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A RECALCULATION OF CLINE'S ESTIMATES OF THE GAINS TO TRADE LIBERALIZATION IN THE TEXTILE AND APPAREL INDUSTRIES

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I. Introduction

Currently, the U.S. textile industry operates under the protection of what has been described to be one of the most trade-restraining international agreements for manufactured products in existence, the Multi-Fiber Arrangement. In order for Congress to rationally formulate trade policy in this area, it needs to be cognizant of the magnitudes of the associated costs and benefits accruing to various sectors of society. To that end, several studies have been conducted which have attempted to estimate these magnitudes.[1] One of the most recent, that of Cline (1987), concluded on the basis of a welfare analysis of economic surplus that the current textile trade restrictions involve a net efficiency loss of $811 million per year, while those for apparel involve a loss of $7.3 billion per year. Moreover, the associated consumer costs were, as one would expect, considerably more.[2]

The objectives of the following paper are twofold. First, within the framework of Cline's analysis of textile and apparel trade restrictions, it presents a more theoretically sound methodology of welfare analysis of societal surplus. Specifically, it focuses on three methodological issues: the measurement of changes in consumer surplus when two or more prices change simultaneously, the appropriate characterization of policy-induced changes in social welfare, and the inter-relationship of economic surplus' of two vertically related industries. Second, upon modifying the analysis so as to address two of these methodological issues, this paper recalculates Cline's estimates of the gains to trade liberalization in the U.S. textile industry. This recalculation reinforces Cline's depiction of the relatively high cost of protection.

The comparative static analysis employed here is identical to that of Cline, in that it assumes: 1) two goods, one domestic and one imported, that are imperfect substitutes in consumption; 2) an upward-sloped domestic supply curve and a perfectly elastic import supply curve; and 3) import restrictions in the form of both a tariff and a quota, the latter permitting the accrual of "quota rents" to foreign suppliers. The initial equilibrium with restricted imports is illustrated in Figure I at a price of P_{d0} for the domestic good and a price of P_{m0} for the imported good, read off the initial demand curves, D_d and D_m.

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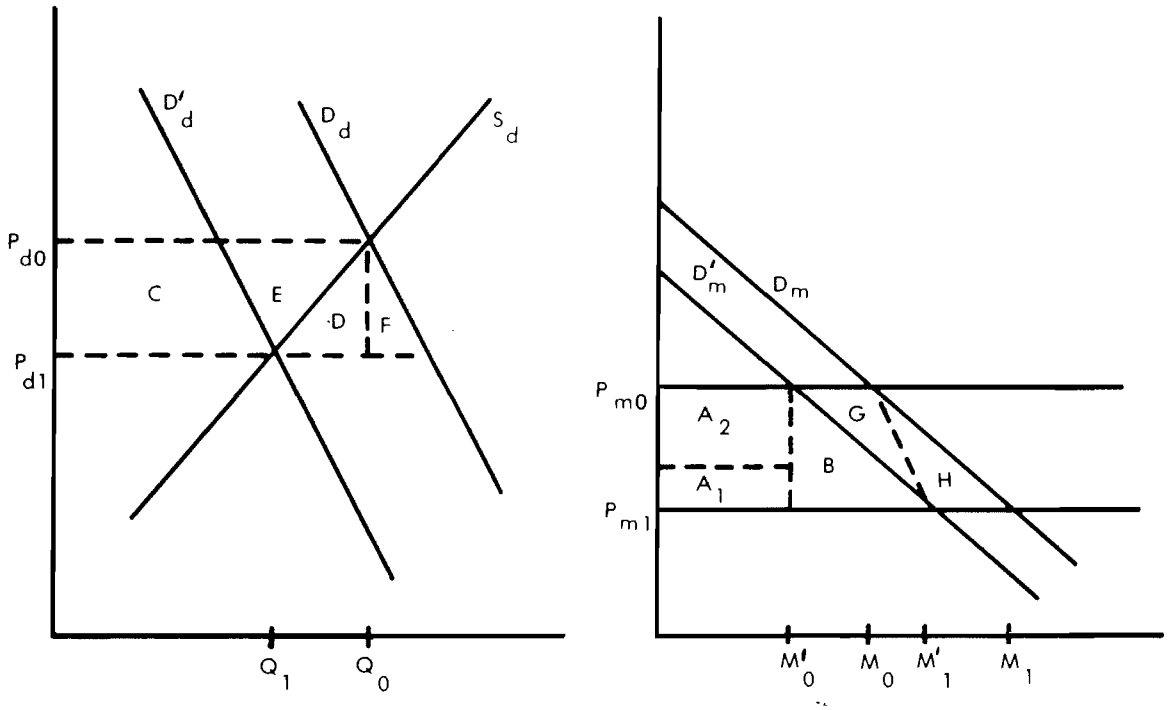
[1] For example, see Tarr & Morkre (1984), Hufbauer, Berliner & Elliott (1986), and Cline (1987).

