OPTIMUM TRADE RESTRICTIONS AND THEIR CONSEQUENCES

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By Lester C. Thurow and Halbert White[1]

This paper develops a simulation model to study the income distribution effects—total and factorial—of optimum restrictions on the flows of factors and products across national boundaries. Imposing both optimum tariffs and optimum taxes on factor flows allows an increase in national income that is much larger than the sum of the two effects evaluated separately. Often there are large shifts in the incomes of factors even though total income changes only slightly.

Recent theoretical work by Kemp [2] and Jones [1] has extended the optimum tariff literature to cover the case of capital exports. Similar techniques can be used to show that there is also an optimum export of labor, technology, or managerial ability [3]. All of these formulations demonstrate that it is possible to exercise some degree of monopoly power whenever a country is faced with downward sloping demand curves for its commodities, its factors of production, or its knowledge. The problem, however, is to gain some information as to the quantitative importance of these optimum restrictions. Are the potential gains large or small?

The type of analysis used by Kemp and Jones is theoretically interesting but it does not lend itself easily to empirical estimations of the potential increases in national income. Differential analysis is used and while the derivatives may be reasonable approximations for rather small changes in the variables controlling the system, these values cannot generally indicate more than the direction of change (if that much) for finite nonmarginal changes. In addition, they do not provide estimates of how the income gains (or losses) are distributed within a country.

The purpose of this paper is to construct a simulation model within which it is possible to estimate the size and distribution of gains from optimum restrictions on international trade. The model focuses on trade restrictions and capital restrictions but could just as easily focus on labor restrictions since the model is symmetrical with respect to its treatment of capital and labor. The reader needs merely to assume that the letter "K" stands for labor rather than capital.

1. THE MODEL

The model is a standard neo-classical, two-country, two-good model. Two production functions (Cobb-Douglas or CES) are specified for the two internationally traded goods in each country, but the functions are not identical in terms of their parameters. If they were, the model would generate no competitive capital flows, as a result of the Heckscher-Ohlin theorem.

(1) $$X_1 = A_1 L_1^{\lambda_1} K_1^{1-\lambda_1},$$

(2) $$X_2 = A_2 L_2^{\lambda_2} K_2^{1-\lambda_2},$$

[1] We would like to thank Professor Kindleberger for his comments.

(3) $$X_1^* = A_1^* L_1^{*\lambda_1^*} K_1^{*1-\lambda_1^*},$$

(4) $$X_2^* = A_2^* L_2^{*\lambda_2^*} K_2^{*1-\lambda_2^*},$$

where X is output, L is the labor input, K is the capital input, A is the efficiency parameter, λ is the output elasticity, and the subscripts 1 and 2 refer to goods 1 and 2. The superscript * refers to the foreign country. The capital stock is assumed mobile between countries, and is always totally utilized. Thus

(5) $$\bar{K} = K_1 + K_2 + K,$$

(6) $$\bar{K}^* = K_1^* + K_2^* - K,$$

where $\bar{K}$ is the total capital endowment, K_1, K_2 are the capital used in production of goods 1 and 2, respectively, and K represents capital movements from the view of the home country ($K > 0$ signifies capital exports). Labor is not assumed to be mobile between countries since it is unnecessary to have complete factor mobility in more than one factor.[2] Labor is, however, mobile between industries within each country.

(7) $$\bar{L} = L_1 + L_2,$$

(8) $$\bar{L}^* = L_1^* + L_2^*,$$

where $\bar{L}$ is the total labor endowment.

