

Cross Section Estimation of the Effects of Trade Barriers

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ABSTRACT

Most analyses of trade patterns have been done either on a country-by-country basis using the industry as the unit of observation or on a commodity-by-commodity basis using the country as the unit of observation. The estimation of the effects of trade barriers seems most naturally done for each commodity separately on the implicit assumption that the effect of a barrier on trade of a commodity in one country is likely to be similar to the effect of a similar barrier on a similar commodity in a different country. Pooling across commodities, on the other hand, seems to require the doubtful assumption that similar barriers applied to different commodities will have similar effects. Data sets, however, are usually very brief in terms of countries but very extensive in terms of commodities. These data therefore force us to pool across commodities.

A carefully formulated theory ought to serve as a foundation for the pooling of data across commodities. A central message of this paper is that both the even and the uneven general equilibrium trade models tend to discourage the pooling of data across commodities. Nonetheless, an example of a simple cross commodity study of the effects of tariffs is presented. The discovery of a negative relationship between barriers and trade performance increases concerns about the importance of the reverse relationship that trade barriers are put in place in response to undesirable trade performance.

CROSS SECTION ESTIMATES OF THE EFFECTS OF TRADE BARRIERS

by Edward E. Leamer*

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Preliminary, not for quotation

We scrutinize our organized private charities to assure that there is a minimum of administrative waste and that our contributions are reasonably well targeted on needy groups. Government charitable activities should receive the same degree of scrutiny, but they rarely do. Trade barriers are a good example. The primary purpose of trade barriers is to redistribute income from a broad class of consumers to a narrower class of producers (including workers), but we know next to nothing about the income redistribution that they induce. We typically don't know who the donors are, how much is donated, who the recipients are, how much is received, and how much is administrative waste.

Our lack of knowledge is particularly severe in the case of nontariff barriers. Tariffs have relatively clear primary effects on product prices and arguable secondary effects on employment, earnings, profits, consumer welfare, etc. Nontariff barriers, on the other hand, have quite unclear effects on product prices, and largely unknown secondary effects. For those of us who suspect that we are the donors as a result of the government's largesse, and possibly even for the recipients, the apparent increase in nontariff barriers is cause for concern. Indeed it may be conjectured that the primary reason for nontariff barriers is precisely that their redistributive effects can only be guessed, and the uncertainty diffuses the political response that would be made to tariffs that effected an equivalent redistribution of income.

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Measures of the redistributive effects of tariffs must be based on on elasticities of demand for the product disaggregated by subpopulation and on the elasticities of the supply of factors. The evaluation of nontariff barriers requires in addition some measure of tariff equivalents. The informational requirements are clearly very great.

These substantial informational requirements can be met in several different ways. The kind of econometric exercise discussed in this paper involves a relatively limited amount of information about differences among commodities. The effects of trade barriers are inferred from data on trade and trade barriers. An alternative that is similar in spirit but somewhat indirect links external product prices with internal variables, an example being Chipman's (**) extensive studies of the Stolper-Samuelson mappings of external prices into internal prices for Germany. The estimate of the effect of a trade barrier is then indirect since some method is needed to predict the effect of the barrier on product prices. Another kind of empirical approach is a case study involving a great amount of detailed information about the commodity being studied. A distinctly different approach is "simulation", particularly general equilibrium simulation. Of course the "empirical" approaches also involve simulation in the sense of studying from estimated relationships what would have happened if trade barriers were different. And the general equilibrium simulations are also partly empirical since the models are ordinarily calibrated using actual data. The word "simulation" as an approach to the study of trade barriers is really a euphemism for an exercise that emphasizes computational aspects of the simulation, possibly at the expense of empirical validity.

Each of these approaches is worth pursuing, though each has its drawbacks. A "simulation" exercise may have little empirical validity, and it is difficult to offer very convincing arguments that the simulations represent the actual effects of trade barriers. I always have thought it odd that in a partial equilibrium mode, it is quite rare to find "simulation" exercises. To give a silly example, if we wanted to know the elasticity of demand for automobiles, we would not begin by assuming the utility function to be Cobb-Douglas and then discover by "simulation" that the elasticity is "close" to one. Why, I ask rhetorically, are "simulations" so common in general equilibrium mode when, if anything, assumptions such as the existence of instantaneously clearing competitive markets become both more important and more suspect?

Empirical studies also have shortcomings including their need for incredible assumptions. Studies that deemphasize differences in commodities, such as the kind discussed in this paper, run major risks of attributing features of a data set to trade barriers that might better be attributed to commodity differences. Case studies, on the other hand, can be said to involve a single degree of freedom. The question is whether a story woven around the facts of a particular case is compelling and applicable to other cases.

An econometric study of the relationships among trade barriers and other variables such as trade, employment and earnings is certainly worth doing, though there are four important problems that limit the confidence that we can have in the results. First of all the data sets are very thin in the country and time dimensions but very thick in terms of commodities. There is accordingly a need to pool across commodities,

though as I will argue this can be done only with a great deal of discomfort. A second problem is simultaneity since barriers are often put in place in response to trade performance. A third problem is the incomplete measurement of trade barriers which may lead to erroneous estimates if the unobserved barriers are systematically related to the observed barriers. It is possible, for example, that a whole array of barriers are put in place simultaneously, in which case unmeasured barriers would be positively correlated with measured barriers. Alternatively, barriers may be substitutes for each other in the political arena, and the measured barriers may be negatively correlated with unobserved barriers. A fourth problem is that expectations of the permanence of a barrier may have a major effect on the responses that are made. In this paper, I will concentrate the discussion on the first of these problems: pooling across commodity classes.

The data sets that are generally available on trade barriers are very thin in terms of years, rather thin in terms of countries (no more than twenty advanced developed countries), but quite wide in terms of commodities. Because of the thinness of the data set, neither intertemporal nor cross country comparisons are likely to yield very sharp estimates of the effects of trade barriers. Cross commodity comparisons might yield estimates that are sharp in a statistical sense, but not especially credible unless there is clear theoretical support for cross-commodity pooling of the data. In particular, we need to decide how properly to control for the commodity effects.

The proper way to control for the country, commodity and intertemporal effects can be decided only within the context of a carefully formulated theoretical model. In this paper I consider two

alternative models. The model that seems most natural is the usual general equilibrium model with constant returns to scale and equal numbers of factors and goods. A central point of this paper is that this even model strongly discourages the pooling of data across commodities. And the alternative of the uneven model does little to help the situation. No attempt is made here to consider other assumptions such as increasing returns to scale and/or adjustment costs. Cline(****) is a source ****.

The central conclusion of this paper is that a cross commodity study of trade barriers must rest on a very murky foundation, but we might as well make do with what we have. Accordingly, I report here a somewhat simplistic, somewhat *ad hoc* empirical study of the effects of tariffs in 1978. The study of this data set makes me more concerned about the simultaneity problem: barriers are put in place in response to trade results.

II.A THE EVEN GENERAL EQUILIBRIUM MODEL

A particularly convenient model of the determinants of production and trade is the traditional general equilibrium model with constant returns-to-scale, equal numbers of goods and factors, and with sufficient similarities in factor endowments that countries are all in the same cone of diversification.

The production side of the model can be summarized by the system of equations:

$$Q = A^{-1} V \quad (1)$$

$$w = A'^{-1} p \quad (2)$$

$$A = A(w, t) \quad (3)$$

where Q is the vector of outputs, V is the vector of factor supplies, A is the input-output matrix with elements equal to the amount of a factor used to produce a unit of a good, p is the vector of (internal) commodity prices, and w is the vector of factor returns. Equation (1), which translates factor supplies V into outputs Q , is the inverted form of the factor market equilibrium condition which equates the supply of factors V to the demand for factors AQ . Equation (2), which translates product prices into factor prices, is the inverted form of the zero profit condition which equates product prices p to production costs $A'w$. Equation (3) expresses the dependence of input intensities on factor prices w and on the state of technology t , $A(w, t)$ being the cost minimizing choice of input intensities at time t .

The responsiveness of outputs to changes in product prices is implicit in Equation(3) which identifies the sensitivity of input mixes A to changes in factor prices w . Two explicit assumptions are considered below: the Leontief assumption of a fixed input intensities matrix A ,

and the Cobb-Douglas assumption of fixed budget shares. Both are chosen for convenience with little loss in content of the general discussion. Also for convenience, I use a system of demand implied by a log-linear (Cobb-Douglas) utility function. Maximization of this utility function subject to a budget constraint implies constant expenditure shares. Then the consumption vector satisfies the relations

$$p_c C_c = \alpha_c y \quad (4)$$

where C_c is consumption of commodity c , p_c is the internal (tariff inclusive) price, α_c is the expenditure share, and y is total expenditure. In words, the value of consumption is equal to the consumption share times total expenditure. Then using the identity that trade is the difference between production and consumption, we can solve for the trade equations as:

$$T = A^{-1} V - P^{-1} \alpha y. \quad (5)$$

For purposes of discussion, let us proceed as if all barriers amount to a tax on the international exchange of goods at a preset *ad valorem* rate. These taxes will conveniently be called "tariffs", though I have in mind a wider set of trade impediments. The level of a tariff on commodity c will be denoted by τ_c and the corresponding external price by π_c . Then the internal price of the commodity is

$$p_c = \pi_c (1 + \tau_c).$$

Premultiplying the trade vector by the external prices π and imposing the trade balance condition $0 = \pi' T$, we can calculate the expenditure level:¹

$$y = (\pi' A^{-1} V) / (\pi' P^{-1} \alpha) = \text{GNP} (1 + \tau.), \quad (6)$$

¹ Here I am assuming that the tariff proceeds are redistributed in a lump-sum or that the government utility function conforms with the private sector.

where GNP is the value of output at world prices $\pi'A^{-1}V$, and $\tau.$ is an index of the average level of trade barriers:

$$(1+\tau.) = (\sum \alpha_c / (1+\tau_c))^{-1}.$$

This model leaves unspecified certain details of the structure of world demand and supply that would determine international product prices. These prices may change in response to changes in technology, shifts in world trade barriers, or world-wide growth of factor supplies. Policy analysis and econometric estimation which take international product prices as exogenous will nonetheless be appropriate provided that countries are small enough that internal events such as the imposition of trade barriers have no noticeable effects on international prices.

In order to study in detail the effects of tariffs, we need now to be explicit about the substitutability of inputs in production, and therefore to be explicit about the responsiveness of output to changes in tariffs. Two assumptions are considered here: fixed input-output coefficients and fixed value shares.

Fixed input intensities

Assume initially that the input intensities are technologically fixed, which means that (3) can be replaced by

$$A = A(t) \quad (3')$$

The factor market equilibrium condition (1) implies that for fixed supplies of factors V , tariffs can have an impact on the level of production only to the extent that the tariffs induce changes in the input intensity matrix A . Thus the assumption of fixed input intensities implies that the imposition of tariffs leaves production levels

unchanged and has an impact on trade entirely through the consumption effect.

The model consisting of relationships (1), (2), (3'), (4), (5) and (6) will henceforth be referred to as Model L, suggesting the Leontief assumption of a fixed input-output matrix.