[2] See Cline (1987), p. 198.

Figure I



A. Domestic

B. Import

Consider next the effects of trade liberalization where both the quota and the tariff are eliminated.[3] The price paid by consumers for imports falls, which both increases the quantity of imports demanded and shifts the demand schedule for the domestic good to the left. The latter effect lowers the price of the domestic good, which in turn, shifts the demand schedule for the imported good down as well. The new equilibrium is depicted with the new demand curves D_d' and D_m' and the new prices P_{d1} and P_{m1}.

The remainder of this paper is organized as follows: Sections II, III and IV address the three methodological issues cited above. In Section V, Cline's estimates of the costs and benefits to trade liberalization are recalculated. A conclusion then follows.

II. The Impact of Simultaneous Price Changes on Consumer Surplus Measures

When a policy change involves a change in a single price, the effect on consumer welfare can be conceptualized in a straightforward manner as the area beneath the demand curve bounded by the original and final prices. On the other hand, the representation of the change in consumer surplus is considerably complicated whenever more than one price changes and a shift in the demand curve for one good occurs simultaneously with change in another good's price. In his book, Cline recognizes this difficulty and argues:

> "In comparing pre- and post-liberalization consumer surplus, it is necessary to use the final demand curves in both the import and domestic markets . . . Otherwise the consumer surplus would appear to decrease by the area between the original and final demand curves and above the original prices--a nonsense result that could imply consumers had been hurt by lower prices. In technical terms, the use of the ex post demand curves to evaluate the welfare effects of the price changes amounts to an "index number problem," in which value changes must be measured using either base or terminal period quantity weights. The procedure here applies quantity weights based on the terminal demand curves . . . and may be thought of as analogous to a Paasche (terminal quantity weight) price index. The direction of bias in this approach is to

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[3] The rectangle A in Figure I.A is subdivided into the rectangles A_1, representing the tariff revenue accruing to the government (also denoted G by Cline), and the rectangle A_2, representing the quota rents accruing to foreign suppliers.

> understate welfare gains to consumers, because the corresponding (Laspeyres) base-period weighting approach would apply the ex ante demand curves and would generate larger changes in consumer surplus."[4]

Since Cline's approach seeks to provide a conservative measure of the gains to trade liberalization, it is certainly preferable in this instance to the cited alternative approach (i.e., one employing "base-period weighting"). However, these are neither the only nor the best alternatives from which to choose.[5] Several valuable contributions have been made to the body of economic literature addressing the problem of evaluating changes in consumer surplus arising from the simultaneous change in two (or more) prices. Theoretically, such a calculation should be performed by changing both (or all) prices simultaneously in infinitesimal steps.[6] Unfortunately, this methodology cannot be readily translated to practice. Alternatively, the calculation can be executed in a piece-meal fashion, that is, by changing prices sequentially. For example, in the two good case, one could first find the change in consumer surplus that arises upon changing one price, holding the other constant at its initial price, then summing this with the change in consumer surplus upon changing the second price, holding the first price constant at its subsequent or final value. This approach, while practical, may lead to a path dependence problem in that the result may depend on the sequence in which prices are changed. Fortunately, this potential discrepancy can be dealt with in a reasonable way by defining an estimate for the change in surplus to be the average of the results obtained with all possible sequences of discrete price changes.[7] This approach yields an estimate identical to that proposed by Burns,[8] graphically represented

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[4] See Cline (1987), Appendix B, footnote 2, p. 303.

