

Country Economics Department
The World Bank
January 1990
WPS 326

Do Exporters Gain from Voluntary Export Restraints?

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The results of the model developed here are a strong indictment of VERs. For most plausible parameter values, VERs redirect exports, reduce the size of industries for which countries have comparative advantage, and cause overall economic losses — especially if the affected industry is large in the market for its factors of production.

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Most economic literature concentrates on the rent transfer accruing to exporting countries when a voluntary export restraint (VER) is binding. It suggests that VERs are not very harmful for the exporting country. De Melo and Winters argue that this view is misconceived.

Most work has focused on the welfare loss to the importing country arising from a loss of income transfer combined with a distortionary loss in efficiency. Implicit is the message that the often large rent transfer to the exporting country is likely to compensate for any induced inefficiency losses.

De Melo and Winters study the effects on distribution and efficiency when VERs force factors out of industries in which they are most

productive. They develop a general theoretical model that establishes qualitative conditions under which a VER will result in industry contraction, spillovers of exports to unrestricted markets, and losses in national welfare.

They estimate key parameters of supply and demand for leather footwear exports from Taiwan subject to the U.S. Orderly Marketing Agreement, and explore the implications in a calibrated simulation exercise.

The results are a strong indictment of VERs.

For most plausible parameter values, VERs redirect exports, reduce the size of the industry, and cause overall economic losses, especially if the affected industry is large.

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Table of Contents

I.	Introduction	1
II.	A Simple Model	3
	Industry Profits	4
	Firms' Behavior	5
	Imposing the VER	8
	National Welfare	13
III.	Estimation	18
IV.	Welfare and Distributional Effects of VERs: Some Illustrative Simulations	25
	Conclusions	31
	Notes	33
	References	34
	Appendix	35

We are grateful to Bela Balassa, Paul Brenton, Shanti Chakravarty, Nicola Rossi, Wendy Takacs, and to participants of the STEP-CEPR Conference "Adjustment in Developing Countries" (May 1989), the Europe Research Workshop on International Trade (June 1989), and the George Washington University Economics Seminar for comments on an earlier draft. We thank Maria D. Ameal, Alexander Pfaff, and Julie Stanton for logistic support. This research has been financed by World Bank Research Project 672-40.

I. INTRODUCTION

The distinguishing feature of Voluntary Export Restraints (VERs) is that they are administered by exporting countries. So long as the VER is binding, exports of the product under the VER, earn a scarcity premium and much work has been done to estimate the cost to importing countries -- and hence the gain to exporting countries -- from this transfer.^{1/} There are, however, other effects in exporting countries arising from a binding VER. These effects stem from the contractionary pressure on the industry subjected to the VER and hence against factors employed in it. By forcing factors out of industries in which they are most productive, VERs can impose significant efficiency losses on exporters. Curiously, these losses, which must be balanced against the rent transfer from abroad, have been neglected in the literature. The purpose of this paper is to explore these effects systematically.

We study the negative effects of VERs on exporters from three perspectives. First, we develop a fairly general theoretical model of an industry subject to the VER (section 2). The industry sells its output to two markets, one restricted and one unrestricted. We examine the effects of a VER in the restricted market on sales in the unrestricted market (spillover effect), on industry size and profits, on national welfare, and on the returns to factors in that industry. The analysis suggests that the effects of a VER depend crucially on a few product supply and factor demand elasticities. This leads us, in section 3, to carry out an illustrative exercise to estimate these key elasticities for the case of leather footwear exports from Taiwan which were subject to the USA Orderly Marketing Agreement (OMA) during 1977-81. Although not as precise as

desirable because of data limitations, these econometric estimates suggest that the demand and supply of footwear are quite elastic; they lend strong support to the qualitative prediction that the OMA induced some spillover to unrestricted markets and some contraction of the industry with attendant efficiency losses. Finally, in section 4, we combine the results of the previous two sections into a simple simulation model which analyzes the likely effects of a VER on national welfare and income distribution, taking into account efficiency losses. For plausible elasticity values we establish that a typical VER will lead to a worsening income distribution, as profits in the affected industry rise and the returns to other factors -- notably labour -- fall. Although not formally part of our model, it is clear that factor returns will tend to fall most for immobile factors and especially for labour whose skills are specific to the restricted industry. We also establish that exporting countries are likely to incur an overall welfare loss in spite of the rent transfer gain even when the industry under the VER is of non-negligible size.

The results of this paper are a strong indictment of VERs. To be sure, VERs are less harmful to exporting countries than are equivalent-sized import quotas administered by the importing country, but nonetheless, they can impose notable welfare losses wherever they restrict industries accounting for significant shares of the exporters' economic activity or when they make use of particular and relatively immobile skills or physical capital. This suggests that the complacency with which the economics profession has treated the exporters' consequences of VERs has been misplaced.

II. A SIMPLE MODEL

We consider the simplest possible model of a VER. For convenience we term the restricted industry footwear, but the results generalize to virtual any competitive industry. We assume that firms in an exporting country produce footwear for two markets, A and B, using a single composite variable factor of production, Z . For generality we assume that the two types of footwear may differ and allow for the possibility that the marginal costs of one may depend on the output of the other. One possible justification for this is the existence of a second implicit factor of production which is fixed in supply - e.g. entrepreneurship or infrastructure. We write the variable factor requirements for producing the outputs destined for the two markets, X_A and X_B , as

$$(1) \quad Z = G(X_A, X_B)$$

where Z is the quantity of the composite factor used,

$$G_A, G_B > 0, \text{ where } G_i = \frac{\partial Z}{\partial X_i}, \text{ and}$$

G is homothetic but homogeneous of degree $r < 1$.

We consider the consequences of imposing a VER on exports to market A; those to market B are assumed to be always unrestricted. Firms are assumed to be simple profit-maximizers and the entire output is exported. 2/

Industry Profits

Total profits from footwear in this simple model are

$$(2) \quad \pi = P_A X_A + P_B X_B - WZ$$

where P_i are the prices received from market i , $i = A, B$

X_i the quantities supplied, and

W the "wage" of the composite factor.

Taking the total differential of (2), substituting for dX_B from the differential of (1)

$$(3) \quad dZ = G_A dX_A + G_B dX_B .$$

If we use η_i for the inverse of the mark-up of price over marginal revenue in market i , i.e.

$$(4) \quad \eta_i = 1 + \frac{1}{\epsilon_i} \quad i = A, B, Z ,$$

where ϵ_i is the elasticity of demand, $\epsilon_i < 0$, $i = A, B$ and ϵ_z is the elasticity of supply of the composite factor, $\epsilon_z > 0$, we simply obtain

$$(5) \quad d\pi = \left[\frac{\eta_A P_A}{G_A} - \frac{\eta_B P_B}{G_B} \right] G_A dX_A + \left[\frac{\eta_B P_A}{G_B} - \eta_Z W \right] dZ$$

$$(5') \quad d\pi = M dX_A + N dZ$$

Equation (5) shows that the effect on profits of a shock to the footwear industry may be decomposed into a part relating to changes in the allocation of sales between markets (MdX_A) and a part relating to changes in the overall size of the industry (NdZ). Moreover, the parts bear a perfectly simple interpretation. $\eta_A P_A$ is the marginal revenue from market A and G_A the marginal input requirement for producing for market A: thus the bracketed component of M reflects the marginal return to factors devoted to X_A less that of those devoted to X_B . $G_A dX_A$ is the factor requirement for a marginal change in X_A . If market A generates greater marginal returns to the factor than does market B, an increase in X_A is desirable. The term N compares the marginal returns to employing extra factors producing X_B with their marginal cost. The latter is the wage marked up by a term reflecting any tendency for the wage to have to rise as employment increases. If marginal revenue exceeds marginal costs, additional factor use, i.e. additional output, would be desirable.