Variable input intensities

If input intensities are not fixed, there will also be an effect of tariffs on the production of commodities. Log-linearity is a convenient assumption for production functions as well as utility functions. Cobb-Douglas (log-linear) production functions and cost minimization imply fixed factor shares at a point in time: $\theta_{fct} = w_{ft} A_{fct} / p_{ct}$ where θ_{fct} is a technologically fixed parameter. In matrix form this becomes

$$\theta = W A P^{-1}, \quad (3'')$$

where θ is a matrix of technologically fixed factor shares and where notation indicating the dependence of all of the variables on time is suppressed. Substituting this into (1) yields the production relationships

$$\theta P Q = W V. \quad (1'')$$

In words, the product of the value of output PQ times the input share θ is equal to the value of the input WV .

The Stolper-Samuelson mapping of commodity prices into factor prices given this Cobb-Douglas technology can be found by substituting the cost minimization condition $\theta_{fct}/w_f = V_{fc}$ into the unit value isoquants in logarithmic form:

$$0 = \ln(p_c) + \ln(\alpha_c) + \sum_f \theta_{cf} \ln(V_{fc}), \quad c = 1, 2, \dots,$$

to obtain the system in matrix form:

$$\theta' \ln(w) = \ln(p) + \ln(k) \quad (2'')$$

where $\ln(w)$ is a vector of logarithms of factor returns, $\ln(p)$ is a vector of logarithms of prices, and $\ln(k)$ is a vector of constants. In a more direct notation, the return to factor f as a function of the product prices can be written as:

$$w_f = \prod_c (k_c p_c)^{\theta^{cf}}$$

where θ^{cf} is the (c, f) element of the inverse of θ . Under these assumptions the trade vector becomes

$$T = P^{-1} \theta^{-1} W V - P^{-1} \alpha y \quad (5'')$$

where the internal factor prices W are functions of the product prices according to the log-linear relationship (2''). In words, the level of imports evaluated at internal prices is a linear function of factor supplies evaluated at internal prices and an index of internal prices. Finally, because of the distorting effects of tariffs on the value of GNP, the level of expenditure becomes:

$$y = (\pi' P^{-1} \theta^{-1} W V) / (\pi' P^{-1} \alpha) = \text{GNP} (1 + \tau) \quad (6'')$$

The model summarized by the relationships (1''), (2''), (3''), (4''), (5'') and (6'') will be called Model C, suggesting Cobb-Douglas production functions.

II.B Data Analysis with the Even General Equilibrium Model

Models L and C are very simple general equilibrium models that describe the variability of trade (or output levels) across countries, commodities and time. These models define precise linkages among trade, factor supplies, tastes and technologies. When one or more of these sets of variables are unobservable, or treated as such, the models allow us to make inferences about the unobserved variables from the observed

variables. In principle, by observing the variability of output or trade across countries, we should be able to infer unobserved features of the model that are assumed constant across countries: technology and tastes. And, by observing the variability of output or trade across commodities, we should be able to infer unobserved features of the model that are assumed constant across commodities: factor supplies.

To be more explicit, we can write out the exact form of the trade equations implied by the two models with commodity units selected such that all external prices are one $\pi = 1$.

Model L:

$$T_{ci} = \sum_f A^{cf} V_{fi} - \alpha_c [\sum_f (\omega_f V_{fi})] (1+r_{.i}) / (1+r_{ci}), \quad (7)$$

where i is the country subscript, A^{cf} is the (c,f) element of A^{-1} , and ω_f is the return to the factor if there were no trade impediments, $\omega = A'^{-1}\pi$.

Model C:

$$T_{ci} = \sum_f \theta^{cf} w_f V_{fi} / (1+r_{ci}) - \alpha_c GNP_i (1+r_{.i}) / (1+r_{ci}) \quad (8)$$

where $GNP_i = [\sum_c \sum_f \theta^{cf} w_f V_{fi} / (1+r_{ci})]$

and $w_f = \{ \Pi (k_j [1+r_{ji}]^{\theta^{jf}}) \}$

and where θ^{cf} is the (c,f) element of the inverse of the factor shares matrix θ .

These equations can be estimated for each commodity, using data from different countries, and inferring the variables that do not have a country subscript: A^{cf} , α_c , ω_f , θ^{cf} , and w_f . Or the equations can be estimated for each country, using data on different commodities, and inferring the variables that do not have commodity subscripts: V_{fi} , $\omega_f V_{fi}$, $r_{.i}$, and GNP_i . Each of these approaches is now discussed.

II.B.1 Cross country study for each commodity

If the inverse of the factor share matrix θ (or the factor intensity matrix A), the consumption share vector α , and the internal factor prices W are treated as unobservables, then Model C (or Model L) can be estimated by regressing across countries the level of net exports of some commodity group on a function of the factor supplies and internal prices including variables representing tariffs, transportation costs, and NTB's.

The trade equations are linear in factor supplies but quite complex in prices. The formulation of a workable model will therefore involve some compromises. An equation that can be said to be suggested by these models takes the form:

$$T_c = a_c + b_{1c}K + b_{2c}K(1+\tau_c)/(1+\tau) + b_{3c}L + b_{4c}L(1+\tau_c)/(1+\tau) + b_{5c}GNP_1(1+\tau)/(1+\tau_c) \quad (9)$$

where T_c is the net exports of a commodity, K and L refer to two different factor supplies, τ_c is a tariff average applicable to the commodity aggregate composing T_c , τ is an overall average tariff rate, and where b_j is a regression coefficient. The coefficient b_5 reflects the consumption side of the model. An increase in the relative tariff level on this commodity will deflect demand away from this commodity and make more available for exports. This implies that b_5 is negative. The production side of the model is captured by the other coefficients which in theory may take either sign, a result that is associated with the Rybczynski theorem, though the net effect of an increase in τ , $b_2K + b_4L$, should be positive. For Model L, production is independent of prices, and $b_2 = b_4 = 0$

II.A.2 Cross industry study for each country

If the factor supplies V are unobservable, Model C (or Model L) can be estimated for each country by regressing net exports on measures of the factor shares θ (or factor proportions A), prices $p(-1+r)$ and consumption shares α . Model C implies an equation of the form

$$T_c = b_1 \theta^{Kc} / (1+r_c) + b_2 \theta^{Lc} / (1+r_c) + b_3 \alpha_c / (1+r_c) \quad (10)$$

where θ^{Kc} and θ^{Lc} refer to the capital and labor components of the inverse of the factor share matrix, α is the consumption share, and b_1 , b_2 and b_3 are regression coefficients, referring respectively to the unobservables: capital earnings, labor earnings and expenditures, all of which are constant across commodities. Model L suggests a similar equation:

$$T_c = b_1 A^{Kc} + b_2 A^{Lc} + b_3 \alpha_c / (1+r_c), \quad (11)$$

where a^{Kc} and a^{Lc} refer to the capital and labor components of the inverse of the factor intensity matrix A .

A policy analysis built on cross industry estimates of Model C suffers from the fact that both the coefficients, b_1 and b_2 , are functions of the tariff levels. These coefficients refer to factor earnings, which will change as factor prices respond to the imposition of the trade barriers. In principle, a second set of equations could be estimated to explain the returns to factors as a function of the tariff structure, but the estimation difficulties are likely to be severe since the return to a factor depends on the tariffs on all commodities, and since the prior information that might be employed to estimate this kind of complicated relationship, such as aggregation restrictions, properly involves knowledge of the inverse coefficients $\theta^{j\bar{c}}$ about which few people can be thought to have much information.

This is a difficult problem to deal with, but there is an even more severe difficulty. Neither A^{-1} nor θ^{-1} is directly observable, and only a small portion of either A or θ can be observed, allowing in no sense the direct computation of the elements of the inverse matrix. We might try to substitute observable indicators of the inverse matrix, but these will be highly complex functions of all the elements except in the diagonal case in which each commodity is produced with one and only one of the factors.

These issues have been generally ignored in the literature which contains many cross-industry regressions of trade on input coefficients. At an intuitive level, these regressions seem to make a great deal of sense since countries can be "expected" to concentrate their production on commodities that use intensively the factors that are in relatively abundant supply. The tradition in the literature has been to regress some measure of trade performance on the input intensities, since it seems clear that a country abundant in capital should concentrate its exports on capital intensive products. But Leamer and Bowen(1983) show that in fact the coefficients in this kind of regression cannot be expected to reveal the relative abundance of factors². This negative result leaves open the possibility that these cross-commodity regressions can nonetheless be used to measure the effects of trade barriers, even though they cannot be used to compute the relative abundance of factors.

Let us ignore the theory for the moment and forge ahead with plans to estimate a cross-commodity regression, similar to those that exist in the literature. Then we can ask if the theory helps us understand the

²See also Anderson(1983).

estimates that are obtained. First, in order to estimate cross section regressions, some way of scaling the dependent variable must be found to control for the fact that some commodity groups form large shares of output and consumption whereas others form small shares. If no attempt is made to control for scale, any explanatory variable that is correlated with the size of the commodity group will pick up the scale effect. To put this another way, without some way to correct for the relative sizes of different commodity groups, the estimates will be highly sensitive to the level of aggregation. The scale effect has traditionally been controlled by dividing the dependent variable by some measure of market size. The ideal candidate would seem to be total world output. The basic idea is that a country's share of world output can be expected to depend on the input mix of the commodity: capital abundant countries "ought" to have larger shares of capital intensive industries than of labor intensive industries. The share of world output can also be expected to be influenced by the structure of protection.

But what seems intuitively clear is not always true. To explore this formally, let us focus on the production side of the model

$$A Q = V ,$$

where Q is the vector of outputs. By Cramer's rule, the share of country i 's output of commodity one is

$$Q_{1i}/Q_{1w} = \det[V_i, A_2, A_3, \dots, A_N] / \det[V_w, A_2, A_3, \dots, A_N] \quad (12)$$

where A_j refers to a column of the matrix A , W is a diagonal matrix with factor returns on the diagonal and where V_w is the world's vector of factor endowments. *The surprise is that the share of output of a commodity depends not at all on the factor input mix in that industry.*

If determinants do not constitute what you regard to be a proof, consider Figure 1 which contains the standard construction for the division of two factors between two commodities. The vector A_2 is the expansion path of the second commodity, and V_1 and V_2 represent the endowment vectors of two countries. The division of the two factors between the two industries is represented by a parallelogram with vertex at the endowment point and sides parallel to the expansion vectors. Thus if A_1 is the expansion path for the first commodity, P_1 and P_2 are the amounts of the factors allocated to industry 1 by countries 1 and 2. If A_1' is the expansion vector, the points P_1' and P_2' apply. Elementary trigonometry implies that $P_1/P_2 = P_1'/P_2'$. Thus the share of country one's output of commodity one depends not at all on the input mix of commodity one!

This result seems quite counterintuitive, and stimulates a search for ways to dismiss it. One possibility is that the result refers to the wrong "counterfactual". The thought experiment just described traces out the effect of a change in the input mix of one commodity. Another possible thought experiment involves a change in the resource endowments. But changing the resource endowments clearly is not the experiment underlying a cross commodity regression for a single country. These seem to be the only conceptual experiments that the model allows, and the result cannot be dismissed because it refers to the wrong conceptual experiment.