[5] Certainly, whenever insufficient evidence exists to justify the choice of one assumption (or methodology) over another, then it is appropriate to choose that assumption which yields a conservative (e.g., lower bound) estimate of the gains to a proposed policy change. On the other hand, the choice of a clearly inaccurate assumption (or methodology) over an acceptable alternative should not be made on the basis of this rationale.

[6] See Burns (1973) pp. 339-342.

[7] For example, the change in consumer surplus arising from the simultaneous change in the prices of 2 (or n) goods could be approximated by the average of the calculated changes in consumer surplus for the 2 (or n!) alternative sequences of price changes. This approach is presented mathematically in Appendix A.

[8] See Burns (1973), p. 342.

by a quadrilateral bounded by the price axis, the two prices (initial and subsequent), and a line segment connecting the two equilibrium points on the two demand curves (i.e., initial and subsequent).[9] In Figure I.A, this is given by the sum of areas C and E, while in figure I.B, this is represented by the sum of areas A (or equivalently, A_1+A_2), B and G.[10]

Cline, in choosing the conservative measure (described as a "Paasche" estimate) corresponding to the area (A+B+C), rejected the alternative, less conservative measure (i.e., "Laspeyre") corresponding approximately to (A+B+C+D+E+F+G+H). Hence, the measure proposed here is bounded by the two alternatives considered by Cline, and exceeds that chosen by Cline by (E+G).[11]

III. The Appropriate Definition of Social Welfare

In general, trade liberalization can be expected to benefit consumers (in the form of increased consumer surplus in the consumption of both goods), but harm domestic producers (by decreasing producer surplus), the government (by eliminating tariff revenues on textile imports, represented by A_1 in Figure I), and foreign suppliers (by eliminating quota rents, represented by A_2 in Figure I). Since social welfare is traditionally defined as the sum of consumer surplus (CS), producer surplus (PS), and government revenues (GR), the change in welfare arising from trade liberalization must equal the sum of the changes in these components, i.e.,

$$\Delta W = \Delta CS + \Delta PS + \Delta GR .$$

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[9] Other trade studies have employed this approach. For example, see Rousslang & Suomela (1985), pp. 14-17, and Tarr & Morkre (1980), Appendix 2A, pp. 25-27.

[10] As is indicated by Cline, some controversy exists as to whether the long run domestic supply curve is perfectly or imperfectly inelastic. If it is assumed to be perfectly elastic, then trade liberalization would have no effect on the domestic price. As a logical result, there would be no shift in the demand schedule for the imported good, and hence the change in consumer surplus for the imported good would be represented in its traditional form.

[11] If all schedules are assumed linear, and if all demand shifts parallel, then (by similar triangles) the area (D+F) equals E. Similarly, in Figure I.B, the triangles G and H are equal. As a consequence, the upper bound (denoted Laspeyre) exceeds the lower bound (chosen by Cline) by 2(E+G), and the measure proposed here is exactly midway between the two bounds.

Note that the gain to trade liberalization should exactly equal the allocative inefficiency associated with the market distortions arising from the textile import tariff and quota.[12]

In his discussion of the gains and losses to trade liberalization, Cline argues that:

> ". . . there is an additional benefit from the production side in the form of released real resources which previously had been inefficiently employed."[13]

He goes on to conclude that this gain (represented here by triangle D in Figure I.A) should be included as an input into the calculation of ΔW. This conclusion is inconsistent with the traditional methodology of analysis of economic surplus.[14] The gains to trade liberalization should exactly equal the allocative inefficiency of the existing trade restrictions, i.e., the product of this surplus calculation. Hence, a methodology that employs ad hoc an expected product of that calculation as an input to that same calculation is suspect. Since Cline does not provide any justification for including the so-called "released real resource" gain, it can be presumed that he believes: (1) that it is a real gain to society, and (2) that it would not be captured by the traditional analysis of economic surplus (i.e., by the summing of the changes in consumer surplus, producer surplus, and tariff revenues).