Firms' Behavior

We assume that the footwear industry comprises many identical representative firms, each of which maximizes profits subject to the production relation (1). Using $\tilde{\cdot}$ to denote firms' outputs and inputs, the firms' maximization problem is

$$(6) \quad \max L = P_A \tilde{X}_A + P_B \tilde{X}_B - W\tilde{Z} + \lambda [\tilde{Z} - G(\tilde{X}_A, \tilde{X}_B)]$$

Homotheticity implies that we may use the same derivatives of $G(\cdot)$ for both firm and industry since both face the same prices.

The first order conditions for (6) depend on whether the firm is a price-taker or not. If it takes both prices and wages as given it solves

$$(7a) \quad P_A - \lambda G_A = 0$$

$$(7b) \quad P_B - \lambda G_B = 0$$

$$(7c) \quad W - \lambda = 0$$

$$(7d) \quad Z - G(\) = 0$$

whereas if it recognizes its power in both markets, the first order conditions become

$$(8a) \quad \eta_A P_A - \lambda' G_A = 0$$

$$(8b) \quad \eta_B P_B - \lambda' G_B = 0$$

$$(8c) \quad \eta_Z W - \lambda' = 0$$

$$(8d) \quad Z - G(\) = 0$$

If it has market power only in certain markets it mixes (7) and (8) appropriately.

It is simple to show that if the firm has and exploits the same market power as exists for the footwear industry as a whole, then $M=N=0$. For example, a monopolist with power to discriminate between markets and with monopsony power in factor markets maximizes industry profits as well as his own. Conditions (8a) and (8b) equate the $\eta_i P_i / G_i$ and thus make $M=0$, while conditions (8b) and (8c) give $\eta_B P_B / G_B = \eta_Z W$, and thus make $N=0$. Similarly if the industry and all the firms are genuine price- and wage-takers, so that $|\epsilon_i| = \infty$ all i , $\eta_i = 1$ and (7) ensures that $M=N=0$. In both cases small changes in X_A and Z have no effect on profits because they have

already been maximized with respect to these variables. Non-marginal changes will reduce the monopolist's/monopsonist's profits, but will have no effect on profits in the competitive case. This is because with fixed prices and wages, output for each market is expanded until price just equals marginal cost which, because of competition, equals average cost. It is only the implicit fixed factor, which gives $G(\cdot)$ decreasing returns to scale, that makes the equilibrium determinate in this case.

If, on the other hand, individual firms do not (cannot) exploit the industry's monopoly or monopsony power, profits are not maximized at the market equilibrium, and the possibility arises that policy-induced changes in X_A and Z may be beneficial. This is essentially a situation in which the optimum tariff or export tax is non-zero. Substituting (7) into (5) yields

$$M = \left[\frac{1}{\epsilon_A} - \frac{1}{\epsilon_B} \right] W \quad \text{and} \quad N = \left[\frac{1}{\epsilon_B} - \frac{1}{\epsilon_Z} \right] W$$

The term N is negative, so a contraction in the industry, $dZ < 0$, would always be desirable ceteris paribus. The sign of M is not fixed a priori, but if A were the less elastic market, $|\epsilon_A| < |\epsilon_B|$, a contraction in sales to A would also be desirable ceteris paribus. That is, fixing the size of the industry, $dZ=0$, an enforced switch out of the less elastic market would be desirable. All of these effects arise because atomistic firms cannot exploit national or industry market power.

It is clear that price/wage taking and market power behavior may be mixed. Thus a small industry with the power to sell as a discriminating monopolist will use f.o.c.s (8a), (8b), and (7c). This will render $M=0$ but

$N = -\epsilon_2^1 W < 0$. Conversely an industry that was small on world markets but had monopsony power at home - not an impossible situation for a developing country export sector - would behave according to (7a), (7b), and (8c). This would leave M as above and set $N = \epsilon_B^1 W$.

Imposing the VER

We now consider imposing a VER in market A. We model it as a small reduction in X_A , $d\bar{X}_A < 0$, starting from a position of equilibrium. The effect on profit is given by (5) with M and N evaluated using an appropriate mix of (7) and (8) as above. It remains, however, to calculate dZ , the effect of the VER on total activity, as the industry moves to its new equilibrium. At the new equilibrium firms will have \bar{X}_A imposed upon them, $\bar{X}_A = X_A^0 + d\bar{X}_A$, where X_A^0 is the initial equilibrium point, but they will still maximize profits with respect to the other decision variables X_B and Z . Because there is no optimization relative to X_A , there is no first order condition to determine it. The remaining first order conditions, however, will be unchanged from 7(b) - 7(d) or 8(b) - 8(d), because the VER has no direct effect on equilibration in the B or Z markets. Thus we may calculate the effects of the VER in market A in the standard comparative statics fashion, by differentiating the effective first order conditions and imposing $d\bar{X}_A$ exogenously.

The most interesting case is the competitive one in which firms are price- and wage-takers. Differentiating (7b) to 7(d) gives

$$(9a) \quad dP_B - G_B d\lambda - \lambda dG_B = 0$$

$$(9b) \quad dW - d\lambda = 0$$

$$(9c) \quad dZ - G_A dX_A - G_B dX_B = 0$$

Using the relationship $dG_B = G_{BA}dX_A + G_{BB}dX_B$ and substituting for dP_B and dW along the actual demand and supply schedules, these may be manipulated to obtain

$$(10) \quad \frac{dX_B}{d\bar{X}_A} = \frac{\frac{G_A G_B}{Z\epsilon_2} + G_{BA}}{\frac{G_B}{X_B \epsilon_B} - \frac{G_B^2}{Z\epsilon_2} - G_{BB}}$$

The signing of (10) depends upon the signs of G_{ij} . Assuming increasing marginal costs, i.e. $G_{ii} > 0$, only a strongly negative relationship between costs for X_A and for X_B could make (10) positive. That is, assuming that marginal costs for each product are rising and that increases in the output of one product raise, or at least do not much reduce, the marginal costs of the other, a forced reduction in X_A will lead to an increase in X_B . Competitive firms will respond to a VER in market A by increasing sales in market B - the cause of Hamilton's (1989) domino effect, or in the terminology below, the "domino diversion" of exports.

