PARETO INFERIOR TRADE AND OPTIMAL TRADE POLICY

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David Newbery

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Development Research Department
Economics and Research Staff
World Bank

The views presented here are those of the author, and they should not be interpreted as reflecting those of the World Bank.
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David M. G. Newbery
Churchill College, Cambridge, and The World Bank

and

Joseph E. Stiglitz
Princeton University

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One of the basic tenets of liberal economics is that everyone could be made better off by reducing restrictions on trade. Even though some groups in the population may be made initially worse off, those who gain as a result of trade liberalization can more than afford to compensate those who suffer. We show that in a competitive but risky economy, free trade may be Pareto inferior to no trade, and under fairly general conditions a restriction in trade from the free-trade position will constitute a Pareto improvement. One result consistent with traditional beliefs is that there exists some form of liberalization from the no-trade situation which constitutes a Pareto improvement.

The basic idea behind our model is simple. There are two countries (regions) both of which grow a risky agricultural crop and a safe crop. The output in the two regions is negatively correlated. (The results can easily be extended to cases where the correlation is zero or even positive, so long as the correlation is not perfect.) In the absence of trade, price rises whenever output falls. If demand functions have unitary price elasticity the price variations provide perfect income insurance for the farmer. With free trade, the variations in the output of the risky crop offset each other and stabilize the price, which no longer varies to offset output variations. Consequently, the revenue from the risky crop now varies and the risk faced by the farmers is increased. This induces farmers to shift production away from the risky crop, raising its average price. Since consumers have unit price
elasticity and thus spend a constant amount on both crops, the mean income of the farmers remains constant with the opening of trade while its riskiness increases. Consequently, farmers' welfare necessarily decreases, as shown in Figure 1.

Whereas before trade was opened, consumers bore all the risk, with free trade they bear none, and, other things being equal, this would make them better off. However, the increased riskiness of the risky crop induces farmers to shift their production to the safe crop, and the consequent rise in the average price of the risky crop can make consumers worse off. Near autarky, the risk benefit dominates this allocation effect, as shown in Figure 1, but near free trade the opposite is the case. If the change in supplies and prices is sufficiently large (which it will be if producers are sufficiently risk averse), and if the consumer risk benefits are sufficiently small (which they will be if consumers are not very risk averse), then consumers will be made worse off by opening trade. Since producers are necessarily worse off (in this model), it follows that free trade is Pareto inferior to autarky.

The reconciliation of our results with the standard theorems of Welfare Economics in which free trade is Pareto efficient is straightforward -- the conventional argument requires not only that markets be competitive (as we assume), but also complete. In our model there must be a complete set of insurance markets enabling farmers to purchase both price and output insurance. For a variety of reasons such as moral hazard and adverse selection the set of markets is not complete. In our example autarky provides farmers with income insurance, and opening a new market (international trade in the risky commodity) has the same affect as closing these implicit
insurance markets. With a complete set of markets each market provides one, and only one, marketing service, but with an incomplete set some markets may be providing several services, allocating both goods and risk. Institutional change may change the number of services provided by a particular market, and in our example such changes can make everyone worse off. Welfare analysis which assumes that each market serves only one function can be seriously misleading in these cases.

The model we shall analyze has been kept simple to make the main points as clearly as possible. In particular, we choose very special functional forms -- unit price elasticity -- for consumer demand which allow up to employ the concept of mean preserving changes in risk, and which thus allow a very intuitive explanation of our results. It will become clear from our model that any other specification would greatly complicate the analysis, since changes in trade will in general lead to changes in both mean income and its risk. Our results are, however, quite general, and rely on three critical assumptions. First, there must be some agents who, on average, are net sellers of the risky good (in our model, the farmers) and others who are net buyers (consumers). Since these individuals must engage in trade, their welfare is affected by the price distribution. Second, neither producers nor consumers can buy insurance for the risks (the variability of output of the risky crop and of its price) which they face. Changes in the level of trade change the price distribution and the risks that individuals face. If they could perfectly insure, then there would be no change in risk, and hence no adverse consequences. However, we would argue that it is more realistic to assume that individuals cannot perfectly insure themselves, and that therefore risk, and changes in risk, do matter. Third, output in the different
countries cannot be perfectly correlated, for then (under our assumptions that the countries are otherwise identical) opening up trade would leave the price distribution unaffected. Thus, although we assume in the first section that outputs in the two countries are perfectly negatively correlated, all that is required is the absence of perfect positive correlation. Later in the paper we show that the results continue to hold if the risks in the two countries are symmetric, a much weaker condition than perfect negative correlation.

These three assumptions distinguish our paper from earlier studies of trade and uncertainty. These other studies have (for the most part) employed the concept of a representative consumer-producer, assumed the price distribution was given exogenously, rather than determined endogenously, assumed outputs are perfectly correlated across countries, and/or focused on the case where there are perfect risk markets—so farmers can diversify out of the risks they face. The closest in spirit to the present study is the excellent work of Helpman and Razin (1978) which dealt with general equilibrium effects. However, they assume a perfect equities market (a weaker assumption than a perfect risk market), perfect correlation, and they make use of the concept of a representative consumer-producer.

The paper is divided into three parts. In Part I we develop the basic model and derive the conditions under which free trade is Pareto inferior to no trade. In Part II we use a more general model to analyze trade policy. In Part III we show that the results are more robust than the simple model developed in Parts I and II. We discuss the critical assumptions, present an alternative interpretation of the model, and suggest extensions to the analysis.
I. **Comparison** of Autarky and Free Trade

We construct a simple model with two regions which are identical, except that their output of a **risky agricultural commodity** is perfectly negatively correlated. Each region has n identical farmers and m identical consumers. We first describe the farmers, then the consumers, and finally the market equilibria with and without trade. We then compare the two equilibria and establish conditions under which free trade is Pareto inferior to no trade.

A. **Producers**

Each of the n identical producers owns one unit of **land**. A typical farmer allocates a fraction \( x \) of his land to growing a risky crop, which we denote by subscript \( r \), and the remainder, \( 1 - x \), to the safe crop, denoted by subscript \( s \). Output per acre of the risky crop is \( \theta \), a random variable, with mean unity and **variance** \( \sigma^2 \). The output of the safe crop is always unity. (These are just normalizations.)