It is argued here that the gain is indeed captured by traditional surplus analysis, although it is not obviously so for the heterogeneous goods case modeled by Cline. Since Cline's analytical model permits domestically-produced and imported goods to be imperfect substitutes in consumption, it is a general model that encompasses all possible (presumably positive) values for the cross elasticity of demand between the two goods. Such generality has obvious merits, although the implications (e.g., shifting demand curves) can at times make analysis

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[12] This analysis ignores all costs associated with administering and enforcing the import tariff and quota, as well as any unemployment costs that might arise from trade liberalization. It is important to recognize that the latter unemployment costs are transitory adjustment costs. Accordingly, if such costs are aggregated with allocative inefficiencies (or, equivalently, dead-weight losses) as has sometimes been done, it should be done carefully, since an adjustment cost is a one-time cost, while an allocative inefficiency cost will be on-going.

[13] See Cline (1987), Appendix B, p. 305.

[14] For a general discussion, see Currie, Murphy & Schmitz (1971) and Just, Hueth & Smith (1982), pp. 154-165. Also see Scherer (1980), pp. 216-219 and 395-398. As examples of similar analytical approaches, Cline references Rousslang & Suomela (1985), whose analysis did not incorporate this "resource cost" component.

difficult. On the other hand, by considering those goods having a very high cross elasticity of demand, which is what is done here, the analysis is greatly simplified. If in fact traditional analysis of economic surplus fails to capture Cline's "released real resource" gain, it should fail to do so for goods characterized by both high and low cross elasticities of demand---including those goods which almost are, or indeed are, perfect substitutes. If in fact the traditional analysis does capture this gain, then we should find that Cline's methodology results in double-counting.

Assume that domestic and imported goods have very high cross elasticities of demand. Then, with little loss of generality, the goods can be modeled as if they were perfect substitutes. Unlike the case of imperfect substitutes where two graphs must be employed, one for domestic and one for imported goods, it is sufficient in this case to use only one diagram, i.e., for all goods (domestic plus imported), as is depicted in Figure II.A. However, for the purpose of comparison with the case of imperfect substitutes depicted in Figure I, diagrams corresponding to both imported and domestic are provided in Figures II.B and II.C, respectively. Note that the demand schedule for the imported good, D_m in Figure II.B, is constructed as the horizontal difference between the total demand, D_T, for the good and the domestic supply, S_d. Consequently, Q_m can be read off Figure II.A as the difference between Q_T and Q_d, or off Figure II.B. In addition, the demand curve for the domestic good is given by the kinked demand curve D_d (or P_0ln) in Figure II.C prior to trade liberalization, and by D_d' (or P_1mn) post-liberalization. Hence, just as in the heterogeneous good case, the demand curve for the domestic good shifts down in response to trade liberalization.

By construction, area A of Figures II.A and II.C must equal the sum of A_1 and A_2 in Figure II.B, and similarly, (D + A + F) must equal (A_1 + A_2 + B). Consequently, area B must equal (D + F).

Now traditional analysis of economic surplus would compute the change in total economic surplus, or equivalently the change in social welfare, arising from a decrease in the price as

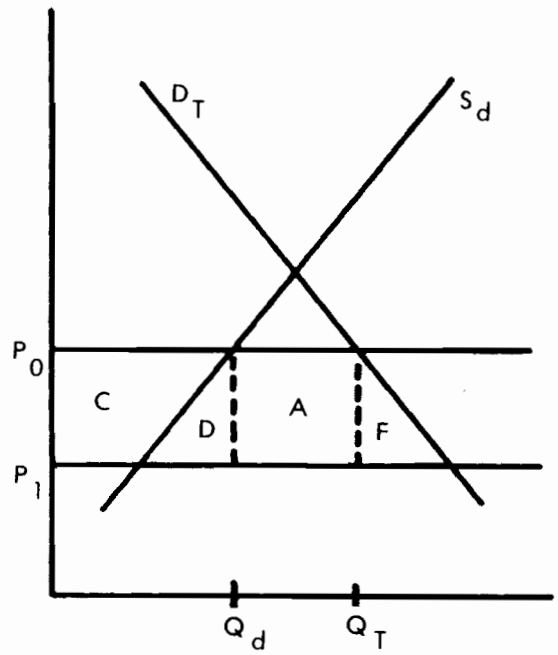
$$\begin{aligned} \Delta W &= \Delta CS + \Delta PS + \Delta R \\ &= [C + D + A + F] + [-C] + [-A_1] \\ &= D + A_2 + F, \end{aligned}$$