Further substitution yields

$$(11) \quad \frac{1}{G_A} \cdot \frac{dZ}{d\bar{X}_A} = \frac{\left[\frac{G_B}{X_B \epsilon_B} - G_{BB} + \frac{G_B}{G_A} G_{BA} \right]}{\left[\frac{G_B}{X_B \epsilon_B} - G_{BB} + \frac{G_B^2}{Z\epsilon_2} \right]} = H$$

The expression H is not immediately interpretable intuitively, but it may readily be shown that almost certainly $H > 0$, i.e. that a VER will lead the industry to contract. The first two terms of the numerator and denominator are identical and negative. The final term of the numerator will be small (and possibly positive), thus either hardly affecting (or possibly reducing) the absolute value of the expression, while the effect of the final term of the denominator is negative, so increasing its absolute value. 3/ Only very strong interactions between products A and B in production could cause H to become negative. If we rule these out, it is plain that an enforced fall in X_A will also reduce the scale of the industry's operations. A VER leads the industry to contract.

Substituting (11) into (5) and recalling the definitions of M and N for price- and wage-taking firms

$$(12) \quad \frac{d\pi}{d\bar{X}_A} = \left[\left[\frac{1}{\epsilon_A} - \frac{1}{\epsilon_B} \right] + \left[\frac{1}{\epsilon_B} - \frac{1}{\epsilon_Z} \right] \bar{x} \right] G_A = [M + N.H]G_A$$

The term $N.H$ is almost certainly negative, so we conclude that unless the difference in the elasticities of demand between the restricted and unrestricted markets is large and favorable, a "small" VER on a price- and wage-taking industry boosts profits.

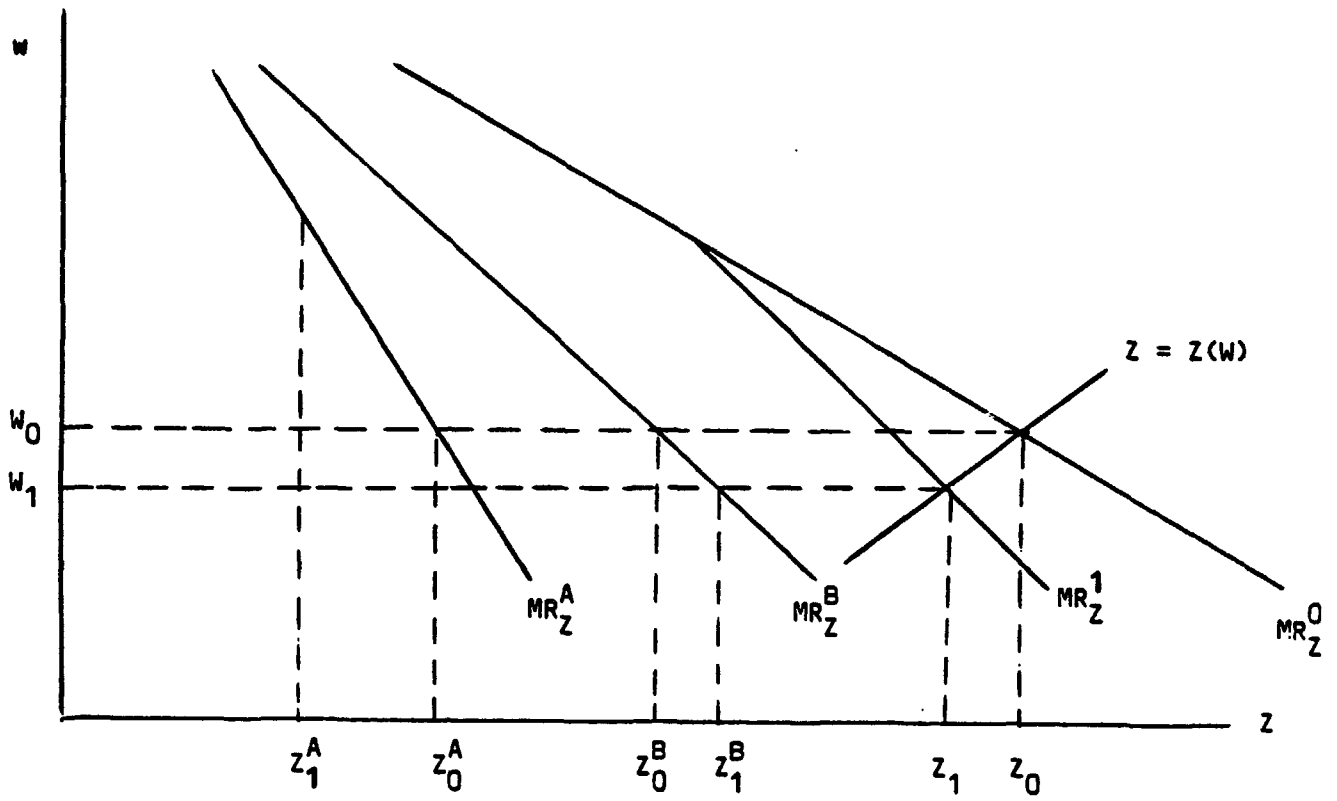
Equation (12) also illustrates some special cases.

- If the industry is genuinely price- and wage-taking, $\epsilon_i = +\infty$, profits are unaffected by the VER. In fact, they are fixed at zero if we assume identical firms.

- If the industry is a genuine wage-taker, $\epsilon_2 = \infty$, there is a presumption that the VER is profit-enhancing, because (12) reduces to $[\epsilon_A^{-1} - (1-H)\epsilon_B^{-1}]$, and H is unlikely to be far different from unity.
- If the elasticities of demand are equal across markets, the VER is certainly profit-enhancing because $M = 0$ while $N < 0$.
- If demand in the unrestricted market is perfectly elastic, $\epsilon_B = \infty$, the VER cannot harm profits.

Figure 1 presents a simplified account of the model of this section. It is drawn in factor-factor price space. The lines MR_2^i report the aggregates of firms' marginal revenues gained from an extra unit of Z being devoted to producing for market i, P_i/G_i or $\eta_i P_i/G_i$, $i=A,B$ according to industry structure. MR_2^0 is their sum under free trade. ^{4/} Coupled with a rising supply curve for Z, $Z = Z(W)$, the total marginal revenue function (MR_2^0) determines the wage rate (W_0) and the size of the industry (Z_0). It is clear that at this wage rate all the first order conditions are met.

When the VER is imposed in A, it implies factor usage Z_1^A . The VER causes the marginal revenue curve to fall to zero at any higher level of input. MR_2^B is unaffected. The aggregate marginal revenue function, MR_2^1 , is now kinked, and the new industry equilibrium is defined by W_1 and Z_1 . It is plain that the industry has contracted, but that at the lower wage more resources are devoted to supplying market B. It is also plain that the sizes of the various changes are affected by the size of the shock, $(Z_1^A - Z_0^A)$, and the slopes of the various schedules. The slopes of the MR_2^i curves depend on ϵ_i , G_i and G_{ii} , while the slope of the factor supply function depends on ϵ_2 .

Figure 1

National Welfare

So far we have equated national welfare with industry profits. This is plainly too restrictive. Assuming that all industries in the economy are competitive, so that wages represent marginal products, we approximate national welfare by the sum of profits (non-zero only in footwear) and factor incomes.

$$(13) \quad U = \pi + WL$$

where L is the size of the factor market from which footwear draws its factors. If there are factors of types which are not used in the footwear industry they are excluded from L and an additional term should be added to (13) to cover their income. However, since this is assumed constant, we can ignore it.