Farmers are risk averse; they choose \( x \) before they know \( \theta \) (the weather) to maximize the expected utility of profits:

\[
\text{EU}(\pi), \quad U' > 0, \quad U'' > 0, \quad \pi = x\theta + q(1 - x)
\]

where

\[
\pi = x\theta + q(1 - x)
\]

are the profits, \( p \) is **the price** of the risky crop, and \( q \) is the price of the safe crop.
Farmers are assumed to know the relationship between the price and 8, but since each farmer is small, he assumes he has no effect on price (in any state of nature). \(^6\) Our analysis thus focuses on competitive rational expectations equilibria. The expected utility maximizing choice of \(x\) is given by the solution to

\[
EU'(\pi)(p\theta - q) = 0. \tag{3}
\]

B. Consumers

It is convenient to represent the representative consumer by his indirect utility function \(V = V(I, p, q)\) where \(I\) is income which is constant. \(^7\) For most of the analysis we shall make use of a special parameterization of the utility function. We let

\[
V = \frac{(Ip-a-b)^{l-p}}{1-p}, \quad \text{for } \rho \neq 1, \tag{4}
\]

\[
\log I - a \log p - b \log q, \quad \text{for } p = 1, \tag{5}
\]

where \(p\) is the coefficient of relative risk aversion. These yield aggregate demand functions for the two commodities which have unitary price and income elasticities:

\[
Q_r = \frac{amI}{p}, \quad Q_s = \frac{bmi}{q}, \tag{6}
\]

where \(Q_i\) is aggregate demand for commodity \(i\) (risky or safe), and \(mI\) is aggregate consumer income.
This specification of the utility function is chosen for several reasons: it greatly simplifies the calculations; it is the utility function for which consumer surplus calculations employed in conventional welfare analysis are valid; and it implies that there will be no income redistribution effects in the policy changes which we shall consider, and thus this specification enables a simple separation of the efficiency and distributional consequences of trade policy. Moreover, demand functions with unitary price elasticity play a critical borderline role in the analysis of risk with more than one commodity: if the elasticity of substitution between the two commodities is less than unity, the induced price variability results in farmers treating the safe commodity as if it were riskier than the risky commodity. (See Stiglitz [1972].) Finally, the utility function exhibits constant relative (income) risk aversion, \( \rho \), and in the special case of unitary risk aversion of equation (5):

\[
V_{ip} = V_{iq} = 0 , 
\]  

\( (7) \)

so changes in price do not affect the marginal utility of income.

C. Market Equilibrium Without Trade

The structure of the equilibrium is simple:

(a) Producers decide on a crop allocation, \( x \), given their expectations about the relationship between price and 8 is in fact the one that emerges.
(b) After the crop is harvested, the crops are marketed competitively. Market prices equate demands (given by equation (6)) to supplies (which depend on \( x \) and \( \theta \)). If all farmers act alike then market clearing prices are

\[
p = \frac{ay}{x\theta}, \quad q = \frac{by}{1 - x},
\]

(8)

where \( y = \frac{wI}{n} \), consumer income per farmer. Equation (8) implies both crops yield perfectly safe returns, which must be identical if both crops are to be grown:

\[
p\theta = q.
\]

(9)

Equations (8) and (9) imply that

\[
\frac{ay}{x} = \frac{by}{1 - x},
\]

(10)

and give the equilibrium solution

\[
x = \frac{a}{a + b}, \quad q = (a + b)y, \quad p = (a + b)y/\theta.
\]

(11)

Producer profits are \( \pi = q \) (using (9) and (2)) so producer, welfare is simply \( u((a + b)y) \). The representative consumer's average welfare in the logarithmic case (5) is

\[
EV = V_0 + \infty \log \delta, \quad V_0 = \infty \left[ 1 - (a + b) \log ((a+b)y) \right],
\]

(12)

where \( V_0 \) is the utility without risk.
Note that the unit elastic consumer demands transfer all the risk from farmers to consumers. Fluctuations in the supply of the risky crop affect only its price and not that of the safe crop. Except in this special case, production risk for one commodity will spill over to generate price risk for other commodities. (Stiglitz [1972]).

D. **Market Equilibrium with Free Trade**

Now suppose that, to the east on the other side of a mountain range there is another region, identical to the one described above in every respect save one -- the weather. When it rains in the West it is dry in the East, and vice versa. The output of the risky crop is perfectly negatively correlated between the two regions. Formally, let \( \theta^E + \theta^W = 2 \). Initially there is no trade between East and West, but there is a pass through the mountains which permits virtually costless exchange. If it is opened, there will be competitive free trade; if not, the regions will remain autarkic. Is free trade desirable?

In Section I.G below we show that there is always a symmetric equilibrium, but there may be additional asymmetric equilibria in which each country relatively specializes in one crop. If farmers are not too risk averse there will be a unique symmetric stable equilibrium, and for most of the paper we shall concentrate on this.

In the symmetric free trade equilibrium, each country will use the same fraction \( x \) of land to the risky crop, \( 1 - x \) to the safe crop, yielding total supplies:

\[
Q_r = nx\theta + nx(2 - \theta) = 2nx, \quad Q_s = 2n(1 - x).
\]  

(13)
Prices will be perfectly stabilized at

\[ \bar{p} = \frac{a y}{x}, \quad \bar{q} = \frac{b y}{1 - x}, \]  

(14)

and so total profits are now

\[ \pi = \bar{p} x \theta + (1 - x) \bar{q} = (a \theta + b) y, \]  

(15)

and farmers' income is now risky, though it has the same mean as before. The allocation of land between the two crops is given by the solution to equation (3):

\[ EU'(y(a \theta + b)) \left( \frac{a y}{x} - \frac{b y}{1 - x} \right) = EM(\theta, x) = 0. \]  

(16)

2. Comparison of Free Trade and Autarky

Denote the equilibrium values of \( x, p, q \), with free trade by \( \hat{x}, \hat{p}, \hat{q} \) and in autarky by \( \{\hat{x}, \hat{p}, \hat{q}\} \). Proposition 1 compares the allocations of the equilibria in the two situations:

**Proposition 1.** If farmers are risk averse, the safe crop is cheaper and the land devoted to the risky crop smaller with free trade than autarky.