or, equivalently,

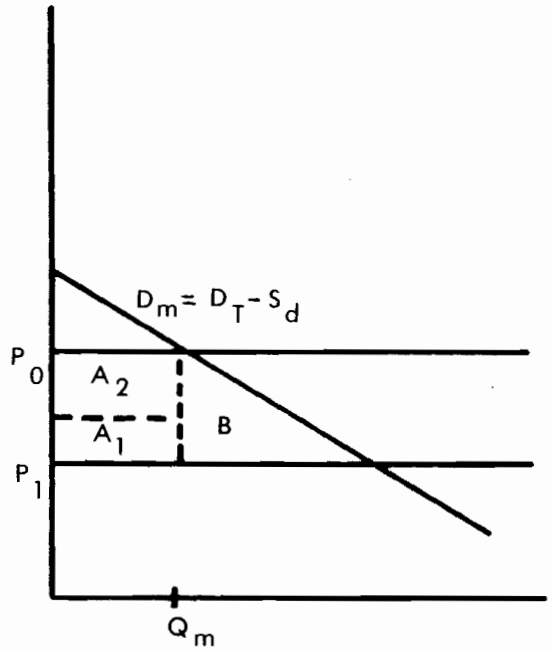
$$\Delta W = B + A_2,$$

(where variables are as defined previously). Clearly, in the case of (near) perfect substitutes, it is unnecessary to "correct" the traditional methodology of economic surplus analysis by adding in the area D. To do so would be double-counting.

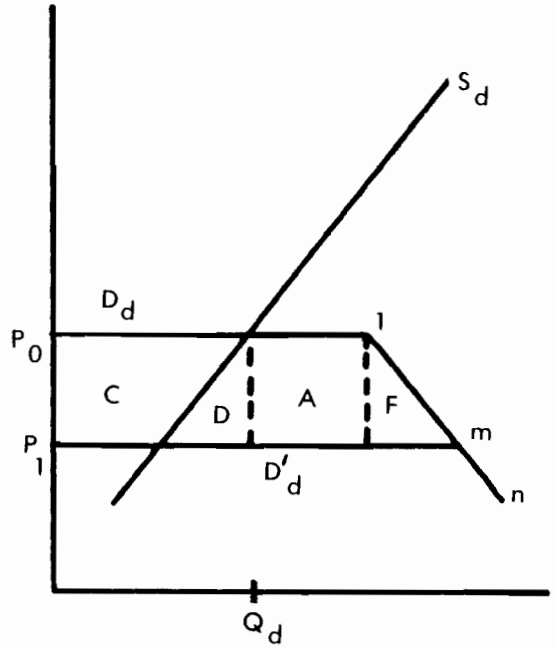
Figure II



A. All Goods



B. Import



C. Domestic

The issue then is whether the ΔW found using traditional analysis of economic surplus within the more general context of imperfect substitutes would include Cline's "released resource gain". For the case of perfect substitutes, it has been shown above that this resource gain appears not only in Figures II.A and II.C as triangle D, but also in Figure II.A subsumed in Cline's triangle B. In the context of the imperfect goods case, it would seem likely by extrapolation that the gain represented by triangle D--while not explicitly a component of the ΔW arrived at with traditional economic surplus analysis--is nevertheless included in this ΔW, by being subsumed in the triangle B. Since Cline's methodology yields an expression for ΔW that includes both B and D, this would appear to involve doublecounting.[15]

IV. Welfare Analysis of Policies Affecting Vertical Industries

In his book, Cline develops an analytical model of trade liberalization for a single hypothetical industry, and then estimates the gains and losses for the two industries, textiles and apparel, in isolation from one another. This approach chooses to neglect the vertical relationship of the two industries considered; for example, while some textiles are sold directly to consumers, some also serve as inputs into the production of apparel. This approach greatly simplifies the analysis, by reducing both the informational needs[16] and the sheer size of the model, but it also fails to provide any indication of the effect trade liberalization in one industry would have on the other. More seriously, this approach, while perhaps appropriate for estimating the impact of trade liberalization in each

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[15] While this has only been shown true under the assumption of homogeneous goods, the more general model assuming imperfect substitutes must have as a limiting case those goods with high or infinite cross elasticities of demand. Hence, the result shown above, i.e., that traditional analysis of economic surplus captures the gain in question, can reasonably be expected to hold for all cross elasticity values. Admittedly, due to the inherent analytical complexity, this has not been shown for all possible cross elasticities. Nevertheless, it would seem that, in departing from the generally accepted methodology for analyzing economic surplus, Cline should assume the burden of proof of showing that the result would not hold for some (presumably small) values of demand cross elasticities.