Nonetheless, it is clear in Figure 1 that the capital abundant country does have a larger share of the capital intensive product. Indeed this is confirmed algebraically by assuming that there are only

two commodities and using expression (12) to form

$$\begin{aligned} & (Q_{1i}/Q_{1w})/(Q_{2i}/Q_{2w}) \\ &= (\det[V_i, A_2]/\det[V_w, A_2]) / (\det[V_i, A_1]/\det[V_w, A_1]) \\ &= \frac{[(K_i/L_i) - (A_{2K}/A_{2L})] [(K_w/L_w) - (A_{1K}/A_{1L})]}{[(K_w/L_w) - (A_{2K}/A_{2L})] [(K_i/L_i) - (A_{1K}/A_{1L})]} \end{aligned}$$

Thus using the data depicted in Figure 1 with $(A_{1K}/A_{1L}) > (K_i/L_i) > (K_w/L_w) > (A_{2K}/A_{2L})$, we have $(Q_{1i}/Q_{1w})/(Q_{2i}/Q_{2w}) > 1$. But notice that the technology of commodity one enters into this expression only because it affects the share of commodity two. The same phenomenon occurs in the higher dimensional case

$$\begin{aligned} (Q_{1i}/Q_{1w})/(Q_{2i}/Q_{2w}) = & \\ & \frac{\det[V_i, A_2, A_3, \dots, A_N] \det[V_w, A_1, A_3, \dots, A_N]}{\det[V_w, A_2, A_3, \dots, A_N] \det[V_i, A_1, A_3, \dots, A_N]} \end{aligned}$$

As your intuition probably suggests, this ratio will go to infinity as the input mix A_1 gets more similar to the endowment mix V_i , but the reason for this is not the intuitive reason that the share of Q_1 increases. On the contrary, the ratio grows because the share of Q_2 decreases to zero.

The foregoing discussion vaguely justifies a regression of ratios of shares $(Q_{ji}/Q_{jw})/(Q_{2i}/Q_{2w})$ on the input mix of commodity j , but this clearly would be a misspecified regression since the input mixes of all of the other commodities ought also be in the equation. In the two dimensional case this misspecification affects the interpretation, but not the fit of the regression, since an endowment ratio that is farther from the input ratio of commodity two is necessarily closer to the input ratio of commodity one.

The variable $(Q_{j1}/Q_{jw})/(Q_{21}/Q_{2w})$ is an odd choice since it depends on the arbitrary choice of normalizing commodity (two). An alternative that involves a neutral normalization is the share of GNP.

$$p_j Q_j / \sum_k p_k Q_k = 1 / \left(\sum_k p_k Q_k / p_j Q_j \right), \quad (13)$$

where the ratio of outputs satisfy relationships such as

$$p_2 Q_2 / p_1 Q_1 = p_2 \det[A_1, V, A_3, \dots, A_N] / p_1 \det[V, A_2, A_3, \dots, A_N].$$

The discussion above about the ratio of shares can more or less be repeated verbatim for the GNP share. As the input mix of commodity one approaches the endowment vector, the share of commodity one in GNP goes to one, primarily because the outputs of the other commodities go to zero. And a regression of the GNP share of commodity j on the input mix of commodity j is a misspecified regression.

Another normalization that is sometimes employed is domestic consumption. Exactly the same comment applies. Consider Model L absent of trade barriers. Then the consumption vector is $sQ_w = s A^{-1} V_w$, where V_w is the total world supply of the factors and s is the consumption share. The corresponding trade equation is $T = A^{-1}(V - sV_w)$. Thus the trade dependence ratio for the first commodity is

$$T_{11}/C_{11} = \det(V - sV_w, A_2, A_3, \dots, A_N) / s \det(V_w, A_2, A_3, \dots, A_N). \quad (14)$$

The same result thus applies: the trade dependence ratio is altogether unrelated to the industry characteristics.

This discussion does little to relieve the considerable intellectual tension between the result that the output share of a commodity does not depend on its technology and the firmly held belief that the Heckscher-Ohlin model implies that countries concentrate production on commodities that use inputs in combinations similar to

their supply. This tension is further relieved by a study of simple correlations. As we have seen, the model implies that after properly controlling for the effects of other industries, characteristics of the selected industry are of no consequence for determining trade. But if the characteristics of the other industries are not controlled, characteristics of the selected industry do help predict trade. What I mean is that although multiple correlation analysis is inappropriate, the model does justify a study of simple correlations for the following reason. The trade equation for model C can be written as

$$\Theta PT = WV - WAC,$$

where Θ is the matrix of factor shares, P is the diagonal price matrix, W is the diagonal factor return matrix and $A C$ is the vector of factors embodied in consumption. The simple (cross-industry) correlation between the value-of-trade vector and a row of the factor shares matrix, say the labor input intensities θ_L , is

$$\begin{aligned} \text{cor}(PT, \theta_L) &= \theta_L' PT / [\theta_L' \theta_L]^{1/2} [T' P' PT]^{1/2} \\ &= w_L (L - \theta_L' C) / [\theta_L' \theta_L]^{1/2} [(V-AC)' W' (\Theta \Theta')^{-1} W (V-AC)]^{1/2}, \quad (15) \end{aligned}$$

where I have used the trade balance condition $1' PT = 0$. This correlation takes the sign of the excess supply of labor: it is positive if the country is abundantly supplied in labor in the sense that labor supply exceeds labor embodied in consumption: $L - \theta_L' C > 0$. Moreover, it is generally larger the more unusual is the supply of the selected factor, in the sense that the value of excess supply $w_L (L - \theta_L' C)$ is large compared with the values for the other inputs.

Thus the simple correlation between trade and input intensities is to some extent a measure of the peculiarity of the supply of the selected factor. But the focus of this paper is not on the measurement

of trade-revealed factor supplies, but rather inference regarding the effects of tariffs on trade, production and factor returns. Indeed, these simple correlations will depend on tariff structures, but knowledge of that dependence is not sufficient to identify the effects that tariffs have on trade (or output levels).

This discussion creates a very substantial dilemma. The cross country model as formulated in the previous section involves five variables without even including the many other factor supply variables that could be conjectured to have a substantial affect on trade. If land alone were added to the model, the number of variables would be increased by four. But the number of countries for which there is adequate tariff and nontariff data is very limited, sixteen industrial countries at most. These countries can be expected to have similar resource endowments and also similar barriers. It seems quite unlikely that a study of the cross-country covariability of trade and tariffs would allow very sharp inferences about the effects of the barriers.

Although typical data sets are very thin in terms of countries, they are often very thick in terms of commodities, and one way to increase the effective size of the data set is to pool across commodities. But, as we have seen, the even Heckscher-Ohlin model does not lend itself to a natural cross-commodity regression study. The study of simple correlations can be justified as a way to study the resource endowments revealed by the trade vector, but not as a method of studying the effects of trade barriers. What are we to do?

III. THE UNEVEN HECKSCHER-OHLIN MODEL

One answer to this question is to dump the even Heckscher-Ohlin model as not only unworkable, but also highly unlikely as well. The most

commonly discussed alternative to the even model is the uneven general equilibrium model with more goods than factors. For most choices of product prices, the uneven model implies that a commodity is produced only if it uses inputs in proportions "similar" to their available supply. This seems to justify a two dimensional regression (across countries and commodities) of a measure of trade performance on a measure of the similarity of factor endowments and factor intensities. However, the surprising results for the even model should make clear the need for close scrutiny of the uneven model. In particular, we will need to find a proper measure of "similarity", and we will require some resolution of the ticklish problem of normalization: should we divide by some measure of total world market, domestic consumption or what?

Figure 2 illustrates the typical pattern of outputs as a function of the factor supplies for a model with fixed input coefficients for the industries and with two inputs, capital and labor. The vertical axis is the ratio of output in a sector divided by the total labor force, and the horizontal axis is total capital divided by total labor force. These piecewise linear functions have peaks where the capital per man endowment is equal to the capital per man input ratios. At these points, only a single commodity is produced. The slopes of these line segments will depend on how closely packed are the commodities along the capital per man axis.

One of these piecewise linear functions in the neighborhood of its maximum might be approximated by a quadratic equation of the form:

$$Q_{ci}/L_i = \frac{1}{A_{cL}} \left[1 - b_c \left(\frac{K}{L} - \frac{A_{cK}}{A_{cL}} \right)^2 \right] \quad (16)$$

This equation would lend itself to cross commodity pooling only if the coefficients b_c varied in some systematic way across commodities, which is not necessarily the case. These coefficients reflect the closeness of neighboring commodities, and cannot credibly be treated as exactly the same for all commodities. In principle, a variable could be added to measure the concentration of commodities, but this gets hopelessly complex in realistic multidimensional settings. Furthermore, this quadratic equation is a very poor approximation of the cross commodity variation of output which in principle is zero except for the two commodities that have input mixes adjacent to the abundance ratio.

We are now at the point of decision: It seems pretty clear that a literal interpretation of these general equilibrium models will incapacitate any data analysis. I am inclined then not to take the theory so literally, but rather to allow it to suggest but not to completely rule the data analysis. But in a setting such as this, in which the translation of the theory into a data analysis is loose, the standard by which we judge the empirical results has to be higher to compensate for the weakness of the theoretical foundation. The reason for this is that when an estimating equation is derived without benefit of a fully articulated theory, there is always the risk that future theoretical developments will suggest slight or major changes in the model that will completely reverse the apparent inferences. If the model is derived from a carefully defined and credible theory, there is less risk that theoretical developments in the future will reveal that the inferences are inappropriate.

An *ad hoc* model with two inputs that I am prepared to explore

takes the form:

$$\log Q_{ci}/L_i = \alpha_c + \beta \left[\left(\frac{K_i}{L_i} - \frac{A_{cK}}{A_{cL}} \right)^2 \right] + \gamma \tau_{ci}/\tau_{.i} \quad (17)$$

The logarithmic transformation of the dependent variable seems necessary to reasonably argue that β is constant across industries. The intercept α_c identifies a set of commodity dummy variables and is intended to control for the scale effect. The model implies that the composition of output is similar in all countries, except that output concentrates on commodities that use inputs in combinations similar to their availability and also concentrates on commodities that are heavily protected. The crucial assumptions that allow pooling across commodities are that the coefficients β and γ are constant across commodities. In particular it is assumed that the elasticity of output with respect to the tariff is the same for all commodities. This is an assumption that merits careful checking with the data.

The ratio A_{cK}/A_{cL} in (17) could be treated as an observable or an unobservable depending on whether the modal value of Q_{ci}/L_i can be treated as known. If it is treated as an unknown, the cross-commodity pooling would be considerably weakened. A partial step in that direction would be to include a variable K_i/L_i with a coefficient with a commodity subscript.

IV. DATA ANALYSIS

An exploratory study of an accessible data set will serve to illustrate some of the difficulties in drawing inferences about the effect of trade barriers. I will focus in this section on the problems of pooling across commodities, but I will be alert to suggestions in the data of other problems, particularly the simultaneity problem. Tariff data are taken from Deardorff and Stern(1985) who report post-Kennedy Round tariff averages at the three-digit ISIC level, weighted by the level of imports. The three-digit classification scheme and the tariff data are reported in an appendix. The question that I now address is whether these measured trade barriers can be shown to have a clear effect on the the composition of output as measured by the 1978 value of outputs from the U.N. Yearbook of Industrial Statistics.