**Proof:** With free trade and risk averse farmers the average return to the risky crop must exceed that of the safe crop:

\[ \exists \theta = \bar{p} > q \quad \text{or} \quad \frac{a y}{x} > \frac{b y}{1 - x}. \]
from (14). A comparison with the autarky equilibrium (10) implies

\[ \hat{x} > x \]  and hence \( \bar{q} < \hat{q} \).

More generally, if \( Ax = \hat{x} - x \) is the fall in land allocated to the risky crop in moving from autarky to free trade, then Proposition 2 identifies two of the critical parameters determining the magnitude of \( Ax \).

**Proposition 2.** (a) The more risk averse are farmers the greater is \( Ax \).

(Diamond and Stiglitz [1974]); (b) The greater the riskiness of \( \theta \) (in the sense of Rothschild-Stiglitz [1970]), the greater is \( Ax \), provided

(i) the range of \( \theta \) is not too great, or

(ii) there is constant relative risk aversion \( R \) with \( R < 1 \).

Either of these conditions ensure that the expression \( M(\theta, x) \) is concave in \( \theta \), and ensures the result.

F. Welfare Analysis

The next result follows immediately from equation (15):

**Proposition 3.** Farmers are always worse off as a result of the opening of trade. In the new equilibrium mean income is unchanged but risk is increased.\[13\]

Consumers now face no risk. This makes them better off but in return there is a change in \( x \), which makes them worse off. To see this, we ask what allocation \( x \) maximizes consumer welfare

\[ v = v \{ I(\frac{ax}{x}) (\frac{by}{1-x}) \} \]  (17)
where \( Z(\theta) > 0 \) depends on trade policy. Thus under autarky \( Z = \theta^a \) whilst in free trade \( Z = 1 \). However, for any \( Z(\theta) > 0 \), we observe that the solution is

\[
x = \frac{a}{a + b} = \hat{x},
\]

the farmers' choice under autarky. Any other choice makes the consumer worse off. Hence, the change in consumer welfare in moving from autarky to free trade will depend on the magnitude of the resource shift, \( \Delta x \), and on the consumer gain from the elimination of the risk he faces.

From Proposition 2, \( \Delta x \) depends on the size of the risk and the degree of farmers' risk aversion, while the consumers' benefit from risk reduction depends on the size of risk, and the degree of consumers' risk aversion.

It therefore looks as though consumers will be worse off with free trade provided farmers are sufficiently risk averse, and this is indeed true when comparing the symmetric free trade equilibrium with autarky. However, above a critical level of farmer risk aversion, the symmetric free trade equilibrium is unstable. It is therefore necessary to consider the question of stability before concluding that free trade can be Pareto inferior to autarky. This we now do.

G. Multiple Equilibria and Stability

Stability can only be examined in the context of a particular adjustment process, which in turn requires a specification of the way farmers form their expectations. We shall assume that farmers hold a weaker form of
rational expectations: given their expectations about the land allocated to the risky crop in each country, they can deduce the price distribution and hence determine their own land allocation. Out of equilibrium the farmers predict what their fellow countrymen will do (since they are identical) but can only observe last year's crop allocation in the other country. Suppose that in year $t$ country 2 chose $x_{2t}$, which farmers in country 1 correctly predict will be their choice in year $t + 1$. Given this, country 1 farmers choose the rational expectations utility maximizing choice $x_{1t+1}$ which depends on $x_{2t+1} = x_{2t}$: $x_{1t+1} = g(x_{2t})$, where the function $g$ is derived from the first order conditions of the farmer's choice. In year $t + 1$ country 2 farmers realize that their choice was incorrect, and the following year, having observed $x_{1t+1}$ and correctly predicting $x_{1t+2} = x_{1t+1}$, they choose $x_{2t+2} = g(x_{1t+1})$, where, by symmetry, the function $g$ is the same. Thus farmers are correct half the time, and only adjust after they observe that they have made an error. Figure 2 illustrates the dynamics associated with these reaction functions, and a free trade equilibrium is any pair $(x_1, x_2)$ such that

$$x_1^* = g(x_2^*), \quad x_2^* = g(x_1^*) \quad (19)$$

and is thus a fixed point of the function $g(g(\cdot))$. It is clear from symmetry that there is always a symmetric equilibrium, but there may be multiple equilibria, as in Figure 2, which shows a case in which there are three equilibria, with the symmetric equilibrium being unstable. The critical condition for (local) stability is
If farmers are risk neutral, it can be shown that the symmetric equilibrium is unique and stable, whilst if farmers are infinitely risk averse there are multiple equilibria, and the symmetric equilibrium is unstable (Newbery and Stiglitz [1981b]. It is thus reasonable to conjecture that there is some critical value of (relative) risk aversion, \( R^* \) say, (which will depend on the parameters \( a \), \( b \), and the distribution of \( \theta \)) below which the symmetric equilibrium is unique and stable, and above which there are multiple equilibria, with the symmetric equilibrium unstable, and this can be demonstrated for constant absolute or relative risk aversion utility functions and a two point distribution for \( \theta \) [15].

Since farmers are always worse off in a free trade equilibrium, free trade will be Pareto inferior to autarky if consumers are worse off under free trade, i.e., if

\[
E \left( \frac{(p-a)^{1-p} - b(a)}{1-p} \right) < E \left( \frac{(p-a)^{1-p} - b(a)}{1-p} \right)
\]

In the symmetric equilibrium, substituting for prices, this is equivalent to

\[
\frac{1}{a(1-p)} < \{E \theta^a(1-p)\} \quad (22)
\]
The RHS is a monotonically decreasing function of consumer's relative risk aversion $\rho$ while the LHS is a monotonically decreasing function of farmers' relative risk aversion $R$. It follows that there is a monotonically increasing critical function $R = f(\rho)$ for which consumers are indifferent between autarky and the symmetric free trade equilibrium, and it can be shown that $f(0) \equiv R_o > 0$, where the value of $R_o$ depends on the form of the utility function, the nature of risk, and other parameters. The crucial question is whether $R_o < R^*$, the critical value at which the symmetric equilibrium becomes unstable.