In equilibrium the marginal value product of the factors of production will be equal in both uses within the country, and when free trade is allowed capital will flow to equalize marginal value products both within and across countries.[3] National income (Y) is the sum of total domestic output, valued in terms of the numeraire, plus or minus the revenue earned by exported or imported capital. In a Cobb-Douglas specification incomes would be given by equations (9) and (10):

(9) $$Y = X_1 + pX_2 + (1 - \lambda_1^*)\frac{X_1^*}{K_1^*}K,$$

(10) $$Y^* = X_1^* + pX_2^* - (1 - \lambda_1^*)\frac{X_1^*}{K_1^*}K.$$

On the consumption side, the model assumes that consumers maximize their utility—a function of the two internationally traded consumption goods. Utility functions are either Cobb-Douglas or CES and the social welfare function is simply the summation of identical homothetic individual utility functions. Social welfare is thus invariant to changes in the distribution of income (hence utility):

(11) $$U = BC_1^{\alpha}C_2^{1-\alpha}$$

[2] Allowing both capital and labor to move could lead to an indeterminacy. It would not be possible to specify whether capital would move to the labor force or whether labor would move to where capital was located.

[3] In the case of tariffs home country marginal value products and utilities are equalized at the domestic terms of trade p.

or

(12) $U = (aC_1^{-\beta} + bC_2^{-\beta})^{-1/\beta}$;

where U is utility, B is the scale factor, C_1 is consumption of good 1, C_2 is consumption of good 2, α is a taste parameter, a, b, are taste parameters, and $\beta = (1 - \sigma)/\sigma$, where σ is the elasticity of substitution. The same utility functions are applicable to the foreign country with * superscripts appropriately inserted. Maximizing utility subject to the budget constraints $C_1 + pC_2 = Y$ and $C_1^* + pC_2^* = Y^*$ yields market demand curves which can be shown to be the following:

(13) $C_1 = \alpha Y$,

(14) $C_2 = (1 - \alpha)\frac{Y}{p}$,

(15) $C_1^* = \alpha^* Y^*$, and

(16) $C_2 = (1 - \alpha^*)\frac{Y^*}{p}$,

or, for the CES specification,

(17) $C_1 = \frac{b^{-\sigma}}{a^{-\sigma}p^{(1-\sigma)} + b^{-\sigma}} Y$,

(18) $C_2 = \frac{a^{-\sigma}p^{-\sigma}}{a^{-\sigma}p^{(1-\sigma)} + b^{-\sigma}} Y$,

and symmetrically with * superscripts for the foreign country.

Since total imports must equal total exports it is sufficient that one market clear. This leads to a system of 22 equations in 22 unknowns. The entire system is summarized in the appendix. The model can be extended to examine the income distribution effects of a tariff on the home country's importable (good 1) by adding an equation to show the price effects of a tariff and modifying three other equations to allow domestic income to be valued at world prices (see equations (A.23)–(A.26) in the appendix).

There is one further problem, however. As Jones states in his comments on a similar model: "If capital is mobile between countries whether or not impeded by a tax, complete specialization is apt to occur in at least one of the countries, regardless of the similarities or differences in technical knowledge as between the two countries" [1]. The somewhat complex reasons for this conclusion are discussed in the last section of Jones' paper [1, pp. 31–38] and will not be reviewed here, but our simulations confirmed his results. Persistent attempts to simulate a model in which neither country specialized failed.

As a result we assume that the foreign country is specialized in production of good 1 for all price ratios. This is an arbitrary assumption, but an irrelevant one since the two possibilities involve the same process—only the point of view with respect to the good would be shifted.

2. PARAMETER VALUES

Parameter values were set to bracket a range of values that would be indicative of real world conditions. The utility function parameters were set to yield two goods with significantly different demand conditions.

Initially, the level of technical knowledge is assumed equal in both industries and countries. Since units of measurement are arbitrary A_1, A_2, and A_1^* are all set equal to 100. Since λ indicates factor shares, its values are set to bracket and yield a weighted average close to the domestic value of 0.75. Therefore, $\lambda_1 = .6$, $\lambda_2 = .8$, and $\lambda_1^* = .7$. Domestic capital and labor endowments are set equal to 100 and the foreign labor endowment was also held constant at 100. This makes it easy to calculate percentage changes. To simulate a world where the foreign country has a lower capital-labor ratio than the domestic country, the foreign capital endowment was alternatively set at 20, 40, 60, 80, and 100.[4]

On the consumption side, $\alpha = \alpha^* = .63$ and $B = B^* = 100$ for the Cobb-Douglas specification, and $a = a^* = 3$, $b = b^* = 1$ for the CES specification. These values were set to avoid complete specialization in both countries.

