \nu_j^*) R_{K+1,j}.$$

Thus, if $t_j > t_k$ $(k = 1,\dots,K; k \neq j)$ net substitutability is sufficient for a decrease in $t_j$ to reduce consumption distortions. This is reflected in the negative sign of the first right-hand-side term of (11). However, production distortions are not necessarily diminished by a reduction in $t_j$, even if $R_{kj} < 0$ for all $k \neq j$, and $R_{K+1,j} < 0$. The sufficient condition is that $\nu_j / \nu_j^* - \nu_k / \nu_k^*$ be positive for all $k = 1,\dots K$ $(k \neq j)$. That is, the final good with the highest import tariff should also be subject to the highest effective rate of protection. This result considerably reduces the usefulness of the concertina method of tariff reform. Thus, suppose we start from the most favorable situation such that the above condition is satisfied at the initial equilibrium by good $j$. As we reduce the tariff of good $j$, welfare improves. After the tariff on good $j$ has been reduced to the level of the second-highest tariff (say, good $i$), we would like to reduce the tariffs on both good $j$ and good $i$. However, for this to be welfare-improving unambiguously, we need the effective protection on both goods $i$ and $j$ to be higher than that on any other good in the new equilibrium, and so on. Thus, as the tariff reform based on the concertina method proceeds, the sufficiency condition is progressively more likely to be violated.

## V. Conclusion

The principal conclusion of this paper is that the key assumption of substitutability required by the concertina theorem of piecemeal tariff reform is not consistent with the Rybczynski relationship in the presence of pure imported intermediates. We have shown that for three popular models of international trade the substitutability condition between the imported input and all final goods is impossible to satisfy.

Thus, the presence of imported inputs considerably limits the usefulness of the concertina method of tariff reform. In the case when the highest tariff applies to a final good, one of the sufficiency conditions requires that the good(s) subject to the highest nominal tariff also be subject to the highest effective protection.[12] This is a rather stringent requirement. In the case when the highest nominal tariff applies to an imported input, we are unable even to spell out a meaningful set of sufficiency conditions for welfare improvement in response to a reduction in this tariff. Ironically, the sufficiency conditions for a decline in welfare turn out to be straightforward in this case.

The lack of applicability of the concertina theorem in this latter case is serious because, as indicated in Section III, imports of intermediates and capital goods in several of the largest developing countries are subject to very high tariffs. In these countries, the prime instruments to protect final goods are import prohibitions or quantitative restrictions, not tariffs, and thus the highest tariffs affect intermediates rather than final goods. Moreover, even if the highest tariffs affect a final good, as the concertina method is implemented, very soon a point is reached where an imported input is subject to the highest tariff.

## Appendix

We show here that in the context of the Heckscher-Ohlin framework, the revenue

[12]Incidentally, the estimates of the correlation coefficient between nominal and effective rates of protection usually range between 0.85 and 0.9. The conditions for the breakdown of the concertina theorem may appear to be less stringent than is argued here. However, the effective-rate measures include interindustry flows but not pure imported inputs, so it is not clear how relevant they are in the present context.

function can be expressed in terms of value-added prices ($\boldsymbol{\nu}$), satisfying the same properties with respect to the elements of $\mathbf{q}$ as in the fixed-coefficients case. Long-run competitive equilibrium implies that output prices equal average costs:

$$\text{(A1)} \quad p_i = c^i(\mathbf{w}, 1+\tau) \qquad i = 1,2,3$$

where $p_1 = 1 + t_1$, $p_2 = 1 + t_2$, and $p_3 = 1$ are the domestic prices of the three outputs, $\mathbf{w} = (w_1, w_2, w_3)$ is the vector of the three primary-factor prices, and $1+\tau$ is the domestic price of the imported input. In this "even" case, one can solve (A1) for the primary-factor prices and obtain $\mathbf{w} = \tilde{\mathbf{w}}(\mathbf{p}, 1+\tau) = \mathbf{w}(\mathbf{q})$, where $\mathbf{q} = (1+t_1, 1+t_2, 1, 1+\tau)$ is the vector of exogenous prices.

Using Shephard's lemma, we obtain the cost-minimizing level of the vector of primary factors and imported inputs for each industry. We have

$$\text{(A2)} \quad \mathbf{z}_i / x_i = c^i_{\mathbf{w}}(\mathbf{w}, 1+\tau) \equiv \alpha_i(\mathbf{q})$$

$$m_i / x_i = c^i_{\tau}(\mathbf{w}, 1+\tau) \equiv a_i(\mathbf{q})$$

$$i = 1,2,3$$

where $x_i$ is output of industry $i$, $\mathbf{z}_i$ is the vector of primary factors used by industry $i$, and $m_i$ is the level of the imported input used in industry $i$. Note that $\alpha_i(\cdot)$ and $a_i(\mathbf{q})$ are homogeneous of degree 0 in $\mathbf{q}$.

The economy's revenue function can now be defined as

$$\text{(A3)} \quad R = \max_{\mathbf{z}_i, m_i} \left[ \sum_i p_i F^i(\mathbf{z}_i, m_i) - (1+\tau) \times \sum_i m_i + \lambda\left(\mathbf{z} - \sum_i \mathbf{z}_i\right) \right]$$

where $F^i(\cdot)$ is the constant-returns-to-scale production function of industry $i$, and $\lambda$ is the Lagrangian multiplier.

Using the linear homogeneity condition of the function $F^i(\cdot)$, expression (A3) can be expressed as

$$\text{(A4)} \quad R = \max_{m_i} \left[ \sum_i p_i m_i f^i(\beta_i(\mathbf{q})) - (1+\tau) \sum_i a_i(\mathbf{q}) m_i f^i(\beta_i(\mathbf{q})) + \lambda\left(\mathbf{z} - \sum_i \beta_i(\mathbf{q}) m_i\right) \right]$$

where $\beta_i(q) \equiv \alpha_i(q)/a_i(q)$ is also homogeneous of degree 0. Collecting terms, we obtain

$$\text{(A5)} \quad R = \max_{m_i} \left\{ \sum_i [p_i - (1+\tau) a_i(\mathbf{q})] f_i(\beta_i(\mathbf{q})) m_i + \lambda\left(\mathbf{z} - \sum_i \beta_i(\mathbf{q}) m_i\right) \right\}$$

which yields the following expression for the revenue function:

$$\text{(A6)} \qquad R = R(\boldsymbol{\nu}(\mathbf{q}), \boldsymbol{\beta}(\mathbf{q}); \mathbf{z})$$

where $\boldsymbol{\nu}$ is a vector of value-added prices [i.e., $\nu_i = p_i - (1+\tau) a_i(\mathbf{q})$] and $\boldsymbol{\beta}(\mathbf{q})$ is the vector of the $\beta_i(\mathbf{q})$ ($i = 1,2,3$). We note again that the $\beta_i(\mathbf{q})$ are homogeneous of degree 0 in $\mathbf{q}$, while the $\nu_i(\mathbf{q})$ are homogeneous of degree 1 in $\mathbf{q}$. This revenue function is thus of the same structure as the one defined by (4) in the text, the only difference being that the $a_i$ coefficients are not fixed, but rather a function of the vector of output prices and the price of the imported input. By inspection of (A5) it is clear that $R(\cdot)$ is linearly homogeneous in $\boldsymbol{\nu}$ and that, since each of the $\nu_i(\mathbf{q})$ functions is also linearly homogeneous in $\mathbf{q}$, it satisfies all the properties of the revenue function defined in the imported-input fixed-coefficients case.

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