The change in national welfare differs from the change in industry profits by

$$(14) \quad LdW = \frac{LW}{Z\epsilon_Z} dz$$

This effect may be added to N in equation (5), so that in the case of price- and wage-taking firms, the new value of N becomes

$$(15) \quad \tilde{N} = \left[\frac{1}{\epsilon_B} + \frac{1}{\epsilon_Z} \left(\frac{L - Z}{Z} \right) \right]$$

It is plain that \dot{N} could now be positive and that it is more likely to be so the lower the elasticity of supply of factors to footwear and the larger the stock of factors outside footwear whose wage is affected by developments in the footwear sector. Since the extension of the welfare criterion affects no part of the previous calculations other than N , we may straight-forwardly generalize (12) to write

$$(16) \quad \frac{dU}{d\bar{x}_A} = \left[\left(\frac{1}{\epsilon_A} - \frac{1}{\epsilon_B} \right) + \left(\frac{1}{\epsilon_B} + \frac{1}{\epsilon_Z} \cdot \frac{L-Z}{Z} \right) \right] G_A$$

This is more likely to be positive than (12) because ϵ_Z^{-1} now enters with a positive sign and is multiplied by a factor that may exceed unity. All the special cases discussed above follow through to (16). An additional case of interest is where only those factors initially in the footwear industry enter the welfare criterion. This implies that one is considering the effect of the VER on the industry (workers and entrepreneurs) as a whole. In this case (16) collapses to $\epsilon_A^{-1} - (1-H)\epsilon_B^{-1}$, which is likely to be negative unless demand in the restricted market (A) is significantly more elastic than demand in the unrestricted market (B). 5/

Further manipulation allows us to rewrite \dot{N} as

$$\dot{N} = \left[\frac{1}{\epsilon_B} - \frac{1}{\epsilon_N} \right]$$

where ϵ_N is the elasticity of demand for factors with respect to the wage in the non-footwear sectors using L, $\epsilon_N < 0$. This expression would be relevant to an assessment of a footwear VER because if the total stock of factors were fixed, then the change in the supply of factors to the footwear industry would merely be the opposite of the change in the demand for them elsewhere. With this definition of \hat{N} , our final welfare criterion becomes:

$$(17) \quad \frac{dU}{d\bar{X}_A} = \left[\left(\frac{1}{\epsilon_A} - \frac{1}{\epsilon_B} \right) + \left(\frac{1}{\epsilon_B} - \frac{1}{\epsilon_N} \right) \right] G_A$$

Intuitively, (17) suggests that the effects of a VER depends on an allocation component and a size component. The allocation component asks whether switching output between markets is beneficial and the size component whether switching factors between sectors is beneficial. 6/

To recapitulate, equations (16) and (17) suggest that an empirical estimate of the welfare effects of a VER must consider:

- the elasticities of demand in restricted and unrestricted markets;
- the elasticity of factor supply to the affected industry or the elasticity of factor demand elsewhere in the economy; and
- the parameters of the production function or factor input process.

So far, we have analyzed the effects of a VER entirely in primal terms, dealing directly with the parameters of the demand and production functions. That approach is useful both in its intuitive transparency and in its ability to deal with non-price-taking behaviour. Once we come to estimation however, it is less powerful than working with dual functions. Since in section 3 we exploit duality and flexible functional forms to specify our output/allocation equations, we briefly restate our main results in those terms here. It turns out that the crucial derivatives G_{ij} may be signed in terms of estimable parameters based on dual profit functions.

The empirical application of duality requires price-taking behaviour. Thus we are considering a new approach only to the evaluation of dX_B and dZ and the variables dependent upon them. The evaluation of the factors M and N is unchanged by the switch to duality. For a price-taking firm the profit function governing the production and allocation of exports may be written as $\pi = \pi(P_A, P_B, W)$, and using Sheppard's lemma, the profit function yields consistent output supply and input demand functions. For the sake of concreteness, we represent the profit function by Diewert's (1974) Generalized Leontief form used in the remainder of the paper.

$$(18) \quad \pi = \sum_i \sum_j \gamma_{ij} (-P_i^{1/2} P_j^{1/2})$$

where $i = A, B, Z$ and P_Z is just the wage (W). Concavity of the profit function requires $\gamma_{ij} = \gamma_{ji}$ and $\gamma_{ij} \geq 0$ $i \neq j$ if outputs (X_A, X_B) are measured with positive signs and inputs (Z) with negative signs.

Differentiating (18) yields the general "netput" equation ('netputs' are both inputs and outputs)

$$(19) \quad X_i = -\gamma_{ii} - \sum_{j \neq i} \gamma_{ij} (P_j/P_i)^{1/2}$$

where $X_2 = -Z$ in our earlier notation.

Neary and Roberts (1980) show that a constrained equilibrium can be expressed in terms of the parameters of the unconstrained compensated demand or supply functions by means of virtual prices. Virtual prices are the prices at which the actual quantities traded would have been traded voluntarily according to the compensated functions. For unconstrained netputs, virtual prices equal actual prices, and for constrained netputs they may be derived by inverting the compensated netput functions. Solving (19) for \tilde{P}_A , the virtual price of sales to market A given a value of \bar{X}_A , and substituting into the two unconstrained netput functions yields:

$$(20) \quad \bar{X}_k = - \left[\gamma_{kk} - \frac{\gamma_{kA}^2}{(\bar{X}_A + \gamma_{AA})} \right] - \left[\gamma_{k1} - \frac{\gamma_{kA}\gamma_{A1}}{(\bar{X}_A + \gamma_{AA})} \right] \left[\frac{P_1}{P_k} \right] \quad k, 1=B, Z$$

Now at the initial, unconstrained, equilibrium (X_A^*, X_B^*, Z^*) , (20) will hold as well as (19), so that to calculate the effects of a "small" VER, we need only differentiate (20) w.r.t. \bar{X}_A . This simply indicates that provided $\gamma_{ij} \geq 0$

$$\frac{d\bar{X}_k}{d\bar{X}_A} \leq 0$$

which, given the sign convention, shows that a VER in market A will boost supplies to market B and reduce factor inputs, 2. That is, the assumptions necessary to ensure the concavity of the generalized Leontief profit-function are sufficient to sign expressions (10) and (11) above if the duality requirement that $|\epsilon_3| = |\epsilon_2| = \bullet$ is satisfied. But once they are signed under these conditions, (10) and (11) may be signed (in the same direction) for all values of the elasticities, so concavity is sufficient to establish a general result of "domino diversion" and "industry contraction" in response to a VER.

Using this approach, the quantification of the effects of the VER depends on both the parameters of the profit function and the various industry elasticities, and apparently cannot be further simplified as we did with the primal analysis above. As a practical application, we now estimate as many of the parameters as possible and use a simulation model to combine the estimates. Using a simulation model has the additional virtue of allowing us to consider non-marginal VERs as well.