3. RESULTS

Simulations were performed to determine results without trade and without factor movements, with trade but without factor movements, with trade and with factor movements, with trade and optimum capital restrictions to maximize either domestic income or domestic utility, and with optimum trade restrictions and optimum capital restrictions. To conserve space the results are not reported for all of the simulations. Anyone wishing the complete simulation results can obtain them from the authors. In the rest of this paper results are shown for the CES utility function with a substitution elasticity of 0.5 and for Cobb-Douglas production functions. National income varied by less than 0.2 per cent when Cobb-Douglas utility functions were used with their substitution elasticities of one. Shifting to CES production functions with substitution elasticities of 0.67 had similar small effects on national income but approximately double the magnitudes of the gains or losses in capital and labor income. As a result, the Cobb-Douglas results presented in the paper are conservative with respect to the size of the distribution effects.

As is to be expected, when the simulations open up the possibilities of commodity trade, both domestic utilities and income increase for all values of $\bar{K}^*$ (see Table I). There are very different effects, however, on the income of capital and labor. Analytically these changes can be broken down into three components.

Since

$$Y_k = S_k \cdot Y, \tag{19}$$

$$Y_1 = S_1 \cdot Y, \tag{20}$$

[4] On the production side of the model it is the relative capital-labor ratios that count. The absolute size of the variables are only relevant in that they determine the extent of the capital flows that are necessary to achieve factor-price equalization. For this reason the two countries are assumed to have the same size labor forces.

TABLE I
OPTIMUM CAPITAL RESTRICTIONS
$\bar{K}^* = 60$

	No trade	Commodity trade	Commodity trade and unimpeded capital flows	Optimal capital restrictions: Income maximization	Optimal capital restrictions: Utility maximization
X_1	6,447.04	3,407.48	2,342.59	3,261.18	3,042.77
X_2	3,775.94	6,813.66	7,007.83	6,847.23	6,892.92
X_1^*	N.A.[a]	8,579.16	9,658.85	8,746.89	8,985.23
K	N.A.[a]	N.A.[a]	29.07	4.01	10
K_1	77.84	49.23	28.80	46.23	41.87
K_2	22.15	50.77	42.12	49.76	48.13
L_1	56.85	26.66	20.41	25.84	25.60
L_2	43.14	73.37	79.59	74.16	74.40
Y	10,116.30	10,436.50	10,139.50	10,444.7	10,424
Y^*	N.A.[a]	8,579.16	8,713.04	8,582.88	8,600.14
C_1	6,447.04	6,578.70	6,454.76	6,591.53	6,590.56
C_2	3,775.94	3,739.59	3,769.04	3,758.62	3,776.88
C_1^*	N.A.[a]	5,407.93	5,546.67	5,416.54	5,437.42
C_2^*	N.A.[a]	3,074.08	3,238.79	3,088.61	3,116.04
p	.97	1.032	.977	1.025	1.015
U	1,368.55	1,382.31	1,369.69	1,386.61	1,388.96
U^*	N.A.[a]	1,136.31	1,176.99	1,139.43	1,145.93
Y_k	3,312.66	2,768.79	3,258.07	2,872.35	3,002.4
Y_1	6,803.60	7,667.68	6,886.44	7,572.35	7,422.6

[a] N.A. indicates not applicable.