[16] For example, one might need to know the share of textiles that go into apparel production, the elasticities of demand for textiles for consumers and for textile manufacturers (if different), as well as the elasticity of demand for textiles with respect to the price of apparel and the elasticity of supply of apparel with respect to the price of textiles.

industry individually, does not yield an accurate measure of the impact of trade liberalization in both textiles and apparel. That is, the sum of the calculated effects of removing trade restraints individually from two industries may be greater than or less than the total effect of simultaneously removing those same trade restraints. The direction and magnitude of the error cannot be known a priori. Ideally, to analyze the effects of joint trade restrictions (or simultaneous trade liberalization) in two or more industries that are vertically related, a single integrated model should be constructed instead of two or more "ceteris paribus" industry models.[17]

V. Revised Estimates of the Gains to Trade Liberalization

In this section, the gains and losses arising from trade liberalization of the textile and apparel industries estimated by Cline are revised in accordance with the methodological revisions proposed in Sections II and III. These revisions are summarized in Table I in terms of the areas labeled in Figure I. The revised gains and losses accruing to each segment of society (e.g., consumers, producers, and government revenues) are contrasted with those underlying Cline's estimates.

The two specifications for consumer surplus can be seen to differ by the triangles E and G; this difference is fully attributable to the aforementioned problem of defining changes in consumer surplus whenever two prices change simultaneously. On the other hand, Cline's definition of the change in producer surplus is inconsistent with the traditionally accepted definition (i.e., the area to the left of the supply curve between the two price lines), leading to an underestimate of this change amounting to the triangle E.[18] This difference partially offsets the preceding one. That is, by omitting the gain of E to consumers and omitting the loss of E to producers, the net error amounts to an understatement of G. Finally, as discussed previously, Cline adds in the gain of "released real resources which previously had been inefficiently employed," area D.[19]

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[17] For example, see Anderson & Metzger (1987).

[18] Moreover, upon approximating the area of the trapezoid C, Cline uses the larger rectangle defined by the product of the new quantity and the change in the price of the domestic good.

[19] In contrast, Hufbauer et al concluded the deadweight loss of the domestic market (Figure I.A) to be the triangle formed by the original domestic demand and supply schedules above the price line corresponding to P_{d1}; this triangle includes D, and moreover is equivalent to the triangle E if all schedules are linear and if the two

Table I

Expected Gains and Losses to Society
from Trade Liberalization

	Cline	True
Consumer (ΔSurplus)	+ $[A_1+A_2+B+C]$	+ $[A_1+A_2+B+C+E+G]$
Producer (ΔSurplus)	- $[C]$	- $[C+E]$
Government (ΔRevenues)	- $[A_1]$	- $[A_1]$
"Resource Cost"	+ $[D]$	. . . .
Net Gain	+ $[A_2+B+D]$	+ $[A_2+B+G]$

Therefore, Cline's determination of the net gain to trade liberalization underestimates the actual gain by the amount (G-D). In order to revise Cline's estimate of the dollar value of this gain, it is necessary to know the area of the two triangles D and G. The value for D is reported by Cline,[20] while G must be calculated.[21] Note that in adopting these values, one implicitly accepts, inter alia, Cline's conclusions as to the magnitude of surplus presently accruing to foreign producers in the form of quota rents, as well as his estimates of expected prices and quantities post-liberalization.

The computed values for D and G, as well as the revised estimates of the gains to trade liberalization are presented in Table II. On the basis of these calculations, the gain to trade liberalization is seen to be in the order of $822 million and $7 billion per year (respectively) for textiles and apparel. It can be seen in this table that the adjustments for the two methodological issues proved to be relatively small, at least with respect to the net gain, primarily because the effects were partially offsetting. In Tables III and IV, where the changes in surplus for consumers, producers and government revenues are reported, the adjustments are seen to be more significant.