III. ESTIMATION

In this section we describe two attempts to estimate the principal parameters of the model above for Taiwanese exports of leather footwear (CCCN 6402). Most Taiwanese footwear exports are sold in the USA, which between July 1977 and June 1981 imposed on them a voluntary export restraint (the so-called Orderly Marketing Agreement). The OMA has been investigated several times from the USA's point of view -- e.g. Pearson (1983) and Aw and Roberts (1986) -- but not, to our knowledge, from Taiwan's. We estimate the model for leather footwear sales because they were all affected by the OMA, whereas the other major aggregate available

to us (CCCN 6401), although accounting for a larger share of Taiwanese footwear exports, comprises rubber and plastic footwear, the former of which was not limited by the OMA. We distinguish two markets for footwear, the USA and the rest of the world and use quarterly data 1974-1986. 7/

We estimate the various parameters of the model presented in section II in a simultaneous system of non-linear equations using three stage iterative instrumental variable methods from SAS's SYSNLIN procedures. 8/ The purpose of this estimation is to establish the plausibility of our approach and to obtain "ball-park" estimates of the critical parameters for later policy simulations. Thus we have not experimented with large numbers of specifications nor have we concerned ourselves much about insignificant but implausible estimates of non-critical parameters.

Our first attempt at estimation was a limited one. Recognizing the paucity of data on the production side of the model, we estimated a system comprising only demand curves and an export allocation model to divide a given volume of exports between markets. We had originally intended to use a constant elasticity of transformation (CET) allocation model -- see de Melo and Winters (1989) -- but it has the unfortunate property of obliging G_{AB} from equation (10) above to be negative. This immediately implies that a VER in A will contract sales to market B in the fully price-taking case. Therefore, in order to avoid imposing such an implication, and to allow the data scope to determine the nature of the spillover, we derived an alternative allocation model from the restricted profit function of the Generalized Leontief form given by equation (18) above.

McFadden and Fuss (1978) show that profit functions can be rewritten to describe the maximum profit available given exogenous values

for certain netputs. They show that such restricted profit functions must be linear homogeneous in the exogenous quantities and should be concave in the prices of the remaining unconstrained netputs. Hence, we fix total inputs (Z) exogenously and proxy Z, by total exports of footwear (X), as an allocation model suggests is appropriate. This allows us to write $X_A = f(P_A, P_B) \cdot X$, which, using a Generalized Leontief form, specializes to

$$(21) \quad X_A/X = - \gamma_{AA} - \gamma_{AB} (P_B/P_A)^{1/2}$$

The corresponding equation for X_B is implicit in (21) given adding up.

Equation (21) was estimated along with demand functions for leather footwear for the USA and for the rest of the world. These were normalized to express the price of Taiwanese footwear relative to a linear combination of the prices of locally produced footwear (P_i^L) and Korean exports to the market concerned (P_i^K) as the dependent variable. Normalizing the demand curve on price is necessary if the data are to have the opportunity to record infinitely elastic demands. The additional explanatory variables were a cyclical variable (the index of industrial production, Q_i) and the quantity of exports. Thus the two demand curves were of the form:

$$(22) \quad P_i = (\beta_0^i + \beta_1^i Q_i + \beta_2^i X_i) [(1 - \beta_3^i) P_i^L + \beta_3^i P_i^K] \quad i = A, B$$

All three equations were given seasonal dummies and, in view of the evident serial correlation when estimated straightforwardly, were also adjusted for first order serial correlation.

During the OMA the demand equations still applied, relating actual prices and quantities, but the allocation function was over-ridden by the VER and its implication, given Z, for sales X_B . Thus the quarters 1977:3 to 1981:2 had to be removed from the estimation of equation (21).^{9/} The set of instrumental variables included the exogenous variables used in (21) and (22). The initial estimates of (22) were highly unstable: the serial correlation coefficients fluctuated around unity and consequently the resolution on the constant terms β_0^i was very weak. The only solution appeared to be to estimate the demand equations in first difference form, dropping the constants. Table 1 reports these results as model I.

The most striking feature of model I is its strong positive estimate of γ_{AB} : given total exports the share allocated to market A rises strongly as their relative price rises. This result is sufficient to indicate negative spillovers between markets -- i.e. that $G_{AB} > 0$ -- and consequently that both "domino diversion" and "industry contraction" occur, albeit the latter via an indirect route. The elasticity of the USA share of exports with respect to its price implied by the estimate is about 3.5 in 1976/7; that is, holding total exports constant, a 1% increase in the price available in the USA would have increased exports to the USA by 3.5%.

On the demand side, the results indicate that the USA's demand for Taiwanese footwear is insensitive to the state of the business cycle and appears to be related only to local footwear prices rather than to those of competing suppliers from Korea. The price is, however, negatively related to the quantity of exports with an elasticity of about -14 evaluated at the mean levels of exports and prices in the year prior to the OMA (1976:3 - 1977:2).^{10/} The demand in the rest of the world seems to be fairly strongly influenced by the state of demand (prices rise with the cycle),

**Table 1: ESTIMATES OF SUPPLY AND DEMAND FUNCTIONS
FOR TAIWANESE FOOTWEAR**

	Model I <u>a/</u>		Model II <u>b/</u>	
γ_{AA}	-4.67	(1.81)	-	
γ_{AB}	4.31	(2.14)	1.32	(0.90)
γ_{AZ}	-		0.49	(0.19)
γ_{BB}	-		-	
γ_{BZ}	-		-0.05	0.09
ρ	0.87	(0.12)	1.00	(-)
β_1^A	0.0003	(0.0094)	0.0010	(0.0080)
β_2^A	-0.0016	(0.0018)	0.0009	(0.0012)
β_3^A	-0.308	(0.366)	-0.087	(0.242)
β_1^B	0.0389	(0.0564)	-0.0031	(0.0519)
β_2^B	0.0108	(0.0130)	0.0073	(0.0103)
β_3^B	0.5941	(0.171)	0.625	(0.147)
<u>R²/DW</u>				
X_A	0.903	1.93	0.964	1.89
X_B	-	-	0.958	2.06
P_A	0.985	1.86	0.988	2.08
P_B	0.955	2.46	0.965	2.52

Notes:

a/ See text and equation (22).

b/ See text and equations (19) and (20).

and to be related to the prices of both local footwear and competitive footwear from Korea. The positive term on exports is very fragile, depending on the dynamics of the equation system, it is best interpreted as indicating a horizontal demand curve rather than a perverse one. Thus comparing the USA market in which Taiwan is an important supplier with the world market in which it is less so we find a lower elasticity of demand (-14 vs. - ∞) and less direct competition for Korea. This seems intuitively plausible. Omitting the two implausible coefficients (β_3^A and β_2^B) has little effect on the other parameters except for increasing absolutely γ_{AA} and γ_{AB} by about 0.25. Finally, the R^2 and Durbin-Watson statistics are acceptable.

The second estimation exercise attempts to incorporate the size of the industry into the system of estimating equations. As argued above, this is most easily accomplished by means of the profit function. Thus in addition to the two demand curves (22), we attempted to estimate three supply functions: equations (19) for $i = A, B$ and (20) for $i=B$. Equations (19) rule during periods of free trade and equations (20) during the OMA. The factor demand equation, (19) with $i=Z$, is not estimable because no data exist on factor inputs, but with the exception of γ_{ZZ} , its parameters are recoverable from the other equations by symmetry. If the stochastic behaviour of the supply model is unaffected by the OMA, the error structure of (20) is derivable from that of (19). 11/ However, it would be exceedingly complex to do this, as Winters and Brenton (1988) have shown using other functional forms, so it seemed most rational to treat (20) as a separate equation with its own stochastic errors.