TABLE II
OPTIMUM TARIFF AND OPTIMUM CAPITAL CONTROLS
$\bar{K}^* = 40$

Variable	Unimpeded commodity and capital trade	Optimum tariff and unimpeded capital trade	Optimum tariff and optimum capital restrictions
X_1	2,200	0	0
X_2	6,817	9,077	10,000
X_1^*	9,307	9,296	7,597
Y	10,047	23,424	27,354
Y^*	7,934	7,930	7,597
C_1	6,430	14,332	16,656
C_2	3,809	7,531	8,644
C_1^*	5,077	4,174	3,886
C_2^*	3,008	1,546	1,397
P^*	N.A.[a]	2.43	2.74
P	.95	1.21	1.24
U	1,372	2,923	3,381
U^*	1,083	732	663
Y_k	3,548	5,777	5,471
Y_1	6,500	17,646	21,884
t	N.A.[a]	1.013	1.21
K	39	38	0
K_2	36.5	61.6	100

[a] N.A. indicates not applicable.

where Y_k is capital's income, Y_1 is labor's income, S_k is capital's share, S_1 is labor's share, and Y is total income,

$$dY_k = Y \cdot dS_k + S_k\,dY + dS_k \cdot dY, \tag{21}$$

$$dY_1 = Y \cdot dS_1 + S_1\,dY + dS_1 \cdot dY. \tag{22}$$

The change in shares is due to the trade-induced shift from good X_1 in which capital's share is relatively large to X_2 where it is relatively smaller. This change occurs as the domestic terms of trade shift in favor of good 2, making it more attractive to produce as good 1 becomes more abundant.

As $\bar{K}^*$ declines, the equilibrium price ratio moves downward since $\bar{K}^*$ controls the amount of good 1 that may be produced abroad. X_1^* falls and it becomes more expensive in international markets (p falls since good 1 is the numeraire). As a result, capital's share rises as p falls, although incomes fall as well (the total capital stock is smaller). (See Table II.) The overall effect on capital is to cause its income to rise even though total incomes are falling. Labor's income, however, falls both because overall incomes fall and because its share falls. Since welfare overall has decreased, it is clearly not possible for capital to compensate labor for its losses. Note, however, that compared to the no-trade situation, labor has gained at the expense of capital in all cases.

Relaxing the assumption that capital is prohibited from moving leads to further welfare gains as marginal productivities are equalized by the unimpeded flow of capital. Under the parameters chosen here, capital exports amount to 9.5 per cent of the total domestic capital stock when domestic and foreign capital labor ratios coincide (not shown in the tables). As the foreign capital stock decreases, the foreign marginal productivity of capital rises, leading to approximately 10 more units of capital exported for each 20 unit reduction in the foreign capital stock. The effect on the terms of trade works in the same manner as before but with the additional influence of the capital exports working behind the scenes. Capital exports lead to more of good 1 since the marginal productivity of capital is higher abroad. But as capital moves out of the production of good 1 at home, labor's marginal product falls, causing a flow into domestic production of good 2. The simultaneous working of all forces acting to equalize marginal products results in more of good 2 being produced than in the case with capital restrictions with a concomitant lower p.

The net effect of allowing capital exports in addition to commodity trade is to lower the utility index and income of the home country while raising utility and income in the foreign country. Before, the home country was essentially benefiting from the existence of a restrictive policy with respect to capital movements. The increase in foreign income and utility is high enough, however, to compensate the home country.

Within the home country, capital's share and income are both augmented above the commodity trade results while labor's position has universally deteriorated. For $\bar{K}^* \geqslant 60$ domestic capital is worse off than in a no-trade world, but for $\bar{K}^* \leqslant 40$ capital is always better off. Because of this phenomenon, the utility index for the home country has a "U" shape when graphed against foreign capital stock. Utility declines as $\bar{K}^*$ falls to 60 but at $\bar{K}^* = 40$ the utility index starts to rise. Utility rises because of the increased consumption of good 2 made possible by the falling terms of trade.

Table I presents data on the differences between income and utility maximization. It should be no surprise that utility and income maximization are not the same when terms of trade are allowed to vary. Remember that it is labor that gains when capital flows are restricted; capital loses. For all of the cases utility maximization results in less restrictions on capital movements than income maximization. This occurs since simple income maximization distorts the production of good 1 and good 2 too much relative to their relative weights in the utility function. Once again utility follows a "U" shaped pattern with respect to foreign capital stock. It decreases as $\bar{K}^*$ declines to 80 and then starts to increase. Utility gains spring from improvement in the terms of trade and a higher marginal productivity of capital.