For the two point distribution, $\Theta = 1 + a$, and values of $\sigma = 9.9$ there is a wide range of values of $a$ and $b$ for which $R_o < R^* : 0.2 \leq a \leq 0.8 ; a + b \leq 0.9$, for both constant absolute and relative risk aversion utility functions. $R_o$ increases with $b$, decreases with $a$, and is less than 3.0 for $a \geq 0.4$. However, for $a \leq 0.8$ there are very few such configurations, and hence for free trade to be Pareto inferior to autarky, the degree of risk must be quite extreme.

When the symmetric equilibrium is unstable, there will in general exist stable equilibria, and it is also possible that these equilibria are Pareto inferior to autarky. For our two point distribution example, computer simulation confirmed that there is also a set of values of $\Theta$ above $R^*$ for which the asymmetric equilibria are stable and Pareto inferior to free trade, bounded by a curve $R = f(\rho)$ which near $R^*$ is decreasing in $\rho$ and which intersects $R = f(\rho)$ at $R^*$.

These computer simulations allow us to assert

**Proposition 4.** There exist sets of parameter values for which the stable free trade equilibrium is Pareto inferior to autarky.
The simulations suggest that the range of values of \((R,p)\) for which this is true increases with \(\sigma\), \(a\), and \(b\). There is a larger range of values of \((R, p)\) for which free trade is potentially Pareto inferior to autarky in the sense that though consumers would be better off with free trade, they would not be willing to pay the fixed sum needed to compensate producers for accepting free trade.

In the remainder of the paper we shall confine attention to the symmetric free trade equilibrium and hence restrict attention to cases where \(R < R^*\).

II. TRADE POLICY

The preceding section demonstrated that the opening up of trade could, in the absence of perfect risk markets, result in all individuals in both countries being worse off. Whilst the example is dramatic, and has the merit of simplicity, it is clearly a special case, and needs considerable extension if it is to provide any practical insights. It is special in a number of ways, many of which have already been mentioned, but here we wish to draw attention to, and relax, two of these special features. First, the assumption that production is perfectly negatively correlated allowed us to use a single risk parameter, \(\theta\), to describe the state of the world, whilst avoiding the degenerate case of perfectly positively correlated risk. However, this is an extreme assumption which we shall replace by the much weaker assumption that risk is symmetric. That is, to every state \(s\) there corresponds a state \(s'\) such that country 1 in state \(s\) is indistinguishable from country 2 in state \(s'\), and vice versa (in the symmetric equilibrium). Second, the absence of a complete set of insurance markets constitutes a market failure, and hence
raises the question of what is the best feasible intervention -- in this case what is the best trade policy? Whilst there is a presumption that free trade is not optimal (since it may be dominated by autarky), it will be shown below that autarky is also not optimal. A model which only compares these two extremes does little to shed light on the more important question of the best choice of trade policy.

This question turns out to be very complicated to answer in general, for the following reason. In the absence of risk, trade policy is concerned to influence the level of trade, and it makes little difference in a competitive world (aside from reallocations of rent) whether this is achieved by tariffs or quotas. In the presence of risk, however, tariffs and quotas have a quite different effect on the distribution of trade, prices, and hence the risks borne by consumers and producers -- a result already noted in a partial equilibrium context by Fishelson and Flatters (1975) and Dasgupta and Stiglitz (1977). In short, it is no longer enough to choose the level of trade, but rather, the level of trade in each state of the world, or the trade intervention policy as a function of the state of the world.

Whilst it is possible to characterise this optimal mode of intervention, it is not clear that this is the right way to formulate the policy question. If the government can, ex post, identify the state of the world and make policy contingent on this state, then it might just as well offer insurance, in which case the problem disappears. Presumably, the reasons that militate against completing the market structure also gravely limit the choice of trade policy. In practice, trade policy appears to be largely a question of choosing between relatively simply instruments such as a uniform tariff or quota and it therefore seems sensible to ask of the
unconstrained optimum trade policy whether it looks more like a tariff or a quota. **Alternatively,** one can ask directly which of these two alternatives is preferable, and when.

In this section, we prove two general propositions concerning the effects of small deviations from the free trade and autarky position; provide a general characterization of the risk effects of quotas versus tariffs within our general **equilibrium** model; pose the question of choosing the optimal set of barriers to trade; and provide some partial answers to the evaluation of alternative trade restrictions. For simplicity, we assume each country pursues identical trade policies, so that symmetry is not disturbed. We also assume throughout that any revenues from trade policy are distributed as lump sum payments to producers. Symmetry requires that states of the world occur in equally **probable** pairs, $s, s'$, so that when the output of the risky crop in country $i$ is $x_i \theta_i(s)$, then,

$$\theta_1(s) = \theta_2(s''); \theta_1(s'') = \theta_2(s).$$  \hspace{1cm} (23)

**Symmetry** of trade policy means that when a policy instrument is set at level $z$, in state $s$, and the level of imports in country $i$ is $x_i t(\theta_i(s), z)$, then, in the symmetric equilibrium when $x_1 = x_2 = x$

$$t(\theta_i(s), z) = -t(\theta_i(s''), z'').$$  \hspace{1cm} (24)

If increases in $z$ correspond to **liberalizing** trade policy, and if the effect of the liberalization is to increase trade in every state of the world (or not
decrease it), then $i$ will import in state $s$ if $\theta_i(s) < \theta_j(s) = \theta_i(s')$, $j \neq i$, and

$$\frac{dt(\theta_i(s), z)}{dz} = -\frac{dt(\theta_i(s'), z)}{dz} > 0 \text{ for } \theta_i(s) < \theta_i(s').$$  (25)

Symmetry also implies that

$$E_t = 0, \text{ and } E \frac{dt}{dz} = 0.$$  (26)

The corresponding distribution of domestic prices is

$$p_i(s, x, z) = \frac{ay/x}{\theta_i(s) + t(\theta_i(s), z)}.$$  (27)

Trade policy has two effects — it changes the risk facing producers and consumers, and hence changes the allocation of land between the two crops. Starting from autarky ($z = 0$), increasing trade increases the risk facing farmers, and this will, in general, cause them to switch land from the risky to the safe crop. Rather than specify restrictions on the utility functions, risk, and trade policy which guarantee this, it is more direct to specify the allocative consequences of trade policy. We shall say that trade policy has a monotonic allocative effect if the share of land allocated to the risky crop decreases monotonically with trade liberalization.