We approached the incorporation of supply responses with great trepidation. The factor price data necessary for equations (19) are available only on ISIC rather than on SITC commodity classifications and

refer only to wages. Data were also available to us only annually for the earlier part of our sample, and thus had to be interpolated into quarterly series. Moreover, it is possible that wages are endogenous. Hence, wages have to be instrumented in our estimation procedure. For instruments, we used employment and wages in the whole of Taiwanese manufacturing. Thus, one should not place great reliance on the results of the expanded estimation.

The results of the full estimation are reported as model II of table 1. As previously, severe serial correlation suggested that working in first differences was a necessary simplification, but this time it affected all equations. This made it impossible to estimate the constants of the supply functions which, in turn, meant that (20) was inestimable. Thus our final system comprised four rather than five equations. The estimates of the demand functions are even less well defined in model II than in model I; the only notable change is that the coefficient relating prices to the quantities of exports in the USA is insignificantly positive. As before, we interpret this as indicating a horizontal not an upward-sloping demand curve.

Turning to the supply responses, we find them reduced by the inclusion of factor prices. For sales to the USA -- the major market -- both terms are positive: exports to the USA depend positively on their price relative to the prices of both sales elsewhere and factor inputs. The implied arc elasticity of supply is around 3.1 in 1977. The coefficients on relative prices for exports to the rest of the world are positive relative to the price of USA sales but just negative relative to factor inputs. The latter sign implies implausible behaviour at some sets of prices, but does not disturb the signs of the elasticities at the prices

experienced over our sample period. The own price elasticity of supply for exports to the rest of the world is about 1.0 in 1977, but grows to 1.5 by 1986.

The results for model II are disappointing in their lack of precision. However, they do suggest that important supply responses exist and that a more detailed study with better data would be rewarding. They also suggest that responses are around the levels suggesting that it is fruitful to study the effects of VERs on resource allocation and welfare. Thus, until firmer empirical work is undertaken, we take the estimates here as bases from which to explore the effects of different elasticity assumptions on the costs of VERs to developing country exporters.

IV. WELFARE AND DISTRIBUTIONAL EFFECTS OF VERs: SOME ILLUSTRATIVE SIMULATIONS.

The econometric estimates in section 3 for Taiwanese leather footwear exports suggest that factor demand and output supply responsiveness are sufficient to produce "domino diversion" towards unrestricted markets and industry contraction. However, both because we were unable to estimate precisely all the demand and supply parameters, and because our estimates are not representative of those in other sectors subject to VERs, we complete the analysis with some counterfactual simulations inspired by our earlier results. We loosely base these simulations on Taiwanese leather footwear exports to the USA and to the ROW using volume and price data at the eve of the OMA agreement. The simulations are drawn by applying elasticities to the partial equilibrium model developed in section 2. The notation is the same, and the set of equations describing output demand and factor supply responses (constant

elasticity demand curves and constant elasticity supply for the factor of production) are detailed in the appendix along with the calibration procedure. The output supply and factor demand functions are modelled with the generalized Leontief form, but they are expressed below in terms of elasticities for the sake of intuitive transparency.

The results of simulations under different assumptions about demand and supply elasticities are reported in table 1. All simulations refer to a negotiated 10 percent cut in exports of Taiwanese leather footwear to the USA. The objective of the simulations is to establish how sensitive the results are to systematic variations in demand and supply elasticities. At this stage, we assume that the footwear industry is small in the market for its factor Z , so that P_Z , the price of the factor is fixed.

In all the simulations, we rely on pairwise variations in the parameters of the Generalized Leontief production function. For all pairwise variations, the conditions for local concavity of the profit function (i.e. $\gamma_{ij} > 0$) are met, as suggested by our econometric estimates. At this stage, all simulations assume identical pairwise supply and demand elasticities, since we have no a priori ground for presuming that supply elasticities to restricted and unrestricted markets should be different or for presuming that export demand elasticities should be different (unless market shares in the restricted and unrestricted markets are radically different).

As was established in section 2, the simulations in columns 1 to 3 show that the spillover is an increasing function of export demand elasticities. The results of varying export demand elasticities also show that, other things equal, the rent transfer gain decreases as the size of

**Table 2: SENSITIVITY RESULTS TO ELASTICITY SPECIFICATION (SMALL INDUSTRY CASE)
(10% REDUCTION IN EXPORTS TO RESTRICTED MARKET) ^{a/}**

Elasticities\Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Factor demand elasticity ϵ_2^d ^{b/}	-1	-1	-1	-1/4	-1/4	-1/4	-2	-2	-2
Output supply elasticities $\epsilon_A^s = \epsilon_B^s$ ^{c/}	2	2	2	1/2	1/2	1/2	4	4	4
Export demand elasticities $\epsilon_A^d = \epsilon_B^d$	1/2	2	4	1/2	2	4	1/2	2	4
Exports to unrestricted market (% change)	0.016	0.036	0.046	0.034	0.049	0.053	0.009	0.026	0.036
Factor use (% change)	-0.063	-0.045	-0.041	-0.041	-0.036	-0.034	-0.056	-0.05	-0.045
Change in profits ^{d/}	7.954	1.452	0.592	6.702	0.989	0.259	8.375	1.649	0.708
Change in "virtual" profits ^{e/}	-3.287	-2.709	-2.428	-9.699	-7.997	-7.541	-1.778	-1.540	-1.381

^{a/} Initial values $P_A = 1.54$; $X_A = 27.5$; $P_B = 1.25$; $X_B = 22.0$. Small industry case, i.e. P_Z fixed.

^{b/} Holding output prices constant.

^{c/} Holding P_Z constant.

^{d/} Initial profits equal to zero. Change in sales revenue minus change in value of factor inputs.

^{e/} Initial profits equal to zero. Restricted profits evaluated at virtual prices.

the spillover increases. This is because with more spillover there is less contraction which in turn reduces industry profits.

More interesting are the results of varying factor demand and output supply elasticities. Raising output supply response alone increases the spillover and hence reduces profit to the industry as there is less contraction. This negative effect on industry profits is offset if the elasticity of demand for the factor of production is raised. Doubling the elasticity of factor demand approximately halves the size of the spillover effect. Holding export demand elasticities constant, doubling all production function elasticities (col. 3 to col. 9) reduces the spillover effect by about 50 percent and increases marginally the amount of contraction and hence profits.

As we saw in section 2 and in figure 1, as a result of the VER $MR^A = 0$ while MR^B is unaffected. Breaking the equality of marginal revenues of the industry factor between sales to the restricted and unrestricted markets creates an inefficiency. A measure of that inefficiency is provided by industry profits evaluated at "virtual" profits. Virtual prices are the set of prices which would cause actual quantities to be supplied voluntarily - i.e., the set of prices which, with maximizing behaviour, would support the observed quantity outcome. Given such prices, "virtual" profits are the maximum that exporters could earn and thus represent the efficiency losses that the VER imposes. In the absence of the VER, actual profits equal virtual profits, both being equal to zero. As can be seen from the last row of table 2, virtual profits are more negative - i.e. efficiency losses are greater - the lower demand and supply elasticities.