Starting from a free trade position (see Table II) tariffs are increased as long as income (or utility) rises. For each possible foreign capital stock the optimum tariff with capital exports is just sufficient to cause the home country to specialize in the production of their exportable (good 2). Once specialization occurs, further tariff increases reduce both income and utility. Interestingly, the optimum tariff varies inversely with the foreign capital stock. As a result, domestic income rises as foreign capital stocks fall.

Comparing the optimum tariff results with the free trade results, one is struck by the potential power of the optimum tariff. Using international prices, domestic incomes are more than doubled with labor receiving proportionally more than capital since production is shifted towards good 2 where labor's share is higher. Measured in constant dollar free trade prices home country incomes rise 31 per cent.

While the income gains from tariffs seem much larger than those that can be gotten from optimum capital restrictions (31 per cent vs. 3 per cent) it should be remembered that tariffs can only directly affect that proportion of national income that enters international trade while capital restrictions affect the entire capital stock. As a result, the two types of restrictions are about equally effective in a country where 10 per cent of production enters international trade. It should also be remembered that it is not possible to retaliate against optimum capital restrictions by limiting the amount of inflowing capital without lowering your own income.

If optimum trade restrictions are combined with optimum capital restrictions it is possible to make further gains in home country income (see Table II). Measured in constant free trade prices, home country incomes rise 31 per cent with the imposition of optimum tariffs and 44 per cent with the imposition of optimum tariffs and optimum capital controls. Thus optimum capital controls are capable of causing a much larger increase in home country income in conjunction with optimum tariffs than they are on their own. While optimum tariffs raise capital and labor incomes, optimum capital restrictions lower capital's income below what it would have been if optimum tariffs had existed without optimum capital restrictions. Labor's gains are more than enough, however, to compensate for its losses.

The net result is that there is room for a significant increase in both national incomes and utilities by restrictions on capital and product flows. Even more importantly, the model brings out the large changes that can occur in capital and labor incomes under different assumptions about trade, trade restriction, capital movements, and capital restrictions.

While the previous model clearly represents an oversimplified view of the world, it does provide a crude estimate of the income gains to be made by capital export restrictions. With a $\bar{K}^*$ of 60, optimum capital restrictions raise domestic incomes by 3 per cent over the case of unimpeded capital and commodity flows. This is a reasonably small number, but it hides a significant shift in domestic incomes. Optimum restrictions raise labor's income by 10 per cent and lower capital's income by 12 per cent vis-a-vis the free commodity and factor trade position. Viewed from an alternative position, optimum restrictions raise labor's income by 9 per cent and lower capital's income by 9 per cent vis-a-vis the no-trade, no-factor flow position. These changes do not fall within the range of what could be considered insignificant shifts in the distributions of income.

Measured in constant dollar free trade prices, home country incomes rise 31 per cent with the imposition of optimum tariffs and 44 per cent with the imposition of optimum tariffs and optimum capital controls when $\bar{K}^* = 40$. Once again the distributional effects are large. When capital restrictions are added to tariffs, capital's income falls absolutely at the same time that total income is rising 13 per cent.

As a result, the model indicates that trade in goods and factors and restrictions on it induce large shifts in the distribution of income. The problem of compensation is a real problem that cannot be easily dismissed even when the changes in total incomes are small.