We are now in a position to state and prove two remarkable results:

**Proposition 5:** Any small symmetric trade liberalization from autarky is Pareto improving.
Proposition 6: Any small symmetric trade restriction at the symmetric free trade equilibrium is Pareto improving provided the allocative effect is monotonic.

Thus, while the previous section established that no trade may be Pareto superior to free trade, this section establishes that neither policy is itself, in general, Pareto efficient, and hence there exist alternative trade policies which make some individuals better off without making any individual worse off. To establish this result, we need to analyze the effects of trade policy on producers and consumers.

A. Effect of Trade Policy on Producers

In equilibrium producers must receive the amount spent by consumers on the safe and risky crops, less the value of consumers' purchases of the risky crop from the other country, so producer profits will be

\[ \pi(\theta(s), z) = (a + b)y - D(\theta(s), z) \]  \hspace{1cm} (28)

where \( D(\theta(s), z) \) is the trade deficit; its value will depend on the world price, which in turn will depend on the specification of trade policy. For example, with quotas it will depend on how the rents generated by the quotas are allocated between exporting and importing countries. Fortunately, it is not necessary to be specific about the determination of \( D(\theta, z) \) since we can use the symmetry assumption:

\[ D(\theta(s), z) = -D(\theta(s'), z) \geq 0 \text{ as } \theta(s) \leq \theta(s') \]  \hspace{1cm} (29)
and the fact that the deficit increases with imports:

\[
\text{ED} = 0 \quad \text{and} \quad \frac{dD}{dz} > 0 \quad \text{as} \quad \theta(s) \leq \theta(s').
\]  

(30)

It is immediate \(^{18}/\) from (30) that any finite opening of trade represents a mean-preserving spread in farmers' profits compared to autarky and so they must be worse off. Moreover, an infinitesimal trade liberalization has an infinitesimal effect on risk, which, starting at zero risk, is costless. (Note that in Figure 1 farmers' utility is flat at autarky.)

B. Effect of Trade Policy on Consumers

The effect on consumer welfare of a small change in trade policy is described by

\[
\frac{d\text{EV}}{dz} = \frac{\partial \text{EV}}{\partial z} + \frac{\partial \text{EV}}{\partial x} \frac{dx}{dz}.
\]  

(31)

After some manipulation \(^{19}/\) this can be written as

\[
\frac{d\text{EV}}{dz} = \text{EV}_1 \left[ px \frac{dt}{dz} + (p(\theta + t) - q) \frac{dx}{dz} \right].
\]  

(32)

We can now examine the effects of trade policy at autarky and free trade.

1. Autarky. At \( z = 0 \), \( t = 0 \), \( p\theta = q \), so

\[
\frac{d\text{EV}}{dz} = x\text{EV}_1 p \frac{dt}{dz}.
\]  

(33)
If the country is importing in state \( s (\theta(s) < \theta(s')) \), so that \( t \) and \( \frac{dt}{dz} \) are positive, then \( p \) will be high, whilst in state \( s' \), with the country exporting, \( \frac{dt}{dz} \) is negative, and \( p \) will be low. The whole expression will be positive if \( p V_I \) is positively correlated with \( p \), which it is from (4) for

\[
\frac{d}{dp}(p V_I) = V_I (1 + \frac{p V_I}{p}) = 1 - a(1 - \rho) > 0. \tag{34}
\]

The effect of trade liberalization from the consumer's point of view is that of a mean quantity preserving decrease in the riskiness of consumption, which, if consumers are risk averse, that is, if utility is concave in the risky good, is beneficial.

2. Free Trade. At free trade prices are the same in both countries. Consider the effect on consumer welfare of restrictive in states \( s \) and \( s' \) taken together, in which prices are the same (and hence so is consumer welfare). From (32)

\[
\frac{d}{dz} \{V(s) + V(s')\} = 2 V_I \left[ \frac{a y}{\theta(s) + \theta(s')} \left( \frac{dt(s)}{dz} + \frac{dt(s')}{dz} \right) + \left( \frac{a y - by}{x} \right) \frac{dx}{dz} \right]. \tag{35}
\]

The first term cancels by (26), whilst if \( x \) is monotonically decreasing in \( z \), since at autarky \( p\theta = ay/x = q = by/(1 - x) \), the second term is negative, and hence at free trade

\[
\frac{dEV}{dz} \bigg|_{z=1} < 0.
\]
Consequently, both producers and consumers benefit from trade restrictions at free trade, and, as shown in Figure 1 there is an intermediate level of trade, between no trade and free trade, at which consumers' welfare is maximized. Any restrictions up to this level will make both producers and consumers better off.

C. Optimal Trade Policy

Restrictions on trade obviously introduce an inefficiency: the marginal rate of substitution between the risky crop and other commodities will differ in the two countries. At the same time, restrictions on trade serve as a partial substitute for the insurance (risk) markets which are absent. There is thus a standard, second best welfare problem, balancing the direct allocative inefficiencies with the gains from the improved distribution of risk.

Assume, for instance, that tariffs or quotas could be made state contingent (in that case, tariffs and quotas would be equivalent). Let $t_{i}(s)x$ be the quantity of imports into country $i$ in state $s$. Given symmetry, it is only necessary to look at one country in choosing policy, and so the set of Pareto efficient symmetric trade policies are the solutions to

$$\max_{\{t(s), x\}} \text{EV}(p(s), q)$$

such that

$$\text{EU}(\pi) > \bar{U} \quad \text{and} \quad \frac{20}{\text{EU}^\prime}(\pi)\left[p(s)x(s)-q \right] = 0$$