This data set is typical in terms of country coverage - fifteen countries in total. The data set is not necessarily typical in terms of the number of commodity groups - nineteen commodity aggregates. Because the level of aggregation of commodities is fairly high, the value of pooling across commodities will be somewhat limited, but the difficulties in doing so will nonetheless apply equally to this data set as to more disaggregated ones.

A crucial first observation is that the tariff schedules of the fifteen countries are extraordinarily similar. In an ideal experiment, identical countries would be "treated" with distinctly different tariff schedules, and differences in the composition of output would be attributed fully to the trade barriers. Unfortunately, the actual tariff schedules are so similar that we cannot expect to infer a great deal about the effect of trade barriers from these data. For example, Table

1 contains the cross commodity correlations of tariffs for pairs of countries, one row and column corresponding to the overall averages. These correlations are typically in excess of .7 and many are higher than .9. The highest correlations are generally among the EEC countries: Denmark, France, Germany, Ireland, Italy, the Netherlands and the UK. The designers of the common external tariffs for the EEC surely did not have in mind my task of inferring the effect of tariff barriers.³

To provide a sense of these data beyond that offered by the simple correlations, I report in Figures 4-6 plots of the tariff data for three countries (Canada, Japan and the U.S.) compared with cross-country averages. If the tariff schedules of all countries were identical, all the points in these graphs would lie on the forty-five degree line. The line would be shifted upward or downward if a country had generally either higher or lower than other countries but otherwise the same structure of tariffs. If the tariffs lay along any line, the problem of drawing inferences about the protective effect would be severe, since it would then be difficult to identify an industry in any country that could be convincingly argued to have been subjected to an especially high or low tariff.

The Canadian case is fairly typical. The tariffs lie generally on a straight line, with one substantial outlier for ISIC 384, transport equipment. The U.S. and Japanese scatters seem at first glance more promising, but neither of these tariff schedules is especially distinct. These three countries are not unusual. If anything, these three

³ The tariff data reported by Deardorff and Stern are averages weighted by the levels of imports. Import weights have the well known defect that barriers high enough to deter trade substantially are assigned inappropriately small weights, the ideal weights being the level of imports that would have occurred in the absence of trade barriers. For the EEC countries, which have a common external tariff, much of the measured differences in the tariff barriers may be a consequence only of the import weights, which vary from country to country.

countries have atypically large dispersion in their tariff schedules, a fact that is reflected in the correlations in Table 1.

Just like the tariff schedules, the output compositions of these fifteen countries are also quite similar. Table 2 contains the correlations, and Figures 7-9 are scatter plots of outputs for the same three countries. However, the similarity in output mixes should not be regarded to be altogether undesirable. If inference about the effects of tariffs were the goal, similar countries would be subjected to dissimilar tariff schedules. Since the tariff schedules are quite similar, great dissimilarity in output mixes would indicate that the countries were in fact rather dissimilar, and we would require carefully selected variables to control for the apparent differences in the countries. Thus the similarity in output mixes can be taken to mean that we need not be too diligent in the search for other explanatory variables.

On that relatively optimistic note, we can compare the tariff graphs and the output graphs to find if the subtle differences in the tariff schedules are evidenced in the output graphs. We have already noted the relatively low tariff in Canada on ISIC 384. This "unprotected" industry might be expected to have a relatively low level of output, but Figure 7 indicates the opposite is true: Canada has an unusually high level of output.⁴ Likewise, the apparent protection by Japan of machinery is associated with relatively low levels of output, as is the U.S. protection of ISIC 324, shoes.

A more formal comparison of the unusual tariffs with the unusual output levels is reported in Table 3, which contains Studentized

⁴ This Canadian observation brings up the shortcoming of the output data since much of Canadian output may be value added in U.S. locations.

residuals of the regressions of tariffs and outputs on their corresponding averages. A Studentized residual is computed by dividing a residual by its standard error to create something like a t-statistic. In fact, a Studentized residual is the t-statistic of a dummy variable selecting one observation only, in a model that includes only this one dummy variable.⁵ All Studentized residuals in excess of two in absolute value are reported in this table first for tariffs and then for outputs. In addition, the table contains the corresponding Studentized residual for the other variable. For example, the Canadian Studentized tariff residual for ISIC 384 is -3.4 and the corresponding value for output is 5.1, large numbers that conform with the discussion of the scatters.

This table reveals the especially high barriers of the EEC countries on chemicals, a high Austrian barrier on transportation equipment, and high barriers to shoes in Japan and Norway, as well as the unusually low level of protection of transportation equipment by Canada. Japan, it is interesting to note, has unusually high protection for footwear and machinery, but low protection for textiles.

If tariffs have the expected protective effect, the signs of the Studentized residuals for outputs and tariffs will conform. In fact, there are many cases in which they do not conform. The Austrian protection of transportation has not prevented her output from being unusually low, nor the Norwegian and Japanese protection of shoes. But the protection of chemicals in many of the EEC countries seems at this first glance to be effective, though Germany is an interesting exception. In general, perusal of this table makes me think that the

⁵ See Belsley, Kuh and Welsch(1980) for a full discussion. Note that the Student-t interpretation of this statistic is only appropriate for the model that includes only a single dummy variable. The implicit complete model with one dummy for each observation is underidentified.

simultaneity problem may be more severe than I had previously suspected, since the industries that receive an unusual degree of protection are often the industries that are doing poorly in comparison to the same industry in other countries. On the other hand, the similarity in the tariff schedules of these countries does not sit well with the literature on the political economy of protection since the political pressures for protection might have been expected to be dissimilar in these different countries and thus produce dissimilar tariff schedules.

It is also of interest to identify the industries that have unusual levels of output, and to examine their levels of protection. The second half of the Table 3 indicates the Studentized residuals for the regressions of outputs on the averages, and the corresponding Studentized residuals for the tariff regressions. The biggest outlier is the Finnish production of paper and paper products, presumably associated with abundance of softwood forests, not protection. Most of the other outliers also seem unrelated to trade barriers, and are at least partly explained by the availability of other resources.

Incidentally, the models that I am using assume that trade with all countries is subject to the same barriers, and these models do not apply well to common market countries. For example, the relatively high level of protection for transportation equipment imported from non-EEC countries makes it appear that the Austrian barrier is ineffective, but the effect of the barrier is likely not to encourage local production of transportation equipment, but only to divert imports from the US and Japan to the EEC exporters: Germany, Italy and the U.K.

The impression created by this preliminary data analysis is not substantially affected by regression analysis now to be discussed in

which two characteristics of countries (capital and labor) are controlled for. Regressions of the form (9) are reported for each commodity in Table 4, with the K(capital) and L(labor) taken from a data set compiled by Harry Bowen. The five uncertain coefficients are a heavy burden for the fifteen observations to carry, and we can expect there to be a very high degree of sensitivity of the results to changes in the model. The F-statistics measuring the joint "significance" of the tariff variables are reported in the table. In several cases, the F-statistics are large enough to suggest that tariffs have a measurable effect. But often the F-statistics are quite low, suggesting that pooling across commodities could help sharpen the estimates of the tariff effects.

For this model, the derivative of output with respect to the tariffs depends on the levels of capital per man. The table accordingly includes estimates of the derivatives of output divided by the labor force for the lowest value and the highest value of capital per man. In almost all cases, the sign of the effect changes over this range of capital per man. The last column of the table contains the value of capital per man at which the effect of the tariff changes sign. For example, according to this model, tariffs have a protective effect on textiles and clothing for countries with low levels of capital abundance, but have a perverse effect at high levels. This again is suggestive of the political economy model, with countries abundant in capital struggling against the pressures of comparative advantage to preserve the output levels of labor intensive products.⁶

⁶ Robert Baldwin suggested this interpretation.

Pooled estimates are reported in Table 5. The top half of the table contains results based on the model (17) with differences in countries fully attributed to differences in capital abundance. The bottom half of the table contains results based on a weaker model with country dummy variables instead of the capital abundance variables. Both absolute and relative tariff variables are used.

As is to be strongly suspected from the study of Studentized residuals, the estimate of the tariff effect is negative for the model with country and commodity dummies. But essentially the same estimate is computed for all the ways of controlling the country and commodity effects. The distressing conclusion that seems clear from this discussion is that high barriers are associated with poor performance of the industry, as would be suggested by the political economy model with the direction of causation flowing from industry characteristics to trade barriers.⁷ This conclusion is distressing since it implies that any attempt to form credible estimates of the impact of trade barriers will have to confront directly the difficult simultaneity problem.

The central question in this paper, however, is how to pool data across commodities. The F-statistics in Table 5 indicate what the data think about pooling. In the top half of the table, the large F equal to 29.1 for the hypothesis ($\alpha_c = \alpha$, $\beta_c = \beta$) reveals that the model with complete pooling (no distinctions among commodities) is strongly rejected by the data. The much smaller F's for the hypotheses $\alpha_c = \alpha$ and $\beta_c = \beta$ separately suggest that only one form of control for differences in

⁷ By the way, as I have shown in Leamer(1981), it is quite appropriate to regress quantity on price, and interpret the estimated function to be a demand curve if the estimate is negative or a supply curve if it is positive, provided the residuals in the demand and supply curve are independent. Likewise the discussion here is (loosely) interpreting the relationship between outputs and tariffs to reflect the effect of protection if the estimate is positive, but to reflect the demand for protection if the estimate is negative.

commodities is required. The relatively large F for $\alpha_c = \alpha$ compared with $\beta_c = \beta$ indicates that the data prefer different intercepts and identical slopes. The F-statistics for the "analysis of covariance" model in the bottom half of this table reveal again the need to control for difference in the commodities, but also suggest that controlling for country effects with country dummy variables is unimportant. This is not surprising since the pure country scale effect has been eliminated by dividing the dependent variable by the total labor force. The country effects that are suggested by the Heckshcher-Ohlin model interact with the commodity effects, which would be much better represented by a bilinear model with interactive effects $\alpha_c \delta_i$. A bilinear model would certainly be an interesting alternative to explore, though canned computer programs for estimating this kind of model do not exist, to my knowledge.

There is one last observation that I think lends credibility to the kind of quadratic model that I have used here. The logic of an equation such as (17) is that output concentrates on industries that use factors in ratios similar to their availability. In principle, the explanatory variable is the squared difference between the capital per man abundance ratio and the capital per man used in the industry. In estimating this quadratic model, I have treated the capital per man in the industry as an unobservable parameter. The model allows us to estimate this parameter since it is the value of the capital per man abundance ratio at which the peak level of output per man occurs, namely $-2\gamma/\beta_c$. These numbers for the general model with both intercept and slope dummy variables are reported in Table 6. Given the substantial uncertainty in the estimates of β_c , these numbers have a remarkable

intuitive appeal. Leather products have the smallest estimate of capital per man of \$16,700. Textiles and footwear have similarly low estimated capital intensities. Some of the more capital intensive products are chemicals and iron and steel. The surprise in this table might be the high capital intensities for paper, wood products and furniture. The paper and wood results are pulled around by outliers for Finland and Sweden, which happen to have high levels of estimated capital abundance. This suggests that an important variable has been omitted, namely abundance of softwood forests. The result for furniture, however, is not explainable by outliers, and even the larger data set studied in Leamer(1985) has the same result.