Massachusetts Institute of Technology

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APPENDIX

The Model

(A.1) $$X_1 = A_1 K_1^{1-\lambda_1} L_1^{\lambda_1},$$

(A.2) $$X_2 = A_2 K_2^{1-\lambda_2} L_2^{\lambda_2},$$

(A.3) $$X_1^* = A_1^* K_1^{*1-\lambda_1^*} L_1^{*\lambda_1^*},$$

(A.4) $$X_2^* = A_2^* K_2^{*1-\lambda_2^*} L_2^{*\lambda_2^*},$$

(A.5) $$K = \bar{K} - K_1 - K_2,$$

(A.6) $$K_2^* = \bar{K}^* + K - K_1^*,$$

(A.7) $$L_2 = \bar{L} - L_1,$$

(A.8) $$L_2^* = \bar{L}^* - L_1^*,$$

(A.9) $$K_1 = \frac{1-\lambda_1}{p(1-\lambda_2)} \frac{X_1}{X_2} K_2,$$

(A.10) $$K_2 = p\frac{(1-\lambda_2)}{(1-\lambda_1^*)}\frac{X_2}{X_1^*}K_1^*,$$

(A.11) $$L_1 = \frac{\lambda_1}{p(\lambda_2)}\frac{X_1}{X_2}L_2,$$

(A.12) $$L_1^* = \frac{\lambda_1^*}{p(\lambda_2^*)}\frac{X_1^*}{X_2^*}L_2^*,$$

(A.13) $$K_1^* = \frac{1-\lambda_1^*}{p(1-\lambda_2^*)}\frac{X_1^*}{X_2^*}K_2^*,$$

(A.14) $$Y = X_1 + pX_2 + (1-\lambda_1^*)\frac{X_1^*}{K_1^*}K,$$

(A.15) $$Y^* = X_1^* + pX_2^* - (1-\lambda_1^*)\frac{X_1^*}{K_1^*}K,$$

(A.16) $$C_1 = \alpha Y,$$

(A.17) $$C_2 = (1-\alpha)Y/p,$$

(A.18) $$C_1^* = \alpha^* Y^*,$$

(A.19) $$C_2^* = (X_2 - C_2) + X_2^*,$$

(A.20) $$p = (1-\alpha^*)Y^*/C_2^*,$$

(A.16a) $$C_1 = Y\cdot b^{-\sigma}/(a^{-\sigma}p^{(1-\sigma)} - b^{-\sigma}),$$

(A.17a) $$C_2 = Y\cdot a^{-\sigma}p^{(1-\sigma)}/(a^{-\sigma}p^{(1-\sigma)} + b^{-\sigma})p,$$

(A.18a) $$C_1^* = Y^*\cdot b^{*-\sigma^*}/(a^{*-\sigma^*}p^{(1-\sigma^*)} + b^{*-\sigma^*}),$$

(A.19a) $$C_2^* = (X_2 - C_2) + X_2^*,$$

(A.20a) $$p = \frac{b^*}{a^*}\left[\frac{C_1^*}{C_2^*}\right]^{1/\sigma^*},$$

(A.21) $$U = BC_1^{\alpha}C_2^{(1-\alpha)},$$

(A.22) $$U^* = B^*C_1^{*\alpha^*}C_2^{*(1-\alpha^*)},$$

(A.21a) $$U = (aC_1^{-\beta} + bC_2^{-\beta})^{-1/\beta},$$

(A.22a) $$U^* = (a^*C_1^{*-\beta^*} + b^*C_2^{*-\beta^*})^{-1/\beta^*},$$

(A.23) $$p^* = p/(1+t),$$

(A.24) $$y = X_1 + p^*X_2 + (1-\lambda_1^*)\frac{X_1^*}{K_1^*}K,$$

(A.25) $$y_l = \lambda_1 X_1 + \lambda_2 p^* X_2,$$

(A.26) $$y_k = (1-\lambda_1)X_1 + (1-\lambda_2)p^*X_2 + (1-\lambda_1^*)\frac{X_1^*}{K_1^*}K.$$

Definition of Symbols

$A_.$: technical efficiency coefficient,
a: CES utility function taste parameter,
B: Cobb-Douglas utility function scale parameter,
b: CES utility function taste parameter,
$C_.$: consumption,
K: capital export,
$K_.$: capital input,
$\bar{K}$: capital endowment,
$L_.$: labor input,
$\bar{L}$: labor endowment,