(36)

where $p(s)$ is given by (27) and $q$ by (8). Consider a pair of states $s, s'$, such that the country imports in state $s$ and hence exports in state $s'$,
and suppose that the importing country imposes state contingent tariffs, but the exporting country is always passive. The tariff revenue will be \( \{p(s) - p(s')\}t(s)x \) in state \( s \), and zero in \( s' \), and so producer income including the lumpsum payment from the government is

\[
\pi(s) = p(s)x\theta(s) + q(1 - x) + \{p(s) - p(s')\}t(s)x
\]

\[
= ay \left[ \frac{\theta(s)}{\theta(s)+t(s)} + t(s)\left\{ \frac{1}{\theta(s)+t(s)} - \frac{1}{\theta(s')-t(s)} \right\} \right] + by,
\]

\[
\pi(s) = (a + b)y - \frac{ay t(s)}{\theta(s') - t(s)}, \quad \theta(s) < \theta(s'), \tag{38}
\]

while when the country exports

\[
\pi(s') = p(s')x\theta(s') + q(1 - x) = ay\left\{ \frac{\theta(s')}{\theta(s') - t(s)} \right\} + by
\]

\[
\pi(s') = (a + b)y + \frac{ay t(s)}{\theta(s') - t(s)}, \quad \theta(s') > \theta(s). \tag{39}
\]

Equation (38) and its symmetric counterpart (39) can be inserted into the constraints (37) and, in principle, the optimum trade policy can be solved. The first order conditions demonstrate, as expected, that the effects of a change in the level of trade have three effects. First, increasing trade symmetrically constitutes a mean preserving increase in producer risk and thus lowers producers' expected utility. Second, this causes an allocative effect as producers reduce the area of land allocated to the risky crop (under the monotonicity hypothesis). This allocative effect reduces consumer welfare as shown in I.F above. Third, the reduction in price variability reduces
consumer risk which benefits consumers. The optimal level of trade represents a balancing of these three effects. Since producers are unambiguously worse off as trade increases, it must be the case that at the optimum, consumers are better off, i.e. the gains from risk reduction exceed the losses from the allocative effect. Although the detailed form of the optimum trade policy depends on the nature of risk, attitudes to risk, and other parameters, there is one strong result that follows directly from our earlier analysis:

**Proposition 7:** It is never desirable to prevent trade in any state.

The importance of this result is that tariffs necessarily prevent trade in those states where the price difference between the countries is less than the height of the tariff wall, whilst quotas never completely prevent trade. In this sense, then, quotas are preferable to tariffs, or, more precisely, the state contingent optimal trade policy works more like a quota than a tariff for those state where price differences are small. The proof follows exactly the same steps as Proposition 5, except it is confined to those states where trade has been prevented. Liberalization is then Pareto improving.

D. Restricted Trade Policy

The previous subsection demonstrated that the choice of optimal trade policy involves a second best compromise between the allocative benefits of free trade and one risk consequences. The second best nature or the problem persists even though we have imposed no constraints on trade policy.

We argued in the introduction to this part that the information required to implement the unconstrained optimal policy were essentially the same as that required to complete the market structure and hence eliminate the second best aspects of the problem. Arguably, the reasons which prevent the
creation of the missing insurance markets will also limit the flexibility of
trade policy. In practice governments usually limit themselves to choosing
simple trade policies such as specific or ad valorem tariffs and/or quota.
This choice raises two natural questions: (a) which of the two polar policies,
tariffs or quotas, both set at their optimal level, generates the highest
level of welfare? and (b) if it is possible to combine the two policies,
e.g., impose a quota in addition to ad valorem tariff, is it desirable to do
so?

The key difference between quotas and tariffs is that quotas offer
better insurance to farmers than tariffs, whilst tariffs offer better
insurance to consumers than quotas. This is most easily seen for the case of
perfect negative correlation between output risks. Figures 3, 4 and 5 give
the distribution of prices, consumption and profits for the two policies in
this case. Thus tariffs restrict trade most for values of \( \Theta \) near unity, when
the risks facing the farmers with free trade would be small, whilst quotas
restrict trade for extreme values of \( \Theta \) for which free trade is most risky.
Conversely, tariffs are better at truncating the tails of the price
distribution, which cause most consumer risk. This suggests that near
autarky, where producer risk is negligible, tariffs are superior to quotas,
whilst near free trade, where producers bear most of the risk, quotas will be
superior to tariffs.

The second question posed above can also be answered for the case of
perfect negative correlation, where it can be shown that even after the
optimal tariff is imposed, it will be desirable to impose a quota, while with
the optimal quota, it is in general not desirable to impose a small tariff.
which would only operate neat free trade, where we showed that no intervention
is optimal. (The details are given in Newbery and Stiglitz, 1982c).

III. Extensions and Limitations

The previous sections of the paper used an extremely simple model to
establish a number of quite strong results: not only may free trade be Pareto
inferior to no trade, some trade restrictions will always be desirable, and
there is a sense in which quotas are superior to tariffs. To what extent are
the results dependent on the special parameterizations we have employed? And
to what extent do they depend on the particular institutional assumptions we
have made? The critical assumption in our analysis, we contend, is the
absence of perfect risk markets, an assumption which, though not justified
within the context of the model, seems empirically more plausible (at least in
the context investigated here) than the other polar assumption conventionally
employed, that risk markets are perfect.

To see why this is important, let us consider briefly the nature of
equilibrium under alternative assumptions, and concentrate on the results of
the first part of the paper, which assume perfect negative output correlation.

A. Financial Markets

First, we note that in the central case of consumers having
logarithmic utility functions, there is no scope for futures markets in the no
trade situation; for then $V_{1p} = 0$, the marginal utility of income is the same
independent of the state of nature, and hence market equilibrium requires that
if a small futures market were introduced, it be actuarially fair. But for
producers, profits are constant, and they too would require an actuarially
fair futures market. Hence the only equilibrium is one where there is no
trade on the futures market. With perfect negative output correlation, there would be no scope for a futures market in the free trade situation either, since prices would not vary.

The consequences of opening up a market for ownership shares in farms is more serious. (We ignore all the problems of moral hazard, which are fundamental to an understanding of why such markets might not exist.) If farmers could purchase shares in each others' farms, then income of farmers would be constant; they would thus be indifferent between the opening of trade and autarky, but consumers would be unambiguously better off. Thus, the standard result that free trade is preferable to no trade is restored, if there is a complete set of securities markets.