In practice, however, industries that enter into VERs are not small in their domestic economy. Indeed, it is precisely because these industries have been rapidly gaining market shares in developed-country markets, that VER arrangements are negotiated in the first place. In table 3, therefore, we report on allocation and welfare effects of the same VER reduction as for three sets of elasticities selected from table 2, but now recognizing that the industry faces an upward sloping supply curve for its factor, Z, so that contraction is accompanied by a fall in the wage of the industry factor, P_z . Because the share of the industry in the market for Z is likely to vary from case to case, we report welfare effects for different assumptions about the size of the industry in the factor market. Welfare calculations are reported in the bottom of table 3 as a percentage of the income of factors in the industry prior to the VER and for factor market sizes ranging from 1 to 20 times the initial allocation of factors in the industry. Of course, the elasticity of factor supply to the industry is not independent of its size in the market for factors so that the welfare estimate grid should be interpreted accordingly with high values of the elasticity of factor supply corresponding to cases where the industry is small in the market for its factors. For example, elasticities of factor supply in the range between 1 and 5 and factor market sizes in the range between 1 and 5 times the initial factor allocation, could be taken as representative for analyzing a VER in textiles. On the other hand, for a smaller industry like footwear, a more likely factor supply elasticity range would be between 5 and 10 with a correspondingly higher range for the size of the factor market in relation to the footwear industry.

Table 3: DISTRIBUTIONAL AND WELFARE EFFECTS OF A VER

Elasticities	Factor Supply Elasticity = 1			Factor Supply Elasticity = 5			Factor Supply Elasticity = 10			Factor Supply Elasticity = ∞		
	Low g/	Medium b/	High s/	Low g/	Medium b/	High s/	Low g/	Medium b/	High s/	Low g/	Medium b/	High s/
Exports to unrestricted markets (% change)	0.042	0.065	0.084	0.036	0.043	0.051	0.035	0.040	0.044	0.049	0.036	0.038
Factor use (% change)	-0.036	-0.033	-0.027	-0.041	-0.042	-0.040	-0.041	-0.043	-0.043	-0.036	-0.045	-0.045
Factor price (% change)	-0.038	-0.033	-0.027	-0.008	-0.009	-0.008	-0.004	-0.004	-0.004	0.0	0.0	0.0
Change in profits	8.849	3.302	2.198	7.168	1.924	1.156	8.936	1.696	0.947	0.987	1.452	0.708
Change in virtual profits	-8.451	-1.775	-0.647	-9.429	-2.472	-1.162	-9.563	-2.566	-1.265	-7.997	-2.709	-1.381
Change in welfare d/	(1) 0.088	0.014	0.005	0.094	0.019	0.008	0.095	0.020	0.009	0.0	0.0	0.0
	(5) -0.065	-0.120	-0.103	0.061	-0.015	-0.024	0.078	0.002	-0.008	0.0	0.0	0.0
	(10) -0.257	-0.287	-0.237	0.020	-0.058	-0.065	0.057	-0.020	-0.030	0.0	0.0	0.0
	(20) -0.641	-0.621	-0.508	-0.063	-0.143	-0.148	0.015	-0.064	-0.073	0.0	0.0	0.0

Notes:

g/ Same elasticities as table 3, column 3.

b/ Same elasticities as table 3, column 2.

s/ Same elasticities as table 3, column 9.

d/ Numbers in parentheses refer to factor market size in relation to initial factor allocation in the industry. Change in welfare calculated from equation (54) and expressed as a percentage of initial factor income in the industry before the VER.

With wage flexibility the distributional effects of a VER are more pronounced than earlier. Industry profits rise relatively more as they shed factors and use remaining factors at a lower wage. Taking the medium elasticity scenario as a reference, with an industry factor supply elasticity of 5, profits rise by 30 percent more than in the case of infinite supply elasticity, and industry wages fall by one percent. In addition to producing re-deployment, a VER raises profits and lowers wages. Thus it has a strong adverse effect on the distribution of income.

The harmful effects of a VER, however, are not confined to the adverse distributional shifts arising from higher profits, lower wages and lower factor use. In addition, as can be seen from the grid of welfare changes displayed in the bottom of table 3, for most factor market sizes and for factor supply elasticities of below 10, the VER results in a net welfare loss. For example, with medium elasticities as a reference, a VER reducing exports to the restricted market by 10 percent would lead to a welfare loss of 12 percent of factor income (prior to the VER) for a factor supply elasticity of 1 and a factor market 5 times the size of the initial factor allocation in the industry. Of course, higher factor supply elasticities mitigate the welfare loss and so would differential export demand elasticities (with relatively lower demand elasticities in the restricted market). However, the results in the bottom of table 3 suggest that for most plausible elasticity configurations, a VER is more likely than not to reduce national welfare in the exporting country.

6. Conclusions

The bulk of the economic literature gives the impression that VERs are not very harmful for the exporting country. Most work on the subject has focused on establishing the welfare loss to the importing country

arising from the conjunction of an income transfer loss and a distortionary efficiency loss. Implicit in that work is that the exporting country is likely to receive adequate compensation for any induced inefficiency losses through the often large rent transfer.

This paper has argued that this view is misconceived. A fairly general theoretical model of the industry subject to the VER shows that a VER is likely to lead to both industry contraction and spillover to unrestricted export markets. We call spillover "domino diversion" since it lends support to the preoccupation of countries that have not negotiated VERs with seeing their markets flooded by sales diverted from the restricted markets. Our econometric estimates for Taiwanese leather footwear exports to the USA lend support to the fairly general conditions under which spillover and industry contraction will occur, namely that with rising marginal costs in the production of sales to both restricted and unrestricted markets, any increase in the output of one product does not reduce much (or increases) the marginal cost of the other product.

We also establish that unless there are very strong interactions in production between the products sold to the restricted and unrestricted markets, a VER will lead to industry contraction, rising private profits (because of the rent transfer from abroad), and a lower wage for the factors employed in the industry, especially those with skills with few alternative uses in other industries. Thus VERs have strongly negative distributional implications for exporting countries as profits rise and wages and employment fall. Finally, illustrative simulations show that for a plausible range of elasticities and relative sizes of the restricted industry, national welfare may well fall in spite of the rent transfer from abroad.