VI. CONCLUSION

I am quite uncomfortable with the theoretical foundation for pooling across commodities, but I am reasonably satisfied with the empirical results. However, this data set has greatly increased my apprehension about the simultaneity problem, and I suspect that credible estimates of the effects of trade barriers may require a simultaneous equations treatment, allowing for the political processes by which barriers are put in place.

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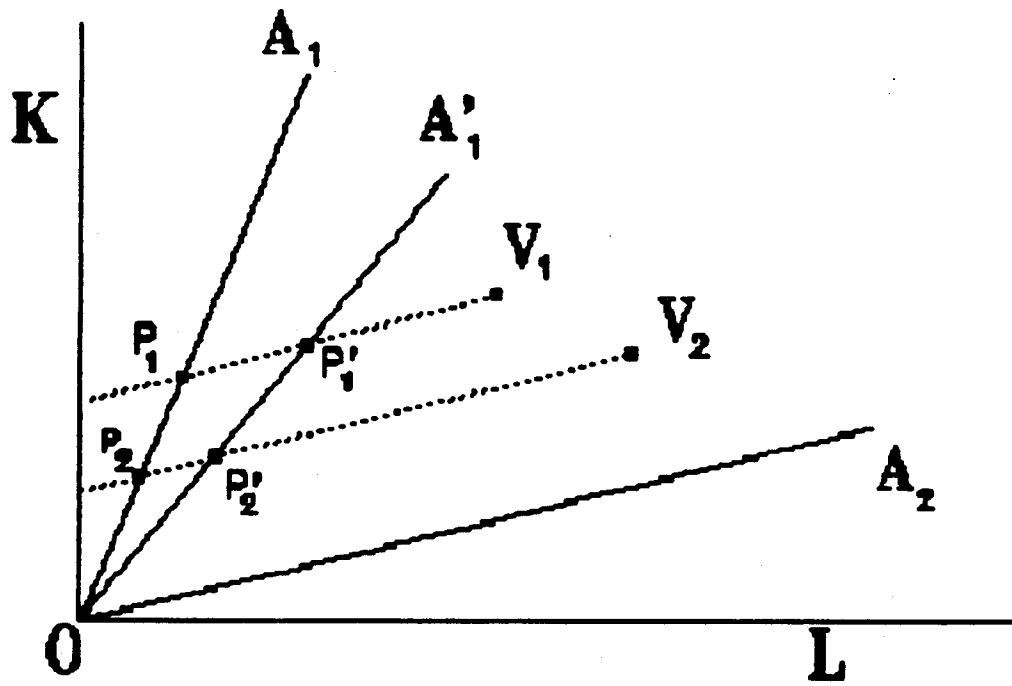


Figure 1
Shares and Technology

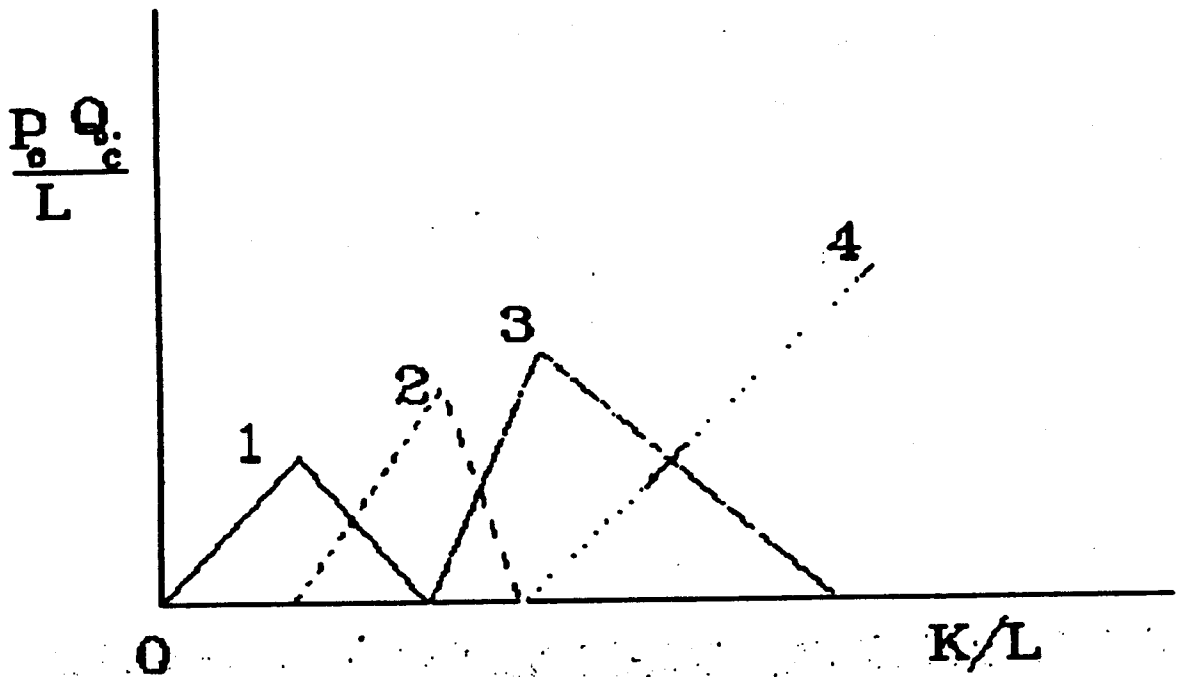


Figure 2
Production of Four Commodities

Table 1 Tariff Correlations

	ASL	AST	CAN	DEN	FIN	FRA	GFR	IRE	ITL	JAP	NET	NOR	SWE	UK	US	AVG
ASL	1.00	.82	.73	.51	.61	.63	.67	.56	.63	.71	.65	.69	.65	.67	.73	.85
AST	.82	1.00	.76	.72	.74	.84	.84	.79	.80	.75	.83	.70	.83	.81	.72	.92
CAN	.73	.76	1.00	.65	.72	.67	.69	.55	.57	.67	.65	.84	.75	.69	.73	.84
DEN	.51	.72	1.00	1.00	.68	.90	.87	.93	.82	.63	.91	.69	.75	.83	.67	.82
FIN	.61	.74	.72	.68	1.00	.71	.74	.65	.64	.59	.72	.80	.83	.65	.86	.85
FRA	.63	.84	.67	.90	.71	1.00	.98	.91	.95	.77	.96	.73	.86	.93	.75	.91
GFR	.67	.84	.69	.87	.74	.98	1.00	.87	.95	.79	.97	.78	.89	.95	.75	.93
IRE	.56	.79	.55	.93	.65	.91	.87	1.00	.84	.67	.92	.62	.78	.81	.61	.82
ITL	.63	.80	.57	.82	.64	.95	.95	.84	1.00	.82	.92	.70	.81	.92	.66	.87
JAP	.71	.75	.67	.63	.59	.77	.79	.84	.82	1.00	.73	.82	.81	.82	.57	.84
NET	.65	.83	.65	.91	.72	.96	.97	.67	.82	.73	1.00	.74	.87	.94	.70	.90
NOR	.69	.70	.84	.69	.80	.73	.78	.62	.70	.82	.74	1.00	.90	.76	.75	.88
SWE	.65	.83	.75	.75	.83	.86	.89	.78	.81	.81	.87	.90	1.00	.85	.75	.92
UK	.67	.81	.69	.83	.65	.93	.95	.81	.92	.82	.94	.76	.85	1.00	.69	.89
US	.73	.72	.73	.67	.86	.75	.75	.61	.66	.57	.70	.75	.75	.69	1.00	.86
AVG	.85	.92	.84	.82	.85	.91	.93	.82	.87	.84	.90	.88	.92	.89	.86	1.00

Table 2 Output Correlations

	ASL	AST	CAN	DEN	FIN	FRA	GFR	IRE	ITL	JAP	NET	NOR	SWE	UK	US	AVG
ASL	1.00	.67	.79	.69	.32	.83	.81	.49	.81	.85	.72	.81	.75	.87	.88	.88
AST	.67	1.00	.34	.68	.30	.66	.77	.49	.80	.79	.80	.45	.52	.77	.65	.72
CAN	.79	.34	1.00	.43	.47	.75	.70	.40	.64	.74	.50	.81	.85	.70	.83	.80
DEN	.69	.68	.43	1.00	.33	.77	.77	.58	.72	.69	.85	.67	.61	.87	.77	.78
FIN	.32	.30	.47	.33	1.00	.33	.30	.16	.25	.32	.30	.60	.70	.34	.38	.37
FRA	.83	.66	.75	.77	.33	1.00	.97	.53	.93	.93	.74	.78	.79	.95	.96	.98
GFR	.81	.77	.70	.77	.30	.97	1.00	.54	.91	.96	.80	.76	.80	.95	.95	.98
IRE	.49	.49	.40	.58	.16	.53	.54	1.00	.54	.59	.52	.39	.42	.58	.57	.58
ITL	.81	.80	.64	.72	.25	.93	.91	.54	1.00	.92	.76	.59	.65	.92	.87	.92
JAP	.85	.79	.74	.69	.32	.93	.96	.59	.92	1.00	.81	.75	.79	.92	.94	.97
NET	.72	.80	.50	.85	.30	.74	.80	.52	.76	.81	1.00	.61	.59	.87	.79	.81
NOR	.81	.45	.81	.67	.60	.78	.76	.39	.59	.75	.61	1.00	.93	.77	.84	.82
SWE	.75	.52	.85	.61	.70	.79	.80	.42	.65	.79	.59	.93	1.00	.77	.85	.84
UK	.87	.77	.70	.87	.34	.95	.95	.58	.92	.92	.87	.77	.77	1.00	.96	.97
US	.88	.65	.83	.77	.38	.96	.95	.57	.87	.94	.79	.84	.85	.96	1.00	.99
AVG	.88	.72	.80	.78	.37	.98	.98	.58	.92	.97	.81	.82	.84	.97	.99	1.00

Table 3 Extreme Tariffs and Outputs:
Studentized Residuals selected from regressions on averages