But, an essential part of the argument so far is that trade is costless. With costly trade, the possibility that opening trade will at least lower the welfare of producers is restored. With free trade in securities, farmers' income is smoothed, but the opening of trade leads to farmers' net income being lowered by the expenditure on transport costs. Thus farmers are worse off as a result of the opening of trade.

The major reason that the unit price elasticity assumption is employed is that it avoids the confusion between transfer and risk effects. If the elasticity of demand is not unity, a mean quantity preserving change in demand curves have constant elasticity greater than unity, farmers' revenue is a convex function of consumption, so, at each value of x, mean income is higher under autarky than with free trade. Although in autarky, producers' income is variable, it is less variable than output, and hence less variable than income under free trade.
It can thus be shown that (i) a slight increase in trade from the no trade position always increases producers' welfare; (ii) provided the elasticity is not too large, a slight restriction on trade from the free trade position also increases producers' welfare.

The effect on consumers is more difficult to analyze. There are now three effects: (i) the risk effect; as before, opening trade reduces consumer risk; (ii) the transfer effect; because of the change in the distribution of prices, mean expenditure of consumers is increased, which makes them worse off; (iii) the allocation effect; because of the transfer effect, the allocation effect will be smaller, and may actually be positive rather than negative.

Similarly, if the elasticity of demand is less than unity the reduction in price variability reduces producers' mean income, and, if the elasticity is greater than 0.5, opening trade increases the variability of their income. Thus, producers are unambiguously worse off. Again, the effects on consumers are more complicated: now the transfer effect is positive, but the allocation effect is larger. Thus there are a large variety of possible patterns.

If the price elasticity is very small (less than 0.5), then pre-trade income variability is greater than post-trade income variability, in which case the opening of trade may be Pareto superior even without direct compensation schemes.

For elasticities of demand near unity, however, the qualitative properties remain unaffected: free trade may be Pareto inferior to no trade, provided farmers are sufficiently risk averse; if the elasticity is greater than unity, a slight liberalization of trade from the no trade position is
Pareto improving; if the elasticity is less than unity, producers are strictly worse off; a slight restriction on trade from the free trade position is Pareto improving provided producers are sufficiently risk averse.

C. The Theory of Comparative Advantage

Specialists in traditional trade theory have, on a number of occasions, expressed an uneasiness with our analysis, on the grounds that it appears to ignore the principle of comparative advantage which underlies conventional trade theory. Note that this is not quite correct. Although there is no long run comparative advantage, each of the countries having precisely the same endowments and tastes, every period there is a significant comparative advantage, depending simply on the weather.

This, in fact, we would claim is one of the attractive features of our analysis: There is considerable evidence that much trade cannot be explained solely on the basis of factor endowments or tastes. It seems, according as desirable to explore models in which there is trade without long run comparative advantage.  

We can, nonetheless, easily incorporate elements of traditional comparative advantage theory within our framework. Although we leave the formal development of such a synthesis to another occasion, let us briefly show how it may be done. Assume, for simplicity, that there are two factors, sav capital and labor. Assume, that the safe crop is labor intensive. For simplicity, let us assume that the two countries have the same factor endowments. Clearly, there is again no long run comparative advantage. We can ask, however, what happens as a result of the opening up to trade. Our previous analysis applies almost identically, except now farmers do not face a straight line production possibilities schedule, but face a concave production
possibilities schedule. It is still true, however, that the opening up of trade will lead to an increase in the production of the safe crop (in this case labor). Assume, now, that the two countries have slightly different factor endowments. There will now be two effects: in the absence of risk, the opening up of trade will lead to the equalization of factor prices, a decrease in the price of labor in one country, and an increase in its price in the other. Now, however, there is an additional risk effect, which will tend to shift production toward the safe crop (more, presumably, in the country which has a comparative advantage in its production). This effect may outweigh the first effect, so that, still, the price of labor in both countries rises; it is even possible that factor price differentials widen.

IV. Concluding Remarks

There is an argument, popular with economists, that if markets are competitive and agents well informed, then government intervention will lead to inefficiency. This argument has been used both to argue against restrictions on trade and against the establishment of international buffer stocks. 23/

Our analysis questions the premises of this reasoning. We show that there is no presumption that free markets will be Pareto optimal. But our analysis is not simply negative. We provide a framework which enables, in any situation, a detailed evaluation to be made of whether trade liberalization (or a commodity buffer stock) will be a Pareto improvement. Our analysis suggests that, under some quite plausible conditions, it is desirable for the government not only not to introduce a buffer stock, but actually to restrict the arbitrage activities of speculators. Our analysis also shows that some
trade restrictions may be desirable in the presence of imperfectly correlated risk.

Our analysis has, quite obviously, left out all considerations of the political processes by which trade policy becomes determined. Though the greater effectiveness of quotas in reducing producer uncertainty, which we established in Section 11, may provide part of the explanation of the seeming preference of many trade associations for quotas over tariffs, there is little to suggest that present trade barriers are chosen with the considerations we have raised in mind. What our analysis does explain, however, is why the simplistic arguments for free trade, making use of the competitive paradigm, with all of its assumptions, including that of a complete set of risk markets, are often far from persuasive.
FOOTNOTES

1/ Elsewhere (Newbery and Stiglitz [1982a]) we have demonstrated the inefficiency (except under very stringent conditions) of competitive (i.e., free trade) equilibria for a more general model. The result that there exists some intervention to the free trade equilibrium derived in the present paper is robust, and would continue to apply in more general models.

2/ Thus, if individuals are all identical, the changes in price distribution which are central to our analysis have no welfare consequences.

3/ For an extensive survey of the recent literature on trade and uncertainty, see Pomery (1979). Among the studies focusing on the small country case with the price distribution given exogenously are those of Batra and Russell (1975) and Ruffin (1974). The Batra and Russell and Ruffin papers also assumed producers had no output variability whereas the relationship between the variability of output and prices plays a crucial role in our analysis.

4/ Even when there are perfect equities markets, the assumption of identical consumers is crucial. Stiglitz (1982) has shown, for instance, that while the stock market equilibrium with multiplicative uncertainty and two commodities is always a constrained Pareto optimum with Identical consumers, it essentially never is if consumers differ, either in their preferences for goods or their attitudes towards risk.