Notes

- 1/ See e.g. Greenaway and Hindley (1985), Tarr and Morkre (1984), and Feenstra (1984).
- 2/ The assumption that all output is exported simplifies the welfare analysis since only producer surplus need be considered. In the following, we assume that society's objective function is merely to maximize industry profits. This assumption is relaxed below.
- 3/ The second order conditions for profit maximization require that either or both $(G_{BB}/G_B - G_{BA}/G_A)$ or $(G_{AA}/G_A - G_{AB}/G_B)$ be positive. Thus the numerator of (11) is unlikely to become positive.
- 4/ A restriction of the diagram is that marginal costs for the two products are unrelated - i.e. $G_{AB} = 0$. If that were not true, the location of MR_A would depend on Z^B , etc.
- 5/ This case is not the same as assuming that the industry size is fixed, i.e. that $dZ=0$. The case considered here is less likely to show the VER as harmful because it allows for the factors initially employed in footwear to find useful employment elsewhere in the economy albeit at a lower wage.
- 6/ The allocation component essentially compares the marginal revenues $(1+\epsilon_I^{-1})$ available to factors in different markets. If it is higher in other industries than in footwear, diversion to the former is beneficial.
- 7/ We assume that all output is exported and that the exports to the rest of the world are not constrained.
- 8/ The exogenous data plus time and seasonal dummies were used as instruments. Data sources and data manipulation to obtain a quarterly wage series are described in the appendix.
- 9/ When the serial correlation adjustment was made, 1981:3 also had to be dropped because no unrestricted lagged value of X_A was available from 1981:2. For the omitted quarter, actual values of X_A and X_B were used in equation (22) because they were the exogenous.
- 10/ Our estimate of the US price elasticity of demand for Taiwanese footwear may appear on the high side. For example, Aw (1989) reports an average price elasticity of demand of about 3.0, a result higher than previous global estimates (Szenberg et al. 1977).
- 11/ The term $(X_A + \gamma_{AA})$ in (20) will become $(X_A + \gamma_{AA} - u_A)$ where u_A is an error term distributed identically throughout our sample period.
- 12/ For evidence that wages and output fall (relative to industry trends) in the case of VERs on Korean footwear exports, see de Melo and Winters (1989).

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Appendix:A1. Data Sources for Econometric Estimates

Exports and export unit values:	Foreign Trade of China, Taiwan Province CCN 6402; pairs and US\$ per pair
Korean export unit values:	Korean Customs data - see de Melo and Winters (1989) for details
Domestic prices/unit values:	US: Bureau of Census Current Industrial Report non-rubber footwear RoW: British Footwear Manufacturers Federation, UK domestic production unit value and I.F.S. average exchange rate (rf)
Indices of industrial production:	} I.F.S. RoW = OECD less USA weighted by GDP weights
Wholesale prices:	
Exchange rate:	
Wages and unemployment:	Yearbook of Labor Statistics, Republic of China wages and employment in leather footwear and average exchange rate

All data were quarterly except for Taiwanese wages and employment for which only annual data were available consistent form. These were interpolated into quarterly series as follows.

We assume each series grows by a constant amount throughout each year. Thus in any year:

$$q_{tj} = x_t + (j - 2.5) y_t \quad j=1\dots 4; t=1\dots n$$

where q_{tj} is the observation for quarter j year t
 x_t is the annual observation
 y_t is the quarterly growth in year t

Observation x_t is centered between quarters 2 and 3 and q_{tj} at the centers of their respective quarters.

In addition, there is a requirement that the continuous function represented by x connect at the end of each year and at the beginning of the next. Thus

$$x_t + 2y_t = x_{t+1} - 2y_{t+1}$$

from which

$$2y_t + 2y_{t+1} = x_{t+1} - x_t = \Delta x_{t+1}$$

Writing this in matrix form yields:

$$(A1) \quad \begin{bmatrix} 2 & 0 & \dots & \dots & 0 \\ 2 & 2 & 0 & \dots & 0 \\ 0 & 2 & 2 & 0 & \dots & 0 \\ \cdot & & & & & \cdot \\ \cdot & & & & & \cdot \\ \cdot & & & & & \cdot \\ 0 & \dots & 0 & 2 & 2 \end{bmatrix} \begin{bmatrix} y \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} = \begin{bmatrix} d \\ \Delta x \\ \cdot \\ \cdot \\ \cdot \\ \cdot \end{bmatrix}$$

where d is an arbitrary starting condition.

(A.1) is solvable once d is known and we choose d to minimize the variance in growth rates - i.e. we choose to make the quarterly series q_{tj} as smooth as possible.

Minimizing $y'y$ w.r.t. d yields:

$$d = - \left[\sum_{t=2}^n \Delta x_t (m_{t1} + m_{1t}) \right] / 2m_{11}$$

where m_{ij} is an element of M , and $M=N'N$, where N is the matrix in (A.1).

A2. Simulation Model

The results in section 4 are based on simulations calibrated to volumes and unit values of Taiwanese leather footwear exports at the eve of the OMA. The simulations are based on solutions derived from the equations system below. Subscripts k , $k \in A, B$ refers to the demands in the restricted and unrestricted markets respectively. Subscripts i and j , $i, j \in A, B, Z$ refer to the two outputs and the single composite input Z , in the Generalized Leontief production function which describes technology. Bars

over a variable indicate an exogenous parameter, stars denote the initial unconstrained equilibrium, and a tilde over a variable, \sim , refers to the prices at which unconstrained producers would replicate the input and output allocation decisions imposed on them by binding constraints in the relevant market.

$$(A2) \quad X_k = \bar{A}_k P_k^{-e_k} \quad ; \quad e_k > 0 \quad ; \quad k \in A, B$$

$$(A3) \quad X_3 = Z = \bar{A}_z \tilde{P}_z^{e_z} \quad ; \quad \tilde{P}_z = \tilde{P}_3 \quad ; \quad e_z > 0$$

$$(A4) \quad X_i = -\gamma_{ii} - \sum_{j \neq i}^3 \gamma_{ij} (\tilde{P}_j / \tilde{P}_i)^{1/2} \quad ; \quad i, j \in A, B, Z$$

$$(A5) \quad \tilde{P}_A < P_A \quad \text{where} \quad X_A < X_A^*$$

Equations (A2) and (A3) describe the output demand and factor supply curves facing the all-around price-taking firms in the industry subject to the VER. Equation (A4) is obtained from applying Sheppard's lemma to the generalized Leontief restricted profit function

$$(A5) \quad \pi(P; a) = K \left[\sum_{i=1}^3 \sum_{j=1}^3 \gamma_{ij} ((-\tilde{P}_i \tilde{P}_j)^{1/2}) \right]$$

where K is a fixed factor (not modelled) which ensures a determinate firm size. Equation (A6) states that when export volumes in the restricted market are below their free trade values, the price \tilde{P}_A at which unconstrained suppliers would have voluntarily applied the restricted quantity X_A is less than the premium-ridden price at which sales are actually made,

i.e. $P_A > P_A^* > \tilde{P}_A$ where P_A^* is the free trade price in the restricted market.

Industry profits, π , is the difference between sales revenues and costs, both evaluated at the VER-ridden prices, whereas "virtual" profits given by (A6) are evaluated at virtual prices \tilde{P} . The welfare measure is:

$$(A7) \quad \Delta W = W_1 - W^* = (\Delta\pi + \Delta P_2 L) / P_2^* Z^*$$

where L is a scalar indicating the size of the industry in the market for Z .

The elasticities in tables 2 and 3 are used to calibrate the parameters γ_{ij} appearing in the factor demand equations (A3). Calibration is completed by treating parametrically initial price and quantity data and by choosing an initial parametric value for Z so that profits are initially equal to zero.

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