	ISIC	Extreme Tariffs		ISIC	Extreme Outputs	
		Tariff Student	Output Student		Output Student	Tariff Student
ASL	362 GLASS	-2.3	-.9	ASL 372 NONFER.	2.3	.5
	332 FURN.	2.0	-.3	381 METAL	2.2	.6
				383 ELECT	-2.0	.0
AST	384 AUTOS	3.1	-4.7	AST 384 AUTOS	-4.7	3.1
CAN	384 AUTOS	-3.4	5.1	CAN 384 AUTOS	5.1	-3.4
				382 MACH	-2.4	-.9
DEN	323 LEATHER	-2.5	-.2	DEN 35A CHEM	2.9	2.2
	35A CHEM	2.2	2.9	384 AUTOS	-2.8	-.3
FIN	36A CHINA	2.4	-.6	FIN 341 PAPER	8.4	.0
FRA	35A CHEM	2.6	1.0	FRA 381 METAL	-3.1	-.4
	323 LEATHER	-2.3	.5			
GFR	35A CHEM	4.2	-.2	GFR 383 ELECT	2.4	.8
				382 MACH	2.3	-.3
IRE	341 PAPER	1.9	-.1	IRE 321 TEXT	3.1	-.1
				36A CHINA	2.2	-.2
ITL	35A CHEM	3.0	1.9	ITL 371 IRON	2.8	.2
JAP	324 SHOES	3.0	-.4	JAP 383 ELECT	3.1	.3
	321 TEXT	-2.5	.8	371 IRON	2.4	.3
	382 MACH	2.3	-1.3			
NET	35A CHEM	3.5	2.4	NET 384 AUTOS	-3.0	1.6
				35A CHEM	2.4	3.5
				383 ELECT	2.0	.5
NOR	324 SHOES	3.7	-.6	NOR 331 WOOD	2.3	.0
SWE	322 CLOTHES	-2.3	-.7	SWE 341 PAPER	3.4	-1.1
				331 WOOD	2.3	-.8
UK	35A CHEM	3.1	4.0	UK 35A CHEM	4.0	3.1
				384 AUTOS	-2.8	.8
US	322 CLOTHES	2.9	.7	US 371 IRON	-2.7	.5
	355 RUBBER	2.3	-1.0	383 ELECT	-2.5	-.7
	324 SHOES	-2.1	.0	384 AUTOS	2.4	-1.5

Table 4 Regressions by Industry

$$Q_c = a_c + b_{c1}K + b_{c2}L + (e_{c1}K + e_{c2}L) t_{ci}/t_c.$$

ISIC Descrip	Cons.	Capital	Cap*Tar	Labor	Lab*Tar	R-sq	F-stat	D1	D2	(K/L)*
321 TEXT	-744.07	.27	-.26	-5.29	5.63	.997	18.6	1.98	-6.19	21.27
322 CLOTHES	548.02	.57	-.52	-15.26	14.12	.986	28	6.97	-9.04	27.23
323 LEATHER	-2.00	-.03	.03	1.52	-1.54	.984	28.2	-1.06	.00	44.61
324 SHOES	291.27	.09	-.08	-2.13	2.10	.829	2.4	.96	-1.57	25.52
331 WOOD	679.31	-.42	.45	3.98	-4.27	.976	6.6	1.98	15.98	9.41
332 FURN.	-57.70	.29	-.28	-7.08	7.10	.981	5	3.24	-5.41	25.35
341 PAPER	394.82	.27	-.27	-2.49	2.73	.950	4	-.96	-9.22	10.21
342 PRINT	-1220.17	-.92	.97	29.73	-30.57	.988	1.8	-17.16	12.82	31.45
35A CHEM	-467.56	-.84	.82	24.86	-25.20	.985	3.1	11.84	13.58	28.17
355 RUBBER	70.63	.66	-.68	-17.77	18.43	.985	1.4	9.04	-11.97	27.07
36A CHINA	-753.81	.43	-.44	-8.78	9.27	.993	19.6	3.22	-10.33	21.12
362 GLASS	-135.35	.41	-.40	-11.12	10.91	.987	8.7	5.43	-6.81	27.48
371 IRON	-283.38	-.61	.66	12.22	-12.41	.974	1.3	-3.36	16.89	18.90
372 NONFER.	-1083.04	-.74	.79	24.77	-25.88	.970	2.7	-14.98	9.41	32.74
38A MISC	-3209.46	.28	-.26	-6.69	7.17	.980	.3	3.59	-4.41	27.65
381 METAL	-2363.38	.37	-.35	-7.90	8.54	.970	.23	3.70	-7.13	24.33
382 MACH	-4308.09	-.98	1.03	36.53	-36.47	.988	11.4	-22.29	9.46	35.46
383 ELECT	-3479.85	.63	-.58	-19.26	18.93	.978	1.1	10.98	-6.80	32.85
384 AUTOS	-2817.28	.19	-.14	7.94	-7.33	.998	89.4	-9.30	-13.70	-51.31

Notes: R-sq = Adjusted R²

F-stat = F statistics for testing the joint significance of tariff variables.

D1 is derivative of Q/L with respect to tariffs at low value of K/L.

D2 is derivative of Q/L with respect to tariffs at high value of K/L.

(K/L)* is the value of capital per man at which the derivative changes sign.

Table 5

Pooled Regression Results

$$\text{Model 1 : } \log(Q_{ci}/L_i) = \alpha_c + \beta_c(K_i/L_i) + \gamma(K_i/L_i)^2 + \theta \tau_{ci}$$

Restrictions	Relative Tariff			Absolute Tariff		
	F-stat	θ	t-value	F-stat	θ	t-value
None	.	-.13	-2.1	.	-.01	-1.9
$\alpha_c = \alpha$	3.9	-.09	-3.2	8.1	-.01	-1.9
$\beta_c = \beta$	1.7	-.17	-2.6	3.1	-.01	-1.4
$\alpha_c = \alpha, \beta_c = \beta$	29.1	-.26	-3.0	29.2	-.02	-.28

$$\text{Model 2: } \log(Q_{ci}/L_i) = \alpha_c + \delta_i + \theta \tau_{ci}$$

Restrictions	Relative Tariff			Absolute Tariff		
	F-stat	θ	t-value	F-stat	θ	t-value
None	.	-.23	-3.5	.	-.01	-2.8
$\alpha_c = \alpha$	69.9	-.28	-3.2	66.6	-.02	-2.6
$\delta_i = \delta$	8.3	-.14	-2.1	7.4	-.01	-1.7
$\alpha_c = \alpha, \delta_i = \delta$	42.6	-.28	-2.8	40.8	-.02	-2.6

Note: c = commodity subscript, i = country subscript.

Table 6 Estimated Industry Capital Intensities¹

ISIC	-2 γ/β_c
323 Leather Products	16.74
321 Textiles	24.14
324 Footwear	24.49
355 Rubber Products	25.08
362 Glass and glass products	28.23
38A Miscellaneous	28.49
322 Apparel	28.50
384 Transport Equipment	29.43
36A Pottery, china, etc.	31.74
381 Metal Products	35.27
382 Nonelectrical Machinery	36.22
383 Electrical Machinery	36.49
35A Chemicals	37.41
371 Iron and Steel	38.78
342 Printing and Publishing	39.80
341 Paper and Paper Products	40.25
331 Wood Products	43.43
332 Furniture and Fixtures	43.64
372 Nonferrous metals	48.53

¹ Value of capital per man at which maximum of output per man occurs, computed from pooled quadratic regression with commodity dummies for both intercepts and slopes.

Table A1
Industrial Classification
Source: Deardorff and Stern(1985)

<u>ISIC</u>	<u>Description</u>
321	Textiles
322	Wearing apparel, excluding footwear
323	Leather and leather and fur products
324	Footwear
331	Wood products, excluding furniture
332	Furniture and fixtures, excluding metal
341	Paper and paper products
342	Printing, publishing
35A	Industrial chemicals(351);Other chemical products(352)
35B	Petroleum refineries(353); Miscellaneous production of petroleum and coal(354)
355	Rubber Products
36A	Pottery, china and earthenware(361); Other nonmetallic mineral products(369)
362	Glass and glass products
371	Iron and Steel basic industries
372	Nonferrous metal basic industries
381	Metal products, excluding machinery
382	Machinery, excluding electrical
383	Electrical machinery
384	Transport equipment
38A	Plastic products, n.e.c.(356); Professional photographic goods, etc.(385); Other manufacturing industries(390)

Table A2

POST KENNEDY ROUND TARIFFS(Source: Deardorff and Stern(19**))

	321	322	323	324	331	332	341	342	35A	355
ASL	21.5	61.8	25.7	33.8	13.6	40	7.1	1.8	5.8	3.8
AST	18.7	36.3	9.1	24.1	4.8	23	15.9	2.4	8.1	14.6
CAN	18.9	25.4	8.2	24.5	5.8	19.4	11.8	5.7	7.9	12.2
DEN	12.1	16.4	3.6	11.5	4.4	8.4	10.8	4.4	11.9	6.7
FIN	24.1	37.2	12.6	17.5	.5	8.7	8	1.8	3.1	13.9
FRA	9.8	16.7	3.6	11.5	3.3	8.5	7.6	3.4	10.9	5.2
GFR	10.3	16.8	5.1	11.7	3.9	8.5	7.1	3.3	11.6	5.7
IRE	10.7	16.4	5.4	11.9	3.2	8.5	10.9	2.4	10.7	5.6
ITL	7.5	16.6	1.7	10.8	1	8.5	3.7	2.7	11.8	4
JAP	3.3	13.8	3	16.4	.3	7.8	2.1	.2	6.2	1.5
NET	11.8	16.8	5.2	11.2	3.6	8.5	8.4	3.5	11.9	6.1
NOR	16.2	22.8	6.6	24.6	2	7.6	2.9	4.3	8.1	7.3
SWE	10.9	14.4	4.8	13.8	.9	5.4	3	.2	6.3	6.5
UK	9.2	16.9	2.8	12.5	4	8.5	6.6	3.3	11.4	4
US	14.4	27.8	5.6	8.8	3.6	8.1	.5	1.1	3.8	3.6
Average	13.3	23.7	6.9	16.3	3.7	12.0	7.1	2.7	8.6	6.7

	36A	362	371	372	381	382	383	384	38A	AVERAGE
ASL	1.6	5.2	.8	5.3	24.1	14.2	21.6	22.1	13	14.03
AST	8.9	17.5	6.2	4.5	19.3	10.8	18.7	24.5	13.7	14.06
CAN	9.5	11.3	6.7	2	14.1	6.1	12.9	2.4	8.8	8.59
DEN	6.7	9.7	7.2	8.1	7.9	6.4	9.3	8.5	10	8.56
FIN	3.8	25.4	5.7	1.2	9.6	8.7	11	6	18.1	8.55
FRA	7	9.8	6.6	3.1	7.8	6.4	9.8	10.3	9.6	8.20
GFR	5.4	10.2	6.3	2.3	8	6.6	10.2	9.9	9.1	8.20
IRE	6	9.5	7.5	8	7.7	6.1	9.5	12	11.2	8.79
ITL	3.3	9.6	4.7	2.2	8	6.5	9.9	10.7	9.4	7.63
JAP	.6	7.5	3.3	1.1	6.9	9.1	7.4	6	6	5.36
NET	4.4	9.3	7.1	4.3	7.8	6.4	10	10.9	8.7	8.51
NOR	2.8	10.5	2.2	1.1	6.3	8.8	8.6	3.5	8.9	6.58
SWE	3.1	9.3	4.7	.9	5.3	4.9	7	8.2	6.1	5.74
UK	3.2	10.4	6.3	2	8	6.4	10	9.3	4.9	7.59
US	9.1	10.7	4.7	1.2	7.5	5	6.6	3.3	7.8	5.55
AVG	5.0	11.1	5.3	3.2	9.9	7.5	10.8	9.8	9.8	