5/ An inessential simplification of this analysis is that producers do not consume what they produce; their welfare depends only on what they obtain from selling their crops.
In our simple model, since the only source of price variability is supply variability, price will be a deterministic function of \( \Theta \); in more general models, it would be a stochastic function.

I is the consumer's endowment of a third good (or a Yicksian composite commodity, representing all other goods), which is taken to be the numeraire.

See Samuelson (1942).

For other utility functions mean income of farmers will increase or decrease as a result of the opening of trade. See Section III.B below.

The dollar value of the loss from the randomness in \( \Theta \) is approximately \( \frac{a}{2} \sigma^2 \). In the case of constant relative risk aversion not equalling unity

\[
EV = E \frac{\Theta^a (1-\rho) V_0}{1 - \rho}, \quad V_0 = \left\{ \frac{n}{m(a+b)} \right\}^{(1-\rho)(a+b)} I(1-\rho)(1-a-b)
\]

The dollar value of the loss from risk is then approximately

\[
\frac{1}{2} a (1 - a(1 - \rho)) \sigma^2
\]

which agrees with the logarithmic case fot \( p = 1 \).

This rules out the conventional reasons for trade and allows us to concentrate on the risk aspect alone. Regions have a comparative advantage in weather alone in this model. Obviously, this heavily qualifies any policy conclusions which might be drawn from the study. See also III.C below.
Since \[ M = U'[a\theta + b]y(\frac{a\theta}{x} \theta - \frac{b}{1-x}), \] and \[ R = -\frac{\pi U''(\pi)}{U'(\pi)}, \]

\[
\frac{\partial M}{\partial \theta} = ayU' \left\{ \frac{1}{x} - \frac{R}{a\theta + b} \left( \frac{a}{x} \theta - \frac{b}{1-x} \right) \right\}
\]

\[
\frac{\partial^2 M}{\partial \theta^2} = \frac{Ra^2U'y}{(a\theta+b)^2} \left[ \frac{a\theta}{x} - b \left( \frac{c}{x} + \frac{1}{1-x} \right) + \left\{ R - \frac{R'}{R} \right\} \left( \frac{a\theta}{x} - \frac{b}{1-x} \right) \right].
\]

If the range of \( \theta \) is small, \( \frac{a\theta}{x} - \frac{b}{1-x} \) will be small, so \( \frac{\partial^2 M}{\partial \theta^2} < 0 \).

Alternatively, if \( R' = 0 \) and \( R < 1 \), \( \frac{\partial^2 M}{\partial \theta^2} < 0 \). Clearly, these conditions can be weakened.

A quantitative estimate of their welfare loss expressed as a percentage of mean income is provided by Taylor Series approximation:

\[
\frac{\Delta U}{U[a+b]yU'} = \frac{U[a+b]}{(a+b)yU'} - \frac{EU[(a\theta+b)y]}{(a+b)yU'} = \frac{1}{2} \left( \frac{a}{a+b} \right)^2 R^2.
\]

Stability must be defined relative to a particular adjustment process, which is discussed in section 1.6 below.

Details available from Newbery on request.

The conditions required for this to be true are discussed in Newbery and Stiglitz (1981).

There may, of course, exist alternative policies which constitute a Pareto improvement, the most obvious of which is the opening of additional insurance markets.
The effect of a small change in policy can be found by differentiating totally with respect to \( z \). Where \( z = 0 \) corresponds to autarky (\( t = 0 \)) and \( z = 1 \) corresponds to free trade. The effect on producer's welfare is,

from (28)

\[
\frac{dEU}{dz} = acu \frac{\partial x}{\partial z} - EU' \frac{dB[\theta(s), z]}{dz}
\]

The first term is zero by the envelope theorem, whilst the second is best considered by taking sums of pairs of states, \( s, s' \):

\[
- \psi'(s) \frac{dD(s)}{dz} - \psi'(s') \frac{dD(s')}{dz} = - \frac{dD(s)}{dz} \{U'(s) - U'(s')\}
\]

using symmetry, which, by the mean value theorem is, for some level of profits \( n^* \),

\[
- \frac{dD(s)}{dz} \{\pi(s) - \pi(s')\} U''(n^*) = 2 \frac{dD(s)}{dz} U''(n^*) \leq 0 \text{ if } |D| \geq 0
\]

At \( t = 0, D = 0 \), and there is (locally) no effect on producers' welfare, otherwise trade liberalization is harmful.

From (31)

\[
\frac{d\psi}{dz} = E(v_p \frac{\partial p}{\partial z} + E(v_q \frac{\partial q}{\partial x} + \frac{\partial q}{\partial x}) \frac{\partial x}{dz}
\]

Differentiate (30) and (8) to obtain \( \partial p/\partial x, \partial p/\partial z \) and \( \partial q/\partial x \), and observe from Roy's identity that \( V_p = V_L x(\theta + t), V_q = - V_L (1 - x) \).
20/ We could have formulated the problem letting \( x \) be a function of \( t \); it is simpler, however, if we let \( x \) be a control variable and adjoin the constraint.

21/ Brazilian coffee growers do not as a rule own shares in Kenyan coffee farms, or conversely. Although we have not explained this absence of perfect risk markets, it would not be difficult to construct a model which is consistent with our analysis and which would simultaneously have the property that there is imperfect risk sharing. See, for instance, Arnott and Stiglitz (1981).

22/ Of course, there are other possible models, emphasizing economies of scale and monopolistic competition; again, in such models, opening trade need not be Pareto improving.

23/ The parallel between the opening of trade between two countries and the opening of trade between two dates should be obvious. Our analysis implies that a buffer stock that perfectly stabilizes prices (corresponding to free trade) may be Pareto inferior to having no buffer stock. Our analysis suggests that, in the absence of a complete set of securities markets, the market may generate an excessive amount of intertemporal arbitrage, and the amount of price stabilization may be greater than is Pareto optimal. See Newbery and Stiglitz (1981, 1982b).
REFERENCES


Figure 1: Welfare Consequences of Opening Trade

Figure 2: Multiple Equilibria, symmetric equilibrium unstable
Figure 3: Price Distribution

Figure 4: Consumption Distribution

Figure 6: Profit Distribution