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demand curves are parallel. This was arrived at by subtracting the change in producer surplus (i.e., C + E) from the change in consumer surplus calculated beneath the original demand curve (i.e., approximately, C + 2E). The deadweight loss of Figure I.B was defined in a manner similar to that of Cline. See Hufbauer, Berliner & Elliott (1986), pp. 32-37.

[20] See Cline (1987), Table 8.1, p.191.

[21] This area can be approximated by the expression

$$G = \tfrac{1}{2} (P_{m0} - P_{m1}) (M_0 - M_0') .$$

Since Cline specifies the import demand function to be $M = m_0 P_m^a P_d^b$ where m_0 is the original level of imports, G can be re-expressed as

$$G = \tfrac{1}{2} (P_{m0} - P_{m1}) \; m_0 P_{m1}^a (P_{d0}^b - P_{d1}^b)$$

Given that original prices are assumed to be unity,

$$G = \tfrac{1}{2} (\%\Delta P_m/100) \, m_0 [(1+(\%\Delta P_d/100))^b - 1] .$$

Cline reports the percent changes in prices and the base value of imports, m_0, in Table 8.1 (p. 191), and the elasticity b in Table B.1 (p. 311).

Table II

Revisions of Cline's Estimates of the Gains to Society from Trade Liberalization

	D	G	Net Gain Adjustment (G-D)	Cline Net Gain	Revised Net Gain
Textiles	24	46	+ 11	811	833
Apparel	933	832	-101	7317	7216

TABLE III

TEXTILE TRADE LIBERALIZATION:
ESTIMATED GAINS AND LOSSES
(millions 1986 dollars)

	Cline Estimate	Revised Cline
CONSUMERS		
Imported Textiles	(+1,275)	(+1,310)
Domestic Textiles	(+1,513)	(+1,537)
Total	+2,788	+2,847
TEXTILE PRODUCERS	-1,513	-1,537
TARIFF REVENUE	-488	-488
"RESOURCE COST"	24	---
TOTAL	+811	+822

TABLE IV

APPAREL TRADE LIBERALIZATION:
ESTIMATED GAINS AND LOSSES
(millions 1986 dollars)

	Cline Estimate	Revised Cline
CONSUMERS		
Imported Apparel	(+9,551)	(+10,383)
Domestic Apparel	(+8,005)	(+8,938)
Total	+17,556	+19,321
APPAREL PRODUCERS	-8,005	-8,938
TARIFF REVENUE	-3,167	-3,167
"RESOURCE COST"	+933	---
TOTAL	+7,317	+7,216

VI. Conclusion

The primary objective of this paper has been to suggest improvements in the methodology adopted by Cline in his analysis of the benefits of trade liberalization in the textile and apparel industries. Consistent with these, it also re-estimated the magnitudes of such gains. Rather than detracting from the results of Cline's analysis, this paper has reaffirmed his conclusion that significant gains are attainable from the elimination of trade restrictions on the import of textiles and apparel.

Appendix A

Derivation of Consumer Surplus Change when Two Prices Change Simultaneously

Let the demand for X and for Y be functions only of their prices, i.e., $X(P_x;P_y)$ and $Y(P_y;P_x)$.[22] Then, the change in consumer surplus arising from a change in the prices from (P_x^0,P_y^0) to (P_x',P_y^0) can be expressed as:

$$\Delta CS = \int_{P_{x0}}^{P_x'} X(p;P_{y0})\, dp \ .$$

Similarly, for a change in (only) the price of Y, the change in consumer surplus is given by

$$\Delta CS = \int_{P_{y0}}^{P_y'} Y(p;P_{x0})\, dp \ .$$

Note that to evaluate a simultaneous change in both prices it is not sufficient to simply sum the two discrete changes, since this neglects the simultaneous shifting of the two demand curves.[23] The correct approach is to evaluate the change in consumer surplus as both prices change simultaneously. One could conceptualize this as finding

$$\Delta CS = \int_{P_{x0}}^{P_x'} X[p;f(p)]\, dp + \int_{P_{y0}}^{P_y'} Y[p;g(p)]\, dp$$

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[22] For purposes of this presentation, it can be assumed that the demand curves are income-compensated, that is, the demand curve for X (Y) holds income constant for changes in the price of X (Y). This is an assumption that not only simplifies the following analysis, but is also commonly invoked (implicitly or explicitly) in public policy applications due to inherent data limitations. On the other hand, it should be noted that the demand curve for X (Y) is not income compensated for changes in the price of Y (X), so that the demand function for X shifts whenever P_y changes, both due to a substitution and an income effect.