FA Table A3

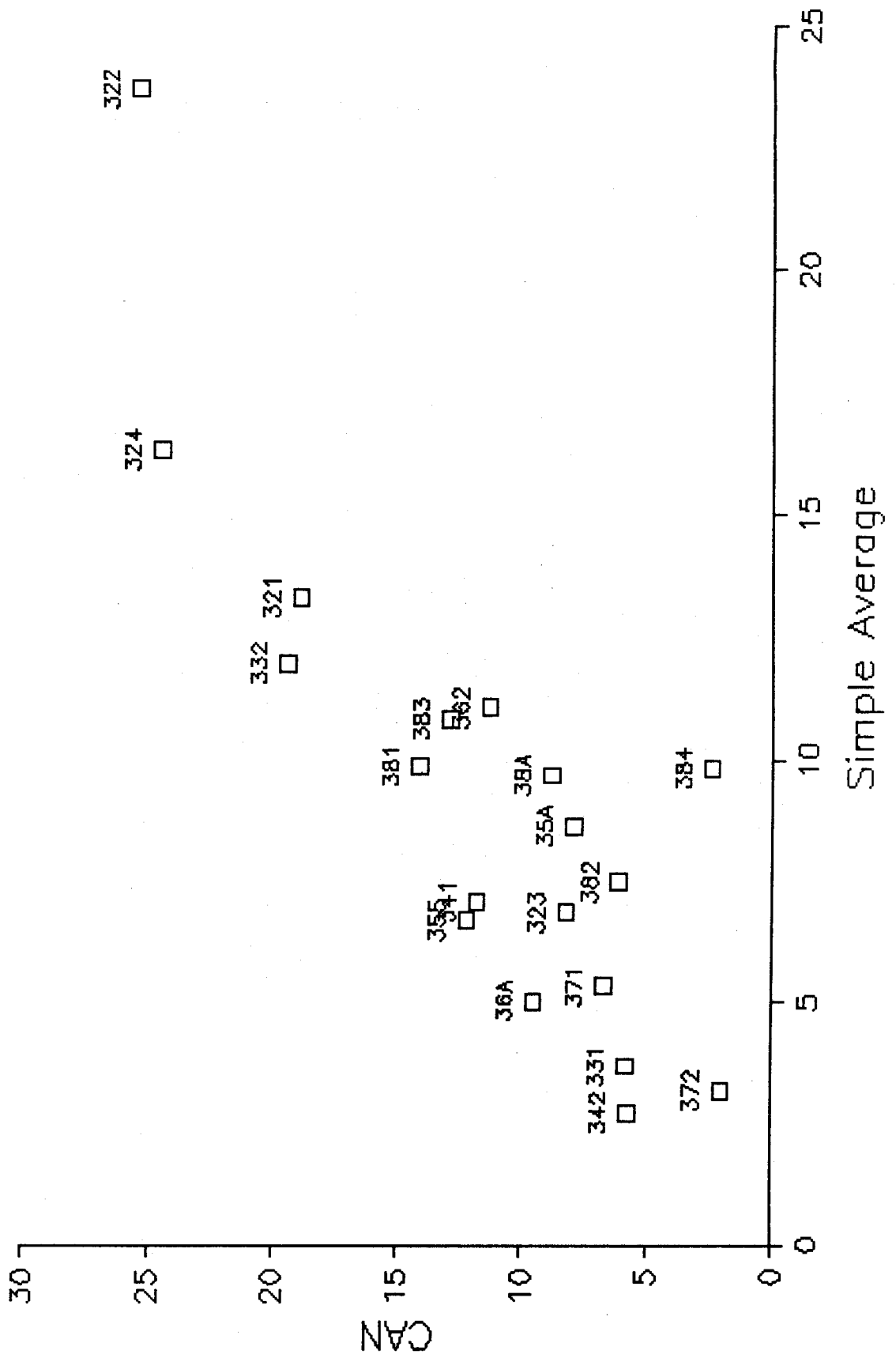
INDUSTRY OUTPUTS, 1978 (Billions US\$)

	321	322	323	324	331	332	341	342	35A	355
ASL	2,181	1,388	220	366	1,907	893	1,581	2,424	4,138	584
AST	1,756	881	124	413	441	957	1,357	930	2,913	427
CAN	3,980	2,998	316	508	6,873	1,560	9,082	3,743	8,109	1,578
DEN	682	348	58	85	432	441	506	1,039	2,468	116
FIN	649	661	82	150	1,637	294	4,095	1,214	1,440	124
FRA	11,811	6,980	1,485	2,039	4,166	3,900	7,800	7,601	26,569	3,767
GFR	16,081	8,663	1,842	2,290	11,112	6,127	10,803	8,314	42,169	5,427
IRE	637	203	86	65	132	61	215	255	219	92
ITL	10,486	4,140	1,560	2,407	1,942	2,359	3,870	3,588	17,667	2,457
JAP	37,635	10,663	2,433	1,701	22,909	7,674	23,888	26,763	61,015	8,026
NET	2,440	1,197	183	206	1,485	664	1,890	4,622	7,713	1,212
NOR	439	227	38	42	1,415	429	1,305	1,223	1,404	80
SWE	919	423	108	104	3,561	699	4,732	1,996	3,041	416
UK	12,061	4,947	1,361	1,534	4,334	3,337	8,150	9,473	28,456	3,701
US	51,900	34,600	3,700	4,500	34,600	17,200	57,100	56,200	131,300	16,600
Shr	.050	.025	.004	.005	.031	.015	.044	.042	.109	.014

	36A	362	371	372	381	382	383	384	38A	Share
ASL	2,170	329	3,538	2,945	4,208	3,515	2,372	5,443	2,272	.014
AST	1,667	331	2,954	716	3,092	2,672	3,519	1,446	1,240	.009
CAN	2,893	605	5,321	4,366	7,828	5,742	6,005	22,565	4,094	.032
DEN	965	129	292	192	1,242	2,289	1,046	1,204	898	.005
FIN	597	109	1,227	520	860	1,839	894	1,227	454	.006
FRA	6,426	2,282	17,861	6,404	10,747	31,422	18,924	36,253	11,279	.070
GFR	12,048	3,634	31,365	9,459	26,735	55,710	46,300	56,755	19,665	.121
IRE	506	100	63	36	393	514	389	478	420	.002
ITL	6,331	1,583	15,202	1,677	8,158	13,803	12,157	17,539	7,032	.043
JAP	26,107	4,719	63,210	18,267	45,647	70,733	79,381	93,884	44,241	.210
NET	1,867	490	2,360	1,009	4,714	4,696	7,012	4,456	3,342	.017
NOR	639	103	775	1,272	1,055	2,091	1,095	2,369	551	.005
SWE	1,164	230	2,773	1,186	3,464	5,661	3,245	6,854	1,151	.013
UK	7,057	1,918	13,730	6,174	17,737	27,248	18,658	27,843	11,333	.067
US	31,100	10,800	75,000	38,300	91,600	153,100	104,700	204,400	80,800	.387
Shr	.033	.009	.076	.030	.073	.123	.099	.156	.061	1.000

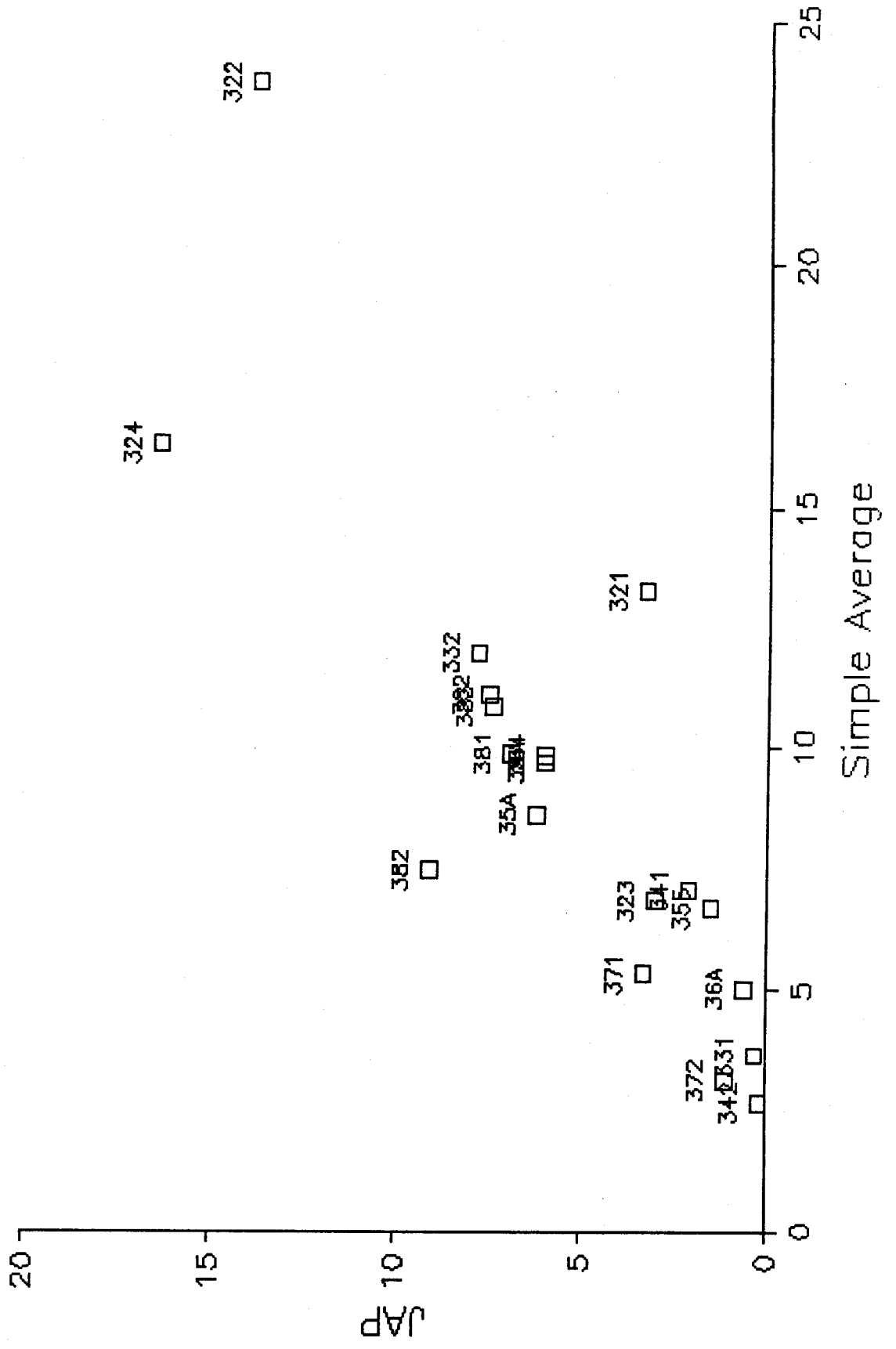
POST KENNEDY ROUND TARIFFS

Comparison with Overall Average



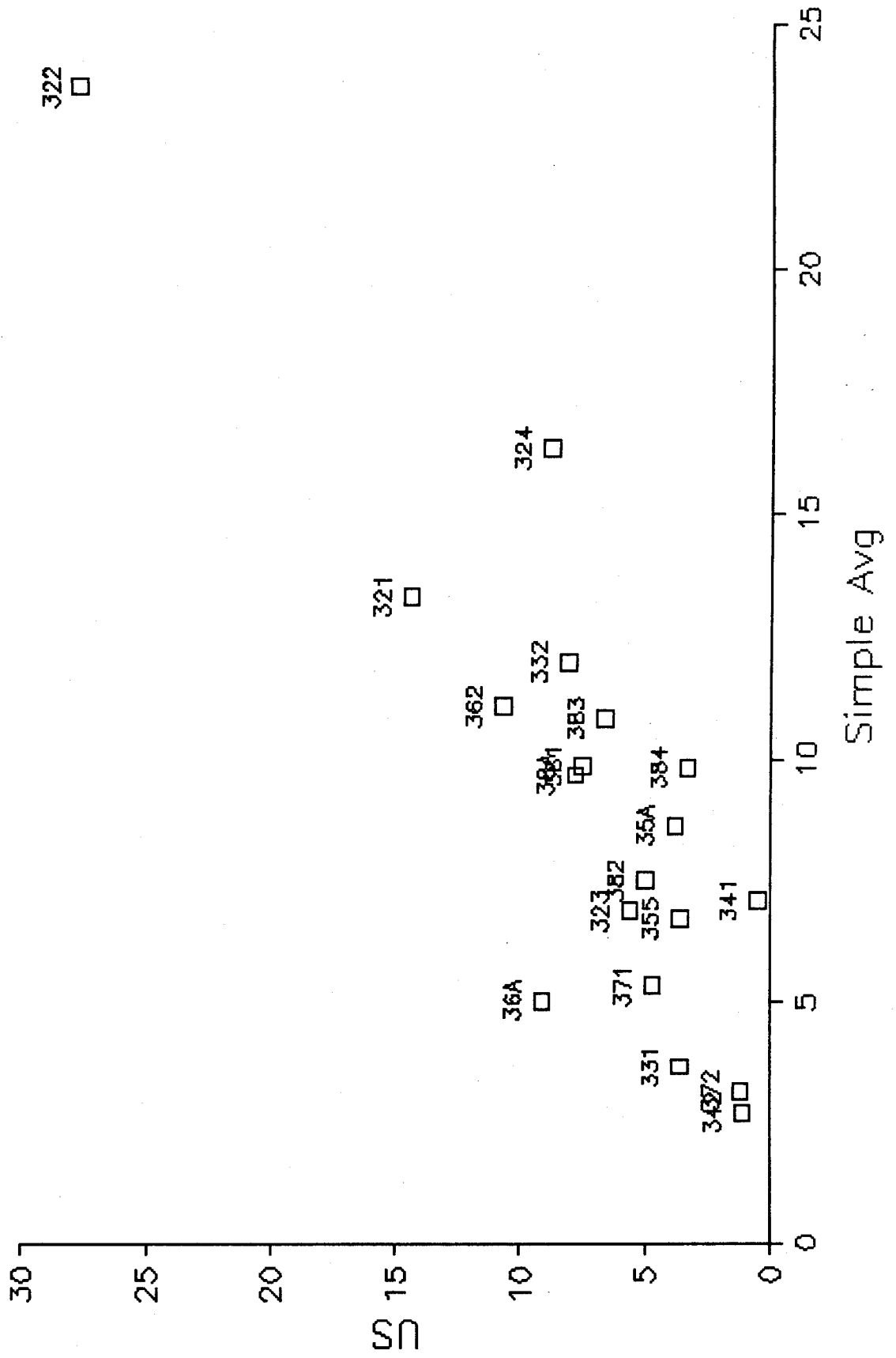
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Comparison with Overall Average



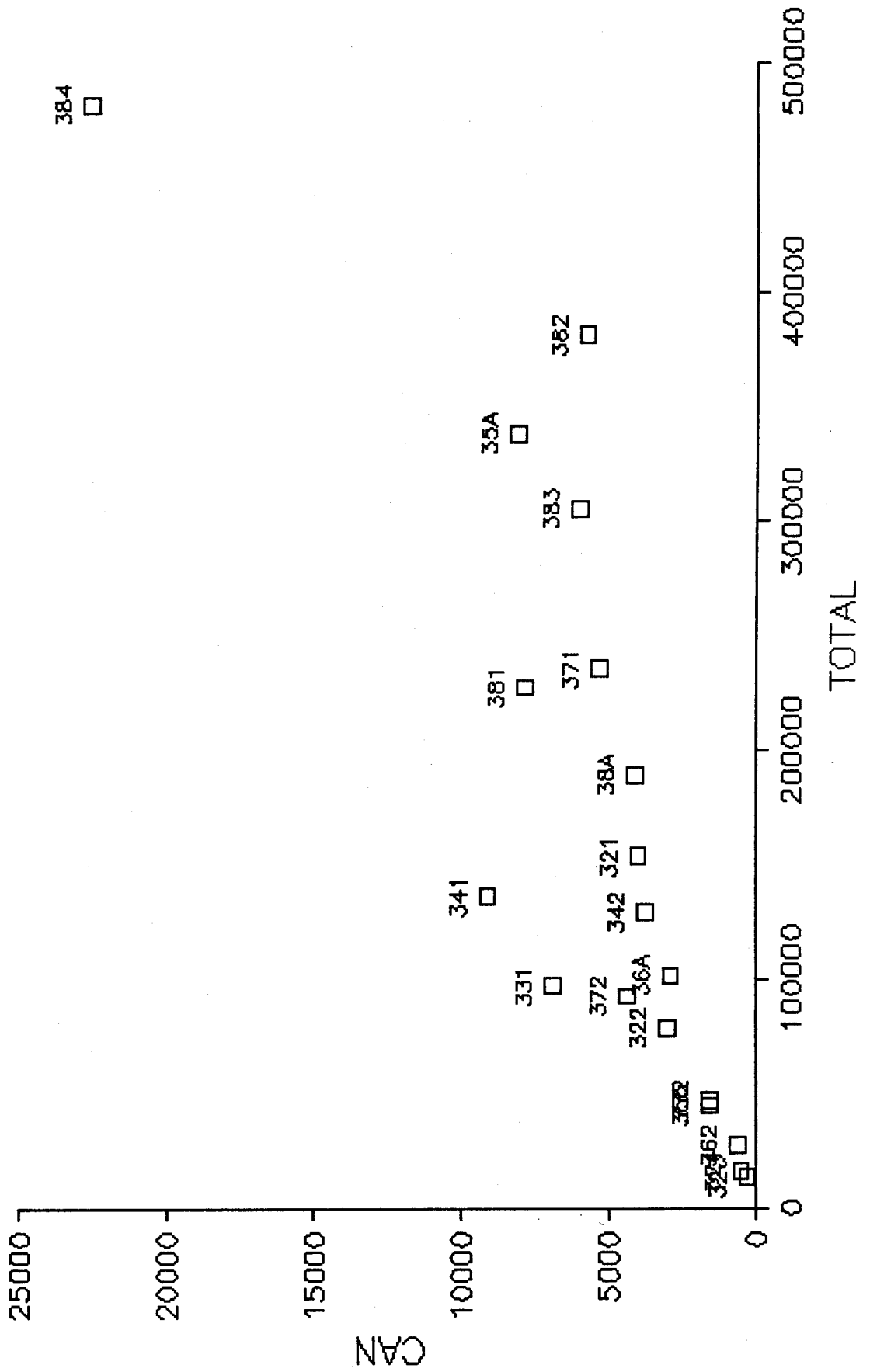
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Comparison with Overall Average



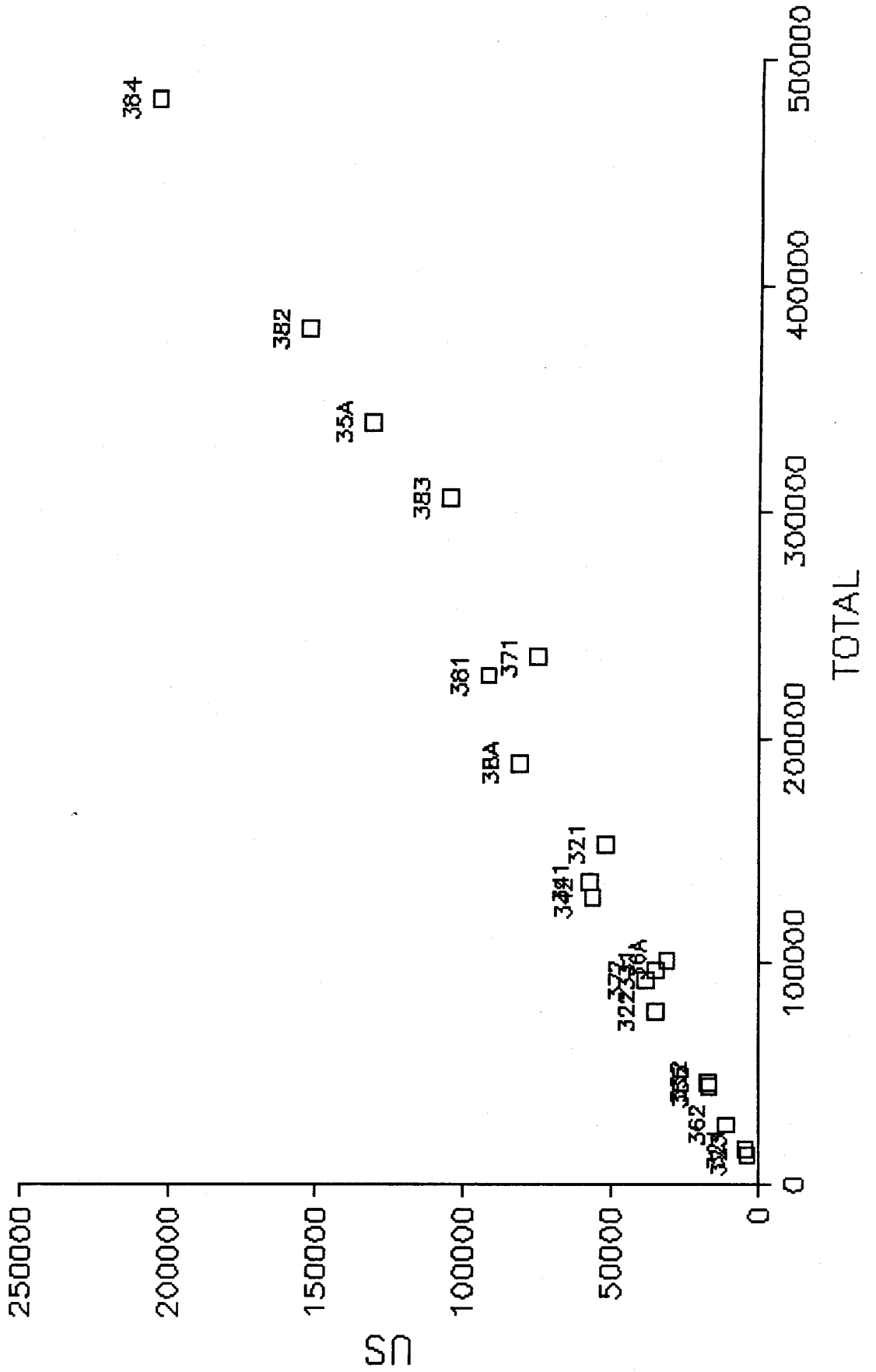
INDUSTRY OUTPUTS, 1978

Comparison with Totals



INDUSTRY OUTPUTS, 1978

Comparison with Totals



INDUSTRY OUTPUTS, 1978

Comparison with Totals