[23] Such an approach, i.e., evaluating the change in consumer surplus beneath the original demand curves, would be equivalent to the so-called Laspeyres measure rejected by Cline. The method adopted by Cline, i.e., that of measuring the change in consumer surplus beneath the subsequent demand curves, is similarly inaccurate, although for the case considered it does provide a more conservative (i.e., lower bound) estimate of the benefits of trade liberalization.

where f(p) would be defined to range from P_y^0 to P_y' as the price of X ranges from P_x^0 to P_x', and similarly, g(p) would be defined to range from P_x^0 to P_x' as the price of Y ranges from P_y^0 to P_y'. It can be shown that if the functions f and g are assumed to be linear, then the resultant ΔCS is approximated by the sum of two trapezoids, where each trapezoid is defined by the price axis, the two horizontal price lines corresponding to the original and subsequent prices, and a line segment connecting the original and subsequent consumption points.[24] This corresponds to the approximation proposed by Burns (1973). In Figure I, this is given by (C+E) plus (A+B+G) for the domestic and imported goods, respectively.

Alternatively, one could treat a simultaneous change in n prices as the sum of n discrete changes in the n prices. In the two good example, one could find the changes in consumer surplus along the paths of (P_x^0, P_y^0) to (P_x', P_y^0) and (P_x', P_y^0) to (P_x', P_y'), and then summing:

$$\begin{aligned}\Delta CS = & \left\{ \int_{P_{x0}}^{P_x'} X(p;P_{y0})\, dp + \int_{P_{y0}}^{P_y^0} Y(p;P_x)\, dp \right\} \\ & + \left\{ \int_{P_x'}^{P_x'} X(p;P_y)\, dp + \int_{P_{y0}}^{P_y'} Y(p;P_x')\, dp \right\} \\ = & \int_{P_{x0}}^{P_x'} X(p;P_{y0})\, dp + \int_{P_{y0}}^{P_y'} Y(p;P_x')\, dp\end{aligned}$$

A second path in which the prices are changed in reverse order would yield yet another estimate of the change in consumer surplus, namely,

$$\Delta CS = \int_{P_{x0}}^{P_x'} X(p;P_y')\, dp + \int_{P_{y0}}^{P_y'} Y(p;P_x^0)\, dp .$$

In general, the estimate of the change in consumer surplus will be path dependent, so these two expressions for ΔCS will differ. Upon taking the average of the two estimates, one obtains

$$\begin{aligned}\Delta CS = & \int_{P_{x0}}^{P_x'} \tfrac{1}{2} [X(p;P_y^0) + X(p;P_y')]\, dp \\ & + \int_{P_{y0}}^{P_y'} \tfrac{1}{2} [Y(p;P_x^0) + Y(p;P_x')]\, dp .\end{aligned}$$

Graphically, this is represented by the sum of two trapezoids, where each trapezoid is defined by the price axis, the two prices, P_x' and P_{x0} (or P_y' and P_{y0}), and a line segment connecting the equilibrium points on the new and old demand curves for X (or Y). This representation is

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[24] This approximation is exact in the two good case if the demand functions are linear and additively separable in prices, or equivalently, if $X_{P_x,P_y} = Y_{P_y,P_x} = 0$ and $X_{P_y,P_y} = Y_{P_x,P_x} = 0$.

identical to the approximation, described above, for the ΔCS obtained by changing both prices simultaneously in a linear manner. This derivation can be generalized to the case of n price changes, in which case the average would be calculated over n! different price paths. Nevertheless, the change in consumer surplus for a given good would be graphically represented in an identical manner, i.e., the trapezoid would be defined by the equilibrium points on the new and original demand curve for that good.

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